PARTICLE DEVICE FIRMWARE

The Particle Raspberry Pi project has been discontinued. You can still follow these instructions, however there will be no future updates and support is no longer available for this product.

Cloud Functions

Overview of API field limits

API Field	Prior to 0.8.0	Since 0.8.0	Comment
Variable Key	12	64	
Variable Data	622	622	
Function Key	12	64	
Function Argument	63	622	
Publish/Subscribe Event Name	64	64	
Publish/Subscribe Event Data	255	622	

Note: Spark Core limits remain as-is prior to 0.8.0

Particle.variable()

Expose a *variable* through the Cloud so that it can be called with `GET /v1/devices/{DEVICE_ID}/{VARIABLE}`. Returns a success value - `true` when the variable was registered.

Particle.variable registers a variable, so its value can be retrieved from the cloud in the future. You only call Particle.variable once per variable, typically passing in a global variable. You can change the value of the underlying global variable as often as you want; the value is only retrieved when requested, so simply changing the global variable does not use any data. You do not call Particle.variable when you change the value.

```
// EXAMPLE USAGE

int analogvalue = 0;
double tempC = 0;
char *message = "my name is particle";
String aString;
```

```
void setup()
{
  Particle.variable("analogvalue", analogvalue);
  Particle.variable("temp", tempC);
  if (Particle.variable("mess", message)==false)
  {
      // variable not registered!
  }
  Particle.variable("mess2", aString);

  pinMode(A0, INPUT);
}

void loop()
{
  // Read the analog value of the sensor (TMP36)
  analogvalue = analogRead(A0);
  //Convert the reading into degree celcius
  tempC = (((analogvalue * 3.3)/4095) - 0.5) * 100;
  delay(200);
}
```

Up to 20 cloud variables may be registered and each variable name is limited to a maximum of 12 characters (*prior to 0.8.0*), 64 characters (*since 0.8.0*). The Spark Core remains limited to 12 characters.

Note: Only use letters, numbers, underscores and dashes in variable names. Spaces and special characters may be escaped by different tools and libraries causing unexpected results.

When using SYSTEM_THREAD(ENABLED) you must be careful of when you register your variables. At the beginning of setup(), before you do any lengthy operations, delays, or things like waiting for a key press, is best. The reason is that variable and function registrations are only sent up once, about 30 seconds after connecting to the cloud. Calling Particle.variable after the registration information has been sent does not re-send the request and the variable will not work.

You will almost never call Particle.variable from loop() (or a function called from loop()).

String variables must be UTF-8 encoded. You cannot send arbitrary binary data or other character sets like ISO-8859-1. If you need to send binary data you can use a text-based encoding like Base64.

Prior to 0.4.7 firmware, variables were defined with an additional 3rd parameter to specify the data type of the variable. From 0.4.7 onward, the system can infer the type from the actual variable. Additionally, the variable address was passed via the address-of operator (`&`). With 0.4.7 and newer, this is no longer required.

This is the pre-0.4.7 syntax:

```
int analogvalue = 0;
double tempC = 0;
char *message = "my name is particle";

void setup()
{
  Particle.variable("analogvalue", &analogvalue, INT);
  Particle.variable("temp", &tempC, DOUBLE);
  if (Particle.variable("mess", message, STRING)==false)
      // variable not registered!
  pinMode(A0, INPUT);
}
```

There are three supported data types:

- `INT`
- `DOUBLE`
- `STRING` (maximum string length is 622 bytes)

```
# EXAMPLE REQUEST IN TERMINAL
# Device ID is 0123456789abcdef
# Your access token is 123412341234
curl "https://api.particle.io/v1/devices/0123456789abcdef/analogvalue?
access_token=123412341234"
curl "https://api.particle.io/v1/devices/0123456789abcdef/temp?
access_token=123412341234"
curl "https://api.particle.io/v1/devices/0123456789abcdef/mess?
access_token=123412341234"
```

```
# In return you'll get something like this:
960
27.44322344322344
my name is particle
```

Particle.function()

Expose a *function* through the Cloud so that it can be called with `POST /v1/devices/{DEVICE_ID}/{FUNCTION}`.

Particle.function allows code on the device to be run when requested from the cloud API. You typically do this when you want to control something on your Raspberry Pi, say a LCD display or a buzzer, or control features in your firmware from the cloud.

```
// SYNTAX
bool success = Particle.function("funcKey", funcName);

// Cloud functions must return int and take one String
int funcName(String extra) {
  return 0;
}
```

Up to 15 cloud functions may be registered and each function name is limited to a maximum of 12 characters (*prior to 0.8.0*), 64 characters (*since 0.8.0*). The Spark Core remains limited to 12 characters.

Note: Only use letters, numbers, underscores and dashes in function names. Spaces and special characters may be escaped by different tools and libraries causing unexpected results. A function callback procedure needs to return as quickly as possible otherwise the cloud call will timeout.

In order to register a cloud function, the user provides the `funcKey`, which is the string name used to make a POST request and a `funcName`, which is the actual name of the function that gets called in your app. The cloud function has to return an integer; `-1` is commonly used for a failed function call.

A cloud function is set up to take one argument of the String datatype. This argument length is limited to a max of 63 characters (*prior to 0.8.0*), 622 characters (*since 0.8.0*). The Spark Core remains limited to 63 characters. The String is UTF-8 encoded.

When using SYSTEM_THREAD(ENABLED) you must be careful of when you register your functions. At the beginning of setup(), before you do any lengthy operations, delays, or things like waiting for a key press, is best. The reason is that variable and function registrations are only sent up once, about 30 seconds after connecting to the cloud. Calling Particle.function after the registration information has been sent does not re-send the request and the function will not work.

```
// EXAMPLE USAGE

int brewCoffee(String command);

void setup()
{
  // register the cloud function
  Particle.function("brew", brewCoffee);
}

void loop()
{
  // this loops forever
}

// this function automagically gets called upon a matching POST request
int brewCoffee(String command)
{
  // look for the matching argument "coffee" <-- max of 64 characters long
  if(command == "coffee")
  {
    // some example functions you might have
    //activateWaterHeater();
    //activateWaterPump();
    return 1;
  }
  else return -1;
}
```

You can expose a method on a C++ object to the Cloud.

```
// EXAMPLE USAGE WITH C++ OBJECT

class CoffeeMaker {
  public:
    CoffeeMaker() {
    }

    void setup() {
      // You should not call Particle.function from the constructor
      // of an object that will be declared as a global variable.
      Particle.function("brew", &CoffeeMaker::brew, this);
    }

    int brew(String command) {
      // do stuff
      return 1;
    }
};

CoffeeMaker myCoffeeMaker;

void setup() {
    myCoffeeMaker.setup();
}
```

The API request will be routed to the device and will run your brew function. The response will have a return_value key containing the integer returned by brew.

```
COMPLEMENTARY API CALL
POST /v1/devices/{DEVICE_ID}/{FUNCTION}

# EXAMPLE REQUEST
curl https://api.particle.io/v1/devices/0123456789abcdef/brew \
     -d access_token=123412341234 \
     -d "args=coffee"
```

Particle.publish()

Publish an *event* through the Particle Device Cloud that will be forwarded to all registered listeners, such as callbacks, subscribed streams of Server-Sent Events, and other devices listening via `Particle.subscribe()`.

This feature allows the device to generate an event based on a condition. For example, you could connect a motion sensor to the device and have the device generate an event whenever motion is detected.

Particle.publish pushes the value out of the device at a time controlled by the device firmware. Particle.variable allows the value to be pulled from the device when requested from the cloud side.

Cloud events have the following properties:

- name (1–64 ASCII characters)

Note: Only use letters, numbers, underscores, dashes and slashes in event names. Spaces and special characters may be escaped by different tools and libraries causing unexpected results.

- PUBLIC/PRIVATE (prior to 0.8.0 default PUBLIC - thereafter it's a required parameter and PRIVATE is advisable)
- ttl (time to live, 0–16777215 seconds, default 60) !! **NOTE:** TTL is not implemented, hence the ttl value has no effect. Events must be caught immediately; once sent they will be gone *immediately*.
- optional data (up to 255 characters (*prior to 0.8.0*), 622 characters (*since 0.8.0*)). The Spark Core remains limited to 255 characters.

Anyone may subscribe to public events; think of them like tweets. Only the owner of the device will be able to subscribe to private events.

A device may not publish events beginning with a case-insensitive match for "spark". Such events are reserved for officially curated data originating from the Cloud.

Calling `Particle.publish()` when the cloud connection has been turned off will not publish an event. This is indicated by the return success code of `false`.

If the cloud connection is turned on and trying to connect to the cloud unsuccessfully, Particle.publish may block for 20 seconds to 5 minutes. Checking `Particle.connected()` can prevent this.

For the time being there exists no way to access a previously published but TTL-unexpired event.

String variables must be UTF-8 encoded. You cannot send arbitrary binary data or other character sets like ISO-8859-1. If you need to send binary data you can use a text-based encoding like Base64.

NOTE 1: Currently, a device can publish at rate of about 1 event/sec, with bursts of up to 4 allowed in 1 second. Back to back burst of 4 messages will take 4 seconds to recover.

NOTE 2: `Particle.publish()` and the `Particle.subscribe()` handler(s) share the same buffer. As such, calling `Particle.publish()` within a `Particle.subscribe()` handler will wipe the subscribe buffer! In these cases, copying the subscribe buffer's content to a separate char buffer prior to calling `Particle.publish()` is recommended.

Publish a private event with the given name, no data, and the default TTL of 60 seconds.

```
// SYNTAX
Particle.publish(const char *eventName, PublishFlags flags);
Particle.publish(String eventName, PublishFlags flags);
```

Returns: A `bool` indicating success: (true or false)

```
// EXAMPLE USAGE
bool success;
success = Particle.publish("motion-detected", PRIVATE);
if (!success) {
  // get here if event publish did not work
}
```

Publish a private event with the given name and data, with the default TTL of 60 seconds.

```
// SYNTAX
Particle.publish(const char *eventName, const char *data, PublishFlags
flags);
Particle.publish(String eventName, String data, PublishFlags flags);

// EXAMPLE USAGE
Particle.publish("temperature", "19 F", PRIVATE);
```

Publish a private event with the given name, data, and TTL.

```
// SYNTAX
Particle.publish(const char *eventName, const char *data, int ttl,
PublishFlags flags);
Particle.publish(String eventName, String data, int ttl, PublishFlags
flags);

// EXAMPLE USAGE
Particle.publish("lake-depth/1", "28m", 21600, PRIVATE);
```

Publish a private event with the given name, data, and TTL.

```
// SYNTAX
Particle.publish(const char *eventName, const char *data, int ttl,
PublishFlags flags);
Particle.publish(String eventName, String data, int ttl, PublishFlags
flags);

// EXAMPLE USAGE
Particle.publish("front-door-unlocked", NULL, 60, PRIVATE);
```

Publish a public event with the given name.

```
// SYNTAX
Particle.publish(const char *eventName, PublishFlags flags);
Particle.publish(String eventName, PublishFlags flags);
```

```
// EXAMPLE USAGE
Particle.publish("front-door-unlocked", PRIVATE);
```

```
COMPLEMENTARY API CALL
GET /v1/events/{EVENT_NAME}

# EXAMPLE REQUEST
curl -H "Authorization: Bearer {ACCESS_TOKEN_GOES_HERE}" \
    https://api.particle.io/v1/events/motion-detected

# Will return a stream that echoes text when your event is published
event: motion-detected
data: {"data":"23:23:44","ttl":"60","published_at":"2014-05-
28T19:20:34.638Z","deviceid":"0123456789abcdef"}
```

`WITH_ACK` flag

Since 0.6.1:

This flag causes `Particle.publish()` to return only after receiving an acknowledgement that the published event has been received by the Cloud.

```
// SYNTAX

Particle.publish("motion-detected", NULL, WITH_ACK);
Particle.publish("motion-detected", NULL, PRIVATE, WITH_ACK);
Particle.publish("motion-detected", NULL, ttl, PRIVATE, WITH_ACK);
```

Since 0.7.0:

`Particle.publish()` flags can be combined using a regular syntax with OR operator (|).

```
// EXAMPLE - combining Particle.publish() flags

Particle.publish("motion-detected", PRIVATE | WITH_ACK);
```

If you wish to send a public event, you should specify PUBLIC explictly. This will be required in the future, but is optional in 0.7.0.

```
Particle.publish("motion-detected", PUBLIC);
```

PUBLIC and PRIVATE are mutually exclusive.

Unlike functions and variables, you typically call Particle.publish from loop() (or a function called from loop).

Particle.publishVitals()

Since 1.2.0:

```
// SYNTAX

system_error_t Particle.publishVitals(system_tick_t period_s =
particle::NOW)

Particle.publishVitals();  // Publish vitals immmediately
Particle.publishVitals(particle::NOW);  // Publish vitals immediately
Particle.publishVitals(5);  // Publish vitals every 5 seconds, indefinitely
Particle.publishVitals(0);  // Publish immediately and cancel periodic
publishing
```

Publish vitals information

Provides a mechanism to control the interval at which system diagnostic messages are sent to the cloud. Subsequently, this controls the granularity of detail on the fleet health metrics.

Argument(s):

- `period_s` The period *(in seconds)* at which vitals messages are to be sent to the cloud (default value: `particle::NOW`)

- `particle::NOW` - A special value used to send vitals immediately
- `0` - Publish a final message and disable periodic publishing
- `s` - Publish an initial message and subsequent messages every `s` seconds thereafter

Returns:

A `system_error_t` result code

- `system_error_t::SYSTEM_ERROR_NONE`
- `system_error_t::SYSTEM_ERROR_IO`

Examples:

```
// EXAMPLE - Publish vitals intermittently

bool condition;

setup () {
}

loop () {
  ...  // Some logic that either will or will not set "condition"

  if ( condition ) {
    Particle.publishVitals();  // Publish vitals immmediately
  }
}
```

```
// EXAMPLE - Publish vitals periodically, indefinitely

setup () {
  Particle.publishVitals(3600);  // Publish vitals each hour
}

loop () {
}
```

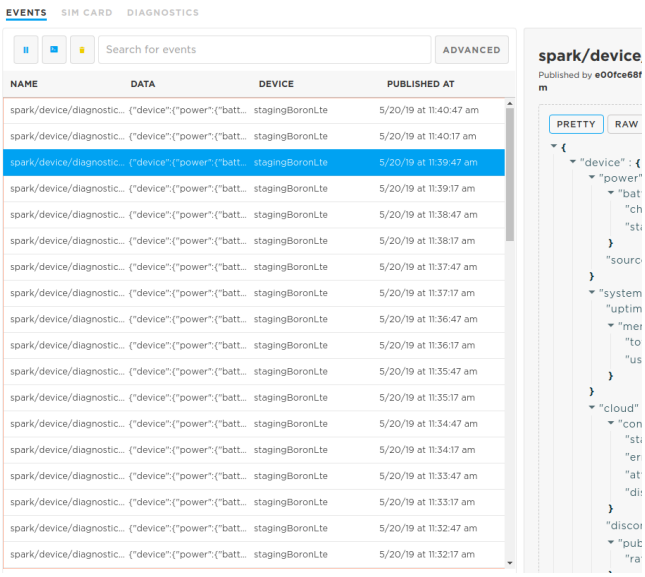
```
// EXAMPLE - Publish vitals each minute and cancel vitals after one hour

size_t start = millis();

setup () {
  Particle.publishVitals(60);  // Publish vitals each minute
}

loop () {
  // Cancel vitals after one hour
  if (3600000 < (millis() - start)) {
    Particle.publishVitals(0);  // Publish immediately and cancel periodic
publishing
  }
}
```

NOTE: *Diagnostic messages can be viewed in the Console. Select the device in question, and view the messages under the "EVENTS" tab.*



Particle.subscribe()

Subscribe to events published by devices.

This allows devices to talk to each other very easily. For example, one device could publish events when a motion sensor is triggered and another could subscribe to these events and

respond by sounding an alarm.

```
int i = 0;

void myHandler(const char *event, const char *data)
{
  i++;
  Serial.print(i);
  Serial.print(event);
  Serial.print(", data: ");
  if (data)
    Serial.println(data);
  else
    Serial.println("NULL");
}

void setup()
{
  Particle.subscribe("temperature", myHandler, ALL_DEVICES);
  Serial.begin(9600);
}
```

To use `Particle.subscribe()`, define a handler function and register it in `setup()`.

You can listen to events published only by your own devices by adding a `MY_DEVICES` constant.

```
// only events from my devices
Particle.subscribe("the_event_prefix", theHandler, MY_DEVICES);
```

- Specifying MY_DEVICES only receives PRIVATE events.
- Specifying ALL_DEVICES or omitting the third parameter only receives PUBLIC events.

flags	subscribe ALL_DEVICES	subscribe MY_DEVICES	subscribe default
publish PUBLIC	Y	-	Y
publish PRIVATE	-	Y	-
publish default	Y	-	Y

You can register a method in a C++ object as a subscription handler.

```
#include "Particle.h"

SerialLogHandler logHandler;

class MyClass {
public:
    MyClass();
    virtual ~MyClass();

    void setup();

    void subscriptionHandler(const char *eventName, const char *data);
};

MyClass::MyClass() {
}

MyClass::~MyClass() {
}

void MyClass::setup() {
    Particle.subscribe("myEvent", &MyClass::subscriptionHandler, this,
MY_DEVICES);
}

void MyClass::subscriptionHandler(const char *eventName, const char *data) {
    Log.info("eventName=%s data=%s", eventName, data);
}

// In this example, MyClass is a globally constructed object.
MyClass myClass;

void setup() {
    myClass.setup();
}

void loop() {

}
```

You should not call `Particle.subscribe()` from the constructor of a globally allocated C++ object. See Global Object Constructors for more information.

A subscription works like a prefix filter. If you subscribe to "foo", you will receive any event whose name begins with "foo", including "foo", "fool", "foobar", and "food/indian/sweet-curry-beans".

Received events will be passed to a handler function similar to `Particle.function()`. A *subscription handler* (like `myHandler` above) must return `void` and take two arguments, both of which are C strings (`const char *`).

- The first argument is the full name of the published event.
- The second argument (which may be NULL) is any data that came along with the event.

`Particle.subscribe()` returns a `bool` indicating success. It is OK to register a subscription when the device is not connected to the cloud - the subscription is automatically registered with the cloud next time the device connects.

NOTE 1: A device can register up to 4 event handlers. This means you can call `Particle.subscribe()` a maximum of 4 times; after that it will return `false`.

NOTE 2: `Particle.publish()` and the `Particle.subscribe()` handler(s) share the same buffer. As such, calling `Particle.publish()` within a `Particle.subscribe()` handler will wipe the subscribe buffer! In these cases, copying the subscribe buffer's content to a separate char buffer prior to calling `Particle.publish()` is recommended.

Unlike functions and variables, you can call Particle.subscribe from setup() or from loop(). The subscription list can be added to at any time, and more than once.

Particle.unsubscribe()

Removes all subscription handlers previously registered with `Particle.subscribe()`.

```
// SYNTAX
Particle.unsubscribe();
```

Particle.connect()

`Particle.connect()` connects the device to the Cloud. This will automatically activate the network connection and attempt to connect to the Particle cloud if the device is not already connected to the cloud.

```
void setup() {}

void loop() {
  if (Particle.connected() == false) {
    Particle.connect();
  }
}
```

After you call `Particle.connect()`, your loop will not be called again until the device finishes connecting to the Cloud. Typically, you can expect a delay of approximately one second.

In most cases, you do not need to call `Particle.connect()`; it is called automatically when the device turns on. Typically you only need to call `Particle.connect()` after disconnecting with `Particle.disconnect()` or when you change the system mode.

Particle.disconnect()

`Particle.disconnect()` disconnects the device from the Cloud.

```
int counter = 10000;

void doConnectedWork() {
  digitalWrite(D7, HIGH);
  Serial.println("Working online");
}

void doOfflineWork() {
  digitalWrite(D7, LOW);
  Serial.println("Working offline");
}

bool needConnection() {
```

```
  --counter;
  if (0 == counter)
    counter = 10000;
  return (2000 > counter);
}

void setup() {
  pinMode(D7, OUTPUT);
  Serial.begin(9600);
}

void loop() {
  if (needConnection()) {
    if (!Particle.connected())
      Particle.connect();
    doConnectedWork();
  } else {
    if (Particle.connected())
      Particle.disconnect();
    doOfflineWork();
  }
}
```

**NOTE:* When the device is disconnected, many features are not possible, including over-the-air updates, reading Particle.variables, and calling Particle.functions.

If you disconnect from the Cloud, you will NOT BE ABLE to flash new firmware over the air. Safe mode can be used to reconnect to the cloud.

Particle.connected()

Returns `true` when connected to the Cloud, and `false` when disconnected from the Cloud.

```
// SYNTAX
Particle.connected();


// EXAMPLE USAGE
void setup() {
  Serial.begin(9600);
```

```
}

void loop() {
  if (Particle.connected()) {
    Serial.println("Connected!");
  }
  delay(1000);
}
```

Particle.process()

Runs the background loop. This is the public API for the former internal function `SPARK_WLAN_Loop()`.

```
void setup() {
  Serial.begin(9600);
}

void loop() {
  // Do not do this in real code. You should return from loop() instead!
  while (1) {
    Particle.process();
    redundantLoop();
  }
}

void redundantLoop() {
  Serial.println("Well that was unnecessary.");
}
```

`Particle.process()` is a blocking call, and blocks for a few milliseconds. `Particle.process()` is called automatically after every `loop()` and during delays. Typically you will not need to call `Particle.process()` unless you block in some other way and need to maintain the connection to the Cloud, or you change the system mode. If the user puts the device into `MANUAL` mode, the user is responsible for calling `Particle.process()`. The more frequently this function is called, the more responsive the device will be to incoming messages, the more likely the Cloud connection will stay open, and the less likely that the Wi-Fi module's buffer will overrun.

Particle.syncTime()

Synchronize the time with the Particle Device Cloud. This happens automatically when the device connects to the Cloud. However, if your device runs continuously for a long time, you may want to synchronize once per day or so.

```
#define ONE_DAY_MILLIS (24 * 60 * 60 * 1000)
unsigned long lastSync = millis();

void loop() {
  if (millis() - lastSync > ONE_DAY_MILLIS) {
    // Request time synchronization from the Particle Device Cloud
    Particle.syncTime();
    lastSync = millis();
  }
}
```

Note that this function sends a request message to the Cloud and then returns. The time on the device will not be synchronized until some milliseconds later when the Cloud responds with the current time between calls to your loop. See `Particle.syncTimeDone()`, `Particle.timeSyncedLast()`, `Time.isValid()` and `Particle.syncTimePending()` for information on how to wait for request to be finished.

Particle.syncTimeDone()

Since 0.6.1:

Returns `true` if there is no `syncTime()` request currently pending or there is no active connection to Particle Device Cloud. Returns `false` when there is a pending `syncTime()` request.

```
// SYNTAX
Particle.syncTimeDone();


// EXAMPLE

void loop()
```

```
{
  // Request time synchronization from the Particle Device Cloud
  Particle.syncTime();
  // Wait until Raspberry Pi receives time from Particle Device Cloud (or
connection to Particle Device Cloud is lost)
  waitUntil(Particle.syncTimeDone);
  // Print current time
  Serial.println(Time.timeStr());
}
```

See also `Particle.timeSyncedLast()` and `Time.isValid()`.

Particle.syncTimePending()

Since 0.6.1:

Returns `true` if there a `syncTime()` request currently pending. Returns `false` when there is no `syncTime()` request pending or there is no active connection to Particle Device Cloud.

```
// SYNTAX
Particle.syncTimePending();


// EXAMPLE

void loop()
{
  // Request time synchronization from the Particle Device Cloud
  Particle.syncTime();
  // Wait until Raspberry Pi receives time from Particle Device Cloud (or
connection to Particle Device Cloud is lost)
  while(Particle.syncTimePending())
  {
    //
    // Do something else
    //

    Particle.process();
  }
  // Print current time
```

```
  Serial.println(Time.timeStr());
}
```

See also `Particle.timeSyncedLast()` and `Time.isValid()`.

Particle.timeSyncedLast()

Since 0.6.1:

Used to check when time was last synchronized with Particle Device Cloud.

```
// SYNTAX
Particle.timeSyncedLast();
Particle.timeSyncedLast(timestamp);
```

Returns the number of milliseconds since the device began running the current program when last time synchronization with Particle Device Cloud was performed.

This function takes one optional argument:

- `timestamp`: `time_t` variable that will contain a UNIX timestamp received from Particle Device Cloud during last time synchronization

```
// EXAMPLE

#define ONE_DAY_MILLIS (24 * 60 * 60 * 1000)

void loop() {
  time_t lastSyncTimestamp;
  unsigned long lastSync = Particle.timeSyncedLast(lastSyncTimestamp);
  if (millis() - lastSync > ONE_DAY_MILLIS) {
    unsigned long cur = millis();
    Serial.printlnf("Time was last synchronized %lu milliseconds ago",
millis() - lastSync);
    if (lastSyncTimestamp > 0)
    {
      Serial.print("Time received from Particle Device Cloud was: ");
      Serial.println(Time.timeStr(lastSyncTimestamp));
```

```
    }
    // Request time synchronization from Particle Device Cloud
    Particle.syncTime();
    // Wait until Raspberry Pi receives time from Particle Device Cloud (or
connection to Particle Device Cloud is lost)
    waitUntil(Particle.syncTimeDone);
    // Check if synchronized successfully
    if (Particle.timeSyncedLast() >= cur)
    {
      // Print current time
      Serial.println(Time.timeStr());
    }
  }
}
```

Get Public IP

Using this feature, the device can programmatically know its own public IP address.

```
// Open a serial terminal and see the IP address printed out
void handler(const char *topic, const char *data) {
    Serial.println("received " + String(topic) + ": " + String(data));
}

void setup() {
    Serial.begin(115200);
    Particle.subscribe("particle/device/ip", handler, MY_DEVICES);
    Particle.publish("particle/device/ip", PRIVATE);
}
```

Get Device name

This gives you the device name that is stored in the cloud,

```
// Open a serial terminal and see the device name printed out
void handler(const char *topic, const char *data) {
    Serial.println("received " + String(topic) + ": " + String(data));
}
```

```
void setup() {
    Serial.begin(115200);
    Particle.subscribe("particle/device/name", handler);
    Particle.publish("particle/device/name");
}
```

Get Random seed

Grab 40 bytes of randomness from the cloud and {e}n{c}r{y}p{t} away!

```
void handler(const char *topic, const char *data) {
    Serial.println("received " + String(topic) + ": " + String(data));
}

void setup() {
    Serial.begin(115200);
    Particle.subscribe("particle/device/random", handler);
    Particle.publish("particle/device/random");
}
```

Input/Output

Additional information on which pins can be used for which functions is available on the pin information page.

pinMode()

`pinMode()` configures the specified pin to behave either as an input (with or without an internal weak pull-up or pull-down resistor), or an output.

```
// SYNTAX
pinMode(pin,mode);
```

`pinMode()` takes two arguments, `pin` : the number of the pin whose mode you wish to set and `mode` : `INPUT, INPUT_PULLUP, INPUT_PULLDOWN or OUTPUT.`

`pinMode()` does not return anything.

```
// EXAMPLE USAGE
int button = D0;                        // button is connected to D0
int LED = D1;                           // LED is connected to D1

void setup()
{
  pinMode(LED, OUTPUT);                 // sets pin as output
  pinMode(button, INPUT_PULLDOWN);      // sets pin as input
}

void loop()
{
  // blink the LED as long as the button is pressed
  while(digitalRead(button) == HIGH) {
    digitalWrite(LED, HIGH);            // sets the LED on
    delay(200);                         // waits for 200mS
    digitalWrite(LED, LOW);             // sets the LED off
    delay(200);                         // waits for 200mS
  }
}
```

- When using INPUT_PULLDOWN make sure a high level signal does not exceed 3.3V.

getPinMode(pin)

Retrieves the current pin mode.

```
// EXAMPLE

if (getPinMode(D0)==INPUT) {
  // D0 is an input pin
}
```

digitalWrite()

Write a `HIGH` or a `LOW` value to a GPIO pin.

```
// SYNTAX
digitalWrite(pin, value);
```

If the pin has been configured as an `OUTPUT` with `pinMode()` or if previously used with `analogWrite()`, its voltage will be set to the corresponding value: 3.3V for HIGH, 0V (ground) for LOW.

