# HullPixelbot Code Specification

Version 2.1

Rob Miles

## Arduino Connection

The program monitors the primary serial port on an Arduino device. Statements that are entered are executed immediately or stored internally using the RM command.

The connection between the Arduino and the host is configured to run at 1200 baud. This is to allow successful storage of program code in the EEPROM in the Arduino.

## Statement format

All statements are a single, zero terminated, string.

A statement is one or more alphabetic command characters followed by a number of numeric parameters. Characters can be upper or lower case. In this document they will be expressed in upper case.

Numbers are expressed as signed decimal integers with an optional leading sign character which can be + or -. If the sign character is omitted, the value is assumed to be positive. Numbers are terminated by a non-digit character or the end of the statement. In this document a numeric value is expressed as a sequence of three lower case characters, for example ddd. The function of the sequence will be explained in the accompanying text.  Any alphanumeric character (0-9 and A-Z) will be represented by the character c.

Parameters are separated by a single non-numeric character. In this document the separator is expressed as a single comma.

A comment statement starts with a hash character (#) and is ignored by the robot.

## Information: Initial character I

### Version: IV

```
IV
```

The robot responds with the version of the software followed by a linefeed character.

### Distance: ID

```
ID
```

The robot responds with current reading from the distance sensor followed by a linefeed character.

### Program: IP

```
IP
```

The robot responds with a listing of the current program.

### Status: IS

```
IS
```

The robot responds with current program status as a single digit value:

```
0       PROGRAM_STOPPED
1       PROGRAM_PAUSED
2       PROGRAM_ACTIVE
3       PROGRAM_AWAITING_MOVE_COMPLETION
4       PROGRAM_AWAITING_DELAY_COMPLETION5
5       SYSTEM_CONFIGURATION_CONNECTION
```

A status value of 5 indicates that the serial connection is actually to a configuration program rather than a live robot. This is used during configuration of the network processor in the Hull Pixelbot. You will never see this status value during normal operation. The configuration options for the robot are described in the document “Hull Pixelbot Configuration”.

### Messaging: IM

```
IMddd
```

This command is used to set the level of messaging that is produced by the robot when programs are running. The command is followed by an 8 bit decimal value that sets the messaging level. The message levels are set as bits in the messaging level value.

| | |
|---|---|
| `STATEMENT_CONFIRMATION 1` | outputs a confirmation message after each statement. This will either be xxOK, where xx is the command, or xxFAIL: reason. Some commands, for example conditional jumps, will give additional information. |
| `LINE_NUMBERS 2` | displays the program position of each statement prior to execution |
| `ECHO_DOWNLOADS 4` | echoes each downloaded statement during a remote download |
| `DUMP_DOWNLOADS 8` | dumps a downloaded program before executing it |

If the corresponding bitfield is set the program will output information as described. Note that these commands can result in significant traffic on the serial connection and are only intended to be used for debugging.

When the robot is restarted the messaging level is set to 0 (i.e. all messages are turned off).

## Read sensors: IR

```
IR
```

This command reads all the sensors on the robot and provides a json formatted string that gives their values. The present version presents the information in the following form:

```
{"version":1,"distance":[3],"lightLevel":[311,312,317]}
```

The version value allows the consumer to know the version of the data packet. The distance and lightLevel arrays are populated with distance and light level values. The distance value is nominally in cm and the light level values are in the range 0-1023 and reflect the analogue values on ports A0, A1 and A2 respectively.

## Movement: Initial character M

### Forwards: MF

```
MFddd,ttt
```

The robot moves the number of steps given by the decimal value ddd. If the number is negative the robot moves backwards that number of steps. If the robot is already moving this command will replace the existing one.  The command can be followed by a comma and an optional time value that give the number of ticks (tenths of a second) that the move will take to complete. If the time value (and the comma) are omitted the robot will move as fast as possible.

```
MF100
```

This would move the robot forwards 100 mm as quickly as possible.

```
MF150,100
```

This would move the robot 150 mm and take 10 seconds to complete (remember that a “tick” is a tenth of a second).

The robot starts moving as soon as the command is received. If the move can be performed and the `STATEMENT_CONFIRMATION` flag is set the robot replies with:

```
MFOK
```

Note that this does not meant that the move command has been completed, rather that the robot has received and understood the command and has started moving.

