

Low Cost DCC (LC-DCC) 2.2  
Hardware Guide & Build Instructions  
24<sup>th</sup> April 2020

## Summary

Provided in this document are the LC-DCC controller hardware build instructions for the M3 and M4 processors.

The hardware design is provided free but the software resident in the ARM processors or for the Windows and Android applications must be licensed by purchasing a license from eBay.

## Disclaimer

The designers accept no responsibility for any damage to any train or accessory decoder connected to this DCC system through incorrect assembly or use of the hardware design.

Please read s-9.1\_electrical\_standards\_2006.pdf NMRA standard before purchasing and using a power supply. Also note some cheap power supplies can give over voltage output.

## License / Usage Terms

All the software components are protected by license. When you buy the software from eBay, you are entitled to one license which will be provided by Email, contact [support@swws.co.uk](mailto:support@swws.co.uk) with processor identification code. Extra licenses may be purchased via PayPal, go to <http://www.swws.co.uk/lc-dcc.html> and complete the PayPal order.

## Existing users of the 1.X design

Existing users will need to obtain a license key, this will be provided free if you have purchased via my eBay account. Users creating their own software who want to upgrade will also need to contact us to obtain an “unlock code” for their M3 or M4 processor. Also, the M3/M4 pins A6/A7/C0/C1/B0/B1 functions have changed so this document should be consulted.

## LC-DCC Forum

A low cost DCC forum can be found at <http://low-cost-dcc.freeforums.net>, this was created in March 2019.

## Buying On EBay

Please note that there are a number of false adverts on eBay that cannot provide support or valid updates for this project and may not even provide anything for your money. The idea of Low Cost DCC is to make available a quality product at a price that everyone can afford. Only buy from the designer and developer of this project. To ensure you are buying from the only official eBay listing check the seller information is as displayed below (seller: johncaffyn, location: Bristol). Any other listing is false.

Low Cost DCC Controller 2amp or 10amp with CV programming and BlueTooth

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Low Cost DCC 2.0

Configuration Track Control Check Updates  
Service Mode Time Table Exit LC-DCC

Have one to sell? [Sell it yourself](#)

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## Introduction

This book describes the hardware components used in the LC-DCC controller system and how to connect and configure the components for various LC-DCC controller designs.

## Components

This section describes the various components required to build an LC-DCC controller. The main components required are:

- Processor card either ARM Cortex M3 or Cortex M4 to generate the DCC command packets
- H Bridge to provide DCC signals and power to the tracks
- Optionally a current monitor used for current overload detection and detecting CV read acknowledge pulses
- Optionally a blue-tooth module to allow LC-DCC control wirelessly
- Optionally a FTDI serial adapter to allow connection to more than one PC application
- Optionally an ADC I2C ADS1115 for analogue control of engine speed using potentiometers

The ARM Cortex M3 processor option is an STM32F103 and the ARM Cortex M4 option is an STM32F411RE. The STM32F103 boards supported are the blue and black pill types. The STM32F411RE board supported is the STM Nucleo board.

### STM32F103 Blue Pill Board

This is the cheapest processor option which is an ARM Cortex M3 but requires soldering skills as they usually come without connectors attached when purchased from eBay. Cheapest purchase sites are eBay and Amazon.



### STM32F103 Black Pill Board

This is also a very cheap ARM Cortex M3 processor option but requires soldering skills as they usually come without connectors attached when purchased from eBay. This board also lacks a +5V pin for use with blue-tooth modules. Cheapest purchase sites are eBay and Amazon.