`digitalWrite()` takes two arguments, `pin`: the number of the pin whose value you wish to set and `value`: `HIGH` or `LOW`.

`digitalWrite()` does not return anything.

```
// EXAMPLE USAGE
int LED = D1;               // LED connected to D1

void setup()
{
  pinMode(LED, OUTPUT);     // sets pin as output
}

void loop()
{
  digitalWrite(LED, HIGH); // sets the LED on
  delay(200);               // waits for 200mS
  digitalWrite(LED, LOW);  // sets the LED off
  delay(200);               // waits for 200mS
}
```

digitalRead()

Reads the value from a specified digital `pin`, either `HIGH` or `LOW`.

```
// SYNTAX
digitalRead(pin);
```

`digitalRead()` takes one argument, `pin` : the number of the digital pin you want to read.

`digitalRead()` returns `HIGH` or `LOW`.

```
// EXAMPLE USAGE
int button = D0;                    // button is connected to D0
int LED = D1;                       // LED is connected to D1
int val = 0;                        // variable to store the read value

void setup()
{
  pinMode(LED, OUTPUT);             // sets pin as output
  pinMode(button, INPUT_PULLDOWN); // sets pin as input
}

void loop()
{
  val = digitalRead(button);        // read the input pin
  digitalWrite(LED, val);           // sets the LED to the button's value
}
```

analogWrite() (PWM)

Writes an analog value to a pin as a digital PWM (pulse-width modulated) signal. The default frequency of the PWM signal is 500 Hz.

Can be used to light a LED at varying brightnesses or drive a motor at various speeds. After a call to analogWrite(), the pin will generate a steady square wave of the specified duty cycle until the next call to `analogWrite()` (or a call to `digitalRead()` or `digitalWrite()` on the same pin).

```
// SYNTAX
analogWrite(pin, value);
analogWrite(pin, value, frequency);
```

`analogWrite()` takes two or three arguments:

- `pin` : the number of the pin whose value you wish to set
- `value` : the duty cycle: between 0 (always off) and 255 (always on). *Since 0.6.0:* between 0 and 255 (default 8-bit resolution) or `2^(analogWriteResolution(pin)) - 1` in general.

NOTE: `pinMode(pin, OUTPUT);` is required before calling `analogWrite(pin, value);` or else the `pin` will not be initialized as a PWM output and set to the desired duty cycle.

`analogWrite()` does not return anything.

```
// EXAMPLE USAGE

int ledPin = D1;                // LED connected to digital pin D1
int analogPin = A0;             // potentiometer connected to analog pin A0
int val = 0;                    // variable to store the read value

void setup()
{
  pinMode(ledPin, OUTPUT);      // sets the pin as output
}

void loop()
{
  val = analogRead(analogPin); // read the input pin
  analogWrite(ledPin, val/16); // analogRead values go from 0 to 4095,
                               // analogWrite values from 0 to 255.
  delay(10);
}
```

NOTE: When used with PWM capable pins, the `analogWrite()` function sets up these pins as PWM only.

Additional information on which pins can be used for PWM output is available on the pin information page.

analogWriteResolution() (PWM)

Since 0.6.0:

Sets or retrieves the resolution of `analogWrite()` function of a particular pin.

`analogWriteResolution()` takes one or two arguments:

- `pin` : the number of the pin whose resolution you wish to set or retrieve
- `resolution` : (optional) resolution in bits. The value can range from 2 to 31 bits. If the resolution is not supported, it will not be applied. The default is 8.

`analogWriteResolution()` returns currently set resolution.

```
// EXAMPLE USAGE
pinMode(D1, OUTPUT);      // sets the pin as output
analogWriteResolution(D1, 12); // sets analogWrite resolution to 12 bits
analogWrite(D1, 3000, 1000); // 3000/4095 = ~73% duty cycle at 1kHz
```

NOTE: The resolution also affects maximum frequency that can be used with `analogWrite()`. The maximum frequency allowed with current resolution can be checked by calling `analogWriteMaxFrequency()`.

analogWriteMaxFrequency() (PWM)

Since 0.6.0:

Returns maximum frequency that can be used with `analogWrite()` on this pin.

`analogWriteMaxFrequency()` takes one argument:

- `pin` : the number of the pin

```
// EXAMPLE USAGE
pinMode(D1, OUTPUT);      // sets the pin as output
analogWriteResolution(D1, 12); // sets analogWrite resolution to 12 bits
int maxFreq = analogWriteMaxFrequency(D1);
analogWrite(D1, 3000, maxFreq / 2); // 3000/4095 = ~73% duty cycle
```

Low Level Input/Output

The Input/Ouput functions include safety checks such as making sure a pin is set to OUTPUT when doing a digitalWrite() or that the pin is not being used for a timer function. These safety measures represent good coding and system design practice.

There are times when the fastest possible input/output operations are crucial to an applications performance. The SPI, UART (Serial) or I2C hardware are examples of low level performance-oriented devices. There are, however, times when these devices may not be suitable or available. For example, One-wire support is done in software, not hardware.

In order to provide the fastest possible bit-oriented I/O, the normal safety checks must be skipped. As such, please be aware that the programmer is responsible for proper planning and use of the low level I/O functions.

Prior to using the following low-level functions, `pinMode()` must be used to configure the target pin.

pinSetFast()

Write a `HIGH` value to a digital pin.

```
// SYNTAX
pinSetFast(pin);
```

`pinSetFast()` takes one argument, `pin` : the number of the pin whose value you wish to set `HIGH` .

`pinSetFast()` does not return anything.

```
// EXAMPLE USAGE
int LED = D7;             // LED connected to D7

void setup()
{
```

```
  pinMode(LED, OUTPUT);     // sets pin as output
}

void loop()
{
  pinSetFast(LED);            // set the LED on
  delay(500);
  pinResetFast(LED);        // set the LED off
  delay(500);
}
```

pinResetFast()

Write a `LOW` value to a digital pin.

```
// SYNTAX
pinResetFast(pin);
```

`pinResetFast()` takes one argument, `pin` : the number of the pin whose value you wish to set `LOW` .

`pinResetFast()` does not return anything.

```
// EXAMPLE USAGE
int LED = D7;               // LED connected to D7

void setup()
{
  pinMode(LED, OUTPUT);     // sets pin as output
}

void loop()
{
  pinSetFast(LED);            // set the LED on
  delay(500);
  pinResetFast(LED);        // set the LED off
  delay(500);
}
```

digitalWriteFast()

Write a `HIGH` or `LOW` value to a digital pin. This function will call pinSetFast() or pinResetFast() based on `value` and is useful when `value` is calculated. As such, this imposes a slight time overhead.

```
// SYNTAX
digitalWriteFast(pin, value);
```

`digitalWriteFast()` `pin`: the number of the pin whose value you wish to set and `value`: `HIGH` or `LOW`.

`digitalWriteFast()` does not return anything.

```
// EXAMPLE USAGE
int LED = D7;               // LED connected to D7

void setup()
{
  pinMode(LED, OUTPUT);     // sets pin as output
}

void loop()
{
  digitalWriteFast(LED, HIGH);           // set the LED on
  delay(500);
  digitalWriteFast(LED, LOW);          // set the LED off
  delay(500);
}
```

pinReadFast()

Reads the value from a specified digital `pin`, either `HIGH` or `LOW`.

```
// SYNTAX
pinReadFast(pin);
```

`pinReadFast()` takes one argument, `pin` : the number of the digital pin you want to read.

`pinReadFast()` returns `HIGH` or `LOW`.

```
// EXAMPLE USAGE
int button = D0;                    // button is connected to D0
int LED = D1;                       // LED is connected to D1
int val = 0;                        // variable to store the read value

void setup()
{
  pinMode(LED, OUTPUT);             // sets pin as output
  pinMode(button, INPUT_PULLDOWN); // sets pin as input
}

void loop()
{
  val = pinReadFast(button);        // read the input pin
  digitalWriteFast(LED, val);       // sets the LED to the button's value
}
```

Advanced I/O

tone()

Generates a square wave of the specified frequency and duration (and 50% duty cycle) on a timer channel pin which supports PWM. Use of the tone() function will interfere with PWM output on the selected pin. tone() is generally used to make sounds or music on speakers or piezo buzzers.

```
// SYNTAX
tone(pin, frequency, duration)
```

`tone()` takes three arguments, `pin` : the pin on which to generate the tone, `frequency` : the frequency of the tone in hertz and `duration` : the duration of the tone in milliseconds (a zero value = continuous tone).

The frequency range is from 20Hz to 20kHz. Frequencies outside this range will not be played.

`tone()` does not return anything.

Additional information on which pins can be used for tone() is available on the pin information page.

```
#include "application.h"
// The Photon has 9 PWM pins: D0, D1, D2, D3, A4, A5, A7, RX and TX.
//
// EXAMPLE USAGE
// Plays a melody - Connect small speaker to speakerPin
int speakerPin = D0;

// Notes defined in microseconds (Period/2)
// from note C to B, Octaves 3 through 7
int notes[] =
{0,
/* C,  C#,   D,  D#,   E,   F,  F#,   G,  G#,   A,  A#,   B */
3817,3597,3401,3205,3030,2857,2703,2551,2404,2273,2146,2024,   // 3 (1-12)
1908,1805,1701,1608,1515,1433,1351,1276,1205,1136,1073,1012,   // 4 (13-24)
 956, 903, 852, 804, 759, 716, 676, 638, 602, 568, 536, 506,   // 5 (25-37)
 478, 451, 426, 402, 379, 358, 338, 319, 301, 284, 268, 253,   // 6 (38-50)
 239, 226, 213, 201, 190, 179, 169, 159, 151, 142, 134, 127 }; // 7 (51-62)

#define NOTE_G3  2551
#define NOTE_G4  1276
#define NOTE_C5  956
#define NOTE_E5  759
#define NOTE_G5  638
#define RELEASE  20
#define BPM      100

// notes in the melody:
int melody[] =
```

```
{NOTE_E5,NOTE_E5,0,NOTE_E5,0,NOTE_C5,NOTE_E5,0,NOTE_G5,0,0,NOTE_G4};

// note durations: 4 = quarter note, 2 = half note, etc.:
int noteDurations[] = {4,4,4,4,4,4,4,4,4,2,4,4};

void setup() {
  // iterate over the notes of the melody:
  for (int thisNote = 0; thisNote < 12; thisNote++) {

    // to calculate the note duration, take one second
    // divided by the note type.
    // e.g. quarter note = 1000 / 4, eighth note = 1000/8, etc.
    int noteDuration = 60*1000/BPM/noteDurations[thisNote];
    tone(speakerPin, (melody[thisNote]!=0)?
(500000/melody[thisNote]):0,noteDuration-RELEASE);

    // blocking delay needed because tone() does not block
    delay(noteDuration);
  }
}
```

noTone()

Stops the generation of a square wave triggered by tone() on a specified pin. Has no effect if no tone is being generated.

The available pins are the same as for tone().

```
// SYNTAX
noTone(pin)
```

`noTone()` takes one argument, `pin`: the pin on which to stop generating the tone.

`noTone()` does not return anything.

```
//See the tone() example
```

shiftOut()

Shifts out a byte of data one bit at a time on a specified pin. Starts from either the most (i.e. the leftmost) or least (rightmost) significant bit. Each bit is written in turn to a data pin, after which a clock pin is pulsed (taken high, then low) to indicate that the bit is available.

NOTE: if you're interfacing with a device that's clocked by rising edges, you'll need to make sure that the clock pin is low before the call to `shiftOut()`, e.g. with a call to `digitalWrite(clockPin, LOW)`.

This is a software implementation; see also the SPI function, which provides a hardware implementation that is faster but works only on specific pins.

```
// SYNTAX
shiftOut(dataPin, clockPin, bitOrder, value)
```

```
// EXAMPLE USAGE

// Use digital pins D0 for data and D1 for clock
int dataPin = D0;
int clock = D1;

uint8_t data = 50;

setup() {
    // Set data and clock pins as OUTPUT pins before using shiftOut()
    pinMode(dataPin, OUTPUT);
    pinMode(clock, OUTPUT);

    // shift out data using MSB first
    shiftOut(dataPin, clock, MSBFIRST, data);

    // Or do this for LSBFIRST serial
    shiftOut(dataPin, clock, LSBFIRST, data);
}

loop() {
    // nothing to do
}
```

`shiftOut()` takes four arguments, 'dataPin': the pin on which to output each bit, `clockPin`: the pin to toggle once the dataPin has been set to the correct value, `bitOrder`: which order to shift out the bits; either MSBFIRST or LSBFIRST (Most Significant Bit First, or, Least Significant Bit First) and `value`: the data (byte) to shift out.

`shiftOut()` does not return anything.

shiftIn()

Shifts in a byte of data one bit at a time. Starts from either the most (i.e. the leftmost) or least (rightmost) significant bit. For each bit, the clock pin is pulled high, the next bit is read from the data line, and then the clock pin is taken low.

NOTE: if you're interfacing with a device that's clocked by rising edges, you'll need to make sure that the clock pin is low before the call to shiftOut(), e.g. with a call to `digitalWrite(clockPin, LOW)`.

This is a software implementation; see also the SPI function, which provides a hardware implementation that is faster but works only on specific pins.

```
// SYNTAX
shiftIn(dataPin, clockPin, bitOrder)
```

```
// EXAMPLE USAGE

// Use digital pins D0 for data and D1 for clock
int dataPin = D0;
int clock = D1;

uint8_t data;

setup() {
    // Set data as INPUT and clock pin as OUTPUT before using shiftIn()
    pinMode(dataPin, INPUT);
    pinMode(clock, OUTPUT);

    // shift in data using MSB first
```

```
    data = shiftIn(dataPin, clock, MSBFIRST);

    // Or do this for LSBFIRST serial
    data = shiftIn(dataPin, clock, LSBFIRST);
}

loop() {
    // nothing to do
}
```

`shiftIn()` takes three arguments, 'dataPin': the pin on which to input each bit, `clockPin`: the pin to toggle to signal a read from dataPin, `bitOrder`: which order to shift in the bits; either MSBFIRST or LSBFIRST (Most Significant Bit First, or, Least Significant Bit First).

`shiftIn()` returns the byte value read.

pulseIn()

Since 0.4.7:

Reads a pulse (either HIGH or LOW) on a pin. For example, if value is HIGH, pulseIn() waits for the pin to go HIGH, starts timing, then waits for the pin to go LOW and stops timing. Returns the length of the pulse in microseconds or 0 if no complete pulse was received within the timeout.

The timing of this function is based on an internal hardware counter derived from the system tick clock. Resolution is 1/Fosc (1/72MHz for Core, 1/120MHz for Photon/P1/Electron). Works on pulses from 10 microseconds to 3 seconds in length. Please note that if the pin is already reading the desired `value` when the function is called, it will wait for the pin to be the opposite state of the desired `value`, and then finally measure the duration of the desired `value`. This routine is blocking and does not use interrupts. The `pulseIn()` routine will time out and return 0 after 3 seconds.

```
// SYNTAX
pulseIn(pin, value)
```

`pulseIn()` takes two arguments, `pin` : the pin on which you want to read the pulse (this can be any GPIO, e.g. D1, A2, C0, B3, etc..), `value` : type of pulse to read: either HIGH or LOW. `pin` should be set to one of three pinMode()'s prior to using pulseIn(), `INPUT` , `INPUT_PULLUP` or `INPUT_PULLDOWN` .

`pulseIn()` returns the length of the pulse (in microseconds) or 0 if no pulse is completed before the 3 second timeout (unsigned long)

```
// EXAMPLE
unsigned long duration;

void setup()
{
    Serial.begin(9600);
    pinMode(D0, INPUT);

    // Pulse generator, connect D1 to D0 with a jumper
    // PWM output is 500Hz at 50% duty cycle
    // 1000us HIGH, 1000us LOW
    pinMode(D1, OUTPUT);
    analogWrite(D1, 128);
}

void loop()
{
    duration = pulseIn(D0, HIGH);
    Serial.printlnf("%d us", duration);
    delay(1000);
}

/* OUTPUT
 * 1003 us
 * 1003 us
 * 1003 us
 * 1003 us
 */
```

Serial

(inherits from `Stream`)

`Serial:` This channel communicates between the terminal and the firmware running. It uses standard input and standard output.

```
// EXAMPLE USAGE
void setup()
{
  Serial.begin();
  Serial.println("Hello World!");
}
```

`Serial1:` This channel is available via the device's TX and RX pins.

IMPORTANT: Support for `Serial1` is not complete for the Raspberry Pi so `Serial1` never returns any data.

To use the Serial1 pins to communicate with your personal computer, you will need an additional USB-to-serial adapter. To use them to communicate with an external TTL serial device, connect the TX pin to your device's RX pin, the RX to your device's TX pin, and the ground of your Core to your device's ground.

```
// EXAMPLE USAGE

void setup()
{
  Serial1.begin(9600);

  Serial1.println("Hello World!");
}
```

To use the hardware serial pins of (Serial1) to communicate with your personal computer, you will need an additional USB-to-serial adapter. To use them to communicate with an external TTL serial device, connect the TX pin to your device's RX pin, the RX to your device's TX pin, and the ground of your Raspberry Pi to your device's ground.

NOTE: Please take into account that the voltage levels on these pins operate at 0V to 3.3V and should not be connected directly to a computer's RS232 serial port which operates at +/- 12V and will damage the Raspberry Pi.

begin()

Available on Serial, Serial1.

Enables serial channel with specified configuration.

```
// SYNTAX
Serial.begin();          // via USB port


Serial1.begin(speed);         // via TX/RX pins
Serial1.begin(speed, config); //  "

Serial1.begin(9600, SERIAL_9N1); // via TX/RX pins, 9600 9N1 mode
Serial1.begin(9600, SERIAL_DATA_BITS_8 | SERIAL_STOP_BITS_1_5 |
SERIAL_PARITY_EVEN); // via TX/RX pins, 9600 8E1.5
```

Parameters:

- `speed` : parameter that specifies the baud rate *(long) (optional for `Serial`)*
- `config` : parameter that specifies the number of data bits used, parity and stop bits *(long) (not used with `Serial`)*

```
// EXAMPLE USAGE
void setup()
{
  Serial.begin(9600);   // open serial over USB

  // Wait for a USB serial connection for up to 30 seconds
  waitFor(Serial.isConnected, 30000);

  Serial1.begin(9600);  // open serial over TX and RX pins
```

```
  Serial.println("Hello Computer");
  Serial1.println("Hello Serial 1");
}

void loop() {}
```

Since 0.5.0: 28800 baudrate set by the Host on `Serial` will put the device in Listening Mode, where a YMODEM download can be started by additionally sending an `f` character. Baudrate 14400 can be used to put the device into DFU Mode.

When using hardware serial channels (Serial1, Serial2), the configuration of the serial channel may also specify the number of data bits, stop bits, parity, flow control and other settings. The default is SERIAL_8N1 (8 data bits, no parity and 1 stop bit) and does not need to be specified to achieve this configuration. To specify one of the following configurations, add one of these defines as the second parameter in the `begin()` function, e.g. `Serial1.begin(9600, SERIAL_8E1);` for 8 data bits, even parity and 1 stop bit.

Pre-defined Serial configurations available:

- `SERIAL_FLOW_CONTROL_NONE` - no flow control
- `SERIAL_FLOW_CONTROL_RTS` - RTS flow control
- `SERIAL_FLOW_CONTROL_CTS` - CTS flow control
- `SERIAL_FLOW_CONTROL_RTS_CTS` - RTS/CTS flow control

end()

Available on Serial, Serial1.

Disables serial channel.

When used with hardware serial channels (Serial1, Serial2), disables serial communication, allowing channel's RX and TX pins to be used for general input and output. To re-enable serial communication, call `SerialX.begin()`.

```
// SYNTAX
Serial1.end();
```

available()

Available on Serial, Serial1.

Get the number of bytes (characters) available for reading from the serial port. This is data that's already arrived and stored in the serial receive buffer.

The receive buffer size for hardware serial channels (Serial1, Serial2) is bytes and cannot be changed.

The receive buffer size for Serial is 64 bytes.

```
// EXAMPLE USAGE
void setup()
{
  Serial.begin(9600);
  Serial1.begin(9600);

}

void loop()
{
  // read from port 0, send to port 1:
  if (Serial.available())
  {
    int inByte = Serial.read();
    Serial1.write(inByte);
  }
  // read from port 1, send to port 0:
  if (Serial1.available())
  {
    int inByte = Serial1.read();
    Serial.write(inByte);
  }
}
```

availableForWrite()

Since 0.4.9: Available on Serial1.

Since 0.5.0: Available on USB Serial (Serial)

Retrieves the number of bytes (characters) that can be written to this serial port without blocking.

If `blockOnOverrun(false)` has been called, the method returns the number of bytes that can be written to the buffer without causing buffer overrun, which would cause old data to be discarded and overwritten.

blockOnOverrun()

Since 0.4.9: Available on Serial1.

Since 0.5.0: Available on USB Serial (Serial)

Defines what should happen when calls to `write()/print()/println()/printlnf()` that would overrun the buffer.

- `blockOnOverrun(true)` - this is the default setting. When there is no room in the buffer for the data to be written, the program waits/blocks until there is room. This avoids buffer overrun, where data that has not yet been sent over serial is overwritten by new data. Use this option for increased data integrity at the cost of slowing down realtime code execution when lots of serial data is sent at once.
- `blockOnOverrun(false)` - when there is no room in the buffer for data to be written, the data is written anyway, causing the new data to replace the old data. This option is provided when performance is more important than data integrity.

```
// EXAMPLE - fast and furious over Serial1
Serial1.blockOnOverrun(false);
Serial1.begin(115200);
```

serialEvent()

A family of application-defined functions that are called whenever there is data to be read from a serial peripheral.

- serialEvent: called when there is data available from `Serial`
- serialEvent1: called when there is data available from `Serial1`

The `serialEvent` functions are called in between calls to the application `loop()`. This means that if `loop()` runs for a long time due to `delay()` calls or other blocking calls the serial buffer might become full between subsequent calls to `serialEvent` and serial characters might be lost. Avoid long `delay()` calls in your application if using `serialEvent`.

Since `serialEvent` functions are an extension of the application loop, it is ok to call any functions that you would also call from `loop()`. Because of this, there is little advantage to using serial events over just reading serial from loop().

```
// EXAMPLE - echo all characters typed over serial

void setup()
{
   Serial.begin(9600);
}

void serialEvent()
{
    char c = Serial.read();
    Serial.print(c);
}
```

peek()

Available on Serial, Serial1.

Returns the next byte (character) of incoming serial data without removing it from the internal serial buffer. That is, successive calls to peek() will return the same character, as will the next call to `read()`.

```
// SYNTAX
Serial.peek();
Serial1.peek();
```

`peek()` returns the first byte of incoming serial data available (or `-1` if no data is available) - *int*

write()

Available on Serial, Serial1.

Writes binary data to the serial port. This data is sent as a byte or series of bytes; to send the characters representing the digits of a number use the `print()` function instead.

```
// SYNTAX
Serial.write(val);
Serial.write(str);
Serial.write(buf, len);
```

```
// EXAMPLE USAGE

void setup()
{
  Serial.begin(9600);
}

void loop()
{
  Serial.write(45); // send a byte with the value 45

  int bytesSent = Serial.write("hello"); //send the string "hello" and
return the length of the string.
}
```

Parameters:

- `val` : a value to send as a single byte
- `str` : a string to send as a series of bytes
- `buf` : an array to send as a series of bytes
- `len` : the length of the buffer

`write()` will return the number of bytes written, though reading that number is optional.

read()

Available on Serial, Serial1.

Reads incoming serial data.

```
// SYNTAX
Serial.read();
Serial1.read();
```

`read()` returns the first byte of incoming serial data available (or -1 if no data is available) - `int`

```
// EXAMPLE USAGE
int incomingByte = 0; // for incoming serial data

void setup() {
  Serial.begin(9600); // opens serial port, sets data rate to 9600 bps
}

void loop() {
  // send data only when you receive data:
  if (Serial.available() > 0) {
    // read the incoming byte:
    incomingByte = Serial.read();

    // say what you got:
    Serial.print("I received: ");
    Serial.println(incomingByte, DEC);
  }
}
```

print()

Available on Serial, Serial1.

Prints data to the serial port as human-readable ASCII text. This command can take many forms. Numbers are printed using an ASCII character for each digit. Floats are similarly printed as ASCII digits, defaulting to two decimal places. Bytes are sent as a single character. Characters and strings are sent as is. For example:

- Serial.print(78) gives "78"
- Serial.print(1.23456) gives "1.23"
- Serial.print('N') gives "N"
- Serial.print("Hello world.") gives "Hello world."

An optional second parameter specifies the base (format) to use; permitted values are BIN (binary, or base 2), OCT (octal, or base 8), DEC (decimal, or base 10), HEX (hexadecimal, or base 16). For floating point numbers, this parameter specifies the number of decimal places to use. For example:

- Serial.print(78, BIN) gives "1001110"
- Serial.print(78, OCT) gives "116"
- Serial.print(78, DEC) gives "78"
- Serial.print(78, HEX) gives "4E"
- Serial.println(1.23456, 0) gives "1"
- Serial.println(1.23456, 2) gives "1.23"
- Serial.println(1.23456, 4) gives "1.2346"

println()

Available on Serial, Serial1.

Prints data to the serial port as human-readable ASCII text followed by a carriage return character (ASCII 13, or '\r') and a newline character (ASCII 10, or '\n'). This command takes the same forms as `Serial.print()`.

```
// SYNTAX
Serial.println(val);
Serial.println(val, format);
```

Parameters:

- `val` : the value to print - any data type
- `format` : specifies the number base (for integral data types) or number of decimal places (for floating point types)

`println()` returns the number of bytes written, though reading that number is optional - `size_t (long)`

```
// EXAMPLE
//reads an analog input on analog in A0, prints the value out.

int analogValue = 0;    // variable to hold the analog value

void setup()
{
  // Make sure your Serial Terminal app is closed before powering your
device
  Serial.begin(9600);
  // Wait for a USB serial connection for up to 30 seconds
  waitFor(Serial.isConnected, 30000);
}

void loop() {
  // read the analog input on pin A0:
  analogValue = analogRead(A0);

  // print it out in many formats:
  Serial.println(analogValue);       // print as an ASCII-encoded decimal
  Serial.println(analogValue, DEC);  // print as an ASCII-encoded decimal
  Serial.println(analogValue, HEX);  // print as an ASCII-encoded
hexadecimal
  Serial.println(analogValue, OCT);  // print as an ASCII-encoded octal
  Serial.println(analogValue, BIN);  // print as an ASCII-encoded binary

  // delay 10 milliseconds before the next reading:
  delay(10);
}
```

printf()

Since 0.4.6:

Available on Serial, Serial1.

Provides printf-style formatting over serial.

`printf` allows strings to be built by combining a number of values with text.

```
Serial.printf("Reading temperature sensor at %s...",
Time.timeStr().c_str());
float temp = readTemp();
Serial.printf("the temperature today is %f Kelvin", temp);
Serial.println();
```

Running this code prints:

```
Reading temperature sensor at Thu 01 Oct 2015 12:34...the temperature today
is 293.1 Kelvin.
```

The last `printf()` call could be changed to `printlnf()` to avoid a separate call to `println()`.

printlnf()

Since 0.4.6:

Available on Serial, Serial1.

formatted output followed by a newline. Produces the same output as printf which is then followed by a newline character, so to that subsequent output appears on the next line.

flush()

Waits for the transmission of outgoing serial data to complete.

```
// SYNTAX
Serial.flush();
Serial1.flush();
```

`flush()` neither takes a parameter nor returns anything.

isConnected()

```
// EXAMPLE USAGE
void setup()
{
  Serial.begin();   // open serial over USB
  while(!Serial.isConnected()) // wait for Host to open serial port
    Particle.process();

  Serial.println("Hello there!");
}
```

Another technique is to use `waitFor` which makes it easy to time-limit the waiting period.

```
// EXAMPLE USAGE
void setup()
{
  Serial.begin();   // open serial over USB

  // Wait for a USB serial connection for up to 30 seconds
  waitFor(Serial.isConnected, 30000);

  Serial.println("Hello there!");
}
```

Since 0.5.3 Available on `Serial`.

Since 0.6.0 Available on `Serial`.

Used to check if host has serial port (virtual COM port) open.

Returns:

- `true` when Host has virtual COM port open.