If the time requested is not possible because the robot cannot move that quickly (for example move 100 mm in 1 tick) the move will not take place. If the `STATEMENT_CONFIRMATION` flag is set the robot replies with an error message:

```
MFFail
```

### Rotate: MR

```
MRddd,ttt
```

The robot rotates clockwise the given number of degrees given by the value ddd (there are 360 degrees in a circle). If the number is negative the robot rotates anticlockwise that number of steps. If the robot is already moving this command will replace the existing one. If the `STATEMENT_CONFIRMATION` flag is set the robot replies with:

```
MROK
```

Note that this does not meant that the move command has been completed, rather that the robot has received and understood the command and has started moving.

If the time is omitted the robot will perform the rotation as quickly as possible.

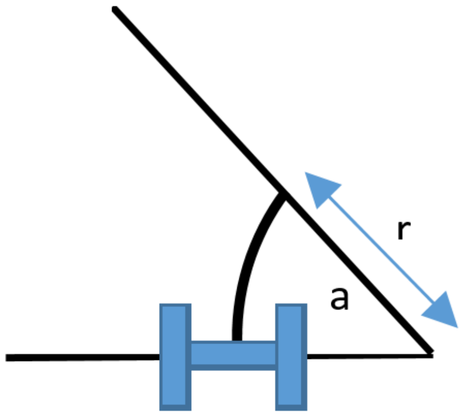
If the time requested is not possible because the robot cannot rotate that quickly (for example rotate 200 mm in 1 tick) the move will not take place. If the `STATEMENT_CONFIRMATION` flag is set the robot replies with an error message:

```
MRFail
```

## Move Arc: MA

```
MArr,aa,tt
```

This statement allows the robot to move in an arc. The first parameter is the radius of the arc, the second is the angular distance around the arc and the third is the time over which the move is to take place.



The figure above shows how this works. If the radius is positive the curve will be about a point which is to the right of the robot, and the robot will turn clockwise as it moves. If the radius is negative the curve will be about a point that is to the left of the robot, and the robot will turn counterclockwise.  The centre point of the arc is on a line drawn between the two wheels.

If the `STATEMENT_CONFIRMATION` flag is set the robot replies with:

```
MAOK
```

Note that this does not meant that the move command has been completed, rather that the robot has received and understood the command and has started moving.

If the time requested is not possible because the robot cannot move that quickly the move will not take place. If the `STATEMENT_CONFIRMATION` flag is set the robot replies with an error message:

```
MAFail
```

As an example the following statement would cause the robot to traverse a complete circle and take a minute to perform this:

```
MA100,360,600
```

The radius of the circle is 100mm, the distance around the circle is 360 degrees and the move will take 600 ticks (remember that a tick is a 10th of a second)

## Move Motors: MM

```
MMlll,rrr,ttt
```

This statement provides direct control of the speed and distance moved of each individual wheel.  It is followed by three integer values that give the distance to be moved for each motor and the time to be taken for the move.

When the motor has moved the specified distance it stops. The distance values can be signed, in which case the motor will run in reverse. The

This is the command that is the basis of the move and rotate commands above.

If the `STATEMENT_CONFIRMATION` flag is set the robot replies with:

```
MMOK
```

Note that this does not meant that the move command has been completed, rather that the robot has received and understood the command and has started moving.  If the turn could not be performed a fail message is generated followed by a value which indicates the reason for the failure.

```
MMFail: d
```

The value of d gives the reason why the move could not take place:

```
1         Left_Distance_Too_Large
2         Right_Distance_Too_Large
3         Left_And_Right_Distance_Too_Large
```

## Check moving: MC

```
MC
```

This command can be used to determine whether the robot has completed a requested move operation. If the motors are still moving the robot replies with:

```
MCmove
```

If the motors are stopped the robot replies with:

```
MCstopped
```

Note that these messages are sent irrespective of the state of the `STATEMENT_CONFIRMATION` flag.

## Stop robot: MS

```
MS
```

Stops any current move behaviour.

If the `STATEMENT_CONFIRMATION` flag is set the robot replies with:

```
MSOK
```

## Wheel configure: MW

```
MWlll,rrr,sss
```

| | |
|---|---|
| lll | left wheel diameter in mm |
| rrr | right wheel diameter in mm |
| sss | wheel separation in mm |

This command can be used to configure the dimensions and spacing of the wheels fitted to the robot. The values are used to calculate all the robot movement. The values are stored in EEPROM inside the robot. The very first time the robot is turned on the dimensions are set to their default values:

| | |
|---|---|
| Wheel diameter | 69mm |
| Wheel spacing | 110mm |

These are the dimensions based on the stl files for the robot.