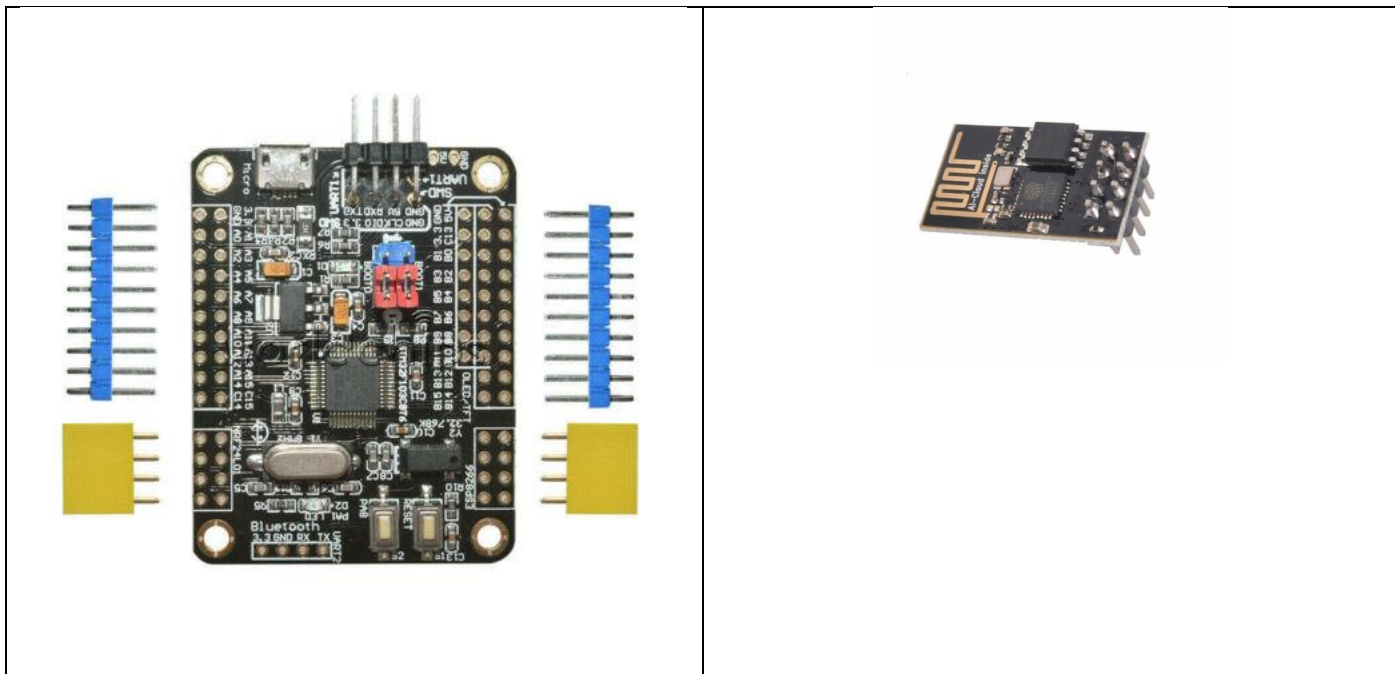
### STM32F411RE Nucleo Board

This is the most expensive processor option which is an ARM Cortex M4 and comes fully assembled and includes a programming interface via the USB connector. Cheapest purchase site is CPC Farnell.



## STM32F103 WIFI Board and ESP8266 Module

The board below is the only board used to support the WIFI version of the LC-DCC controller due to having connector support for the ESP8266 WIFI module also shown below. When buying from eBay this board is described as an STM32F103C8T6 core board.



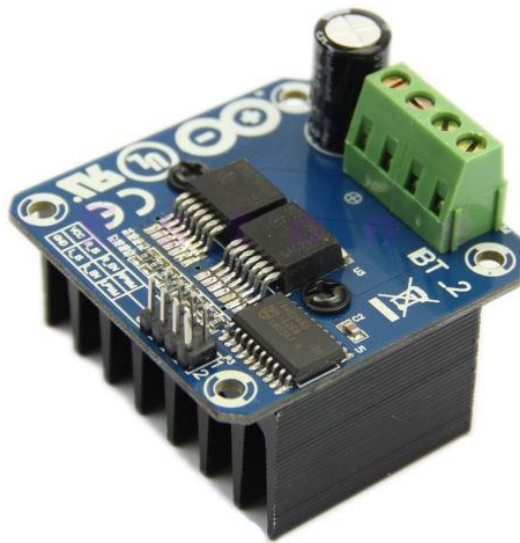
## L298N H Bridge

The purpose of the H Bridge is to convert the M3/M4 processor DCC packet signals into voltage levels suitable for DCC and to provide the current required to program and run the trains and accessories. The L298N has two outputs that can be used for two different track controls A and B. Each track output can supply up to 2 amps. Cheapest purchase sites are eBay and Amazon.



## IBT-2 H Bridge

The IBT-2 H Bridge can source up to 43 amps however it has only ever been tested to 10 amps with the LC-DCC controller system. This H Bridge is only a single output device and two are required if you want to run two tracks. Cheapest purchase sites are eBay and Amazon.