SPI

This library allows you to communicate with SPI devices, with the Raspberry Pi as the master device.

There are dedicated pins for SPI on the Raspberry Pi: `MOSI`, `MISO`, `SCK` and 2 chip select pins `CE0` and `CE1`.

Note: Before using the SPI interface on the Raspberry Pi, you have to enable it in hardware. In a terminal, type `sudo raspi-config`, go to `Advanced Options`, select `SPI` and answer `Yes` to enable it. Reboot the Raspberry Pi before flashing firmware that uses the SPI peripheral.

It is not recommended to use the SPI pins for general purpose IO. If you need to, you must disable the SPI peripheral in `raspi-config`, reboot and use the `MOSI`, `MISO`, `SCK`, `CE0` and `CE1` pins with `pinMode`, `digitalRead` or `digitalWrite`.

begin()

Initializes the SPI bus by setting SCK, MOSI, and a user-specified slave-select pin to outputs, MISO to input. SCK is pulled either high or low depending on the configured SPI data mode (default high for `SPI_MODE3`). Slave-select is pulled high.

Note: The SPI firmware ONLY initializes the user-specified slave-select pin as an `OUTPUT`. The user's code must control the slave-select pin with `digitalWrite()` before and after each SPI transfer for the desired SPI slave device. Calling `SPI.end()` does NOT reset the pin mode of the SPI pins.

```
// SYNTAX
SPI.begin(ss);
SPI1.begin(ss);
```

Where, the parameter `ss` is the `SPI` device slave-select pin to initialize. If no pin is specified, the default pin is:

- Argon, Boron, Xenon: `A5 (D14)`
- B Series SoM: `D8`
- Photon, P1, Electron, and E Series: `A2`

For `SPI1`, the default `ss` pin is `D5`.

```
// Example using SPI1, with D5 as the SS pin:
SPI1.begin();
// or
SPI1.begin(D5);
```

Wire (I2C)

(inherits from `Stream`)

This library allows you to communicate with I2C / TWI (Two Wire Interface) devices.

There are dedicated pins for I2C on the Raspberry Pi: Serial Data Line (SDA) and Serial Clock (SCL). See the pin out diagram to find out where pins are located.

Note: Before using the I2C interface on the Raspberry Pi, you have to enable it in hardware. In a terminal, type `sudo raspi-config`, go to `Advanced Options`, select `I2C` and answer `Yes` to enable it. Reboot the Raspberry Pi before flashing firmware that uses the I2C peripheral.

It is not recommended to use the I2C pins for general purpose IO. If you need to, you must disable the I2C peripheral in `raspi-config`, reboot and use the `SCL` and `SDA` pins with `pinMode`, `digitalRead` or `digitalWrite`.

begin()

Initiate the Wire library and join the I2C bus as a master. This should normally be called only once.

```
// SYNTAX
Wire.begin();
```

end()

Since 0.4.6:

Releases the I2C bus so that the pins used by the I2C bus are available for general purpose I/O.

isEnabled()

Used to check if the Wire library is enabled already. Useful if using multiple slave devices on the same I2C bus. Check if enabled before calling Wire.begin() again.

```
// SYNTAX
Wire.isEnabled();
```

Returns: boolean `true` if I2C enabled, `false` if I2C disabled.

```
// EXAMPLE USAGE

// Initialize the I2C bus if not already enabled
if (!Wire.isEnabled()) {
    Wire.begin();
}
```

requestFrom()

Used by the master to request bytes from a slave device. The bytes may then be retrieved with the `available()` and `read()` functions.

```
// SYNTAX
Wire.requestFrom(address, quantity);
Wire.requestFrom(address, quantity, stop);
```

Parameters:

- `address` : the 7-bit address of the device to request bytes from
- `quantity` : the number of bytes to request (Max. 32)
- `stop` : boolean. `true` will send a stop message after the request, releasing the bus. `false` will continually send a restart after the request, keeping the connection active. The bus will not be released, which prevents another master device from transmitting between messages. This allows one master device to send multiple transmissions while in control. If no argument is specified, the default value is `true` .

Returns: `byte` : the number of bytes returned from the slave device. If a timeout occurs, will return `0` .

beginTransmission()

Begin a transmission to the I2C slave device with the given address. Subsequently, queue bytes for transmission with the `write()` function and transmit them by calling `endTransmission()` .

```
// SYNTAX
Wire.beginTransmission(address);
```

Parameters: `address` : the 7-bit address of the device to transmit to.

endTransmission()

Ends a transmission to a slave device that was begun by `beginTransmission()` and transmits the bytes that were queued by `write()` .

```
// SYNTAX
Wire.endTransmission();
Wire.endTransmission(stop);
```

Parameters: `stop` : boolean. `true` will send a stop message after the last byte, releasing the bus after transmission. `false` will send a restart, keeping the connection active. The bus will not be released, which prevents another master device from transmitting between messages. This allows one master device to send multiple transmissions while in control. If no argument is specified, the default value is `true` .

Returns: `byte` , which indicates the status of the transmission:

- 0: success
- 1: busy timeout upon entering endTransmission()
- 2: START bit generation timeout
- 3: end of address transmission timeout
- 4: data byte transfer timeout
- 5: data byte transfer succeeded, busy timeout immediately after

write()

Queues bytes for transmission from a master to slave device (in-between calls to `beginTransmission()` and `endTransmission()`). Buffer size is truncated to 32 bytes; writing bytes beyond 32 before calling endTransmission() will be ignored.

```
// SYNTAX
Wire.write(value);
Wire.write(string);
Wire.write(data, length);
```

Parameters:

- `value` : a value to send as a single byte
- `string` : a string to send as a series of bytes

- `data` : an array of data to send as bytes
- `length` : the number of bytes to transmit (Max. 32)

Returns: `byte`

`write()` will return the number of bytes written, though reading that number is optional.

```
// EXAMPLE USAGE

// Master Writer running on Device No.1 (Use with corresponding Slave Reader running on Device No.2)

void setup() {
  Wire.begin();              // join i2c bus as master
}

byte x = 0;

void loop() {
  Wire.beginTransmission(4); // transmit to slave device #4
  Wire.write("x is ");       // sends five bytes
  Wire.write(x);             // sends one byte
  Wire.endTransmission();    // stop transmitting

  x++;
  delay(500);
}
```

available()

Returns the number of bytes available for retrieval with `read()`. This should be called on a master device after a call to `requestFrom()`.

```
Wire.available();
```

Returns: The number of bytes available for reading.

read()

Reads a byte that was transmitted from a slave device to a master after a call to `requestFrom()`. `read()` inherits from the `Stream` utility class.

```
// SYNTAX
Wire.read() ;
```

Returns: The next byte received

```
// EXAMPLE USAGE

// Master Reader running on Device No.1 (Use with corresponding Slave Writer running on Device No.2)

void setup() {
  Wire.begin();              // join i2c bus as master
  Serial.begin(9600);        // start serial for output
}

void loop() {
  Wire.requestFrom(2, 6);    // request 6 bytes from slave device #2

  while(Wire.available()){   // slave may send less than requested
    char c = Wire.read();    // receive a byte as character
    Serial.print(c);         // print the character
  }

  delay(500);
}
```

peek()

Similar in use to read(). Reads (but does not remove from the buffer) a byte that was transmitted from a slave device to a master after a call to `requestFrom()`. `read()` inherits from the `Stream` utility class. Useful for peeking at the next byte to be read.

```
// SYNTAX
Wire.peek();
```

Returns: The next byte received (without removing it from the buffer)

IPAddress

Creates an IP address that can be used with TCPServer, TCPClient, and UDP objects.

```
// EXAMPLE USAGE

IPAddress localIP;
IPAddress server(8,8,8,8);
IPAddress IPfromInt( 167772162UL );  // 10.0.0.2 as 10*256^3+0*256^2+0*256+2
uint8_t server[] = { 10, 0, 0, 2};
IPAddress IPfromBytes( server );
```

The IPAddress also allows for comparisons.

```
if (IPfromInt == IPfromBytes)
{
  Serial.println("Same IP addresses");
}
```

You can also use indexing the get or change individual bytes in the IP address.

```
// PING ALL HOSTS ON YOUR SUBNET EXCEPT YOURSELF
IPAddress localIP = WiFi.localIP();
uint8_t myLastAddrByte = localIP[3];
for(uint8_t ipRange=1; ipRange<255; ipRange++)
{
  if (ipRange != myLastAddrByte)
  {
```

```
    localIP[3] = ipRange;
    WiFi.ping(localIP);
  }
}
```

You can also assign to an IPAddress from an array of uint8's or a 32-bit unsigned integer.

```
IPAddress IPfromInt;  // 10.0.0.2 as 10*256^3+0*256^2+0*256+2
IPfromInt = 167772162UL;
uint8_t server[] = { 10, 0, 0, 2};
IPAddress IPfromBytes;
IPfromBytes = server;
```

Finally IPAddress can be used directly with print.

```
// PRINT THE DEVICE'S IP ADDRESS IN
// THE FORMAT 192.168.0.10
IPAddress myIP = WiFi.localIP();
Serial.println(myIP);    // prints the device's IP address
```

TCPServer

Create a server that listens for incoming connections on the specified port.

```
// SYNTAX
TCPServer server = TCPServer(port);
```

Parameters: `port` : the port to listen on (`int`)

```
// EXAMPLE USAGE
```

```
// telnet defaults to port 23
TCPServer server = TCPServer(23);
TCPClient client;

void setup()
{
  // start listening for clients
  server.begin();

  // Make sure your Serial Terminal app is closed before powering your
device
  Serial.begin(9600);
  // Wait for a USB serial connection for up to 30 seconds
  waitFor(Serial.isConnected, 30000);

  Serial.println(WiFi.localIP());
  Serial.println(WiFi.subnetMask());
  Serial.println(WiFi.gatewayIP());
  Serial.println(WiFi.SSID());
}

void loop()
{
  if (client.connected()) {
    // echo all available bytes back to the client
    while (client.available()) {
      server.write(client.read());
    }
  } else {
    // if no client is yet connected, check for a new connection
    client = server.available();
  }
}
```

begin()

Tells the server to begin listening for incoming connections.

```
// SYNTAX
server.begin();
```

available()

Gets a client that is connected to the server and has data available for reading. The connection persists when the returned client object goes out of scope; you can close it by calling `client.stop()`.

`available()` inherits from the `Stream` utility class.

write()

Write data to the last client that connected to a server. This data is sent as a byte or series of bytes. This function is blocking by default and may block the application thread indefinitely until all the data is sent.

Since 0.7.0

The application code may additionally check if an error occurred during the last `write()` call by checking `getWriteError()` return value. Any non-zero error code indicates and error during write operation.

```
// SYNTAX
server.write(val);
server.write(buf, len);
```

Parameters:

- `val` : a value to send as a single byte (byte or char)
- `buf` : an array to send as a series of bytes (byte or char)
- `len` : the length of the buffer

Returns: `size_t` : the number of bytes written

NOTE: `write()` currently may return negative error codes. This behavior will change in the next major release (0.9.0). Applications will be required to use `getWriteError()` to check for write errors.

print()

Print data to the last client connected to a server. Prints numbers as a sequence of digits, each an ASCII character (e.g. the number 123 is sent as the three characters '1', '2', '3').

```
// SYNTAX
server.print(data);
server.print(data, BASE);
```

Parameters:

- `data` : the data to print (char, byte, int, long, or string)
- `BASE` (optional): the base in which to print numbers: BIN for binary (base 2), DEC for decimal (base 10), OCT for octal (base 8), HEX for hexadecimal (base 16).

Returns: `size_t` : the number of bytes written

println()

Print data, followed by a newline, to the last client connected to a server. Prints numbers as a sequence of digits, each an ASCII character (e.g. the number 123 is sent as the three characters '1', '2', '3').

```
// SYNTAX
server.println();
server.println(data);
server.println(data, BASE) ;
```

Parameters:

- `data` (optional): the data to print (char, byte, int, long, or string)
- `BASE` (optional): the base in which to print numbers: BIN for binary (base 2), DEC for decimal (base 10), OCT for octal (base 8), HEX for hexadecimal (base 16).

getWriteError()

Get the error code of the most recent `write()` operation.

Returns: int `0` when everything is ok, a non-zero error code in case of an error.

This value is updated every after every call to `write()` or can be manually cleared by `clearWriteError()`

```
// SYNTAX
int err = server.getWriteError();
```

```
// EXAMPLE
TCPServer server;
// Write in non-blocking mode to the last client that connected to the
server
int bytes = server.write(buf, len, 0);
int err = server.getWriteError();
if (err != 0) {
  Log.trace("TCPServer::write() failed (error = %d), number of bytes
written: %d", err, bytes);
}
```

clearWriteError()

Clears the error code of the most recent `write()` operation setting it to `0`. This function is automatically called by `write()`.

`clearWriteError()` does not return anything.

TCPClient

(inherits from `Stream` via `Client`)

Creates a client which can connect to a specified internet IP address and port (defined in the `client.connect()` function).

```
// SYNTAX
TCPClient client;
```

```
// EXAMPLE USAGE

TCPClient client;
byte server[] = { 74, 125, 224, 72 }; // Google
void setup()
{
  // Make sure your Serial Terminal app is closed before powering your
device
  Serial.begin(9600);
  // Wait for a USB serial connection for up to 30 seconds
  waitFor(Serial.isConnected, 30000);

  Serial.println("connecting...");

  if (client.connect(server, 80))
  {
    Serial.println("connected");
    client.println("GET /search?q=unicorn HTTP/1.0");
    client.println("Host: www.google.com");
    client.println("Content-Length: 0");
    client.println();
  }
  else
  {
    Serial.println("connection failed");
  }
}

void loop()
{
  if (client.available())
  {
    char c = client.read();
    Serial.print(c);
  }

  if (!client.connected())
```

```
  {
    Serial.println();
    Serial.println("disconnecting.");
    client.stop();
    for(;;);
  }
}
```

connected()

Whether or not the client is connected. Note that a client is considered connected if the connection has been closed but there is still unread data.

```
// SYNTAX
client.connected();
```

Returns true if the client is connected, false if not.

status()

Returns true if the network socket is open and the underlying network is ready.

```
// SYNTAX
client.status();
```

This is different than connected() which returns true if the socket is closed but there is still unread buffered data, available() is non-zero.

connect()

Connects to a specified IP address and port. The return value indicates success or failure. Also supports DNS lookups when using a domain name.

```
// SYNTAX
client.connect();
client.connect(ip, port);
client.connect(hostname, port);
```

Parameters:

- `ip` : the IP address that the client will connect to (array of 4 bytes)
- `hostname` : the host name the client will connect to (string, ex.:"particle.io")
- `port` : the port that the client will connect to (`int`)

Returns true if the connection succeeds, false if not.

write()

Write data to the server the client is connected to. This data is sent as a byte or series of bytes. This function is blocking by default and may block the application thread indefinitely until all the data is sent.

Since 0.7.0

The application code may additionally check if an error occurred during the last `write()` call by checking `getWriteError()` return value. Any non-zero error code indicates and error during write operation.

```
// SYNTAX
client.write(val);
client.write(buf, len);
```

Parameters:

- `val` : a value to send as a single byte (byte or char)
- `buf` : an array to send as a series of bytes (byte or char)
- `len` : the length of the buffer

Returns: `size_t` : `write()` returns the number of bytes written.

NOTE: `write()` currently may return negative error codes. This behavior will change in the next major release (0.9.0). Applications will be required to use `getWriteError()` to check for write errors.

print()

Print data to the server that a client is connected to. Prints numbers as a sequence of digits, each an ASCII character (e.g. the number 123 is sent as the three characters '1', '2', '3').

```
// SYNTAX
client.print(data);
client.print(data, BASE) ;
```

Parameters:

- `data` : the data to print (char, byte, int, long, or string)
- `BASE` (optional): the base in which to print numbers: BIN for binary (base 2), DEC for decimal (base 10), OCT for octal (base 8), HEX for hexadecimal (base 16).

Returns: `byte` : `print()` will return the number of bytes written, though reading that number is optional

println()

Print data, followed by a carriage return and newline, to the server a client is connected to. Prints numbers as a sequence of digits, each an ASCII character (e.g. the number 123 is sent as the three characters '1', '2', '3').

```
// SYNTAX
client.println();
client.println(data);
client.println(data, BASE) ;
```

Parameters:

- `data` (optional): the data to print (char, byte, int, long, or string)
- `BASE` (optional): the base in which to print numbers: BIN for binary (base 2), DEC for decimal (base 10), OCT for octal (base 8), HEX for hexadecimal (base 16).

available()

Returns the number of bytes available for reading (that is, the amount of data that has been written to the client by the server it is connected to).

```
// SYNTAX
client.available();
```

Returns the number of bytes available.

read()

Read the next byte received from the server the client is connected to (after the last call to `read()`).

```
// SYNTAX
client.read();
```

Returns the next byte (or character), or -1 if none is available.

or `int read(uint8_t *buffer, size_t size)` reads all readily available bytes up to `size` from the server the client is connected to into the provided `buffer`.

```
// SYNTAX
bytesRead = client.read(buffer, length);
```

Returns the number of bytes (or characters) read into `buffer`.

flush()

Waits until all outgoing data in buffer has been sent.

NOTE: That this function does nothing at present.

```
// SYNTAX
client.flush();
```

remoteIP()

Since 0.4.5:

Retrieves the remote `IPAddress` of a connected `TCPClient`. When the `TCPClient` is retrieved from `TCPServer.available()` (where the client is a remote client connecting to a local server) the `IPAddress` gives the remote address of the connecting client.

When `TCPClient` was created directly via `TCPClient.connect()`, then `remoteIP` returns the remote server the client is connected to.

```
// EXAMPLE - TCPClient from TCPServer

TCPServer server(80);
// ...

void setup()
{
    Serial.begin(9600);
    server.begin(80);
}

void loop()
{
    // check for a new client to our server
    TCPClient client = server.available();
    if (client.connected())
    {
        // we got a new client
```

```
        // find where the client's remote address
        IPAddress clientIP = client.remoteIP();
        // print the address to Serial
        Serial.println(clientIP);
    }
}
```

```
// EXAMPLE - TCPClient.connect()

TCPClient client;
client.connect("www.google.com", 80);
if (client.connected())
{
    IPAddress clientIP = client.remoteIP();
    // IPAddress equals whatever www.google.com resolves to
}
```

stop()

Disconnect from the server.

```
// SYNTAX
client.stop();
```

getWriteError()

Get the error code of the most recent `write()` operation.

Returns: int `0` when everything is ok, a non-zero error code in case of an error.

This value is updated every after every call to `write()` or can be manually cleared by `clearWriteError()`

```
// SYNTAX
int err = client.getWriteError();
```

```
// EXAMPLE
TCPClient client;
// Write in non-blocking mode
int bytes = client.write(buf, len, 0);
int err = client.getWriteError();
if (err != 0) {
  Log.trace("TCPClient::write() failed (error = %d), number of bytes
written: %d", err, bytes);
}
```

clearWriteError()

Clears the error code of the most recent `write()` operation setting it to `0`. This function is automatically called by `write()`.

`clearWriteError()` does not return anything.

UDP

(inherits from `Stream` and `Printable`)

This class enables UDP messages to be sent and received.

```
// EXAMPLE USAGE

// UDP Port used for two way communication
unsigned int localPort = 8888;

// An UDP instance to let us send and receive packets over UDP
UDP Udp;

void setup() {
  // start the UDP
  Udp.begin(localPort);
```

```
  // Print your device IP Address via serial
  Serial.begin(9600);
  Serial.println(WiFi.localIP());
}

void loop() {
  // Check if data has been received
  if (Udp.parsePacket() > 0) {

    // Read first char of data received
    char c = Udp.read();

    // Ignore other chars
    while(Udp.available())
      Udp.read();

    // Store sender ip and port
    IPAddress ipAddress = Udp.remoteIP();
    int port = Udp.remotePort();

    // Echo back data to sender
    Udp.beginPacket(ipAddress, port);
    Udp.write(c);
    Udp.endPacket();
  }
}
```

Note that UDP does not guarantee that messages are always delivered, or that they are delivered in the order supplied. In cases where your application requires a reliable connection, ***`TCPClient`*** *is a simpler alternative.*

There are two primary ways of working with UDP - buffered operation and unbuffered operation.

1. buffered operation allows you to read and write packets in small pieces, since the system takes care of allocating the required buffer to hold the entire packet.

    - to read a buffered packet, call **`parsePacket`**, then use **`available`** and **`read`** to retrieve the packet received
    - to write a buffered packet, optionally call **`setBuffer`** to set the maximum size of the packet (the default is 512 bytes), followed by **`beginPacket`**, then as many calls to

`write` / `print` as necessary to build the packet contents, followed finally by `end` to send the packet over the network.

2. unbuffered operation allows you to read and write entire packets in a single operation - your application is responsible for allocating the buffer to contain the packet to be sent or received over the network.

    - to read an unbuffered packet, call `receivePacket` with a buffer to hold the received packet.
    - to write an unbuffered packet, call `sendPacket` with the packet buffer to send, and the destination address.

begin()

Initializes the UDP library and network settings.

```
// SYNTAX
Udp.begin(port);
```

available()

Get the number of bytes (characters) available for reading from the buffer. This is data that's already arrived.

```
// SYNTAX
int count = Udp.available();
```

This function can only be successfully called after `UDP.parsePacket()`.

`available()` inherits from the `Stream` utility class.

Returns the number of bytes available to read.

beginPacket()

Starts a connection to write UDP data to the remote connection.

```
// SYNTAX
Udp.beginPacket(remoteIP, remotePort);
```

Parameters:

- `remoteIP` : the IP address of the remote connection (4 bytes)
- `remotePort` : the port of the remote connection (int)

It returns nothing.

endPacket()

Called after writing buffered UDP data using `write()` or `print()`. The buffered data is then sent to the remote UDP peer.

```
// SYNTAX
Udp.endPacket();
```

Parameters: NONE

write()

Writes UDP data to the buffer - no data is actually sent. Must be wrapped between `beginPacket()` and `endPacket()`. `beginPacket()` initializes the packet of data, it is not sent until `endPacket()` is called.

```
// SYNTAX
Udp.write(message);
Udp.write(buffer, size);
```

Parameters:

- `message` : the outgoing message (char)

- `buffer` : an array to send as a series of bytes (byte or char)
- `size` : the length of the buffer

Returns:

- `byte` : returns the number of characters sent. This does not have to be read

receivePacket()

Checks for the presence of a UDP packet and returns the size. Note that it is possible to receive a valid packet of zero bytes, this will still return the sender's address and port after the call to receivePacket().

```
// SYNTAX
size = Udp.receivePacket(buffer, size);
// EXAMPLE USAGE - get a string without buffer copy
UDP Udp;
char message[128];
int port = 8888;
int rxError = 0;

Udp.begin (port);
int count = Udp.receivePacket((byte*)message, 127);
if (count >= 0 && count < 128) {
  message[count] = 0;
  rxError = 0;
} else if (count < -1) {
  rxError = count;
  // need to re-initialize on error
  Udp.begin(port);
}
if (!rxError) {
  Serial.println (message);
}
```

Parameters:

- `buffer` : the buffer to hold any received bytes (uint8_t).
- `size` : the size of the buffer.

Returns:

- `int` : on success the size (greater then or equal to zero) of a received UDP packet. On failure the internal error code.

parsePacket()

Checks for the presence of a UDP packet, and reports the size. `parsePacket()` must be called before reading the buffer with `UDP.read()`.

```
// SYNTAX
size = Udp.parsePacket();
```

Parameters: NONE

Returns:

- `int` : the size of a received UDP packet

read()

Reads UDP data from the specified buffer. If no arguments are given, it will return the next character in the buffer.

This function can only be successfully called after `UDP.parsePacket()`.

```
// SYNTAX
count = Udp.read();
count = Udp.read(packetBuffer, MaxSize);
```

Parameters:

- `packetBuffer` : buffer to hold incoming packets (char)
- `MaxSize` : maximum size of the buffer (int)

Returns:

- `int` : returns the character in the buffer or -1 if no character is available

flush()

Waits until all outgoing data in buffer has been sent.

NOTE: That this function does nothing at present.

```
// SYNTAX
Udp.flush();
```

stop()

Disconnect from the server. Release any resource being used during the UDP session.

```
// SYNTAX
Udp.stop();
```

Parameters: NONE

remoteIP()

Returns the IP address of sender of the packet parsed by `Udp.parsePacket()` / `Udp.receivePacket()`.

```
// SYNTAX
ip = Udp.remoteIP();
```

Parameters: NONE

Returns:

- IPAddress : the IP address of the sender of the packet parsed by `Udp.parsePacket()` / `Udp.receivePacket()` .

remotePort()

Returns the port from which the UDP packet was sent. The packet is the one most recently processed by `Udp.parsePacket()` / `Udp.receivePacket()` .

```
// SYNTAX
int port = Udp.remotePort();
```

Parameters: NONE

Returns:

- `int` : the port from which the packet parsed by `Udp.parsePacket()` / `Udp.receivePacket()` was sent.

setBuffer()

Since 0.4.5:

Initializes the buffer used by a `UDP` instance for buffered reads/writes. The buffer is used when your application calls `beginPacket()` and `parsePacket()` . If `setBuffer()` isn't called, the buffer size defaults to 512 bytes, and is allocated when buffered operation is initialized via `beginPacket()` or `parsePacket()` .

```
// SYNTAX
Udp.setBuffer(size); // dynamically allocated buffer
Udp.setBuffer(size, buffer); // application provided buffer

// EXAMPLE USAGE - dynamically allocated buffer
UDP Udp;

// uses a dynamically allocated buffer that is 1024 bytes in size
if (!Udp.setBuffer(1024))
{
    // on no, couldn't allocate the buffer
```

```
}
else
{
    // 'tis good!
}
```

```
// EXAMPLE USAGE - application-provided buffer
UDP Udp;

char appBuffer[800];
Udp.setBuffer(800, appBuffer);
```

Parameters:

- `unsigned int` : the size of the buffer
- `pointer` : the buffer. If not provided, or `NULL` the system will attempt to allocate a buffer of the size requested.

Returns:

- `true` when the buffer was successfully allocated, `false` if there was insufficient memory. (For application-provided buffers the function always returns `true` .)

releaseBuffer()

Since 0.4.5:

Releases the buffer previously set by a call to `setBuffer()` .

```
// SYNTAX
Udp.releaseBuffer();
```

This is typically required only when performing advanced memory management and the UDP instance is not scoped to the lifetime of the application.

sendPacket()

Since 0.4.5:

Sends a packet, unbuffered, to a remote UDP peer.

```
// SYNTAX
Udp.sendPacket(buffer, bufferSize, remoteIP, remotePort);

// EXAMPLE USAGE
UDP Udp;

char buffer[] = "Particle powered";

IPAddress remoteIP(192, 168, 1, 100);
int port = 1337;

void setup() {
  // Required for two way communication
  Udp.begin(8888);

  if (Udp.sendPacket(buffer, sizeof(buffer), remoteIP, port) < 0) {
    Particle.publish("Error");
  }
}
```

Parameters:

- `pointer` (buffer): the buffer of data to send
- `int` (bufferSize): the number of bytes of data to send
- `IPAddress` (remoteIP): the destination address of the remote peer
- `int` (remotePort): the destination port of the remote peer

Returns:

- `int` : The number of bytes written. Negative value on error.

Servo

This library allows your device to control RC (hobby) servo motors. Servos have integrated gears and a shaft that can be precisely controlled. Standard servos allow the shaft to be positioned at various angles, usually between 0 and 180 degrees. Continuous rotation servos allow the rotation of the shaft to be set to various speeds.

This example uses pin D0, but D0 cannot be used for Servo on all devices.

```
// EXAMPLE CODE

Servo myservo;  // create servo object to control a servo
                // a maximum of eight servo objects can be created

int pos = 0;    // variable to store the servo position

void setup()
{
  myservo.attach(D0);  // attaches the servo on the D0 pin to the servo
object
  // Only supported on pins that have PWM
}


void loop()
{
  for(pos = 0; pos < 180; pos += 1)  // goes from 0 degrees to 180 degrees
  {                                  // in steps of 1 degree
    myservo.write(pos);              // tell servo to go to position in
variable 'pos'
    delay(15);                       // waits 15ms for the servo to reach
the position
  }
  for(pos = 180; pos>=1; pos-=1)     // goes from 180 degrees to 0 degrees
  {
    myservo.write(pos);              // tell servo to go to position in
variable 'pos'
    delay(15);                       // waits 15ms for the servo to reach
the position
  }
}
```

NOTE: Unlike Arduino, you do not need to include `Servo.h` ; it is included automatically.

attach()

Set up a servo on a particular pin. Note that, Servo can only be attached to pins with a timer.