If the `STATEMENT_CONFIRMATION` flag is set the robot replies with:

```
MWOK
```

Note that these values are not validated in any way, so if you put silly dimensions you may find that silly things happen. And quite right too.

## View wheel configuration: MV

```
MV
```

This allows you to view the current settings of the wheel configuration values. The display is as follows:

```
Wheel settings
Left diameter: 69
Right diameter: 69
Wheel spacing: 110
```

## Pixel control: Initial character P

The Hull Pixelbot can be fitted with a coloured “pixel”. This can be a single pixel, or it can be composed of a ring of 12 pixels. The Pixel control commands allow you to control individual pixels in the ring, or set an overall “flickering” colour. The rate at which the colour flickers can also be controlled.

### Remote Coloured Candle: PC

```
PCrrr,ggg,bbb
```

| | |
|---|---|
| rrr | red intensity in range 0-255 |
| ggg | green intensity in range 0-255 |
| bbb | blue intensity in range 0-255 |

Sets the pixel display to show a flickering candle of the given colour. This sets the colour of all the pixels in the display.

If the `STATEMENT_CONFIRMATION` flag is set the robot replies with:

```
PCOK
```

If any of the values are missing an appropriate message is displayed, for example:

```
PC255,
```

- would generate the error:

```
PCFAIL: mising colours after red in readColor
```

Note that this message is only output if the `STATEMENT_CONFIRMATION` flag is set.

### Pixels Off: PO

```
PO
```

Turns off all the pixels in the pixel display.

If the `STATEMENT_CONFIRMATION` flag is set the robot replies with:

```
POOK
```

### Pixels Flicker update speed: PF

```
PFnn
```

Sets the flicker update speed for the pixels. The larger the number, the faster the pixels will change colour. The speed is given in the range 1 to 20. A speed of 1 is very gentle, a speed of 20 is manic. When the program starts the speed is set to 8. Values outside the range 1-20 are clamped.

If the `STATEMENT_CONFIRMATION` flag is set the robot replies with:

```
PFOK
```

## Remote Set Individual Pixel: PI

```
PIppp,rrr,ggg,bbb
```

| | |
|---|---|
| ppp | number of the pixel to be set in the range 0 to n-1, where n is the number of pixels |
| rrr | red intensity in range 0-255 |
| ggg | green intensity in range 0-255 |
| bbb | blue intensity in range 0-255 |

Set Individual to the given colour. The state and colours of the other pixels are not affected by this.

If the `STATEMENT_CONFIRMATION` flag is set the robot replies with:

```
PIOK
```

If any errors are detected in the values supplied an appropriate message is displayed instead of the OK message.

## Remote Crossfade color: PC

```
PXss,rrr,ggg,bbb
```

| | |
|---|---|
| ss | face speed in range 1-20 |
| rrr | red intensity in range 0-255 |
| ggg | green intensity in range 0-255 |
| bbb | blue intensity in range 0-255 |

Sets the pixel display to cross fade to a flickering candle of the given colour. This sets the colour of all the pixels in the display.

If the `STATEMENT_CONFIRMATION` flag is set the robot replies with:

```
PXOK
```

If any of the values are missing an appropriate message is displayed, for example:

```
PX20,
```

- would generate the error:

```
PXFAIL: mising colours after red in readColor
```

Note that this message is only output if the `STATEMENT_CONFIRMATION` flag is set.

## Program Control: Initial character C

These commands are performed when the robot is running a program sequence.  The can be entered directly into the robot, but they won't do much.

### Pause when the motors are active: CA

```
CA
```

The program pauses while the motors are active. This allows a program to wait until a movement has completed. If the `STATEMENT_CONFIRMATION` flag is set the robot replies with:

```
CAOK
```

Note the reply is sent when the command has been received **not** when the robot has completed the pause.

### Delay: CD

```
CDddd
```

The program pauses for the number of *ticks* given by the decimal value ddd. The number of ticks can be omitted:

```
CD
```

The program repeats the previous delay. If there was no previous delay the program does not delay. The delay starts as soon as the command is received.

A tick is a tenth of a second.

If the `STATEMENT_CONFIRMATION` flag is set the robot replies with:

```
CDOK
```

Note the reply is sent when the command has been received **not** when the robot has completed the delay. Ongoing move commands will continue to complete, and the robot will respond to other direct commands.

### Label: CL

```
CLcccc
```

This statement declares a label which can be used as the destination of a jump instruction. The label can be any number of characters and will be terminated by the end of the statement.