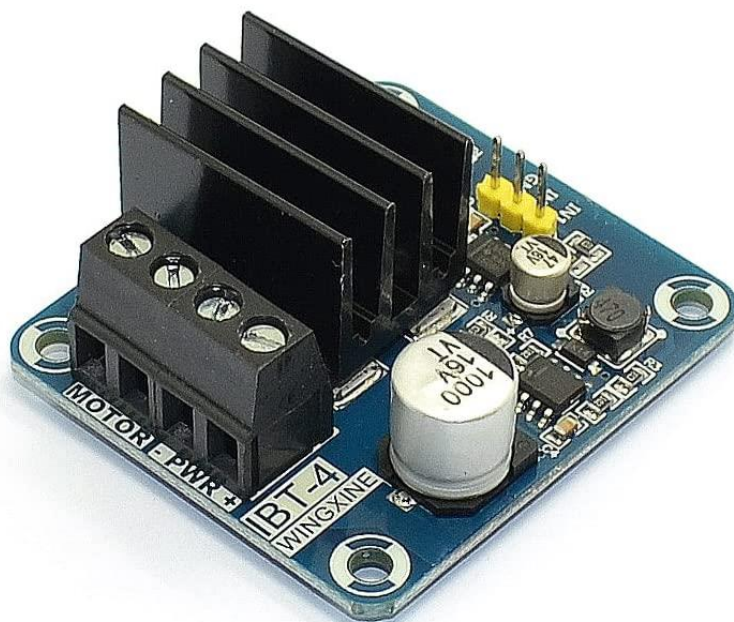
## DRV8871 H Bridge Module

The DRV8871 H Bridge module is 3.6A peak output module with no heatsink and current/temperature protection. This module allows for very small LC-DCC controllers to be built. This module needs LC-DCC controller software version 2.2 onwards as there is no enable control on the module.



## IBT-4 H Bridge

The IBT-4 H Bridge can source up to 50 amps however it has only ever been tested to 5 amps with the LC-DCC controller system. This H Bridge is only a single output device and two are required if you want to run two tracks. Cheapest purchase sites are eBay and Amazon. Note however the maximum input DC voltage for this bridge is 15V, so this bridge is only suitable for 00 gauge and smaller. This module needs LC-DCC controller software version 2.2 onwards as there is no enable control on the module. The module is smaller in volume than the IBT-2 H-Bridge.



## INA219 I2C Current Monitor

The INA219 is an I2C current monitor that can measure up to 3.2 amps as supplied. The current monitor capability is needed if you want current overload detection or the ability to read CV values from your decoders. Cheapest purchase sites are eBay and Amazon.



## HC-05 Blue-tooth Module

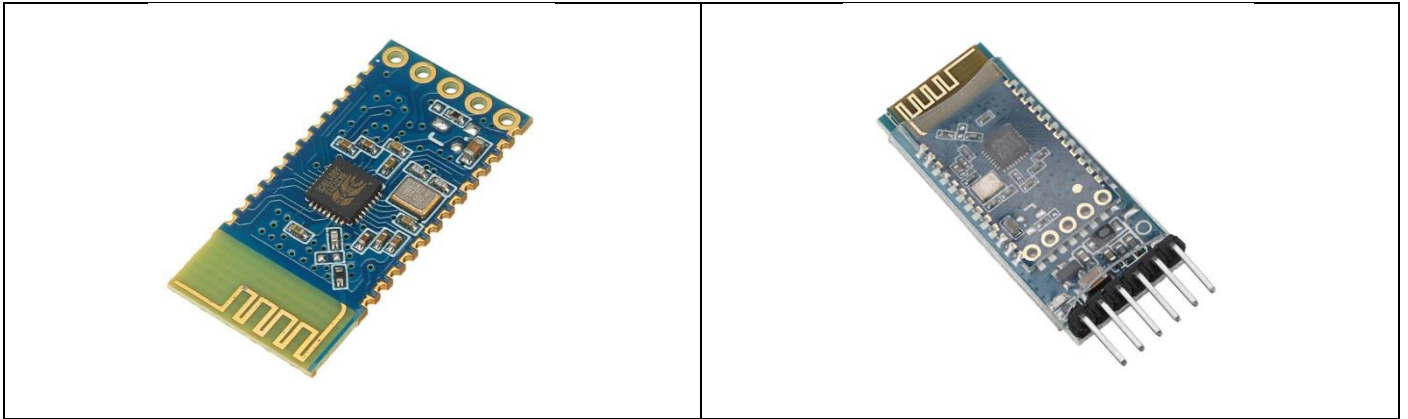
The HC-05 blue-tooth module allows the use of wireless controls with the LC-DCC controller. This is typically an Android phone or tablet. The TX and RX pins on the HC-05 must be connected to one of the M3 or M4 USART interfaces. The HC-05 TX must go to the M3/M4 USART RX pin and the HC-05 RX must go to the M3/M4 USART TX pin. The HC-05 should be powered using +5V from either the M3/M4 or L298N. Cheapest purchase sites are eBay and Amazon.