- on the Core, Servo can be connected to A0, A1, A4, A5, A6, A7, D0, and D1.
- on the Photon, Servo can be connected to A4, A5, WKP, RX, TX, D0, D1, D2, D3
- on the P1, Servo can be connected to A4, A5, WKP, RX, TX, D0, D1, D2, D3, P1S0, P1S1
- on the Electron, Servo can be connected to A4, A5, WKP, RX, TX, D0, D1, D2, D3, B0, B1, B2, B3, C4, C5
- on Gen 3 Argon, Boron, and Xenon devices, pin A0, A1, A2, A3, D2, D3, D4, D5, D6, and D8 can be used for Servo.
- On Gen 3 B Series SoM devices, pins A0, A1, A6, A7, D4, D5, and D6 can be used for Servo.

```
// SYNTAX
servo.attach(pin)
```

write()

Writes a value to the servo, controlling the shaft accordingly. On a standard servo, this will set the angle of the shaft (in degrees), moving the shaft to that orientation. On a continuous rotation servo, this will set the speed of the servo (with 0 being full-speed in one direction, 180 being full speed in the other, and a value near 90 being no movement).

```
// SYNTAX
servo.write(angle)
```

writeMicroseconds()

Writes a value in microseconds (uS) to the servo, controlling the shaft accordingly. On a standard servo, this will set the angle of the shaft. On standard servos a parameter value of 1000 is fully counter-clockwise, 2000 is fully clockwise, and 1500 is in the middle.

```
// SYNTAX
servo.writeMicroseconds(uS)
```

Note that some manufactures do not follow this standard very closely so that servos often respond to values between 700 and 2300. Feel free to increase these endpoints until the servo no longer continues to increase its range. Note however that attempting to drive a servo past its endpoints (often indicated by a growling sound) is a high-current state, and should be avoided.

Continuous-rotation servos will respond to the writeMicrosecond function in an analogous manner to the write function.

read()

Read the current angle of the servo (the value passed to the last call to write()). Returns an integer from 0 to 180 degrees.

```
// SYNTAX
servo.read()
```

attached()

Check whether the Servo variable is attached to a pin. Returns a boolean.

```
// SYNTAX
servo.attached()
```

detach()

Detach the Servo variable from its pin.

```
// SYNTAX
servo.detach()
```

setTrim()

Sets a trim value that allows minute timing adjustments to correctly calibrate 90 as the stationary point.

```
// SYNTAX

// shortens the pulses sent to the servo
servo.setTrim(-3);

// a larger trim value
servo.setTrim(30);

// removes any previously configured trim
servo.setTrim(0);
```

Time

The device synchronizes time with the Particle Device Cloud during the handshake. From then, the time is continually updated on the device. This reduces the need for external libraries to manage dates and times.

Before the device gets online and for short intervals, you can use the `millis()` and `micros()` functions.

millis()

Returns the number of milliseconds since the device began running the current program. This number will overflow (go back to zero), after approximately 49 days.

```
unsigned long time = millis();
```

```
// EXAMPLE USAGE

unsigned long time;

void setup()
{
  Serial.begin(9600);
}
void loop()
{
  Serial.print("Time: ");
  time = millis();
  //prints time since program started
  Serial.println(time);
  // wait a second so as not to send massive amounts of data
  delay(1000);
}
```

Note: The return value for millis is an unsigned long, errors may be generated if a programmer tries to do math with other data types such as ints.

micros()

Returns the number of microseconds since the device booted.

```
unsigned long time = micros();
```

```
// EXAMPLE USAGE

unsigned long time;

void setup()
{
  Serial.begin(9600);
}
```

```
void loop()
{
  Serial.print("Time: ");
  time = micros();
  //prints time since program started
  Serial.println(time);
  // wait a second so as not to send massive amounts of data
  delay(1000);
}
```

In Device OS v0.4.3 and earlier this number will overflow (go back to zero), after exactly 59,652,323 microseconds (0 .. 59,652,322) on the Core and after exactly 35,791,394 microseconds (0 .. 35,791,394) on the Photon and Electron. In newer Device OS versions, it overflows at the maximum 32-bit unsigned long value.

delay()

Pauses the program for the amount of time (in milliseconds) specified as parameter. (There are 1000 milliseconds in a second.)

```
// SYNTAX
delay(ms);
```

`ms` is the number of milliseconds to pause *(unsigned long)*

```
// EXAMPLE USAGE

int ledPin = D1;              // LED connected to digital pin D1

void setup()
{
  pinMode(ledPin, OUTPUT);    // sets the digital pin as output
}

void loop()
{
  digitalWrite(ledPin, HIGH); // sets the LED on
  delay(1000);                // waits for a second
```

```
  digitalWrite(ledPin, LOW);  // sets the LED off
  delay(1000);                // waits for a second
}
```

NOTE: the parameter for millis is an unsigned long, errors may be generated if a programmer tries to do math with other data types such as ints.

delayMicroseconds()

Pauses the program for the amount of time (in microseconds) specified as parameter. There are a thousand microseconds in a millisecond, and a million microseconds in a second.

```
// SYNTAX
delayMicroseconds(us);
```

`us` is the number of microseconds to pause *(unsigned int)*

```
// EXAMPLE USAGE

int outPin = D1;              // digital pin D1

void setup()
{
  pinMode(outPin, OUTPUT);    // sets the digital pin as output
}

void loop()
{
  digitalWrite(outPin, HIGH); // sets the pin on
  delayMicroseconds(50);      // pauses for 50 microseconds
  digitalWrite(outPin, LOW);  // sets the pin off
  delayMicroseconds(50);      // pauses for 50 microseconds
}
```

hour()

Retrieve the hour for the current or given time. Integer is returned without a leading zero.

```
// Print the hour for the current time
Serial.print(Time.hour());

// Print the hour for the given time, in this case: 4
Serial.print(Time.hour(1400647897));
```

Optional parameter: time_t (Unix timestamp), coordinated universal time (UTC), long integer

Returns: Integer 0-23

If you have set a timezone using zone(), beginDST(), etc. the hour returned will be local time. You must still pass in UTC time, otherwise the time offset will be applied twice.

hourFormat12()

Retrieve the hour in 12-hour format for the current or given time. Integer is returned without a leading zero.

```
// Print the hour in 12-hour format for the current time
Serial.print(Time.hourFormat12());

// Print the hour in 12-hour format for a given time, in this case: 3
Serial.print(Time.hourFormat12(1400684400));
```

Optional parameter: time_t (Unix timestamp), coordinated universal time (UTC), long integer

Returns: Integer 1-12

If you have set a timezone using zone(), beginDST(), etc. the hour returned will be local time. You must still pass in UTC time, otherwise the time offset will be applied twice.

isAM()

Returns true if the current or given time is AM.

```
// Print true or false depending on whether the current time is AM
Serial.print(Time.isAM());

// Print whether the given time is AM, in this case: true
Serial.print(Time.isAM(1400647897));
```

Optional parameter: time_t (Unix timestamp), coordinated universal time (UTC), long integer

Returns: Unsigned 8-bit integer: 0 = false, 1 = true

If you have set a timezone using zone(), beginDST(), etc. the hour returned will be local time. You must still pass in UTC time, otherwise the time offset will be applied twice, potentially causing AM/PM to be calculated incorrectly.

isPM()

Returns true if the current or given time is PM.

```
// Print true or false depending on whether the current time is PM
Serial.print(Time.isPM());

// Print whether the given time is PM, in this case: false
Serial.print(Time.isPM(1400647897));
```

Optional parameter: time_t (Unix timestamp), coordinated universal time (UTC), long integer

Returns: Unsigned 8-bit integer: 0 = false, 1 = true

If you have set a timezone using zone(), beginDST(), etc. the hour returned will be local time. You must still pass in UTC time, otherwise the time offset will be applied twice, potentially causing AM/PM to be calculated incorrectly.

minute()

Retrieve the minute for the current or given time. Integer is returned without a leading zero.

```
// Print the minute for the current time
Serial.print(Time.minute());

// Print the minute for the given time, in this case: 51
Serial.print(Time.minute(1400647897));
```

Optional parameter: time_t (Unix timestamp), coordinated universal time (UTC), long integer

Returns: Integer 0-59

If you have set a timezone using zone(), beginDST(), etc. the hour returned will be local time. You must still pass in UTC time, otherwise the time offset will be applied twice.

second()

Retrieve the seconds for the current or given time. Integer is returned without a leading zero.

```
// Print the second for the current time
Serial.print(Time.second());

// Print the second for the given time, in this case: 51
Serial.print(Time.second(1400647897));
```

Optional parameter: time_t (Unix timestamp), coordinated universal time (UTC), long integer

Returns: Integer 0-59

day()

Retrieve the day for the current or given time. Integer is returned without a leading zero.

```
// Print the day for the current time
Serial.print(Time.day());

// Print the day for the given time, in this case: 21
Serial.print(Time.day(1400647897));
```

Optional parameter: time_t (Unix timestamp), coordinated universal time (UTC), long integer

Returns: Integer 1-31

If you have set a timezone using zone(), beginDST(), etc. the hour returned will be local time. You must still pass in UTC time, otherwise the time offset will be applied twice, potentially causing an incorrect date.

weekday()

Retrieve the weekday for the current or given time.

- 1 = Sunday
- 2 = Monday
- 3 = Tuesday
- 4 = Wednesday
- 5 = Thursday
- 6 = Friday
- 7 = Saturday

```
// Print the weekday number for the current time
Serial.print(Time.weekday());

// Print the weekday for the given time, in this case: 4
Serial.print(Time.weekday(1400647897));
```

Optional parameter: time_t (Unix timestamp), coordinated universal time (UTC), long integer

Returns: Integer 1-7

If you have set a timezone using zone(), beginDST(), etc. the hour returned will be local time. You must still pass in UTC time, otherwise the time offset will be applied twice, potentially causing an incorrect day of week.

month()

Retrieve the month for the current or given time. Integer is returned without a leading zero.

```
// Print the month number for the current time
Serial.print(Time.month());

// Print the month for the given time, in this case: 5
Serial.print(Time.month(1400647897));
```

Optional parameter: time_t (Unix timestamp), coordinated universal time (UTC), long integer

Returns: Integer 1-12

If you have set a timezone using zone(), beginDST(), etc. the hour returned will be local time. You must still pass in UTC time, otherwise the time offset will be applied twice, potentially causing an incorrect date.

year()

Retrieve the 4-digit year for the current or given time.

```
// Print the current year
Serial.print(Time.year());

// Print the year for the given time, in this case: 2014
Serial.print(Time.year(1400647897));
```

Optional parameter: time_t (Unix timestamp), coordinated universal time (UTC), long integer

Returns: Integer

now()

Retrieve the current time as seconds since January 1, 1970 (commonly known as "Unix time" or "epoch time"). This time is not affected by the timezone setting, it's coordinated universal time (UTC).

```
// Print the current Unix timestamp
Serial.print(Time.now()); // 1400647897
```

Returns: time_t (Unix timestamp), coordinated universal time (UTC), long integer (32-bit)

local()

Retrieve the current time in the configured timezone as seconds since January 1, 1970 (commonly known as "Unix time" or "epoch time"). This time is affected by the timezone setting.

Note that the functions in the `Time` class expect times in UTC time, so the result from this should be used carefully. You should not pass Time.local() to Time.format(), for example.

Since 0.6.0

Local time is also affected by the Daylight Saving Time (DST) settings.

zone()

Set the time zone offset (+/-) from UTC. The device will remember this offset until reboot.

NOTE: This function does not observe daylight savings time.

```
// Set time zone to Eastern USA daylight saving time
Time.zone(-4);
```

Parameters: floating point offset from UTC in hours, from -12.0 to 14.0

isDST()

Since 0.6.0:

Returns true if Daylight Saving Time (DST) is in effect.

```
// Print true or false depending on whether the DST in in effect
Serial.print(Time.isDST());
```

Returns: Unsigned 8-bit integer: 0 = false, 1 = true

This function only returns the current DST setting that you choose using beginDST() or endDST(). The setting does not automatically change based on the calendar date.

getDSTOffset()

Since 0.6.0:

Retrieve the current Daylight Saving Time (DST) offset that is added to the current local time when Time.beginDST() has been called. The default is 1 hour.

```
// Get current DST offset
float offset = Time.getDSTOffset();
```

Returns: floating point DST offset in hours (default is +1.0 hours)

setDSTOffset()

Since 0.6.0:

Set a custom Daylight Saving Time (DST) offset. The device will remember this offset until reboot.

```
// Set DST offset to 30 minutes
Time.setDSTOffset(0.5);
```

Parameters: floating point offset in hours, from 0.0 to 2.0

beginDST()

Since 0.6.0:

Start applying Daylight Saving Time (DST) offset to the current time.

You must call beginDST() at startup if you want use DST mode. The setting is not remembered and is not automatically changed based on the calendar.

endDST()

Since 0.6.0:

Stop applying Daylight Saving Time (DST) offset to the current time.

You must call endDST() on the appropriate date to end DST mode. It is not calculated automatically.

setTime()

Set the system time to the given timestamp.

NOTE: This will override the time set by the Particle Device Cloud. If the cloud connection drops, the reconnection handshake will set the time again

Also see: `Particle.syncTime()`

```
// Set the time to 2014-10-11 13:37:42
Time.setTime(1413034662);
```

Parameter: time_t (Unix timestamp), coordinated universal time (UTC), long integer

timeStr()

Return string representation for the given time.

```
Serial.print(Time.timeStr()); // Wed May 21 01:08:47 2014
```

Returns: String

NB: In 0.3.4 and earlier, this function included a newline at the end of the returned string. This has been removed in 0.4.0.

format()

Formats a time string using a configurable format.

```
// SYNTAX
Time.format(time, strFormat); // fully qualified (e.g. current time with custom format)
Time.format(strFormat);       // current time with custom format
Time.format(time);            // custom time with preset format
Time.format();                // current time with preset format

// EXAMPLE
time_t time = Time.now();
Time.format(time, TIME_FORMAT_DEFAULT); // Sat Jan 10 08:22:04 2004 , same as Time.timeStr()

Time.zone(-5.25);  // setup a time zone, which is part of the ISO8601 format
Time.format(time, TIME_FORMAT_ISO8601_FULL); // 2004-01-10T08:22:04-05:15
```

The formats available are:

- `TIME_FORMAT_DEFAULT`
- `TIME_FORMAT_ISO8601_FULL`
- custom format based on strftime()

Optional parameter: time_t (Unix timestamp), coordinated universal time (UTC), long integer

If you have set the time zone using Time.zone(), beginDST(), etc. the formatted time will be formatted in local time.

Note: The custom time provided to `Time.format()` needs to be UTC based and *not* contain the time zone offset (as `Time.local()` would), since the time zone correction is performed by the high level `Time` methods internally.

setFormat()

Sets the format string that is the default value used by `format()`.

```
Time.setFormat(TIME_FORMAT_ISO8601_FULL);
```

In more advanced cases, you can set the format to a static string that follows the same syntax as the `strftime()` function.

```
// custom formatting

Time.format(Time.now(), "Now it's %I:%M%p.");
// Now it's 03:21AM.
```

getFormat()

Retrieves the currently configured format string for time formatting with `format()`.

isValid()

Since 0.6.1:

```
// SYNTAX
Time.isValid();
```

Used to check if current time is valid. This function will return `true` if:

- Time has been set manually using `Time.setTime()`
- Time has been successfully synchronized with the Particle Device Cloud. The device synchronizes time with the Particle Device Cloud during the handshake. The application may also manually synchronize time with Particle Device Cloud using `Particle.syncTime()`
- Correct time has been maintained by RTC.

NOTE: When Raspberry Pi is running in `AUTOMATIC` mode this function will block if current time is not valid and there is an active connection to Particle Device Cloud. Once Raspberry Pi synchronizes the time with Particle Device Cloud or the connection to Particle Device Cloud is lost, `Time.isValid()` will return its current state. This function is also implicitly called by any `Time` function that returns current time or date (e.g. `Time.hour()` / `Time.now()` /etc).

```
// Print true or false depending on whether current time is valid
Serial.print(Time.isValid());
```

```
void setup()
{
  // Wait for time to be synchronized with Particle Device Cloud (requires active connection)
  waitFor(Time.isValid, 60000);
}

void loop()
{
  // Print current time
  Serial.println(Time.timeStr());
}
```

Advanced

For more advanced date parsing, formatting, normalization and manipulation functions, use the C standard library time functions like `mktime`. See the note about the standard library on the Raspberry Pi and the description of the C standard library time functions.

Class member callbacks

Since 0.4.9:

A class member function can be used as a callback using this syntax to create the timer:

```
Timer timer(period, callback, instance, one_shot)
```

- `period` is the period of the timer in milliseconds (unsigned int)
- `callback` is the class member function which gets called when the timer expires.
- `instance` the instance of the class to call the callback function on.
- `one_shot` (optional, since 0.4.9) when `true`, the timer is fired once and then stopped automatically. The default is `false` - a repeating timer.

```
// Class member function callback example

class CallbackClass
{
public:
     void onTimeout();
}

CallbackClass callback;
Timer t(1000, &CallbackClass::onTimeout, callback);
```

start()

Starts a stopped timer (a newly created timer is stopped). If `start()` is called for a running timer, it will be reset.

```
start()
```

```
// EXAMPLE USAGE
timer.start(); // starts timer if stopped or resets it if started.
```

stop()

Stops a running timer.

`stop()`

```
// EXAMPLE USAGE
timer.stop(); // stops a running timer.
```

changePeriod()

Changes the period of a previously created timer. It can be called to change the period of an running or stopped timer. Note that changing the period of a dormant timer will also start the timer.

`changePeriod(newPeriod)`

`newPeriod` is the new timer period (unsigned int)

```
// EXAMPLE USAGE
timer.changePeriod(1000); // Reset period of timer to 1000ms.
```

reset()

Resets a timer. If a timer is running, it will reset to "zero". If a timer is stopped, it will be started.

`reset()`

```
// EXAMPLE USAGE
timer.reset(); // reset timer if running, or start timer if stopped.
```

startFromISR()

stopFromISR()

resetFromISR()

changePeriodFromISR()

`startFromISR()` `stopFromISR()` `resetFromISR()` `changePeriodFromISR()`

Start, stop and reset a timer or change a timer's period (as above) BUT from within an ISR. These functions MUST be called when doing timer operations within an ISR.

```
// EXAMPLE USAGE
timer.startFromISR(); // WITHIN an ISR, starts timer if stopped or resets it if started.

timer.stopFromISR(); // WITHIN an ISR,stops a running timer.

timer.resetFromISR(); // WITHIN an ISR, reset timer if running, or start timer if stopped.

timer.changePeriodFromISR(newPeriod);  // WITHIN an ISR, change the timer period.
```

dispose()

`dispose()`

Stop and remove a timer from the (max. 10) timer list, freeing a timer "slot" in the list.

```
// EXAMPLE USAGE
timer.dispose(); // stop and delete timer from timer list.
```

isActive()

Since 0.5.0:

```
bool isActive()
```

Returns `true` if the timer is in active state (pending), or `false` otherwise.

```
// EXAMPLE USAGE
if (timer.isActive()) {
    // ...
}
```

Math

Note that in addition to functions outlined below all of the newlib math functions described at sourceware.org are also available for use by simply including the math.h header file thus:

```
#include "math.h"
```

min()

Calculates the minimum of two numbers.

```
min(x, y)
```

`x` is the first number, any data type `y` is the second number, any data type

The functions returns the smaller of the two numbers.

```
// EXAMPLE USAGE
sensVal = min(sensVal, 100); // assigns sensVal to the smaller of sensVal or
100
                             // ensuring that it never gets above 100.
```

NOTE: Perhaps counter-intuitively, max() is often used to constrain the lower end of a variable's range, while min() is used to constrain the upper end of the range.

WARNING: Because of the way the min() function is implemented, avoid using other functions inside the brackets, it may lead to incorrect results

```
min(a++, 100);   // avoid this - yields incorrect results

a++;
min(a, 100);    // use this instead - keep other math outside the function
```

max()

Calculates the maximum of two numbers.

```
max(x, y)
```

`x` is the first number, any data type `y` is the second number, any data type

The functions returns the larger of the two numbers.

```
// EXAMPLE USAGE
sensVal = max(senVal, 20); // assigns sensVal to the larger of sensVal or 20
                           // (effectively ensuring that it is at least 20)
```

NOTE: Perhaps counter-intuitively, max() is often used to constrain the lower end of a variable's range, while min() is used to constrain the upper end of the range.

WARNING: Because of the way the max() function is implemented, avoid using other functions inside the brackets, it may lead to incorrect results

```
max(a--, 0);   // avoid this - yields incorrect results

a--;           // use this instead -
max(a, 0);     // keep other math outside the function
```

abs()

Computes the absolute value of a number.

```
abs(x);
```

where `x` is the number

The function returns `x` if `x` is greater than or equal to `0` and returns `-x` if `x` is less than `0`.

WARNING: Because of the way the abs() function is implemented, avoid using other functions inside the brackets, it may lead to incorrect results.

```
abs(a++);   // avoid this - yields incorrect results

a++;          // use this instead -
abs(a);       // keep other math outside the function
```

constrain()

Constrains a number to be within a range.

```
constrain(x, a, b);
```

`x` is the number to constrain, all data types `a` is the lower end of the range, all data types `b` is the upper end of the range, all data types

The function will return: `x` : if x is between `a` and `b` `a` : if `x` is less than `a` `b` : if `x` is greater than `b`

```
// EXAMPLE USAGE
sensVal = constrain(sensVal, 10, 150);
// limits range of sensor values to between 10 and 150
```

map()

```
// EXAMPLE USAGE

// Map an analog value to 8 bits (0 to 255)
void setup() {
  pinMode(D1, OUTPUT);
}

void loop()
{
  int val = analogRead(A0);
  val = map(val, 0, 4095, 0, 255);
  analogWrite(D1, val);
}
```

Re-maps a number from one range to another. That is, a value of fromLow would get mapped to `toLow`, a `value` of `fromHigh` to `toHigh`, values in-between to values in-between, etc.

```
map(value, fromLow, fromHigh, toLow, toHigh);
```

Does not constrain values to within the range, because out-of-range values are sometimes intended and useful. The `constrain()` function may be used either before or after this function, if limits to the ranges are desired.

Note that the "lower bounds" of either range may be larger or smaller than the "upper bounds" so the `map()` function may be used to reverse a range of numbers, for example

```
y = map(x, 1, 50, 50, 1);
```

The function also handles negative numbers well, so that this example

```
y = map(x, 1, 50, 50, -100);
```

is also valid and works well.

When called with integers, the `map()` function uses integer math so will not generate fractions, when the math might indicate that it should do so. Fractional remainders are truncated, not rounded.

Parameters can either be integers or floating point numbers:

- `value` : the number to map
- `fromLow` : the lower bound of the value's current range
- `fromHigh` : the upper bound of the value's current range
- `toLow` : the lower bound of the value's target range
- `toHigh` : the upper bound of the value's target range

The function returns the mapped value, as integer or floating point depending on the arguments.

Appendix: For the mathematically inclined, here's the whole function

```
int map(int value, int fromStart, int fromEnd, int toStart, int toEnd)
{
    if (fromEnd == fromStart) {
        return value;
    }
    return (value - fromStart) * (toEnd - toStart) / (fromEnd - fromStart) +
toStart;
}
```

pow()

Calculates the value of a number raised to a power. `pow()` can be used to raise a number to a fractional power. This is useful for generating exponential mapping of values or curves.

```
pow(base, exponent);
```

`base` is the number *(float)* `exponent` is the power to which the base is raised *(float)*

The function returns the result of the exponentiation *(double)*

EXAMPLE **TBD**

sqrt()

Calculates the square root of a number.

```
sqrt(x)
```

`x` is the number, any data type

The function returns the number's square root *(double)*

Random Numbers

The firmware incorporates a pseudo-random number generator.

random()

Retrieves the next random value, restricted to a given range.

```
random(max);
```

Parameters

- `max` - the upper limit of the random number to retrieve.

Returns: a random value between 0 and up to, but not including `max`.

```
int r = random(10);
// r is >= 0 and < 10
// The smallest value returned is 0
// The largest value returned is 9
```

NB: When `max` is 0, the result is always 0.

```
random(min,max);
```

Parameters:

- `min` - the lower limit (inclusive) of the random number to retrieve.
- `max` - the upper limit (exclusive) of the random number to retrieve.

Returns: a random value from `min` and up to, but not including `max`.

```
int r = random(10, 100);
// r is >= 10 and < 100
// The smallest value returned is 10
// The largest value returned is 99
```

NB: If `min` is greater or equal to `max`, the result is always 0.

randomSeed()

```
randomSeed(newSeed);
```

Parameters:

- `newSeed` - the new random seed

The pseudorandom numbers produced by the firmware are derived from a single value - the random seed. The value of this seed fully determines the sequence of random numbers produced by successive calls to `random()`. Using the same seed on two separate runs will produce the same sequence of random numbers, and in contrast, using different seeds will produce a different sequence of random numbers.

On startup, the default random seed is set by the system to 1. Unless the seed is modified, the same sequence of random numbers would be produced each time the system starts.

Fortunately, when the device connects to the cloud, it receives a very randomized seed value, which is used as the random seed. So you can be sure the random numbers produced will be different each time your program is run.

Disable random seed from the cloud

When the device receives a new random seed from the cloud, it's passed to this function:

```
void random_seed_from_cloud(unsigned int seed);
```

The system implementation of this function calls `randomSeed()` to set the new seed value. If you don't wish to use random seed values from the cloud, you can take control of the random seeds set by adding this code to your app:

```
void random_seed_from_cloud(unsigned int seed) {
   // don't do anything with this. Continue with existing seed.
}
```

In the example, the seed is simply ignored, so the system will continue using whatever seed was previously set. In this case, the random seed will not be set from the cloud, and setting the seed is left to up you.

Macros

STARTUP()

Since 0.4.5:

Typically an application will have its initialization code in the `setup()` function. This works well if a delay of a few seconds from power on/reset is acceptable.

In other cases, the application wants to have code run as early as possible, before the cloud or network connection are initialized. The `STARTUP()` function instructs the system to execute the code early on in startup.

```
void setup_the_fundulating_conbobulator()
{
   pinMode(D3, OUTPUT);
   digitalWrite(D3, HIGH);
```

```
}

// The STARTUP call is placed outside of any other function
// What goes inside is any valid code that can be executed. Here, we use a
function call.
// Using a single function is preferable to having several `STARTUP()`
calls.
STARTUP( setup_the_fundulating_conbobulator() );
```

The code referenced by `STARTUP()` is executed very early in the startup sequence, so it's best suited to initializing digital I/O and peripherals. Networking setup code should still be placed in `setup()`.

Note that when startup code performs digital I/O, there will still be a period of at least few hundred milliseconds where the I/O pins are in their default power-on state, namely `INPUT`. Circuits should be designed with this in mind, using pullup/pulldown resistors as appropriate.

PRODUCT_ID()

When preparing software for your product, it is essential to include your product ID and version at the top of the firmware source code.

```
// EXAMPLE
PRODUCT_ID(94); // replace by your product ID
PRODUCT_VERSION(1); // increment each time you upload to the console
```

You can find more details about the product ID and how to get yours in the *Console* guide.

System Events

Since 0.4.9:

System Events Overview

System events are messages sent by the system and received by application code. They inform the application about changes in the system, such as when the system has entered setup mode (listening mode, blinking dark blue), or when an Over-the-Air (OTA) update starts, or when the system is about to reset.