If the `STATEMENT_CONFIRMATION` flag is set the robot replies with:

```
CLOK
```

### Jump: CJ

```
CJcccc
```

This statement causes execution of the program to continue from the given label. The label can be any number of characters and will be terminated by the end of the statement. The program must contain the label requested, or the program will stop.

If the `STATEMENT_CONFIRMATION` flag is set the robot replies with the following messages:

If the label is found and the jump performed the robot replies:

```
CJOK
```

If the label is missing from the program the robot replies with:

```
CJFAIL: no dest
```

## Coin toss jump: CT

```
CTcccc
```

This statement causes execution of the program to continue from the given label fifty percent of the time. The rest of the time the program continues. The label can be any number of characters and will be terminated by the end of the statement. The program must contain the label requested, or the program will stop.

If the `STATEMENT_CONFIRMATION` flag is set the robot replies with the following messages:

If the label is found and the jump performed the robot replies:

```
CTjump
```

If the label is found and the jump not performed the robot replies:

```
CTcontinue
```

If the label is missing from the program the robot replies with:

```
CTFAIL: no dest
```

## Jump when motors inactive: CI

```
CIccc
```

The program will jump to the given label if the motors are inactive.  The robot replies with:

```
CIOK
```

## Measure Distance: CM

```
CMddd,cccc
```

This statement causes execution of the program to continue from the given label if the distance sensor reading is less than the given distance value. The value is given in centimetres.

The label can be any number of characters and will be terminated by the end of the statement. The program must contain the label requested, or the program will stop. If the distance measured is greater than the given value, the program continues at the next statement.

If the `STATEMENT_CONFIRMATION` flag is set the robot replies with the following messages:

If the label is not present in the instruction the robot replies with:

```
CMFail: missing dest
```

If the label is found the robot replies with:

```
CMFail: label not found
```

If the label is found and the distance is less the robot replies with:

```
CMjump
```

If the label is found and the distance is greater the robot replies with:

```
CMcontinue
```

## Remote Management: Initial character R

These commands are performed to allow a new stored program to be downloaded into the EEPROM in the robot and to control program execution by the robot drive system.

### Start Program: RS

This statement starts the execution of the current program (if present).

```
RS
```

This statement is obeyed immediately upon receipt.  The program is started from the first statement in the program.

If the `STATEMENT_CONFIRMATION` flag is set the robot replies with:

```
RSOK
```

### Halt Program: RH

This statement halts the execution of the current program (if present).

```
RH
```

This statement is obeyed immediately upon receipt. The program is halted. It cannot be resumed, it must be restarted.

If the `STATEMENT_CONFIRMATION` flag is set the robot replies with:

```
RHOK
```

### Pause Program: RP

This statement pauses the execution of the current program (if present).

```
RP
```

This statement is obeyed immediately upon receipt. The program is paused. It can be resumed using the RR statement.

If the `STATEMENT_CONFIRMATION` flag is set the robot replies with:

```
RPOK
```

### Resume Running: RR

This statement resumes the execution of the current program (if it has been paused).

```
RR
```

This statement is obeyed immediately upon receipt. The program is resumed.

If the `STATEMENT_CONFIRMATION` flag is set the robot replies with the following messages:

```
RROK
```

This is displayed if the program has been resumed.

```
RRFail:d
```

This is displayed if the program cannot be resumed. The single digit value following the Fail: gives the current program state as for the IS command.

## Remote Download: RM

This statement stops the execution of the current program and switches off the pixel display ready for the receipt of a new program.

```
RM
```

The program is sent as a sequence of statements that directly follow the RM command. Each statement is stored in EEPROM for execution by the robot when the download is complete. A standard Arduino has enough internal storage for around 900 bytes of remote program storage.

Note that the RM command is terminated by a Carriage Return (CR) character (0x0D) as are all commands. Each statement in the program is separated from the next by the CR character. The end of the program is specified by an RE command (see next).

If the `STATEMENT_CONFIRMATION` flag is set the robot replies with the following message:

```
RMOK
```

If the `ECHO_DOWNLOADS` flag is set the robot echoes each statement as it is received.

## Remote Download Exit: RX

This statement completes a download started by the RM command.

If the `STATEMENT_CONFIRMATION` flag is set the robot replies with the following message:

```
RXOK
```

If the program was successfully received it is executed immediately.

If the `DUMP_DOWNLOADS` flag is set the robot dumps a listing of the received program as soon as it has been successfully received.