The blue tooth module must be configured to operate at 38400 baud. This can be done by using the blue tooth terminal application for the M3 or M4 processor found in the downloadable file `bt_terminal.zip`.

## JDY 30/31 Blue-tooth Module

The JDY blue-tooth module is a replacement for the HC-05 blue-tooth module. The module comes in 3.3V and 5V models.



The blue tooth module must be configured to operate at 38400 baud. This can be done by using the blue tooth terminal application for the M3 or M4 processor found in the downloadable file `bt_terminal.zip`.

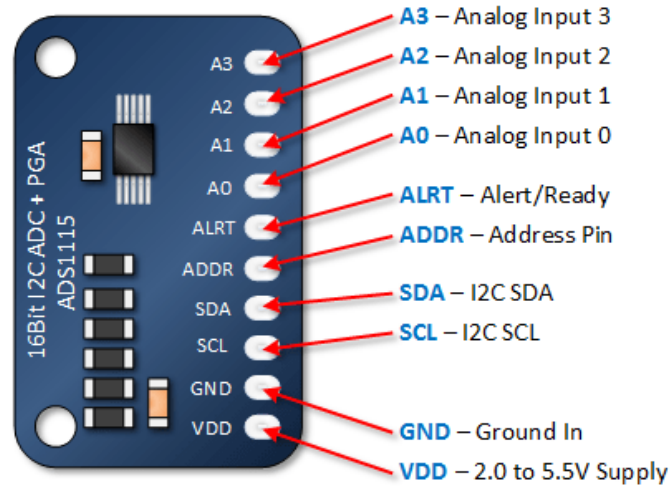
## FTDI USB Serial Adapter

The FTDI serial adapter allows connection to any of the M3 or M4 USART interfaces. This will allow control of the LC-DCC controller with another serial USB connected device such as a laptop. The FTDI RX and TX pins must be connected to the M3 or M4 TX and RX pins. Cheapest purchase sites are eBay and Amazon.



## Analogue Convertor for Potentiometer Speed Control

Both the M3 and M4 designs can optionally have analogue control added to them by the use of one or two 16-bit 4 channel ADC modules. The module connects to the I2C\_2 bus on the M3 (pins B10 & B11) or to the I2C\_3 bus on the M4 (pins PC9 & PA8). Up to eight potentiometers can be added to allow for analogue speed control on up to eight engines. The ADC module is an ADS1115. The VDD must be connected to 3.3V which must also be connected to one side of the potentiometer. The other side of the potentiometer must go to GND and the potentiometer centre tap must go to A0 or A1 or A2 or A3 on the ADS1115 module (see below).



The ADDR pin must be connected to GND for the first ADS1115 and to VDD if a second ADS1115 is added. If two ADS1115 modules are used then the SDA and SCL lines from both modules need to be connected to the M3 or M4 processor.

All potentiometers have engine speed zero as the middle of the potentiometer range. Centre detent linear potentiometers are suggested for this purpose with a value of 10k ohms.

The potentiometers must be set to give a maximum voltage read out when the M3 or M4 processor is powered up otherwise the potentiometer will not be enabled until a reading of more than 3.0V is detected.