System events are received by the application by registering a handler. The handler has this general format:

```
void handler(system_event_t event, int data, void* moredata);
```

Unused parameters can be removed from right to left, giving these additional function signatures:

```
void handler(system_event_t event, int data);
void handler(system_event_t event);
void handler();
```

Here's an example of an application that listens for `reset` events so that the application is notified the device is about to reset. The application publishes a reset message to the cloud and turns off connected equipment before returning from the handler, allowing the device to reset.

```
void reset_handler()
{
    // turn off the crankenspitzen
    digitalWrite(D6, LOW);
    // tell the world what we are doing
    Particle.publish("reset", "going down for reboot NOW!");
}

void setup()
{
    // register the reset handler
    System.on(reset, reset_handler);
}
```

Some event types provide additional information. For example the `button_click` event provides a parameter with the number of button clicks:

```
void button_clicked(system_event_t event, int param)
{
    int times = system_button_clicks(param);
    Serial.printlnf("button was clicked %d times", times);
}
```

Registering multiple events with the same handler

It's possible to subscribe to multiple events with the same handler in cases where you want the same handler to be notified for all the events. For example:

```
void handle_all_the_events(system_event_t event, int param)
{
    Serial.printlnf("got event %d with value %d", event, param);
}

void setup()
{
    // listen for Wi-Fi Listen events and Firmware Update events
    System.on(wifi_listen+firmware_update, handle_all_the_events);
}
```

To subscribe to all events, there is the placeholder `all_events`:

```
void setup()
{
    // listen for network events and firmware update events
    System.on(all_events, handle_all_the_events);
}
```

System Events Reference

These are the system events produced by the system, their numeric value (what you will see when printing the system event to Serial) and details of how to handle the parameter value. The version of firmware these events became available is noted in the first column below.

Setup mode is also referred to as listening mode (blinking dark blue).

Since	Event Name	ID	Description	Parameter
	setup_begin	2	signals the device has entered setup mode	not used
	setup_update	4	periodic event signaling the device is still in setup mode.	milliseconds since setup mode was started
	setup_end	8	signals setup mode was exited	time in ms since setup mode was started
	network_credentials	16	network credentials were changed	`network_credentials_added` or `network_credentials_cleared`
0.6.1	network_status	32	network connection status	one of `network_status_powering_on`, `network_status_on`, `network_status_powering_off`, `network_status_off`, `network_status_connecting`, `network_status_connected`
0.6.1	cloud_status	64	cloud connection status	one of `cloud_status_connecting`, `cloud_status_connected`, `cloud_status_disconnecting`, `cloud_status_disconnected`
	button_status	128	button pressed or released	the duration in ms the button was pressed: 0 when pressed, >0 on release.
	firmware_update	256	firmware update status	one of `firmware_update_begin`, `firmware_update_progress`, `firmware_update_complete`, `firmware_update_failed`
	firmware_update_pending	512	notifies the application that a firmware update is available. This event is sent even when updates are disabled, giving the application chance to re-enable firmware updates with `System.enableUpdates()`	not used
	reset_pending	1024	notifies the application that the system would like to reset. This event is sent even when resets are disabled, giving the application chance to re-enable resets with `System.enableReset()`	not used
	reset	2048	notifies that the system will reset once the application has completed handling this event	not used

Since	Event Name	ID	Description	Parameter
	button_click	4096	event sent each time SETUP/MODE button is clicked.	`int clicks = system_button_clicks(param);` retrieves the number of clicks so far.
	button_final_click	8192	sent after a run of one or more clicks not followed by additional clicks. Unlike the `button_click` event, the `button_final_click` event is sent once, at the end of a series of clicks.	`int clicks = system_button_clicks(param);` retrieves the number of times the button was pushed.
0.6.1	time_changed	16384	device time changed	`time_changed_manually` or `time_changed_sync`
0.6.1	low_battery	32768	generated when low battery condition is detected.	not used
0.8.0	out_of_memory	1<<18	event generated when a request for memory could not be satisfied	the amount in bytes of memory that could not be allocated

System Modes

System modes help you control how the device manages the connection with the cloud.

By default, the device connects to the Cloud and processes messages automatically. However there are many cases where a user will want to take control over that connection. There are three available system modes: `AUTOMATIC`, `SEMI_AUTOMATIC`, and `MANUAL`. These modes describe how connectivity is handled. These system modes describe how connectivity is handled and when user code is run.

System modes must be called before the setup() function. By default, the device is always in `AUTOMATIC` mode.

Automatic mode

The automatic mode of connectivity provides the default behavior of the device, which is that:

```
SYSTEM_MODE(AUTOMATIC);

void setup() {
  // This won't be called until the device is connected to the cloud
}

void loop() {
```

```
  // Neither will this
}
```

- When the device starts up, it automatically tries to connect to Wi-Fi and the Particle Device Cloud.
- Once a connection with the Particle Device Cloud has been established, the user code starts running.
- Messages to and from the Cloud are handled in between runs of the user loop; the user loop automatically alternates with `Particle.process()`.
- `Particle.process()` is also called during any delay() of at least 1 second.
- If the user loop blocks for more than about 20 seconds, the connection to the Cloud will be lost. To prevent this from happening, the user can call `Particle.process()` manually.
- If the connection to the Cloud is ever lost, the device will automatically attempt to reconnect. This re-connection will block from a few milliseconds up to 8 seconds.
- `SYSTEM_MODE(AUTOMATIC)` does not need to be called, because it is the default state; however the user can invoke this method to make the mode explicit.

In automatic mode, the user can still call `Particle.disconnect()` to disconnect from the Cloud, but is then responsible for re-connecting to the Cloud by calling `Particle.connect()`.

Semi-automatic mode

The semi-automatic mode will not attempt to connect the device to the Cloud automatically. However once the device is connected to the Cloud (through some user intervention), messages will be processed automatically, as in the automatic mode above.

```
SYSTEM_MODE(SEMI_AUTOMATIC);

void setup() {
  // This is called immediately
}

void loop() {
  if (buttonIsPressed()) {
    Particle.connect();
```

```
  } else {
    doOfflineStuff();
  }
}
```

The semi-automatic mode is therefore much like the automatic mode, except:

- When the device boots up, `setup()` and `loop()` will begin running immediately.
- Once the user calls `Particle.connect()`, the user code will be blocked while the device attempts to negotiate a connection. This connection will block execution of `loop()` or `setup()` until either the device connects to the Cloud or an interrupt is fired that calls `Particle.disconnect()`.

Manual mode

The "manual" mode puts the device's connectivity completely in the user's control. This means that the user is responsible for both establishing a connection to the Particle Device Cloud and handling communications with the Cloud by calling `Particle.process()` on a regular basis.

```
SYSTEM_MODE(MANUAL);

void setup() {
  // This will run automatically
}

void loop() {
  if (buttonIsPressed()) {
    Particle.connect();
  }
  if (Particle.connected()) {
    Particle.process();
    doOtherStuff();
  }
}
```

When using manual mode:

- The user code will run immediately when the device is powered on.
- Once the user calls `Particle.connect()`, the device will attempt to begin the connection process.
- Once the device is connected to the Cloud (`Particle.connected() == true`), the user must call `Particle.process()` regularly to handle incoming messages and keep the connection alive. The more frequently `Particle.process()` is called, the more responsive the device will be to incoming messages.
- If `Particle.process()` is called less frequently than every 20 seconds, the connection with the Cloud will die. It may take a couple of additional calls of `Particle.process()` for the device to recognize that the connection has been lost.

System Calls

version()

Since 0.4.7:

Determine the version of Device OS available. Returns a version string of the format:

MAJOR.MINOR.PATCH

Such as "0.4.7".

For example

```
void setup()
{
   Serial.printlnf("System version: %s", System.version().c_str());
   // prints
   // System version: 0.4.7
}
```

versionNumber()

Determines the version of Device OS available. Returns the version encoded as a number:

0xAABBCCDD

- `AA` is the major release
- `BB` is the minor release
- `CC` is the patch number
- `DD` is 0

Firmware 0.4.7 has a version number 0x00040700

buttonPushed()

Since 0.4.6:

Can be used to determine how long the System button (MODE on Core/Electron, SETUP on Photon) has been pushed.

Returns `uint16_t` as duration button has been held down in milliseconds.

```
// EXAMPLE USAGE
void button_handler(system_event_t event, int duration, void* )
{
    if (!duration) { // just pressed
        RGB.control(true);
        RGB.color(255, 0, 255); // MAGENTA
    }
    else { // just released
        RGB.control(false);
    }
}

void setup()
{
    System.on(button_status, button_handler);
}

void loop()
{
    // it would be nice to fire routine events while
    // the button is being pushed, rather than rely upon loop
    if (System.buttonPushed() > 1000) {
        RGB.color(255, 255, 0); // YELLOW
```

```
    }
}
```

System Cycle Counter

Since 0.4.6:

The system cycle counter is incremented for each instruction executed. It functions in normal code and during interrupts. Since it operates at the clock frequency of the device, it can be used for accurately measuring small periods of time.

```
// overview of System tick functions
uint32_t now = System.ticks();

// for converting an the unknown system tick frequency into microseconds
uint32_t scale = System.ticksPerMicrosecond();

// delay a given number of ticks.
System.ticksDelay(10);
```

The system ticks are intended for measuring times from less than a microsecond up to a second. For longer time periods, using micros() or millis() would be more suitable.

ticks()

Returns the current value of the system tick count. One tick corresponds to one cpu cycle.

```
// measure a precise time whens something start
uint32_t ticks = System.ticks();
```

ticksPerMicrosecond();

Retrieves the number of ticks per microsecond for this device. This is useful when converting between a number of ticks and time in microseconds.

```
    uint32_t start = System.ticks();
    startTheFrobnicator();
    uint32_t end = System.ticks();
    uint32_t duration = (end-start)/System.ticksPerMicrosecond();

    Serial.printlnf("The frobnicator took %d microseconds to start",
duration);
```

ticksDelay()

Pause execution a given number of ticks. This can be used to implement precise delays.

```
    // delay 10 ticks. How long this is actually depends upon the clock
speed of the
    // device.
    System.ticksDelay(10);

    // to delay for 3 microseconds on any device:
    System.ticksDelay(3*System.ticksPerMicrosecond());
```

The system code has been written such that the compiler can compute the number of ticks to delay at compile time and inline the function calls, reducing overhead to a minimum.

freeMemory()

Since 0.4.4:

Retrieves the amount of free memory in the system in bytes.

```
uint32_t freemem = System.freeMemory();
Serial.print("free memory: ");
Serial.println(freemem);
```

dfu()

The device will enter DFU-mode to allow new user firmware to be refreshed. DFU mode is cancelled by

- flashing firmware to the device using dfu-util, specifying the `:leave` option, or
- a system reset

```
System.dfu()
```

To make DFU mode permanent - so that it continues to enter DFU mode even after a reset until new firmware is flashed, pass `true` to the `dfu()` function.

```
System.dfu(true);   // persistent DFU mode - will enter DFU after a reset
until firmware is flashed.
```

deviceID()

`System.deviceID()` provides an easy way to extract the device ID of your device. It returns a String object of the device ID, which is used to identify your device.

```
// EXAMPLE USAGE

void setup()
{
  // Make sure your Serial Terminal app is closed before powering your
device
  Serial.begin(9600);
  // Wait for a USB serial connection for up to 30 seconds
  waitFor(Serial.isConnected, 30000);

  String myID = System.deviceID();
  // Prints out the device ID over Serial
  Serial.println(myID);
}
```

```
void loop() {}
```

enterSafeMode()

Since 0.4.6:

```
// SYNTAX
System.enterSafeMode();
```

Resets the device and restarts in safe mode.

SleepResult Class

Since 0.8.0:

This class allows to query the information about the latest `System.sleep()`.

reason()

```
// SYNTAX
SleepResult result = System.sleepResult();
int reason = result.reason();
```

Get the wake up reason.

```
// EXAMPLE
SleepResult result = System.sleepResult();
switch (result.reason()) {
  case WAKEUP_REASON_NONE: {
    Log.info("Raspberry Pi did not wake up from sleep");
    break;
  }
  case WAKEUP_REASON_PIN: {
```

```
    Log.info("Raspberry Pi was woken up by a pin");
    break;
  }
  case WAKEUP_REASON_RTC: {
    Log.info("Raspberry Pi was woken up by the RTC (after a specified number
of seconds)");
    break;
  }
  case WAKEUP_REASON_PIN_OR_RTC: {
    Log.info("Raspberry Pi was woken up by either a pin or the RTC (after a
specified number of seconds)");
    break;
  }
}
```

Returns a code describing a reason Raspberry Pi woke up from sleep. The following reasons are defined:

- `WAKEUP_REASON_NONE` : Raspberry Pi did not wake up from sleep
- `WAKEUP_REASON_PIN` : Raspberry Pi was woken up by an edge signal to a pin
- `WAKEUP_REASON_RTC` : Raspberry Pi was woken up by the RTC (after a specified number of seconds)
- `WAKEUP_REASON_PIN_OR_RTC` : Raspberry Pi was woken up either by an edge signal to a pin or by the RTC (after a specified number of seconds)

wokenUpByPin()

```
// SYNTAX
SleepResult result = System.sleepResult();
bool r = result.wokenUpByPin();

// EXAMPLE
SleepResult result = System.sleepResult();
if (result.wokenUpByPin()) {
  Log.info("Raspberry Pi was woken up by a pin");
}
```

Returns `true` when Raspberry Pi was woken up by a pin.

wokenUpByRtc()

Returns `true` when Raspberry Pi was woken up by the RTC (after a specified number of seconds).

```
// SYNTAX
SleepResult result = System.sleepResult();
bool r = result.wokenUpByRtc();

// EXAMPLE
SleepResult result = System.sleepResult();
if (result.wokenUpByRtc()) {
  Log.info("Raspberry Pi was woken up by the RTC (after a specified number
of seconds)");
}
```

rtc()

An alias to `wokenUpByRtc()`.

pin()

```
// SYNTAX
SleepResult result = System.sleepResult();
pin_t pin = result.pin();

// EXAMPLE
SleepResult result = System.sleepResult();
pin_t pin = result.pin();
if (result.wokenUpByPin()) {
  Log.info("Raspberry Pi was woken up by the pin number %d", pin);
}
```

Returns: the number of the pin that woke the device.

error()

Get the error code of the latest sleep.

```
// SYNTAX
SleepResult result = System.sleepResult();
int err = result.error();
```

Returns: `SYSTEM_ERROR_NONE (0)` when there was no error during latest sleep or a non-zero error code.

sleepResult()

Since 0.8.0:

```
// SYNTAX
SleepResult result = System.sleepResult();
```

Retrieves the information about the latest sleep.

Returns: an instance of `SleepResult` class.

wakeUpReason()

Since 0.8.0:

```
// SYNTAX
int reason = System.wakeUpReason();
```

See `SleepResult` documentation.

wokenUpByPin()

Since 0.8.0:

```
// SYNTAX
bool result = System.wokenUpByPin();
```

See `SleepResult` documentation.

wokenUpByRtc()

Since 0.8.0

```
// SYNTAX
bool result = System.wokenUpByRtc();
```

See `SleepResult` documentation.

wakeUpPin()

Since 0.8.0:

```
// SYNTAX
pin_t pin = System.wakeUpPin();
```

See `SleepResult` documentation.

sleepError()

Since 0.8.0:

```
// SYNTAX
int err = System.sleepError();
```

See `SleepResult` documentation.

reset()

Resets the device, just like hitting the reset button or powering down and back up.

```
uint32_t lastReset = 0;

void setup() {
    lastReset = millis();
}

void loop() {
  // Reset after 5 minutes of operation
  // ==================================
  if (millis() - lastReset > 5*60000UL) {
    System.reset();
  }
}
```

disableReset()

This method allows to disable automatic resetting of the device on such events as successful firmware update.

```
// EXAMPLE
void on_reset_pending() {
    // Enable resetting of the device. The system will reset after this
method is called
    System.enableReset();
}

void setup() {
    // Register the event handler
    System.on(reset_pending, on_reset_pending);
    // Disable resetting of the device
    System.disableReset();

}
```

```
void loop() {
}
```

When the system needs to reset the device it first sends the `reset_pending` event to the application, and, if automatic resetting is disabled, waits until the application has called `enableReset()` to finally perform the reset. This allows the application to perform any necessary cleanup before resetting the device.

enableReset()

Allows the system to reset the device when necessary.

resetPending()

Returns `true` if the system needs to reset the device.

Reset Reason

Since 0.6.0:

The system can track the hardware and software resets of the device.

```
// EXAMPLE
// Restart in safe mode if the device previously reset due to a PANIC (SOS code)
STARTUP(System.enableFeature(FEATURE_RESET_INFO));

void setup() {
   if (System.resetReason() == RESET_REASON_PANIC) {
       System.enterSafeMode();
   }
}
```

You can also pass in your own data as part of an application-initiated reset:

```
// EXAMPLE
STARTUP(System.enableFeature(FEATURE_RESET_INFO));

void setup() {
    // Reset the device 3 times in a row
    if (System.resetReason() == RESET_REASON_USER) {
        uint32_t data = System.resetReasonData();
        if (data < 3) {
            System.reset(data + 1);
        }
    } else {
        // This will set the reset reason to RESET_REASON_USER
        System.reset(1);
    }
}
```

Note: This functionality requires `FEATURE_RESET_INFO` flag to be enabled in order to work.

`resetReason()`

Returns a code describing reason of the last device reset. The following codes are defined:

- `RESET_REASON_PIN_RESET` : Reset button or reset pin
- `RESET_REASON_POWER_MANAGEMENT` : Low-power management reset
- `RESET_REASON_POWER_DOWN` : Power-down reset
- `RESET_REASON_POWER_BROWNOUT` : Brownout reset
- `RESET_REASON_WATCHDOG` : Hardware watchdog reset
- `RESET_REASON_UPDATE` : Successful firmware update
- `RESET_REASON_UPDATE_TIMEOUT` : Firmware update timeout
- `RESET_REASON_FACTORY_RESET` : Factory reset requested
- `RESET_REASON_SAFE_MODE` : Safe mode requested
- `RESET_REASON_DFU_MODE` : DFU mode requested
- `RESET_REASON_PANIC` : System panic
- `RESET_REASON_USER` : User-requested reset
- `RESET_REASON_UNKNOWN` : Unspecified reset reason
- `RESET_REASON_NONE` : Information is not available

`resetReasonData()`

Returns a user-defined value that has been previously specified for the `System.reset()` call.

`reset(uint32_t data)`

This overloaded method accepts an arbitrary 32-bit value, stores it to the backup register and resets the device. The value can be retrieved via `resetReasonData()` method after the device has restarted.

System Config [set]

System configuration can be modified with the `System.set()` call.

```
// SYNTAX
System.set(SYSTEM_CONFIG_..., "value");
System.set(SYSTEM_CONFIG_..., buffer, length);
```

The following configuration values can be changed:

- `SYSTEM_CONFIG_DEVICE_KEY` : the device private key. Max length of `DCT_DEVICE_PRIVATE_KEY_SIZE` (1216).
- `SYSTEM_CONFIG_SERVER_KEY` : the server public key. Max length of `SYSTEM_CONFIG_SERVER_KEY` (768).

System Flags [disable]

The system allows to alter certain aspects of its default behavior via the system flags. The following system flags are defined:

- `SYSTEM_FLAG_PUBLISH_RESET_INFO` : enables publishing of the last reset reason to the cloud (enabled by default)
- `SYSTEM_FLAG_RESET_NETWORK_ON_CLOUD_ERRORS` : enables resetting of the network connection on cloud connection errors (enabled by default)

```
// EXAMPLE
// Do not publish last reset reason
System.disable(SYSTEM_FLAG_PUBLISH_RESET_INFO);

// Do not reset network connection on cloud errors
System.disable(SYSTEM_FLAG_RESET_NETWORK_ON_CLOUD_ERRORS);
```

`System.enable(system_flag_t flag)`

Enables the system flag.

`System.disable(system_flag_t flag)`

Disables the system flag.

`System.enabled(system_flag_t flag)`

Returns `true` if the system flag is enabled.

System Uptime

Since 0.8.0

System.millis()

Returns the number of milliseconds passed since the device was last reset. This function is similar to the global `millis()` function but returns a 64-bit value.

System.uptime()

Returns the number of seconds passed since the device was last reset.

Process Control

You can call scripts and run other programs from the firmware. In Linux, a running program is called a process.

This interface is in beta. It might change in non-backwards compatible ways.

run()

Start running another program in the background. It returns a `Process` object so you can interact with the program while it running and after it has exited.

The `command` argument should start with the name of a program or script (with or without path) and can contain other arguments separated by spaces.

The command is executed through the shell: `/bin/sh -c <command>`

```
// SYNTAX
Process proc = Process::run(command)

// EXAMPLE USAGE
// Simple script and block it is finished
Process proc = Process::run("/home/pi/script.sh");
proc.wait();

// Take a picture with a Pi camera
Process proc = Process::run("raspistill -o /home/pi/photo.jpg");
proc.wait();
```

It's important to call `wait()` to block the firmware until the program finishes running or call `exited()` until it returns true. Otherwise when the program completes the operating system will keep information about the process in memory forever, eventually making it impossible to start any new process on the entire device.

wait()

Block the firmware until the program finishes. Returns immediately if the process has already finished.

Returns the exit code of the process.

```
// SYNTAX
process.wait();
```

```
// EXAMPLE USAGE
// Run a Javascript program
Process proc = Process::run("node /home/pi/update.js");
proc.wait();
```

exited()

Returns true if the process has exited, false otherwise.

A "blank" Process that was never started returns true for `exited()`.

```
// SYNTAX
bool done = process.exited();

// EXAMPLE USAGE
// Blink an LED during a long operation
Process proc = Process::run("updatedb");
pinMode(D7, OUTPUT);
while (!proc.exited()) {
  digitalWrite(D7, HIGH);
  delay(100);
  digitalWrite(D7, LOW);
  delay(100);
}

// Restart a server when it crashes
Process proc;

void loop() {
  if (proc.exited()) {
    proc = Process::run("node /home/pi/server.js");
  }
}
```

kill()

Stop the process by sending a signal. Defaults to the `SIGTERM` signal which asks the program to quit. To force-quit an unresponsive process, use `SIGKILL`.

```
// SYNTAX
process.kill();
process.kill(signal);

// EXAMPLE USAGE
// Stop a long operation early
Process proc = Process::run("sleep 10");
proc.kill();
proc.wait();
```

`signal` is either a signal number or name. Here are the most useful signals.

Signal Name	Signal Number	Description
SIGINT	2	Interrupt from keyboard (Ctrl-C)
SIGABRT	6	Abort. Usually from uncaught C++ exception
SIGKILL	9	Force quit
SIGSEGV	11	Bad memory operation (null pointer, bad pointer)
SIGTERM	15	Graceful quit

It's important to still call `wait()` or `exited()` after `kill()` to ensure the process information is recycled by the operating system.

exitCode()

If the process has exited, returns the integer exit code.

```
// SYNTAX
uint8_t code = proccess.exitCode();

// EXAMPLE USAGE
// Did the program finish sucessfully?
Process proc = Process::run("/home/pi/script.sh");
proc.wait();
if (proc.exitCode() == 0) {
  Serial.println("Success!");
}

// Did the program crash?
Process proc = Process::run("my_program");
```

```
proc.wait();
uint8_t code = proc.exitCode();
if (code >= 128) {
  Serial.printlnf("my_program crashed with signal %d", code - 128);
}
```

An exit code of 0 means success. The meaning of non-zero error codes are specific to each program.

If a process exits because of a signal, for example it crashed with a bad pointer, the exit code will be 128 plus the signal value. See the table above for the signal values.

out()

err()

The output generated by a program is available through the `out()` and `err()` Stream for standard output and standard error.

```
// SYNTAX
process.out();
process.err();

// EXAMPLE USAGE
// Get entire output of program
Process proc = Process::run("ls /home/pi");
proc.wait();
String filenames = proc.out().readString();

// Get CPU temperature
Process proc = Process::run("vcgencmd measure_temp");
proc.wait();
// The output is temp=43.5'C, so read past the = and parse the number
proc.out().find("=");
float cpuTemp = proc.out().parseFloat();
```

All the Stream functions are available like `readStringUntil('\n')` to read a line or `parseInt()` to turn the output into an integer.

in()

To provide input to the program, print to `in()`.

```
// SYNTAX
process.in();

// EXAMPLE USAGE
// Run a calculation using the bc, a calculator program
Process proc = Process::run("bc");
proc.in().println("6 * 7");
proc.in().close(); // <-- THIS IS IMPORTANT
proc.wait();
int result = proc.out().parseInt(); // 42
```

The same functions used to print to `Serial` like `println` and `printf` are available.

Note: It is very important to close `in()` so the process knows that no further input is coming. If you don't do this, the process will hang forever waiting for more input.

Advanced Process Control

Linux process control is a deep topic on its own. If the methods in `Process` don't work for what you're trying to accomplish, you can also use any Linux process control functions like `system`, `fork` and `execve` method directly in your firmware. See the note about the standard library on the Raspberry Pi.

```
// Run a command using the Linux system() function instead of Process
// The output won't be available
system("my_command");
```

OTA Updates

This section describes the Device OS APIs that control firmware updates for Particle devices.

Many of the behaviors described below require Device OS version 1.2.0 or higher.

Controlling OTA Availability

This feature allows the application developer to control when the device is available for firmware updates. This affects both over-the-air (OTA) and over-the-wire (OTW) updates. OTA availability also affects both *single device OTA updates* (flashing a single device) and *fleet-wide OTA updates* (deploying a firmware update to many devices in a Product).

Firmware updates are enabled by default when the device starts up after a deep sleep or system reset. Applications may choose to disable firmware updates during critical periods by calling the `System.disableUpdates()` function and then enabling them again with `System.enableUpdates()`.

When the firmware update is the result of an Intelligent Firmware Release, the update is delivered immediately after `System.enableUpdates()` is called.

Standard Firmware Releases are delivered the next time the device connects to the cloud or when the current session expires or is revoked.

Note: Calling `System.disableUpdates()` and `System.enableUpdates()` for devices running Device OS version 1.2.0 or later will result in a message sent to the Device Cloud. This will result in a small amount of additional data usage each time they are called.

System.disableUpdates()

```
// System.disableUpdates() example where updates are disabled
// when the device is busy.

int unlockScooter(String arg) {
  // scooter is busy, so disable updates
  System.disableUpdates();
  // ... do the unlock step
  // ...
  return 0;
}

int parkScooter(String arg) {
```

```
  // scooter is no longer busy, so enable updates
  System.enableUpdates();
  // ... do the park step
  // ...
  return 0;
}

void setup() {
  Particle.function("unlockScooter", unlockScooter);
  Particle.function("parkScooter", parkScooter);
}
```

Disables OTA updates on this device. An attempt to begin an OTA update from the cloud will be prevented by the device. When updates are disabled, firmware updates are not delivered to the device unless forced.

Since 1.2.0

Device OS version 1.2.0 introduced enhanced support of `System.disableUpdates()` and `System.enableUpdates()`. When running Device OS version 1.2.0 or higher, the device will notify the Device Cloud of its OTA availability, which is visible in the Console as well as queryable via the REST API. The cloud will use this information to deliver Intelligent Firmware Releases.

In addition, a cloud-side system event will be emitted when updates are disabled, `particle/device/updates/enabled` with a data value of `false`. This event is sent only if updates were not already disabled.

Version	Self service customers	Standard Product	Enterprise Product
Device OS < 1.2.0	Limited Support	Limited Support	Limited Support
Device OS >= 1.2.0	Full support	Full Support	Full Support

Enterprise Feature

When updates are disabled, an attempt to send a firmware update to a device that has called `System.disableUpdates()` will result in the `System.updatesPending()` function returning `true`.

System.enableUpdates()

```
// System.enableUpdates() example where updates are disabled on startup

SYSTEM_MODE(SEMI_AUTOMATIC);

void setup() {
  System.disableUpdates();  // updates are disabled most of the time

  Particle.connect();       // now connect to the cloud
}

bool isSafeToUpdate() {
  // determine if the device is in a good state to receive updates.
  // In a real application, this function would inspect the device state
  // to determine if it is busy or not.
  return true;
}

void loop() {
  if (isSafeToUpdate()) {
    // Calling System.enableUpdates() when updates are already enabled
    // is safe, and doesn't use any data.
    System.enableUpdates();
  }
  else {
    // Calling System.disableUpdates() when updates are already disabled
    // is safe, and doesn't use any data.
    System.disableUpdates();
  }
}
```

Enables firmware updates on this device. Updates are enabled by default when the device starts.

Calling this function marks the device as available for updates. When updates are enabled, updates triggered from the Device Cloud are delivered to the device.

In addition, a cloud-side system event will be emitted when updates are enabled, `particle/device/updates/enabled` with a data value of `true`. This event is sent only if updates were not already enabled.

Since 1.2.0

Device OS version 1.2.0 introduced enhanced support of `System.disableUpdates()` and `System.enableUpdates()`. If running 1.2.0 or higher, the device will notify the Device Cloud of its OTA update availability, which is visible in the Console as well as queryable via the REST API. The cloud will use this information to deliver Intelligent Firmware Releases.

Version	Self service customers	Standard Product	Enterprise Product
Device OS < 1.2.0	Limited Support	Limited Support	Limited Support
Device OS >= 1.2.0	Full support	Full Support	Full Support

System.updatesEnabled()

```
// System.updatesEnabled() example
bool isSafeToUpdate() {
  return true;
}

void loop() {
  if (!isSafeToUpdate() && System.updatesEnabled()) {
      Particle.publish("error", "Updates are enabled but the device is not
safe to update.");
  }
}
```

Determine if firmware updates are presently enabled or disabled for this device.

Returns `true` on startup, and after `System.enableUpdates()` has been called. Returns `false` after `System.disableUpdates()` has been called.

Version	Self service customers	Standard Product	Enterprise Product
Device OS < 1.2.0	Supported	Supported	Supported
Device OS >= 1.2.0	Supported	Supported	Supported

System.updatesPending()

```
// System.updatesPending() example

SYSETM_MODE(SEMI_AUTOMATIC);
```

```
void setup() {
  // When disabling updates by default, you must use either system
  // thread enabled or system mode SEMI_AUTOMATIC or MANUAL
  System.disableUpdates();

  // After setting the disable updates flag, it's safe to connect to
  // the cloud.
  Particle.connect();
}

bool isSafeToUpdate() {
  // ...
  return true;
}

void loop() {
  // NB: System.updatesPending() should only be used in a Product on the
Enterprise Plan
  if (isSafeToUpdate() && System.updatesPending()) {
        System.enableUpdates();

        // Wait 2 minutes for the update to complete and the device
        // to restart. If the device doesn't automatically reset, manually
        // reset just in case.
        unsigned long start = millis();
        while (millis() - start < (120 * 1000)) {
            Particle.process();
        }
        // You normally won't reach this point as the device will
        // restart automatically to apply the update.
        System.reset();
    }
    else {
      // ... do some critical activity that shouldn't be interrupted
    }
}
```

Enterprise Feature, Since 1.2.0

`System.updatesPending()` indicates if there is a firmware update pending that was not delivered to the device while updates were disabled. When an update is pending, the

`firmware_update_pending` system event is emitted and the `System.updatesPending()` function returns `true`.

When new product firmware is released with the `intelligent` option enabled, the firmware is delivered immediately after release for devices that have firmware updates are enabled.

For devices with updates disabled, firmware updates are deferred by the device. The device is notified of the pending update at the time of deferral. The system event `firmware_update_pending` is emmitted and the `System.updatesPending()` function returns `true`. The update is delivered when the application later re-enables updates by calling `System.enableUpdates()`, or when updates are force enabled from the cloud, or when the device is restarted.

In addition, a cloud-side system event will be emitted when a pending OTA update is queued, `particle/device/updates/pending` with a data value of `true`.

Version	Self service customers	Standard Product	Enterprise Product
Device OS < 1.2.0	N/A	N/A	N/A
Device OS >= 1.2.0	N/A	N/A	Supported

System.updatesForced()

```
// System.updatesForced() example
void loop() {
  if (System.updatesForced()) {
    // don't perform critical functions while updates are forced
  }
  else {
    // perform critical functions
  }
}
```

Since 1.2.0

When the device is not available for updates, the pending firmware update is not normally delivered to the device. Updates can be forced in the cloud either via the Console or the REST API to override the local setting on the device. This means that firmware updates are delivered even when `System.disableUpdates()` has been called by the device application.

When updates are forced in the cloud, the `System.updatesForced()` function returns `true`.

In addition, a cloud-side system event will be emitted when OTA updates are force enabled from the cloud, `particle/device/updates/forced` with a data value of `true`.

Updates may be forced for a particular device. When this happens, updates are delivered even when `System.disableUpdates()` has been called.

When updates are forced in the cloud, this function returns `true`.

Forced updates may be used with Product firmware releases or single device OTA updates.

Version	Self service customers	Standard Product	Enterprise Product
Device OS < 1.2.0	N/A	N/A	N/A
Device OS >= 1.2.0	Supported	Supported	Supported

Checking for Features

User firmware is designed to run transparently regardless of what type of device it is run on. However, sometimes you will need to have code that varies depending on the capabilities of the device.

It's always best to check for a capability, rather than a specific device. For example, checking for cellular instead of checking for the Electron allows the code to work properly on the Boron without modification.

Some commonly used features include:

- Wiring_Cellular
- Wiring_Ethernet
- Wiring_IPv6
- Wiring_Keyboard
- Wiring_Mesh
- Wiring_Mouse
- Wiring_Serial2
- Wiring_Serial3
- Wiring_Serial4
- Wiring_Serial5

- Wiring_SPI1
- Wiring_SPI2
- Wiring_USBSerial1
- Wiring_WiFi
- Wiring_Wire1
- Wiring_Wire3
- Wiring_WpaEnterprise

For example, you might have code like this to declare two different methods, depending on your network type:

```
#if Wiring_WiFi
    const char *wifiScan();
#endif

#if Wiring_Cellular
    const char *cellularScan();
#endif
```

The official list can be found in the source.

Checking Device OS Version

The define value `SYSTEM_VERSION` specifies the system version.

For example, if you had code that you only wanted to include in 0.7.0 and later, you'd check for:

```
#if SYSTEM_VERSION >= SYSTEM_VERSION_v070
// Code to include only for 0.7.0 and later
#endif
```

Checking Platform ID

It's always best to check for features, but it is possible to check for a specific platform:

```
#if PLATFORM_ID == PLATFORM_BORON
// Boron-specific code goes here
#endif
```

You can find a complete list of platforms in the source.

Arduino Compatibility

All versions of Particle firmware to date have supported parts of the Arduino API, such as `digitalRead`, `Serial` and `String`.

From 0.6.2 onwards, the firmware API will continue to provide increasing levels of support for new Arduino APIs to make porting applications and libraries as straightforward as possible.

However, to prevent breaking existing applications and libraries, these new Arduino APIs have to be specifically enabled in order to be available for use in your application or library.

Arduino APIs that need to be enabled explicitly are marked with "requires Arduino.h" in this reference documentation.

Enabling Extended Arduino SDK Compatibility

The extended Arduino APIs that are added from 0.6.2 onwards are not immediately available but have to be enabled by declaring Arduino support in your app or library.

This is done by adding `#include "Arduino.h"` to each source file that requires an extended Arduino API.

Arduino APIs added by Firmware Version

Once `Arduino.h` has been added to a source file, additional Arduino APIs are made available. The APIs added are determined by the targeted firmware version. In addition to defining the new APIs, the `ARDUINO` symbol is set to a value that describes the supported SDK version. (e.g. 10800 for 1.8.0)

The table below lists the Arduino APIs added for each firmware version and the value of the `ARDUINO` symbol.

API name	description	ARDUINO version	Particle version
SPISettings		10800	0.6.2
__FastStringHelper		10800	0.6.2
Wire.setClock	synonym for `Wire.setSpeed`	10800	0.6.2
SPI.usingInterrupt	NB: this function is included to allow libraries to compile, but is implemented as a empty function.	10800	0.6.2
LED_BUILTIN	defines the pin that corresponds to the built-in LED	10800	0.6.2

Adding Arduino Symbols to Applications and Libraries

The Arduino SDK has a release cycle that is independent from Particle firmware. When a new Arduino SDK is released, the new APIs introduced will not be available in the Particle firmware until the next Particle firmware release at the earliest.

However, this does not have to stop applications and library authors from using these new Arduino APIs. In some cases, it's possible to duplicate the sources in your application or library. However, it is necessary to be sure these APIs defined in your code are only conditionally included, based on the version of the Arduino SDK provided by Particle firmware used to compile the library or application.

For example, let's say that in Arduino SDK 1.9.5, a new function was added, `engageHyperdrive()`. You read the description and determine this is perfect for your application or library and that you want to use it.

In your application sources, or library headers you would add the definition like this:

```
// Example of adding an Arduino SDK API in a later Arduino SDK than
presently supported
#include "Arduino.h" // this declares that our app/library wants the
extended Arduino support

#if ARDUINO < 10905   // the API is added in SDK version 1.9.5 so we don't
re-define it when the SDK already has it
// now to define the new API
bool engageHyperdrive() {
   return false;  // womp womp
}
#endif
```

In your source code, you use the function normally. When compiling against a version of firmware that supports an older Arduino SDK, then your own version of the API will be used. Later, when `engageHyperdrive()` is added to Particle firmware, our version will be used. This happens when the `ARDUINO` version is the same or greater than the the corresponding version of the Arduino SDK, which indicates the API is provided by Particle firmware.

By using this technique, you can use new APIs and functions right away, while also allowing them to be later defined in the Arduino support provided by Particle, and crucially, without clashes.

Note: for this to work, the version check has to be correct and must use the value that the Arduino SDK sets the `ARDUINO` symbol to when the new Arduino API is first introduced in the Arduino SDK.

String Class

The String class allows you to use and manipulate strings of text in more complex ways than character arrays do. You can concatenate Strings, append to them, search for and replace substrings, and more. It takes more memory than a simple character array, but it is also more useful.

For reference, character arrays are referred to as strings with a small s, and instances of the String class are referred to as Strings with a capital S. Note that constant strings, specified in "double quotes" are treated as char arrays, not instances of the String class.

String()

Constructs an instance of the String class. There are multiple versions that construct Strings from different data types (i.e. format them as sequences of characters), including:

- a constant string of characters, in double quotes (i.e. a char array)
- a single constant character, in single quotes
- another instance of the String object
- a constant integer or long integer
- a constant integer or long integer, using a specified base

- an integer or long integer variable
- an integer or long integer variable, using a specified base
- a float variable, showing a specific number of decimal places

```
// SYNTAX
String(val)
String(val, base)
```

```
// EXAMPLES

String stringOne = "Hello String";                    // using a constant
String
String stringOne =  String('a');                      // converting a
constant char into a String
String stringTwo =  String("This is a string");       // converting a
constant string into a String object
String stringOne =  String(stringTwo + " with more"); // concatenating two
strings
String stringOne =  String(13);                       // using a constant
integer
String stringOne =  String(analogRead(0), DEC);       // using an int and a
base
String stringOne =  String(45, HEX);                  // using an int and a
base (hexadecimal)
String stringOne =  String(255, BIN);                 // using an int and a
base (binary)
String stringOne =  String(millis(), DEC);            // using a long and a
base
String stringOne =  String(34.5432, 2);               // using a float
showing only 2 decimal places shows 34.54
```

Constructing a String from a number results in a string that contains the ASCII representation of that number. The default is base ten, so

`String thisString = String(13)` gives you the String "13". You can use other bases, however. For example, `String thisString = String(13, HEX)` gives you the String "D", which is the hexadecimal representation of the decimal value 13. Or if you prefer binary,

`String thisString = String(13, BIN)` gives you the String "1101", which is the binary representation of 13.

Parameters:

- val: a variable to format as a String - string, char, byte, int, long, unsigned int, unsigned long
- base (optional) - the base in which to format an integral value

Returns: an instance of the String class

charAt()

Access a particular character of the String.

```
// SYNTAX
string.charAt(n)
```

Parameters:

- `string` : a variable of type String
- `n` : the character to access

Returns: the n'th character of the String

compareTo()

Compares two Strings, testing whether one comes before or after the other, or whether they're equal. The strings are compared character by character, using the ASCII values of the characters. That means, for example, that 'a' comes before 'b' but after 'A'. Numbers come before letters.

```
// SYNTAX
string.compareTo(string2)
```

Parameters:

- string: a variable of type String
- string2: another variable of type String

Returns:

- a negative number: if string comes before string2
- 0: if string equals string2
- a positive number: if string comes after string2

concat()

Combines, or *concatenates* two strings into one string. The second string is appended to the first, and the result is placed in the original string.

```
// SYNTAX
string.concat(string2)
```

Parameters:

- string, string2: variables of type String

Returns: None

endsWith()

Tests whether or not a String ends with the characters of another String.

```
// SYNTAX
string.endsWith(string2)
```

Parameters:

- string: a variable of type String
- string2: another variable of type String

Returns:

- true: if string ends with the characters of string2
- false: otherwise

equals()

Compares two strings for equality. The comparison is case-sensitive, meaning the String "hello" is not equal to the String "HELLO".

```
// SYNTAX
string.equals(string2)
```

Parameters:

- string, string2: variables of type String

Returns:

- true: if string equals string2
- false: otherwise

equalsIgnoreCase()

Compares two strings for equality. The comparison is not case-sensitive, meaning the String("hello") is equal to the String("HELLO").

```
// SYNTAX
string.equalsIgnoreCase(string2)
```

Parameters:

- string, string2: variables of type String

Returns:

- true: if string equals string2 (ignoring case)
- false: otherwise

format()

Since 0.4.6:

Provides printf-style formatting for strings.

```
Particle.publish("startup", String::format("frobnicator started at %s",
Time.timeStr().c_str()));
```

getBytes()

Copies the string's characters to the supplied buffer.

```
// SYNTAX
string.getBytes(buf, len)
```

Parameters:

- string: a variable of type String
- buf: the buffer to copy the characters into (byte [])
- len: the size of the buffer (unsigned int)

Returns: None

c_str()

Gets a pointer (const char *) to the internal c-string representation of the string. You can use this to pass to a function that require a c-string. This string cannot be modified.

The object also supports `operator const char *` so for things that specifically take a c-string (like Particle.publish) the conversion is automatic.

You would normally use c_str() if you need to pass the string to something like Serial.printlnf or Log.info where the conversion is ambiguous:

```
Serial.printlnf("the string is: %s", string.c_str());
```

This is also helpful if you want to print out an IP address:

```
Serial.printlnf("ip addr: %s", WiFi.localIP().toString().c_str());
```

indexOf()

Locates a character or String within another String. By default, searches from the beginning of the String, but can also start from a given index, allowing for the locating of all instances of the character or String.

```
// SYNTAX
string.indexOf(val)
string.indexOf(val, from)
```

Parameters:

- string: a variable of type String
- val: the value to search for - char or String
- from: the index to start the search from

Returns: The index of val within the String, or -1 if not found.

lastIndexOf()

Locates a character or String within another String. By default, searches from the end of the String, but can also work backwards from a given index, allowing for the locating of all instances of the character or String.

```
// SYNTAX
string.lastIndexOf(val)
string.lastIndexOf(val, from)
```

Parameters:

- string: a variable of type String
- val: the value to search for - char or String
- from: the index to work backwards from

Returns: The index of val within the String, or -1 if not found.

length()

Returns the length of the String, in characters. (Note that this doesn't include a trailing null character.)

```
// SYNTAX
string.length()
```

Parameters:

- string: a variable of type String

Returns: The length of the String in characters.

remove()

The String `remove()` function modifies a string, in place, removing chars from the provided index to the end of the string or from the provided index to index plus count.

```
// SYNTAX
string.remove(index)
string.remove(index,count)
```

Parameters:

- string: the string which will be modified - a variable of type String
- index: a variable of type unsigned int
- count: a variable of type unsigned int

Returns: None

replace()

The String `replace()` function allows you to replace all instances of a given character with another character. You can also use replace to replace substrings of a string with a different substring.

```
// SYNTAX
string.replace(substring1, substring2)
```

Parameters:

- string: the string which will be modified - a variable of type String
- substring1: searched for - another variable of type String (single or multi-character), char or const char (single character only)
- substring2: replaced with - another variable of type String (single or multi-character), char or const char (single character only)

Returns: None

reserve()

The String reserve() function allows you to allocate a buffer in memory for manipulating strings.

```
// SYNTAX
string.reserve(size)
```

Parameters:

- size: unsigned int declaring the number of bytes in memory to save for string manipulation

Returns: None

```
//EXAMPLE

String myString;

void setup() {
  // initialize serial and wait for port to open:
  Serial.begin(9600);
  while (!Serial) {
    ; // wait for serial port to connect. Needed for Leonardo only
  }

  myString.reserve(26);
  myString = "i=";
  myString += "1234";
  myString += ", is that ok?";

  // print the String:
  Serial.println(myString);
}

void loop() {
 // nothing to do here
}
```

setCharAt()

Sets a character of the String. Has no effect on indices outside the existing length of the String.

```
// SYNTAX
string.setCharAt(index, c)
```

Parameters:

- string: a variable of type String
- index: the index to set the character at
- c: the character to store to the given location

Returns: None

startsWith()

Tests whether or not a String starts with the characters of another String.

```
// SYNTAX
string.startsWith(string2)
```

Parameters:

- string, string2: variable2 of type String

Returns:

- true: if string starts with the characters of string2
- false: otherwise

substring()

Get a substring of a String. The starting index is inclusive (the corresponding character is included in the substring), but the optional ending index is exclusive (the corresponding character is not included in the substring). If the ending index is omitted, the substring continues to the end of the String.

```
// SYNTAX
string.substring(from)
string.substring(from, to)
```

Parameters:

- string: a variable of type String
- from: the index to start the substring at
- to (optional): the index to end the substring before

Returns: the substring

toCharArray()

Copies the string's characters to the supplied buffer.

```
// SYNTAX
string.toCharArray(buf, len)
```

Parameters:

- string: a variable of type String
- buf: the buffer to copy the characters into (char [])
- len: the size of the buffer (unsigned int)

Returns: None

toFloat()

Converts a valid String to a float. The input string should start with a digit. If the string contains non-digit characters, the function will stop performing the conversion. For example, the strings "123.45", "123", and "123fish" are converted to 123.45, 123.00, and 123.00 respectively. Note that "123.456" is approximated with 123.46. Note too that floats have only 6-7 decimal digits of precision and that longer strings might be truncated.

```
// SYNTAX
string.toFloat()
```

Parameters:

- string: a variable of type String

Returns: float (If no valid conversion could be performed because the string doesn't start with a digit, a zero is returned.)

toInt()

Converts a valid String to an integer. The input string should start with an integral number. If the string contains non-integral numbers, the function will stop performing the conversion.

```
// SYNTAX
string.toInt()
```

Parameters:

- string: a variable of type String

Returns: long (If no valid conversion could be performed because the string doesn't start with a integral number, a zero is returned.)

toLowerCase()

Get a lower-case version of a String. `toLowerCase()` modifies the string in place.

```
// SYNTAX
string.toLowerCase()
```

Parameters:

- string: a variable of type String

Returns: None

toUpperCase()

Get an upper-case version of a String. `toUpperCase()` modifies the string in place.

```
// SYNTAX
string.toUpperCase()
```

Parameters:

- string: a variable of type String

Returns: None

trim()

Get a version of the String with any leading and trailing whitespace removed.

```
// SYNTAX
string.trim()
```

Parameters:

- string: a variable of type String

Returns: None

Stream Class

Stream is the base class for character and binary based streams. It is not called directly, but invoked whenever you use a function that relies on it. The Particle Stream Class is based on the Arduino Stream Class.

Stream defines the reading functions in Particle. When using any core functionality that uses a read() or similar method, you can safely assume it calls on the Stream class. For

functions like print(), Stream inherits from the Print class.

Some of the Particle classes that rely on Stream include : `Serial Wire TCPClient UDP`

setTimeout()

`setTimeout()` sets the maximum milliseconds to wait for stream data, it defaults to 1000 milliseconds.

```
// SYNTAX
stream.setTimeout(time);
```

Parameters:

- stream: an instance of a class that inherits from Stream
- time: timeout duration in milliseconds (unsigned int)

Returns: None

find()

`find()` reads data from the stream until the target string of given length is found.

```
// SYNTAX
stream.find(target);        // reads data from the stream until the target string is found
stream.find(target, length);    // reads data from the stream until the target string of given length is found
```

Parameters:

- stream : an instance of a class that inherits from Stream
- target : pointer to the string to search for (char *)
- length : length of target string to search for (size_t)

Returns: returns true if target string is found, false if timed out

findUntil()

`findUntil()` reads data from the stream until the target string or terminator string is found.

```
// SYNTAX
stream.findUntil(target, terminal);        // reads data from the stream
until the target string or terminator is found
stream.findUntil(target, terminal, length);    // reads data from the stream
until the target string of given length or terminator is found
```

Parameters:

- stream : an instance of a class that inherits from Stream
- target : pointer to the string to search (char *)
- terminal : pointer to the terminal string to search for (char *)
- length : length of target string to search for (size_t)

Returns: returns true if target string or terminator string is found, false if timed out

readBytes()

`readBytes()` read characters from a stream into a buffer. The function terminates if the determined length has been read, or it times out.

```
// SYNTAX
stream.readBytes(buffer, length);
```

Parameters:

- stream : an instance of a class that inherits from Stream
- buffer : pointer to the buffer to store the bytes in (char *)
- length : the number of bytes to read (size_t)

Returns: returns the number of characters placed in the buffer (0 means no valid data found)

readBytesUntil()

`readBytesUntil()` reads characters from a stream into a buffer. The function terminates if the terminator character is detected, the determined length has been read, or it times out.

```
// SYNTAX
stream.readBytesUntil(terminator, buffer, length);
```

Parameters:

- stream : an instance of a class that inherits from Stream
- terminator : the character to search for (char)
- buffer : pointer to the buffer to store the bytes in (char *)
- length : the number of bytes to read (size_t)

Returns: returns the number of characters placed in the buffer (0 means no valid data found)

readString()

`readString()` reads characters from a stream into a string. The function terminates if it times out.

```
// SYNTAX
stream.readString();
```

Parameters:

- stream : an instance of a class that inherits from Stream

Returns: the entire string read from stream (String)

readStringUntil()

`readStringUntil()` reads characters from a stream into a string until a terminator character is detected. The function terminates if it times out.

```
// SYNTAX
stream.readStringUntil(terminator);
```

Parameters:

- stream : an instance of a class that inherits from Stream
- terminator : the character to search for (char)

Returns: the entire string read from stream, until the terminator character is detected

parseInt()

`parseInt()` returns the first valid (long) integer value from the current position under the following conditions:

- Initial characters that are not digits or a minus sign, are skipped;
- Parsing stops when no characters have been read for a configurable time-out value, or a non-digit is read;

```
// SYNTAX
stream.parseInt();
stream.parseInt(skipChar);    // allows format characters (typically commas)
in values to be ignored
```

Parameters:

- stream : an instance of a class that inherits from Stream
- skipChar : the character to ignore while parsing (char).

Returns: parsed int value (long). If no valid digits were read when the time-out occurs, 0 is returned.

parseFloat()

`parseFloat()` as `parseInt()` but returns the first valid floating point value from the current position.

```
// SYNTAX
stream.parsetFloat();
stream.parsetFloat(skipChar);    // allows format characters (typically commas) in values to be ignored
```

Parameters:

- stream : an instance of a class that inherits from Stream
- skipChar : the character to ignore while parsing (char).

Returns: parsed float value (float). If no valid digits were read when the time-out occurs, 0 is returned.

Logging

Since 0.6.0:

This library provides various classes for logging.

```
// EXAMPLE

// Use primary serial over USB interface for logging output
SerialLogHandler logHandler;

void setup() {
    // Log some messages with different logging levels
    Log.info("This is info message");
    Log.warn("This is warning message");
    Log.error("This is error message");
```

```
    // Format text message
    Log.info("System version: %s", (const char*)System.version());
}

void loop() {
}
```

At higher level, the logging framework consists of two parts represented by their respective classes: loggers and log handlers. Most of the logging operations, such as generating a log message, are done through logger instances, while log handlers act as *sinks* for the overall logging output generated by the system and application modules.

The library provides default logger instance named `Log`, which can be used for all typical logging operations. Note that applications still need to instantiate at least one log handler in order to enable logging, otherwise most of the logging operations will have no effect. In the provided example, the application uses `SerialLogHandler` which sends the logging output to the primary serial over USB interface.

Consider the following logging output as generated by the example application:

```
0000000047 [app] INFO: This is info message
0000000050 [app] WARN: This is warning message
0000000100 [app] ERROR: This is error message
0000000149 [app] INFO: System version: 0.6.0
```

Here, each line starts with a timestamp (a number of milliseconds since the system startup), `app` is a default logging category, and `INFO`, `WARN` and `ERROR` are logging levels of the respective log messages.

Logging Levels

Every log message is always associated with some logging level that describes *severity* of the message. Supported logging levels are defined by the `LogLevel` enum (from lowest to highest level):

- `LOG_LEVEL_ALL` : special value that can be used to enable logging of all messages
- `LOG_LEVEL_TRACE` : verbose output for debugging purposes
- `LOG_LEVEL_INFO` : regular information messages

- `LOG_LEVEL_WARN` : warnings and non-critical errors
- `LOG_LEVEL_ERROR` : error messages
- `LOG_LEVEL_NONE` : special value that can be used to disable logging of any messages

```
// EXAMPLE - message logging

Log.trace("This is trace message");
Log.info("This is info message");
Log.warn("This is warning message");
Log.error("This is error message");

// Specify logging level directly
Log(LOG_LEVEL_INFO, "This is info message");

// Log message with the default logging level (LOG_LEVEL_INFO)
Log("This is info message");
```

For convenience, Logger class (and its default `Log` instance) provides separate logging method for each of the defined logging levels.

Log handlers can be configured to filter out messages that are below a certain logging level. By default, any messages below the `LOG_LEVEL_INFO` level are filtered out.

```
// EXAMPLE - basic filtering

// Log handler processing only warning and error messages
SerialLogHandler logHandler(LOG_LEVEL_WARN);

void setup() {
    Log.trace("This is trace message"); // Ignored by the handler
    Log.info("This is info message"); // Ignored by the handler
    Log.warn("This is warning message");
    Log.error("This is error message");
}

void loop() {
}
```

In the provided example, the trace and info messages will be filtered out according to the log handler settings, which prevent log messages below the `LOG_LEVEL_WARN` level from being logged:

```
0000000050 [app] WARN: This is warning message
0000000100 [app] ERROR: This is error message
```

Logging Categories

In addition to logging level, log messages can also be associated with some *category* name. Categories allow to organize system and application modules into namespaces, and are used for more selective filtering of the logging output.

One of the typical use cases for category filtering is suppressing of non-critical system messages while preserving application messages at lower logging levels. In the provided example, a message that is not associated with the `app` category will be logged only if its logging level is at or above the warning level (`LOG_LEVEL_WARN`).

```
// EXAMPLE - filtering out system messages

SerialLogHandler logHandler(LOG_LEVEL_WARN, { // Logging level for non-application messages
    { "app", LOG_LEVEL_ALL } // Logging level for application messages
});
```

Default `Log` logger uses `app` category for all messages generated via its logging methods. In order to log messages with different category name it is necessary to instantiate another logger, passing category name to its constructor.

```
// EXAMPLE - using custom loggers

void connect() {
    Logger log("app.network");
    log.trace("Connecting to server"); // Using local logger
}

SerialLogHandler logHandler(LOG_LEVEL_WARN, { // Logging level for non-application messages
    { "app", LOG_LEVEL_INFO }, // Default logging level for all application
```

```
messages
    { "app.network", LOG_LEVEL_TRACE } // Logging level for networking
messages
});

void setup() {
    Log.info("System started"); // Using default logger instance
    Log.trace("My device ID: %s", (const char*)System.deviceID());
    connect();
}

void loop() {
}
```

Category names are written in all lower case and may contain arbitrary number of *subcategories* separated by period character. In order to not interfere with the system logging, it is recommended to always add `app` prefix to all application-specific category names.

The example application generates the following logging output:

```
0000000044 [app] INFO: System started
0000000044 [app.network] TRACE: Connecting to server
```

Note that the trace message containing device ID has been filtered out according to the log handler settings, which prevent log messages with the `app` category from being logged if their logging level is below the `LOG_LEVEL_INFO` level.

Category filters are specified using *initializer list* syntax with each element of the list containing a filter string and a minimum logging level required for messages with matching category to be logged. Note that filter string matches not only exact category name but any of its subcategory names as well, for example:

- `a` – matches `a`, `a.b`, `a.b.c` but not `aaa` or `aaa.b`
- `b.c` – matches `b.c`, `b.c.d` but not `a.b.c` or `b.ccc`

If more than one filter matches a given category name, the most specific filter is used.

Additional Attributes

As described in previous sections, certain log message attributes, such as a timestamp, are automatically added to all generated messages. The library also defines some attributes that can be used for application-specific needs:

- `code` : arbitrary integer value (e.g. error code)
- `details` : description string (e.g. error message)

```
// EXAMPLE - specifying additional attributes

SerialLogHandler logHandler;

int connect() {
    return ECONNREFUSED; // Return an error
}

void setup() {
    Log.info("Connecting to server");
    int error = connect();
    if (error) {
        // Get error message string
        const char *message = strerror(error);
        // Log message with additional attributes
        Log.code(error).details(message).error("Connection error");
    }
}

void loop() {
}
```

The example application specifies `code` and `details` attributes for the error message, generating the following logging output:

```
0000000084 [app] INFO: Connecting to server
0000000087 [app] ERROR: Connection error [code = 111, details = Connection refused]
```

Log Handlers

In order to enable logging, application needs to instantiate at least one log handler. If necessary, several different log handlers can be instantiated at the same time.

```
// EXAMPLE - enabling multiple log handlers

SerialLogHandler logHandler1;
Serial1LogHandler logHandler2(57600); // Baud rate

void setup() {
    Log.info("This is info message"); // Processed by all handlers
}

void loop() {
}
```

The library provides the following log handlers:

- `SerialLogHandler`
- Additional community-supported log handlers can be found further below.

This handler uses primary serial over USB interface for the logging output (Serial).

```
SerialLogHandler(LogLevel level, const Filters &filters)
```

Parameters:

- level : default logging level (default value is `LOG_LEVEL_INFO`)
- filters : category filters (not specified by default)

```
Serial1LogHandler
```

This handler uses the device's TX and RX pins for the logging output (Serial1).

```
Serial1LogHandler(LogLevel level, const Filters &filters)
Serial1LogHandler(int baud, LogLevel level, const Filters &filters)
```

Parameters:

- level : default logging level (default value is `LOG_LEVEL_INFO`)
- filters : category filters (not specified by default)
- baud : baud rate (default value is 9600)

Community Log Handlers

The log handlers below are written by the community and are not considered "Official" Particle-supported log handlers. If you have any issues with them please raise an issue in the forums or, ideally, in the online repo for the handler.

- Papertrail Log Handler by barakwei. [Particle Build] [GitHub Repo] [Known Issues]
- Web Log Handler by geeksville. [Particle Build] [GitHub Repo] [Known Issues]
- More to come (feel free to add your own by editing the docs on GitHub)

Logger Class

This class is used to generate log messages. The library also provides default instance of this class named `Log`, which can be used for all typical logging operations.

```
Logger()
Logger(const char *name)
```

```
// EXAMPLE
Logger myLogger("app.main");
```

Construct logger.

Parameters:

- name : category name (default value is `app`)

```
const char* name()
```

```
// EXAMPLE
const char *name = Log.name(); // Returns "app"
```

Returns category name set for this logger.

```
void trace(const char *format, ...)
void info(const char *format, ...)
void warn(const char *format, ...)
void error(const char *format, ...)
```

```
// EXAMPLE
Log.trace("This is trace message");
Log.info("This is info message");
Log.warn("This is warn message");
Log.error("This is error message");

// Format text message
Log.info("The secret of everything is %d", 42);
```

Generate trace, info, warning or error message respectively.

Parameters:

- format : format string

```
void log(const char *format, ...)
void operator()(const char *format, ...)
```

```
// EXAMPLE
Log("The secret of everything is %d", 42); // Generates info message
```

Generates log message with the default logging level (`LOG_LEVEL_INFO`).

Parameters:

- format : format string

```
void log(LogLevel level, const char *format, ...)
void operator()(LogLevel level, const char *format, ...)
```

```
// EXAMPLE
Log(LOG_LEVEL_INFO, "The secret of everything is %d", 42);
```

Generates log message with the specified logging level.

Parameters:

- format : format string
- level : logging level (default value is `LOG_LEVEL_INFO`)

```
bool isTraceEnabled()
bool isInfoEnabled()
bool isWarnEnabled()
bool isErrorEnabled()
```

```
// EXAMPLE
if (Log.isTraceEnabled()) {
    // Do some heavy logging
}
```

Return `true` if logging is enabled for trace, info, warning or error messages respectively.

```
bool isLevelEnabled(LogLevel level)
```

```
// EXAMPLE
if (Log.isLevelEnabled(LOG_LEVEL_TRACE)) {
    // Do some heavy logging
}
```

Returns `true` if logging is enabled for the specified logging level.

Parameters:

- level : logging level

Global Object Constructors

It can be convenient to use C++ objects as global variables. You must be careful about what you do in the constructor, however.

The first code example is the bad example, don't do this.

```
#include "Particle.h"

SerialLogHandler logHandler;

class MyClass {
public:
    MyClass();
    virtual ~MyClass();

    void subscriptionHandler(const char *eventName, const char *data);
};

MyClass::MyClass() {
    // This is generally a bad idea. You should avoid doing this from a
constructor.
    Particle.subscribe("myEvent", &MyClass::subscriptionHandler, this,
MY_DEVICES);
}

MyClass::~MyClass() {

}

void MyClass::subscriptionHandler(const char *eventName, const char *data) {
    Log.info("eventName=%s data=%s", eventName, data);
}

// In this example, MyClass is a globally constructed object.
MyClass myClass;

void setup() {

}
void loop() {
```

```
}
```

Making `MyClass myClass` a global variable is fine, and is a useful technique. However, it contains a `Particle.subscribe` call in the constructor. This may fail, or crash the device. You should avoid in a global constructor:

- All functions in the Particle class (Particle.subscribe, Particle.variable, etc.)
- Creation of threads
- Hardware initialization including I2C and SPI
- Calls to `delay()`
- Any class that depends on another globally initialized class instance

The reason is that the order that the compiler initializes global objects varies, and is not predictable. Thus sometimes it may work, but then later it may decide to reorder initialization and may fail.

One solution is to use two-phase setup. Instead of putting the setup code in the constructor, you put it in a setup() method of your class and call the setup() method from the actual setup(). This is the recommended method.

```
#include "Particle.h"

SerialLogHandler logHandler;

class MyClass {
public:
    MyClass();
    virtual ~MyClass();

    void setup();

    void subscriptionHandler(const char *eventName, const char *data);
};

MyClass::MyClass() {
}

MyClass::~MyClass() {
```

```
}

void MyClass::setup() {
    Particle.subscribe("myEvent", &MyClass::subscriptionHandler, this,
MY_DEVICES);
}

void MyClass::subscriptionHandler(const char *eventName, const char *data) {
    Log.info("eventName=%s data=%s", eventName, data);
}

// In this example, MyClass is a globally constructed object.
MyClass myClass;

void setup() {
    myClass.setup();
}

void loop() {

}
```

Another option is to allocate the class member using `new` instead.

```
#include "Particle.h"

SerialLogHandler logHandler;

class MyClass {
public:
    MyClass();
    virtual ~MyClass();

    void subscriptionHandler(const char *eventName, const char *data);
};

MyClass::MyClass() {
    // This is OK as long as MyClass is allocated with new from setup
    Particle.subscribe("myEvent", &MyClass::subscriptionHandler, this,
MY_DEVICES);
}
```

```
MyClass::~MyClass() {

}

void MyClass::subscriptionHandler(const char *eventName, const char *data) {
    Log.info("eventName=%s data=%s", eventName, data);
}

// In this example, MyClass is allocated in setup() using new, and is safe
because
// the constructor is called during setup() time.
MyClass *myClass;

void setup() {
    myClass = new MyClass();
}

void loop() {

}
```

Language Syntax

Particle devices are programmed in C/C++. While the Arduino compatibility features are available as described below, you can also write programs in plain C or C++, specifically:

Device OS Version	C++ (.cpp and .ino)	C (.c)
1.2.1 and later	gcc C++14	gcc C11
earlier versions	gcc C++11	gcc C11

The following documentation is based on the Arduino reference which can be found here.

Structure

setup()

The setup() function is called when an application starts. Use it to initialize variables, pin modes, start using libraries, etc. The setup function will only run once, after each powerup

or device reset.

```
// EXAMPLE USAGE

int button = D0;
int LED = D1;
//setup initializes D0 as input and D1 as output
void setup()
{
  pinMode(button, INPUT_PULLDOWN);
  pinMode(LED, OUTPUT);
}

void loop()
{
  // ...
}
```

loop()

After creating a setup() function, which initializes and sets the initial values, the loop() function does precisely what its name suggests, and loops consecutively, allowing your program to change and respond. Use it to actively control the device. A return may be used to exit the loop() before it completely finishes.

```
// EXAMPLE USAGE

int button = D0;
int LED = D1;
//setup initializes D0 as input and D1 as output
void setup()
{
  pinMode(button, INPUT_PULLDOWN);
  pinMode(LED, OUTPUT);
}

//loops to check if button was pressed,
//if it was, then it turns ON the LED,
//else the LED remains OFF
void loop()
```

```
{
  if (digitalRead(button) == HIGH)
    digitalWrite(LED,HIGH);
  else
    digitalWrite(LED,LOW);
}
```

Control structures

if

`if`, which is used in conjunction with a comparison operator, tests whether a certain condition has been reached, such as an input being above a certain number.

```
// SYNTAX
if (someVariable > 50)
{
  // do something here
}
```

The program tests to see if someVariable is greater than 50. If it is, the program takes a particular action. Put another way, if the statement in parentheses is true, the statements inside the brackets are run. If not, the program skips over the code.

The brackets may be omitted after an *if* statement. If this is done, the next line (defined by the semicolon) becomes the only conditional statement.

```
if (x > 120) digitalWrite(LEDpin, HIGH);

if (x > 120)
digitalWrite(LEDpin, HIGH);

if (x > 120){ digitalWrite(LEDpin, HIGH); }

if (x > 120)
{
  digitalWrite(LEDpin1, HIGH);
```

```
  digitalWrite(LEDpin2, HIGH);
}                                   // all are correct
```

The statements being evaluated inside the parentheses require the use of one or more operators:

Comparison Operators

```
x == y (x is equal to y)
x != y (x is not equal to y)
x <  y (x is less than y)
x >  y (x is greater than y)
x <= y (x is less than or equal to y)
x >= y (x is greater than or equal to y)
```

WARNING: Beware of accidentally using the single equal sign (e.g. `if (x = 10)`). The single equal sign is the assignment operator, and sets x to 10 (puts the value 10 into the variable x). Instead use the double equal sign (e.g. `if (x == 10)`), which is the comparison operator, and tests whether x is equal to 10 or not. The latter statement is only true if x equals 10, but the former statement will always be true.

This is because C evaluates the statement `if (x=10)` as follows: 10 is assigned to x (remember that the single equal sign is the assignment operator), so x now contains 10. Then the 'if' conditional evaluates 10, which always evaluates to TRUE, since any non-zero number evaluates to TRUE. Consequently, `if (x = 10)` will always evaluate to TRUE, which is not the desired result when using an 'if' statement. Additionally, the variable x will be set to 10, which is also not a desired action.

`if` can also be part of a branching control structure using the `if...else`] construction.

if...else

if/else allows greater control over the flow of code than the basic *if* statement, by allowing multiple tests to be grouped together. For example, an analog input could be tested and one action taken if the input was less than 500, and another action taken if the input was 500 or greater. The code would look like this:

```
// SYNTAX
if (pinFiveInput < 500)
{
  // action A
}
else
{
  // action B
}
```

`else` can proceed another `if` test, so that multiple, mutually exclusive tests can be run at the same time.

Each test will proceed to the next one until a true test is encountered. When a true test is found, its associated block of code is run, and the program then skips to the line following the entire if/else construction. If no test proves to be true, the default else block is executed, if one is present, and sets the default behavior.

Note that an *else if* block may be used with or without a terminating *else* block and vice versa. An unlimited number of such else if branches is allowed.

```
if (pinFiveInput < 500)
{
  // do Thing A
}
else if (pinFiveInput >= 1000)
{
  // do Thing B
}
else
{
  // do Thing C
}
```

Another way to express branching, mutually exclusive tests, is with the `switch case` statement.

for

The `for` statement is used to repeat a block of statements enclosed in curly braces. An increment counter is usually used to increment and terminate the loop. The `for` statement is useful for any repetitive operation, and is often used in combination with arrays to operate on collections of data/pins.

There are three parts to the for loop header:

```
// SYNTAX
for (initialization; condition; increment)
{
  //statement(s);
}
```

The *initialization* happens first and exactly once. Each time through the loop, the *condition* is tested; if it's true, the statement block, and the *increment* is executed, then the condition is tested again. When the *condition* becomes false, the loop ends.

```
// EXAMPLE USAGE

// slowy make the LED glow brighter
int ledPin = D1; // LED in series with 470 ohm resistor on pin D1

void setup()
{
  // set ledPin as an output
  pinMode(ledPin,OUTPUT);
}

void loop()
{
  for (int i=0; i <= 255; i++){
    analogWrite(ledPin, i);
    delay(10);
  }
}
```

The C `for` loop is much more flexible than for loops found in some other computer languages, including BASIC. Any or all of the three header elements may be omitted, although the semicolons are required. Also the statements for initialization, condition, and increment can be any valid C statements with unrelated variables, and use any C datatypes including floats. These types of unusual for statements may provide solutions to some rare programming problems.

For example, using a multiplication in the increment line will generate a logarithmic progression:

```
for(int x = 2; x < 100; x = x * 1.5)
{
  Serial.print(x);
}
//Generates: 2,3,4,6,9,13,19,28,42,63,94
```

Another example, fade an LED up and down with one for loop:

```
// slowy make the LED glow brighter
int ledPin = D1; // LED in series with 470 ohm resistor on pin D1

void setup()
{
  // set ledPin as an output
  pinMode(ledPin,OUTPUT);
}

void loop()
{
  int x = 1;
  for (int i = 0; i > -1; i = i + x)
  {
    analogWrite(ledPin, i);
    if (i == 255) x = -1;     // switch direction at peak
    delay(10);
  }
}
```

switch case

Like `if` statements, `switch` ... `case` controls the flow of programs by allowing programmers to specify different code that should be executed in various conditions. In particular, a switch statement compares the value of a variable to the values specified in case statements. When a case statement is found whose value matches that of the variable, the code in that case statement is run.

The `break` keyword exits the switch statement, and is typically used at the end of each case. Without a break statement, the switch statement will continue executing the following expressions ("falling-through") until a break, or the end of the switch statement is reached.

```
// SYNTAX
switch (var)
{
  case label:
    // statements
    break;
  case label:
    // statements
    break;
  default:
    // statements
}
```

`var` is the variable whose value to compare to the various cases `label` is a value to compare the variable to

```
// EXAMPLE USAGE

switch (var)
{
  case 1:
    // do something when var equals 1
    break;
  case 2:
    // do something when var equals 2
    break;
  default:
```

```
    // if nothing else matches, do the
    // default (which is optional)
}
```

while

`while` loops will loop continuously, and infinitely, until the expression inside the parenthesis, () becomes false. Something must change the tested variable, or the `while` loop will never exit. This could be in your code, such as an incremented variable, or an external condition, such as testing a sensor.

```
// SYNTAX
while(expression)
{
  // statement(s)
}
```

`expression` is a (boolean) C statement that evaluates to true or false.

```
// EXAMPLE USAGE

var = 0;
while(var < 200)
{
  // do something repetitive 200 times
  var++;
}
```

do... while

The `do` loop works in the same manner as the `while` loop, with the exception that the condition is tested at the end of the loop, so the do loop will *always* run at least once.

```
// SYNTAX
do
{
  // statement block
} while (test condition);
```

```
// EXAMPLE USAGE

do
{
  delay(50);          // wait for sensors to stabilize
  x = readSensors();  // check the sensors

} while (x < 100);
```

break

`break` is used to exit from a `do`, `for`, or `while` loop, bypassing the normal loop condition. It is also used to exit from a `switch` statement.

```
// EXAMPLE USAGE

for (int x = 0; x < 255; x++)
{
  digitalWrite(ledPin, x);
  sens = analogRead(sensorPin);
  if (sens > threshold)
  {
    x = 0;
    break;  // exit for() loop on sensor detect
  }
  delay(50);
}
```

continue

The continue statement skips the rest of the current iteration of a loop (`do` , `for` , or `while`). It continues by checking the conditional expression of the loop, and proceeding with any subsequent iterations.

```
// EXAMPLE USAGE

for (x = 0; x < 255; x++)
{
    if (x > 40 && x < 120) continue;  // create jump in values

    digitalWrite(PWMpin, x);
    delay(50);
}
```

return

Terminate a function and return a value from a function to the calling function, if desired.

```
//EXAMPLE USAGE

// A function to compare a sensor input to a threshold
 int checkSensor()
 {
    if (analogRead(0) > 400) return 1;
    else return 0;
}
```

The return keyword is handy to test a section of code without having to "comment out" large sections of possibly buggy code.

```
void loop()
{
  // brilliant code idea to test here
```

```
  return;

  // the rest of a dysfunctional sketch here
  // this code will never be executed
}
```

goto

Transfers program flow to a labeled point in the program

```
// SYNTAX

label:

goto label; // sends program flow to the label
```

TIP: The use of `goto` is discouraged in C programming, and some authors of C programming books claim that the `goto` statement is never necessary, but used judiciously, it can simplify certain programs. The reason that many programmers frown upon the use of `goto` is that with the unrestrained use of `goto` statements, it is easy to create a program with undefined program flow, which can never be debugged.

With that said, there are instances where a `goto` statement can come in handy, and simplify coding. One of these situations is to break out of deeply nested `for` loops, or `if` logic blocks, on a certain condition.

```
// EXAMPLE USAGE

for(byte r = 0; r < 255; r++) {
  for(byte g = 255; g > -1; g--) {
    for(byte b = 0; b < 255; b++) {
      if (analogRead(0) > 250) {
        goto bailout;
      }
      // more statements ...
    }
  }
```

```
}
bailout:
// Code execution jumps here from
// goto bailout; statement
```

Further syntax

; (semicolon)

Used to end a statement.

```
int a = 13;
```

Tip: Forgetting to end a line in a semicolon will result in a compiler error. The error text may be obvious, and refer to a missing semicolon, or it may not. If an impenetrable or seemingly illogical compiler error comes up, one of the first things to check is a missing semicolon, in the immediate vicinity, preceding the line at which the compiler complained.

{} (curly braces)

Curly braces (also referred to as just "braces" or as "curly brackets") are a major part of the C programming language. They are used in several different constructs, outlined below, and this can sometimes be confusing for beginners.

```
//The main uses of curly braces

//Functions
  void myfunction(datatype argument){
    statements(s)
  }

//Loops
  while (boolean expression)
  {
     statement(s)
  }

  do
  {
```

```
    statement(s)
  } while (boolean expression);

  for (initialisation; termination condition; incrementing expr)
  {
     statement(s)
  }

//Conditional statements
  if (boolean expression)
  {
     statement(s)
  }

  else if (boolean expression)
  {
     statement(s)
  }
  else
  {
     statement(s)
  }
```

An opening curly brace "{" must always be followed by a closing curly brace "}". This is a condition that is often referred to as the braces being balanced.

Beginning programmers, and programmers coming to C from the BASIC language often find using braces confusing or daunting. After all, the same curly braces replace the RETURN statement in a subroutine (function), the ENDIF statement in a conditional and the NEXT statement in a FOR loop.

Because the use of the curly brace is so varied, it is good programming practice to type the closing brace immediately after typing the opening brace when inserting a construct which requires curly braces. Then insert some carriage returns between your braces and begin inserting statements. Your braces, and your attitude, will never become unbalanced.

Unbalanced braces can often lead to cryptic, impenetrable compiler errors that can sometimes be hard to track down in a large program. Because of their varied usages, braces are also incredibly important to the syntax of a program and moving a brace one or two lines will often dramatically affect the meaning of a program.

// (single line comment)

/* */ (multi-line comment)

Comments are lines in the program that are used to inform yourself or others about the way the program works. They are ignored by the compiler, and not exported to the processor, so they don't take up any space on the device.

Comments only purpose are to help you understand (or remember) how your program works or to inform others how your program works. There are two different ways of marking a line as a comment:

```
// EXAMPLE USAGE

x = 5;  // This is a single line comment. Anything after the slashes is a
comment
        // to the end of the line

/* this is multiline comment - use it to comment out whole blocks of code

if (gwb == 0) {   // single line comment is OK inside a multiline comment
  x = 3;          /* but not another multiline comment - this is invalid */
}
// don't forget the "closing" comment - they have to be balanced!
*/
```

TIP: When experimenting with code, "commenting out" parts of your program is a convenient way to remove lines that may be buggy. This leaves the lines in the code, but turns them into comments, so the compiler just ignores them. This can be especially useful when trying to locate a problem, or when a program refuses to compile and the compiler error is cryptic or unhelpful.

#define

`#define` is a useful C component that allows the programmer to give a name to a constant value before the program is compiled. Defined constants don't take up any program memory space on the chip. The compiler will replace references to these constants with the defined value at compile time.

```
#define constantName value
```

Note that the # is necessary.

This can have some unwanted side effects if the constant name in a `#define` is used in some other constant or variable name. In that case the text would be replaced by the `#define` value.

```
// EXAMPLE USAGE

#define ledPin 3
// The compiler will replace any mention of ledPin with the value 3 at
compile time.
```

In general, the `const` keyword is preferred for defining constants and should be used instead of #define.

TIP: There is no semicolon after the #define statement. If you include one, the compiler will throw cryptic errors further down the page.

```
#define ledPin 3; // this is an error
```

Similarly, including an equal sign after the #define statement will also generate a cryptic compiler error further down the page.

```
#define ledPin = 3 // this is also an error
```

#include

`#include` is used to include outside libraries in your application code. This gives the programmer access to a large group of standard C libraries (groups of pre-made functions), and also libraries written especially for your device.

Note that #include, similar to #define, has no semicolon terminator, and the compiler will yield cryptic error messages if you add one.

Arithmetic operators

= (assignment operator)

Stores the value to the right of the equal sign in the variable to the left of the equal sign.

The single equal sign in the C programming language is called the assignment operator. It has a different meaning than in algebra class where it indicated an equation or equality. The assignment operator tells the microcontroller to evaluate whatever value or expression is on the right side of the equal sign, and store it in the variable to the left of the equal sign.

```
// EXAMPLE USAGE

int sensVal;                // declare an integer variable named sensVal
senVal = analogRead(A0);    // store the (digitized) input voltage at analog
pin A0 in SensVal
```

TIP: The variable on the left side of the assignment operator (= sign) needs to be able to hold the value stored in it. If it is not large enough to hold a value, the value stored in the variable will be incorrect.

Don't confuse the assignment operator `=` (single equal sign) with the comparison operator `==` (double equal signs), which evaluates whether two expressions are equal.

+ - * / (addition subtraction multiplication division)

These operators return the sum, difference, product, or quotient (respectively) of the two operands. The operation is conducted using the data type of the operands, so, for example, `9 / 4` gives 2 since 9 and 4 are ints. This also means that the operation can overflow if the result is larger than that which can be stored in the data type (e.g. adding 1 to an int with the value 2,147,483,647 gives -2,147,483,648). If the operands are of different types, the "larger" type is used for the calculation.

If one of the numbers (operands) are of the type float or of type double, floating point math will be used for the calculation.

```
// EXAMPLE USAGES

y = y + 3;
x = x - 7;
```

```
i = j * 6;
r = r / 5;
```

```
// SYNTAX
result = value1 + value2;
result = value1 - value2;
result = value1 * value2;
result = value1 / value2;
```

`value1` and `value2` can be any variable or constant.

TIPS:

- Know that integer constants default to int, so some constant calculations may overflow (e.g. 50 * 50,000,000 will yield a negative result).
- Choose variable sizes that are large enough to hold the largest results from your calculations
- Know at what point your variable will "roll over" and also what happens in the other direction e.g. (0 - 1) OR (0 + 2147483648)
- For math that requires fractions, use float variables, but be aware of their drawbacks: large size, slow computation speeds
- Use the cast operator e.g. (int)myFloat to convert one variable type to another on the fly.

% (modulo)

Calculates the remainder when one integer is divided by another. It is useful for keeping a variable within a particular range (e.g. the size of an array). It is defined so that `a % b == a - ((a / b) * b)`.

`result = dividend % divisor`

`dividend` is the number to be divided and `divisor` is the number to divide by.

`result` is the remainder

The remainder function can have unexpected behavior when some of the operands are negative. If the dividend is negative, then the result will be the smallest negative equivalency class. In other words, when `a` is negative, `(a % b) == (a mod b) - b` where (a mod b) follows the standard mathematical definition of mod. When the divisor is negative, the result is the same as it would be if it was positive.

```
// EXAMPLE USAGES

x = 9 % 5;   // x now contains 4
x = 5 % 5;   // x now contains 0
x = 4 % 5;   // x now contains 4
x = 7 % 5;   // x now contains 2
x = -7 % 5;  // x now contains -2
x = 7 % -5;  // x now contains 2
x = -7 % -5; // x now contains -2
```

```
EXAMPLE CODE
//update one value in an array each time through a loop

int values[10];
int i = 0;

void setup() {}

void loop()
{
  values[i] = analogRead(A0);
  i = (i + 1) % 10;   // modulo operator rolls over variable
}
```

TIP: The modulo operator does not work on floats. For floats, an equivalent expression to `a % b` is `a - (b * ((int)(a / b)))`

Boolean operators

These can be used inside the condition of an if statement.

&& (and)

True only if both operands are true, e.g.

```
if (digitalRead(D2) == HIGH  && digitalRead(D3) == HIGH)
{
  // read two switches
  // ...
}
//is true only if both inputs are high.
```

|| (or)

True if either operand is true, e.g.

```
if (x > 0 || y > 0)
{
  // ...
}
//is true if either x or y is greater than 0.
```

! (not)

True if the operand is false, e.g.

```
if (!x)
{
  // ...
}
//is true if x is false (i.e. if x equals 0).
```

WARNING: Make sure you don't mistake the boolean AND operator, && (double ampersand) for the bitwise AND operator & (single ampersand). They are entirely different beasts.

Similarly, do not confuse the boolean || (double pipe) operator with the bitwise OR operator | (single pipe).

The bitwise not ~ (tilde) looks much different than the boolean not ! (exclamation point or "bang" as the programmers say) but you still have to be sure which one you want where.

```
if (a >= 10 && a <= 20){} // true if a is between 10 and 20
```

Bitwise operators

& (bitwise and)

The bitwise AND operator in C++ is a single ampersand, &, used between two other integer expressions. Bitwise AND operates on each bit position of the surrounding expressions independently, according to this rule: if both input bits are 1, the resulting output is 1, otherwise the output is 0. Another way of expressing this is:

```
    0  0  1  1    operand1
    0  1  0  1    operand2
    ----------
    0  0  0  1    (operand1 & operand2) - returned result
```

```
// EXAMPLE USAGE

int a =  92;    // in binary: 0000000001011100
int b = 101;    // in binary: 0000000001100101
int c = a & b;  // result:    0000000001000100, or 68 in decimal.
```

One of the most common uses of bitwise AND is to select a particular bit (or bits) from an integer value, often called masking.

| (bitwise or)

The bitwise OR operator in C++ is the vertical bar symbol, |. Like the & operator, | operates independently each bit in its two surrounding integer expressions, but what it does is

different (of course). The bitwise OR of two bits is 1 if either or both of the input bits is 1, otherwise it is 0. In other words:

```
    0  0  1  1    operand1
    0  1  0  1    operand2
    ----------
    0  1  1  1    (operand1 | operand2) - returned result
```

```
// EXAMPLE USAGE

int a =  92;    // in binary: 0000000001011100
int b = 101;    // in binary: 0000000001100101
int c = a | b;  // result:    0000000001111101, or 125 in decimal.
```

^ (bitwise xor)

There is a somewhat unusual operator in C++ called bitwise EXCLUSIVE OR, also known as bitwise XOR. (In English this is usually pronounced "eks-or".) The bitwise XOR operator is written using the caret symbol ^. This operator is very similar to the bitwise OR operator |, only it evaluates to 0 for a given bit position when both of the input bits for that position are 1:

```
    0  0  1  1    operand1
    0  1  0  1    operand2
    ----------
    0  1  1  0    (operand1 ^ operand2) - returned result
```

Another way to look at bitwise XOR is that each bit in the result is a 1 if the input bits are different, or 0 if they are the same.

```
// EXAMPLE USAGE

int x = 12;     // binary: 1100
```

```
int y = 10;     // binary: 1010
int z = x ^ y;  // binary: 0110, or decimal 6
```

The ^ operator is often used to toggle (i.e. change from 0 to 1, or 1 to 0) some of the bits in an integer expression. In a bitwise OR operation if there is a 1 in the mask bit, that bit is inverted; if there is a 0, the bit is not inverted and stays the same.

~ (bitwise not)

The bitwise NOT operator in C++ is the tilde character ~. Unlike & and |, the bitwise NOT operator is applied to a single operand to its right. Bitwise NOT changes each bit to its opposite: 0 becomes 1, and 1 becomes 0. For example:

```
    0  1    operand1
   ----------
    1  0   ~ operand1

int a = 103;    // binary:  0000000001100111
int b = ~a;     // binary:  1111111110011000 = -104
```

You might be surprised to see a negative number like -104 as the result of this operation. This is because the highest bit in an int variable is the so-called sign bit. If the highest bit is 1, the number is interpreted as negative. This encoding of positive and negative numbers is referred to as two's complement. For more information, see the Wikipedia article on two's complement.

As an aside, it is interesting to note that for any integer x, ~x is the same as -x-1.

At times, the sign bit in a signed integer expression can cause some unwanted surprises.

<< (bitwise left shift), >> (bitwise right shift)

There are two bit shift operators in C++: the left shift operator << and the right shift operator >>. These operators cause the bits in the left operand to be shifted left or right by the number of positions specified by the right operand.

More on bitwise math may be found here.

```
variable << number_of_bits
variable >> number_of_bits
```

`variable` can be `byte`, `int`, `long` `number_of_bits` and integer <= 32

```
// EXAMPLE USAGE

int a = 5;         // binary: 0000000000000101
int b = a << 3;    // binary: 0000000000101000, or 40 in decimal
int c = b >> 3;    // binary: 0000000000000101, or back to 5 like we started
with
```

When you shift a value x by y bits (x << y), the leftmost y bits in x are lost, literally shifted out of existence:

```
int a = 5;         // binary: 0000000000000101
int b = a << 14;  // binary: 0100000000000000 - the first 1 in 101 was
discarded
```

If you are certain that none of the ones in a value are being shifted into oblivion, a simple way to think of the left-shift operator is that it multiplies the left operand by 2 raised to the right operand power. For example, to generate powers of 2, the following expressions can be employed:

```
1 <<  0  ==    1
1 <<  1  ==    2
1 <<  2  ==    4
1 <<  3  ==    8
...
1 <<  8  ==  256
1 <<  9  ==  512
1 << 10  == 1024
...
```

When you shift x right by y bits (x >> y), and the highest bit in x is a 1, the behavior depends on the exact data type of x. If x is of type int, the highest bit is the sign bit, determining whether x is negative or not, as we have discussed above. In that case, the sign bit is copied into lower bits, for esoteric historical reasons:

```
int x = -16;     // binary: 1111111111110000
int y = x >> 3;  // binary: 1111111111111110
```

This behavior, called sign extension, is often not the behavior you want. Instead, you may wish zeros to be shifted in from the left. It turns out that the right shift rules are different for unsigned int expressions, so you can use a typecast to suppress ones being copied from the left:

```
int x = -16;                  // binary: 1111111111110000
int y = (unsigned int)x >> 3;  // binary: 0001111111111110
```

If you are careful to avoid sign extension, you can use the right-shift operator >> as a way to divide by powers of 2. For example:

```
int x = 1000;
int y = x >> 3;   // integer division of 1000 by 8, causing y = 125
```

Compound operators

++ (increment), -- (decrement)

Increment or decrement a variable

```
// SYNTAX
x++;  // increment x by one and returns the old value of x
++x;  // increment x by one and returns the new value of x
```

```
x-- ;   // decrement x by one and returns the old value of x
--x ;   // decrement x by one and returns the new value of x
```

where `x` is an integer or long (possibly unsigned)

```
// EXAMPLE USAGE

x = 2;
y = ++x;      // x now contains 3, y contains 3
y = x--;      // x contains 2 again, y still contains 3
```

compound arithmetic

- += (compound addition)
- -= (compound subtraction)
- *= (compound multiplication)
- /= (compound division)

Perform a mathematical operation on a variable with another constant or variable. The += (et al) operators are just a convenient shorthand for the expanded syntax.

```
// SYNTAX
x += y;   // equivalent to the expression x = x + y;
x -= y;   // equivalent to the expression x = x - y;
x *= y;   // equivalent to the expression x = x * y;
x /= y;   // equivalent to the expression x = x / y;
```

`x` can be any variable type `y` can be any variable type or constant

```
// EXAMPLE USAGE

x = 2;
x += 4;      // x now contains 6
x -= 3;      // x now contains 3
```

```
x *= 10;     // x now contains 30
x /= 2;      // x now contains 15
```

&= (compound bitwise and)

The compound bitwise AND operator (&=) is often used with a variable and a constant to force particular bits in a variable to the LOW state (to 0). This is often referred to in programming guides as "clearing" or "resetting" bits.

`x &= y; // equivalent to x = x & y;`

`x` can be a char, int or long variable `y` can be an integer constant, char, int, or long

```
0  0  1  1    operand1
0  1  0  1    operand2
----------
0  0  0  1    (operand1 & operand2) - returned result
```

Bits that are "bitwise ANDed" with 0 are cleared to 0 so, if myByte is a byte variable, `myByte & B00000000 = 0;`

Bits that are "bitwise ANDed" with 1 are unchanged so, `myByte & B11111111 = myByte;`

Note: because we are dealing with bits in a bitwise operator - it is convenient to use the binary formatter with constants. The numbers are still the same value in other representations, they are just not as easy to understand. Also, B00000000 is shown for clarity, but zero in any number format is zero (hmmm something philosophical there?)

Consequently - to clear (set to zero) bits 0 & 1 of a variable, while leaving the rest of the variable unchanged, use the compound bitwise AND operator (&=) with the constant B11111100

```
1  0  1  0  1  0  1  0    variable
1  1  1  1  1  1  0  0    mask
---------------------
1  0  1  0  1  0  0  0
```

```
variable unchanged
                    bits cleared
```

Here is the same representation with the variable's bits replaced with the symbol x

```
  x  x  x  x  x  x  x  x    variable
  1  1  1  1  1  1  0  0    mask
  ----------------------
  x  x  x  x  x  x  0  0

variable unchanged
                    bits cleared
```

So if: `myByte = 10101010; myByte &= B1111100 == B10101000;`

|= (compound bitwise or)

The compound bitwise OR operator (|=) is often used with a variable and a constant to "set" (set to 1) particular bits in a variable.

```
// SYNTAX
x |= y;   // equivalent to x = x | y;
```

`x` can be a char, int or long variable `y` can be an integer constant or char, int or long

```
  0  0  1  1    operand1
  0  1  0  1    operand2
  ----------
  0  1  1  1    (operand1 | operand2) - returned result
```

Bits that are "bitwise ORed" with 0 are unchanged, so if myByte is a byte variable, `myByte | B00000000 = myByte;`

Bits that are "bitwise ORed" with 1 are set to 1 so: `myByte | B11111111 = B11111111;`

Consequently - to set bits 0 & 1 of a variable, while leaving the rest of the variable unchanged, use the compound bitwise OR operator (|=) with the constant B00000011

```
  1  0  1  0  1  0  1  0    variable
  0  0  0  0  0  0  1  1    mask
  ----------------------
  1  0  1  0  1  0  1  1

variable unchanged
                   bits set
```

Here is the same representation with the variables bits replaced with the symbol x

```
  x  x  x  x  x  x  x  x    variable
  0  0  0  0  0  0  1  1    mask
  ----------------------
  x  x  x  x  x  x  1  1

variable unchanged
                   bits set
```

So if: `myByte = B10101010; myByte |= B00000011 == B10101011;`

Variables

HIGH | LOW

When reading or writing to a digital pin there are only two possible values a pin can take/be-set-to: HIGH and LOW.

`HIGH`

The meaning of `HIGH` (in reference to a pin) is somewhat different depending on whether a pin is set to an `INPUT` or `OUTPUT`. When a pin is configured as an INPUT with pinMode, and

read with digitalRead, the microcontroller will report HIGH if a voltage of 3 volts or more is present at the pin.

A pin may also be configured as an `INPUT` with `pinMode`, and subsequently made `HIGH` with `digitalWrite`, this will set the internal 40K pullup resistors, which will steer the input pin to a `HIGH` reading unless it is pulled LOW by external circuitry. This is how INPUT_PULLUP works as well

When a pin is configured to `OUTPUT` with `pinMode`, and set to `HIGH` with `digitalWrite`, the pin is at 3.3 volts. In this state it can source current, e.g. light an LED that is connected through a series resistor to ground, or to another pin configured as an output, and set to `LOW.`

`LOW`

The meaning of `LOW` also has a different meaning depending on whether a pin is set to `INPUT` or `OUTPUT`. When a pin is configured as an `INPUT` with `pinMode`, and read with `digitalRead`, the microcontroller will report `LOW` if a voltage of 1.5 volts or less is present at the pin.

When a pin is configured to `OUTPUT` with `pinMode`, and set to `LOW` with digitalWrite, the pin is at 0 volts. In this state it can sink current, e.g. light an LED that is connected through a series resistor to, +3.3 volts, or to another pin configured as an output, and set to `HIGH.`

INPUT, OUTPUT, INPUT_PULLUP, INPUT_PULLDOWN

Digital pins can be used as INPUT, INPUT_PULLUP, INPUT_PULLDOWN or OUTPUT. Changing a pin with `pinMode()` changes the electrical behavior of the pin.

Pins Configured as `INPUT`

The device's pins configured as `INPUT` with `pinMode()` are said to be in a high-impedance state. Pins configured as `INPUT` make extremely small demands on the circuit that they are sampling, equivalent to a series resistor of 100 Megohms in front of the pin. This makes them useful for reading a sensor, but not powering an LED.

If you have your pin configured as an `INPUT`, you will want the pin to have a reference to ground, often accomplished with a pull-down resistor (a resistor going to ground).

Pins Configured as `INPUT_PULLUP` or `INPUT_PULLDOWN`

The STM32 microcontroller has internal pull-up resistors (resistors that connect to power internally) and pull-down resistors (resistors that connect to ground internally) that you can access. If you prefer to use these instead of external resistors, you can use these argument in `pinMode()`.

Pins Configured as `OUTPUT`

Pins configured as `OUTPUT` with `pinMode()` are said to be in a low-impedance state. This means that they can provide a substantial amount of current to other circuits. STM32 pins can source (provide positive current) or sink (provide negative current) up to 20 mA (milliamps) of current to other devices/circuits. This makes them useful for powering LED's but useless for reading sensors. Pins configured as outputs can also be damaged or destroyed if short circuited to either ground or 3.3 volt power rails. The amount of current provided by the pin is also not enough to power most relays or motors, and some interface circuitry will be required.

true | false

There are two constants used to represent truth and falsity in the Arduino language: true, and false.

`false`

`false` is the easier of the two to define. false is defined as 0 (zero).

`true`

`true` is often said to be defined as 1, which is correct, but true has a wider definition. Any integer which is non-zero is true, in a Boolean sense. So -1, 2 and -200 are all defined as true, too, in a Boolean sense.

Note that the true and false constants are typed in lowercase unlike `HIGH, LOW, INPUT, & OUTPUT.`

Data Types

Note: The Core/Photon/Electron uses a 32-bit ARM based microcontroller and hence the datatype lengths are different from a standard 8-bit system (for e.g. Arduino Uno).

void

The `void` keyword is used only in function declarations. It indicates that the function is expected to return no information to the function from which it was called.

```
//EXAMPLE
// actions are performed in the functions "setup" and "loop"
// but  no information is reported to the larger program

void setup()
{
  // ...
}

void loop()
{
  // ...
}
```

boolean

A `boolean` holds one of two values, `true` or `false`. (Each boolean variable occupies one byte of memory.)

```
//EXAMPLE

int LEDpin = D0;       // LED on D0
int switchPin = A0;   // momentary switch on A0, other side connected to
ground

boolean running = false;

void setup()
{
  pinMode(LEDpin, OUTPUT);
  pinMode(switchPin, INPUT_PULLUP);
}

void loop()
{
  if (digitalRead(switchPin) == LOW)
```

```
  {  // switch is pressed - pullup keeps pin high normally
    delay(100);                          // delay to debounce switch
    running = !running;                  // toggle running variable
    digitalWrite(LEDpin, running)        // indicate via LED
  }
}
```

char

A data type that takes up 1 byte of memory that stores a character value. Character literals are written in single quotes, like this: 'A' (for multiple characters - strings - use double quotes: "ABC"). Characters are stored as numbers however. You can see the specific encoding in the ASCII chart. This means that it is possible to do arithmetic on characters, in which the ASCII value of the character is used (e.g. 'A' + 1 has the value 66, since the ASCII value of the capital letter A is 65). See Serial.println reference for more on how characters are translated to numbers. The char datatype is a signed type, meaning that it encodes numbers from -128 to 127. For an unsigned, one-byte (8 bit) data type, use the `byte` data type.

```
//EXAMPLE

char myChar = 'A';
char myChar = 65;      // both are equivalent
```

unsigned char

An unsigned data type that occupies 1 byte of memory. Same as the `byte` datatype. The unsigned char datatype encodes numbers from 0 to 255. For consistency of Arduino programming style, the `byte` data type is to be preferred.

```
//EXAMPLE

unsigned char myChar = 240;
```

byte

A byte stores an 8-bit unsigned number, from 0 to 255.

```
//EXAMPLE

byte b = 0x11;
```

int

Integers are your primary data-type for number storage. On the Core/Photon/Electron, an int stores a 32-bit (4-byte) value. This yields a range of -2,147,483,648 to 2,147,483,647 (minimum value of -2^31 and a maximum value of (2^31) - 1). int's store negative numbers with a technique called 2's complement math. The highest bit, sometimes referred to as the "sign" bit, flags the number as a negative number. The rest of the bits are inverted and 1 is added.

Other variations:

- `int32_t` : 32 bit signed integer
- `int16_t` : 16 bit signed integer
- `int8_t` : 8 bit signed integer

unsigned int

The Core/Photon/Electron stores a 4 byte (32-bit) value, ranging from 0 to 4,294,967,295 (2^32 - 1). The difference between unsigned ints and (signed) ints, lies in the way the highest bit, sometimes referred to as the "sign" bit, is interpreted.

Other variations:

- `uint32_t` : 32 bit unsigned integer
- `uint16_t` : 16 bit unsigned integer
- `uint8_t` : 8 bit unsigned integer

word

`word` stores a 32-bit unsigned number, from 0 to 4,294,967,295.

long

Long variables are extended size variables for number storage, and store 32 bits (4 bytes), from -2,147,483,648 to 2,147,483,647.

unsigned long

Unsigned long variables are extended size variables for number storage, and store 32 bits (4 bytes). Unlike standard longs unsigned longs won't store negative numbers, making their range from 0 to 4,294,967,295 (2^32 - 1).

short

A short is a 16-bit data-type. This yields a range of -32,768 to 32,767 (minimum value of -2^15 and a maximum value of (2^15) - 1).

float

Datatype for floating-point numbers, a number that has a decimal point. Floating-point numbers are often used to approximate analog and continuous values because they have greater resolution than integers. Floating-point numbers can be as large as 3.4028235E+38 and as low as -3.4028235E+38. They are stored as 32 bits (4 bytes) of information.

Floating point numbers are not exact, and may yield strange results when compared. For example 6.0 / 3.0 may not equal 2.0. You should instead check that the absolute value of the difference between the numbers is less than some small number. Floating point math is also much slower than integer math in performing calculations, so should be avoided if, for example, a loop has to run at top speed for a critical timing function. Programmers often go to some lengths to convert floating point calculations to integer math to increase speed.

double

Double precision floating point number. On the Core/Photon/Electron, doubles have 8-byte (64 bit) precision.

string - char array

A string can be made out of an array of type `char` and null-terminated.

```
// EXAMPLES

char Str1[15];
char Str2[8] = {'a', 'r', 'd', 'u', 'i', 'n', 'o'};
char Str3[8] = {'a', 'r', 'd', 'u', 'i', 'n', 'o', '\0'};
char Str4[ ] = "arduino";
char Str5[8] = "arduino";
char Str6[15] = "arduino";
```

Possibilities for declaring strings:

- Declare an array of chars without initializing it as in Str1
- Declare an array of chars (with one extra char) and the compiler will add the required null character, as in Str2
- Explicitly add the null character, Str3
- Initialize with a string constant in quotation marks; the compiler will size the array to fit the string constant and a terminating null character, Str4
- Initialize the array with an explicit size and string constant, Str5
- Initialize the array, leaving extra space for a larger string, Str6

Null termination: Generally, strings are terminated with a null character (ASCII code 0). This allows functions (like Serial.print()) to tell where the end of a string is. Otherwise, they would continue reading subsequent bytes of memory that aren't actually part of the string. This means that your string needs to have space for one more character than the text you want it to contain. That is why Str2 and Str5 need to be eight characters, even though "arduino" is only seven - the last position is automatically filled with a null character. Str4 will be automatically sized to eight characters, one for the extra null. In Str3, we've explicitly included the null character (written '\0') ourselves. Note that it's possible to have a string without a final null character (e.g. if you had specified the length of Str2 as seven instead of eight). This will break most functions that use strings, so you shouldn't do it intentionally. If you notice something behaving strangely (operating on characters not in the string), however, this could be the problem.

Single quotes or double quotes? Strings are always defined inside double quotes ("Abc") and characters are always defined inside single quotes('A').

Wrapping long strings

```
//You can wrap long strings like this:
char myString[] = "This is the first line"
" this is the second line"
" etcetera";
```

Arrays of strings: It is often convenient, when working with large amounts of text, such as a project with an LCD display, to setup an array of strings. Because strings themselves are arrays, this is in actually an example of a two-dimensional array. In the code below, the asterisk after the datatype char "char*" indicates that this is an array of "pointers". All array names are actually pointers, so this is required to make an array of arrays. Pointers are one of the more esoteric parts of C for beginners to understand, but it isn't necessary to understand pointers in detail to use them effectively here.

```
//EXAMPLE

char* myStrings[] = {"This is string 1", "This is string 2",
"This is string 3", "This is string 4", "This is string 5",
"This is string 6"};

void setup(){
  Serial.begin(9600);
}

void loop(){
  for (int i = 0; i < 6; i++) {
    Serial.println(myStrings[i]);
    delay(500);
  }
}
```

String - object

More info can be found here.

array

An array is a collection of variables that are accessed with an index number.

Creating (Declaring) an Array: All of the methods below are valid ways to create (declare) an array.

```
int myInts[6];
int myPins[] = {2, 4, 8, 3, 6};
int mySensVals[6] = {2, 4, -8, 3, 2};
char message[6] = "hello";
```

You can declare an array without initializing it as in myInts.

In myPins we declare an array without explicitly choosing a size. The compiler counts the elements and creates an array of the appropriate size. Finally you can both initialize and size your array, as in mySensVals. Note that when declaring an array of type char, one more element than your initialization is required, to hold the required null character.

Accessing an Array: Arrays are zero indexed, that is, referring to the array initialization above, the first element of the array is at index 0, hence

`mySensVals[0] == 2, mySensVals[1] == 4`, and so forth. It also means that in an array with ten elements, index nine is the last element. Hence:

```
int myArray[10] = {9,3,2,4,3,2,7,8,9,11};
//  myArray[9]    contains the value 11
//  myArray[10]   is invalid and contains random information (other memory
address)
```

For this reason you should be careful in accessing arrays. Accessing past the end of an array (using an index number greater than your declared array size - 1) is reading from memory that is in use for other purposes. Reading from these locations is probably not going to do much except yield invalid data. Writing to random memory locations is definitely a bad idea and can often lead to unhappy results such as crashes or program

malfunction. This can also be a difficult bug to track down. Unlike BASIC or JAVA, the C compiler does no checking to see if array access is within legal bounds of the array size that you have declared.

To assign a value to an array: `mySensVals[0] = 10;`

To retrieve a value from an array: `x = mySensVals[4];`

Arrays and FOR Loops: Arrays are often manipulated inside `for` loops, where the loop counter is used as the index for each array element. To print the elements of an array over the serial port, you could do something like the following code example. Take special note to a MACRO called `arraySize()` which is used to determine the number of elements in `myPins`. In this case, arraySize() returns 5, which causes our `for` loop to terminate after 5 iterations. Also note that `arraySize()` will not return the correct answer if passed a pointer to an array.

```
int myPins[] = {2, 4, 8, 3, 6};
for (int i = 0; i < arraySize(myPins); i++) {
  Serial.println(myPins[i]);
}
```

Other Functions

The C standard library and other Linux libraries are available on the Raspberry Pi. See this description of the standard library.

For advanced use cases, those functions are available for use in addition to the functions outlined above.

Preprocessor

When you are using the Particle Device Cloud to compile your `.ino` source code, a preprocessor comes in to modify the code into C++ requirements before producing the binary file used to flash onto your devices.

```
// EXAMPLE
/* This is my awesome app! */
#include "TinyGPS++.h"

TinyGPSPlus gps;
enum State { GPS_START, GPS_STOP };

void updateState(State st); // You must add this prototype

void setup() {
  updateState(GPS_START);
}

void updateState(State st) {
  // ...
}

void loop() {
  displayPosition(gps);
}

void displayPosition(TinyGPSPlus &gps) {
  // ...
}

// AFTER PREPROCESSOR
#include "Particle.h" // <-- added by preprocessor
/* This is my awesome app! */
#include "TinyGPS++.h"

void setup(); // <-- added by preprocessor
void loop();  // <-- added by preprocessor
void displayPosition(TinyGPSPlus &gps); // <-- added by preprocessor

TinyGPSPlus gps;
enum State { GPS_START, GPS_STOP };

void updateState(State st); // You must add this prototype

void setup() {
  updateState(GPS_START);
}
```

```
void updateState(State st) {
  // ...
}

void loop() {
  displayPosition(gps);
}

void displayPosition(TinyGPSPlus &gps) {
  // ...
}
```

The preprocessor automatically adds the line `#include "Particle.h"` to the top of the file, unless your file already includes "Particle.h", "Arduino.h" or "application.h".

The preprocessor adds prototypes for your functions so your code can call functions declared later in the source code. The function prototypes are added at the top of the file, below `#include` statements.

If you define custom classes, structs or enums in your code, the preprocessor will not add prototypes for functions with those custom types as arguments. This is to avoid putting the prototype before the type definition. This doesn't apply to functions with types defined in libraries. Those functions will get a prototype.

If you need to include another file or define constants before Particle.h gets included, define `PARTICLE_NO_ARDUINO_COMPATIBILITY` to 1 to disable Arduino compatibility macros, be sure to include Particle.h manually in the right place.

If you are getting unexpected errors when compiling valid code, it could be the preprocessor causing issues in your code. You can disable the preprocessor by adding this pragma line. Be sure to add `#include "Particle.h"` and the function prototypes to your code.

```
#pragma PARTICLE_NO_PREPROCESSOR
//
#pragma SPARK_NO_PREPROCESSOR
```

Device OS Versions

Particle Device OS firmware is open source and stored here on GitHub.

New versions are published here on GitHub as they are created, tested and deployed.

New version release process

The process in place for releasing all Device OS versions as prerelease or default release versions can be found here on GitHub.

GitHub Release Notes

Please go to GitHub to read the Changelog for your desired firmware version (Click a version below).

Firmware Version							
v1.4.x default releases	v1.4.0	v1.4.1	v1.4.2	v1.4.3	v1.4.4	-	-
v1.4.x prereleases	v1.4.0-rc.1	v1.4.1-rc.1	-	-	-	-	-
v1.3.x default releases	v1.3.1	-	-	-	-	-	-
v1.3.x prereleases	v1.3.0-rc.1	v1.3.1-rc.1	-	-	-	-	-
v1.2.x default releases	v1.2.1	-	-	-	-	-	-
v1.2.x prereleases	v1.2.0-beta.1	v1.2.0-rc.1	v1.2.1-rc.1	v1.2.1-rc.2	v1.2.1-rc.3	-	-
v1.1.x default releases	v1.1.0	v1.1.1	-	-	-	-	-
v1.1.x prereleases	v1.1.0-rc.1	v1.1.0-rc.2	v1.1.1-rc.1	-	-	-	-
v1.0.x default releases	v1.0.0	v1.0.1	-	-	-	-	-
v1.0.x prereleases	v1.0.1-rc.1	-	-	-	-	-	-
v0.8.x-rc.x prereleases	v0.8.0-rc.10	v0.8.0-rc.11	v0.8.0-rc.12	v0.8.0-rc.14	-	-	-
v0.8.x-rc.x prereleases	v0.8.0-rc.1	v0.8.0-rc.2	v0.8.0-rc.3	v0.8.0-rc.4	v0.8.0-rc.7	v0.8.0-rc.8	v0.8.0-rc.9
v0.7.x default releases	v0.7.0	-	-	-	-	-	-
v0.7.x-rc.x prereleases	v0.7.0-rc.1	v0.7.0-rc.2	v0.7.0-rc.3	v0.7.0-rc.4	v0.7.0-rc.5	v0.7.0-rc.6	v0.7.0-rc.7
v0.6.x default releases	v0.6.0	v0.6.1	v0.6.2	v0.6.3	v0.6.4	-	-
v0.6.x-rc.x prereleases	v0.6.2-rc.1	v0.6.2-rc.2	-	-	-	-	-
-	v0.6.0-rc.1	v0.6.0-rc.2	v0.6.1-rc.1	v0.6.1-rc.2	-	-	-
v0.5.x default releases	v0.5.0	v0.5.1	v0.5.2	v0.5.3	v0.5.4	v0.5.5	-
v0.5.x-rc.x prereleases	v0.5.3-rc.1	v0.5.3-rc.2	v0.5.3-rc.3	-	-	-	-

Programming and Debugging Notes

If you don't see any notes below the table or if they are the wrong version, please select your Firmware Version in the table below to reload the page with the correct notes. Otherwise, you must have come here from a firmware release page on GitHub and your version's notes will be found below the table :)

Firmware Version							
v1.4.x default releases	v1.4.0	v1.4.1	v1.4.2	v1.4.3	v1.4.4	-	-
v1.4.x prereleases	v1.4.0-rc.1	v1.4.1-rc.1	-	-	-	-	
v1.3.x default releases	v1.3.1	-	-	-	-	-	-
v1.3.x prereleases	v1.3.0-rc.1	v1.3.1-rc.1	-	-	-	-	
v1.2.x default releases	v1.2.1	-	-	-	-	-	-
v1.2.x prereleases	v1.2.0-beta.1	v1.2.0-rc.1	v1.2.1-rc.1	v1.2.1-rc.2	v1.2.1-rc.3	-	
v1.1.x default releases	v1.1.0	v1.1.1	-	-	-	-	-
v1.0.x prereleases	v1.0.1-rc.1	-	-	-	-	-	-
v1.1.x prereleases	v1.1.0-rc.1	v1.1.0-rc.2	v1.1.1-rc.1	-	-		
v1.0.x default releases	v1.0.0	v1.0.1	-	-	-	-	-
v1.0.x prereleases	v1.0.1-rc.1	-	-	-	-	-	-
v0.8.x-rc.x prereleases	v0.8.0-rc.10	v0.8.0-rc.11	v0.8.0-rc.12	v0.8.0-rc.14	-	-	-
v0.8.x-rc.x prereleases	v0.8.0-rc.1	v0.8.0-rc.2	v0.8.0-rc.3	v0.8.0-rc.4	v0.8.0-rc.7	v0.8.0-rc.8	v0.8.0-rc.9
v0.7.x default releases	v0.7.0	-	-	-	-	-	-
v0.7.x-rc.x prereleases	v0.7.0-rc.1	v0.7.0-rc.2	v0.7.0-rc.3	v0.7.0-rc.4	v0.7.0-rc.5	v0.7.0-rc.6	v0.7.0-rc.7
v0.6.x default releases	v0.6.0	v0.6.1	v0.6.2	v0.6.3	v0.6.4	-	-
v0.6.x-rc.x prereleases	v0.6.2-rc.1	v0.6.2-rc.2	-	-	-	-	-
-	v0.6.0-rc.1	v0.6.0-rc.2	v0.6.1-rc.1	v0.6.1-rc.2	-	-	-
v0.5.x default releases	v0.5.0	v0.5.1	v0.5.2	v0.5.3	v0.5.4	v0.5.5	-
v0.5.x-rc.x prereleases	v0.5.3-rc.1	v0.5.3-rc.2	v0.5.3-rc.3	-	-	-	-