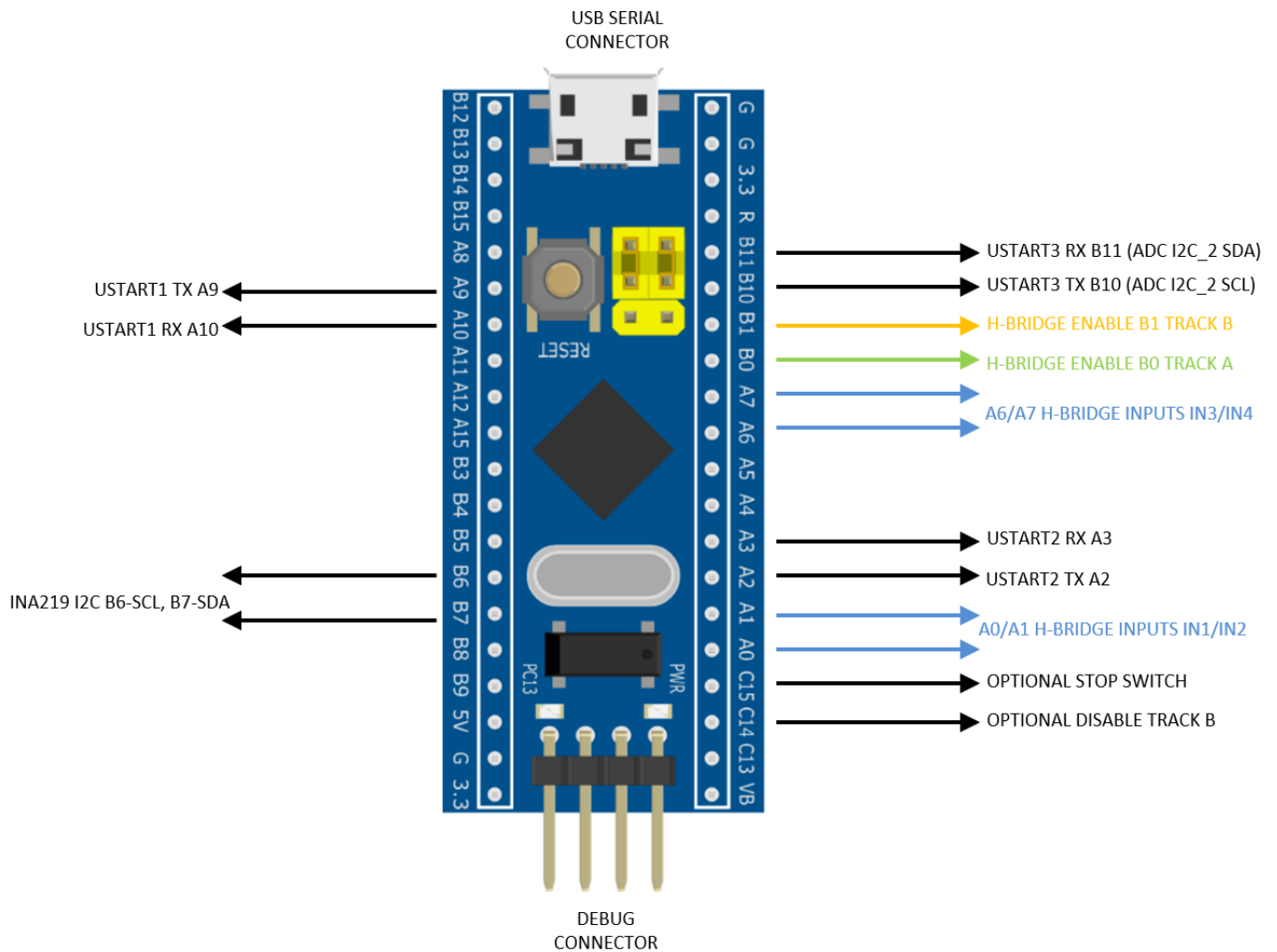
## STM ST-LINK V2 USB Adapter

This can be used to program the STM32F103 boards and can be purchased from eBay or Amazon. Four connections are required between the STM ST-LINK V2 and the STM32F103 board, these are GND, 3V3, CLK and DIO. The 3V3 is not needed if the board is powered via the USB connector.



## STM32F103 Blue Pill Board

The following diagram shows all connections possible for a blue pill board configured as an LC-DCC controller.



The USB connector is configured as a virtual communications port (VCP) so can be controlled using a Windows PC application. The USART connections can be connected to either HC05 blue-tooth modules or an FTDI USB serial adapters. Programming can be achieved by using a ST-LINK V2 USB programmer or by using USART1 and changing the boot jumpers (yellow in the above diagram).

## STM32F103 Connections Blue/Black Pill Boards

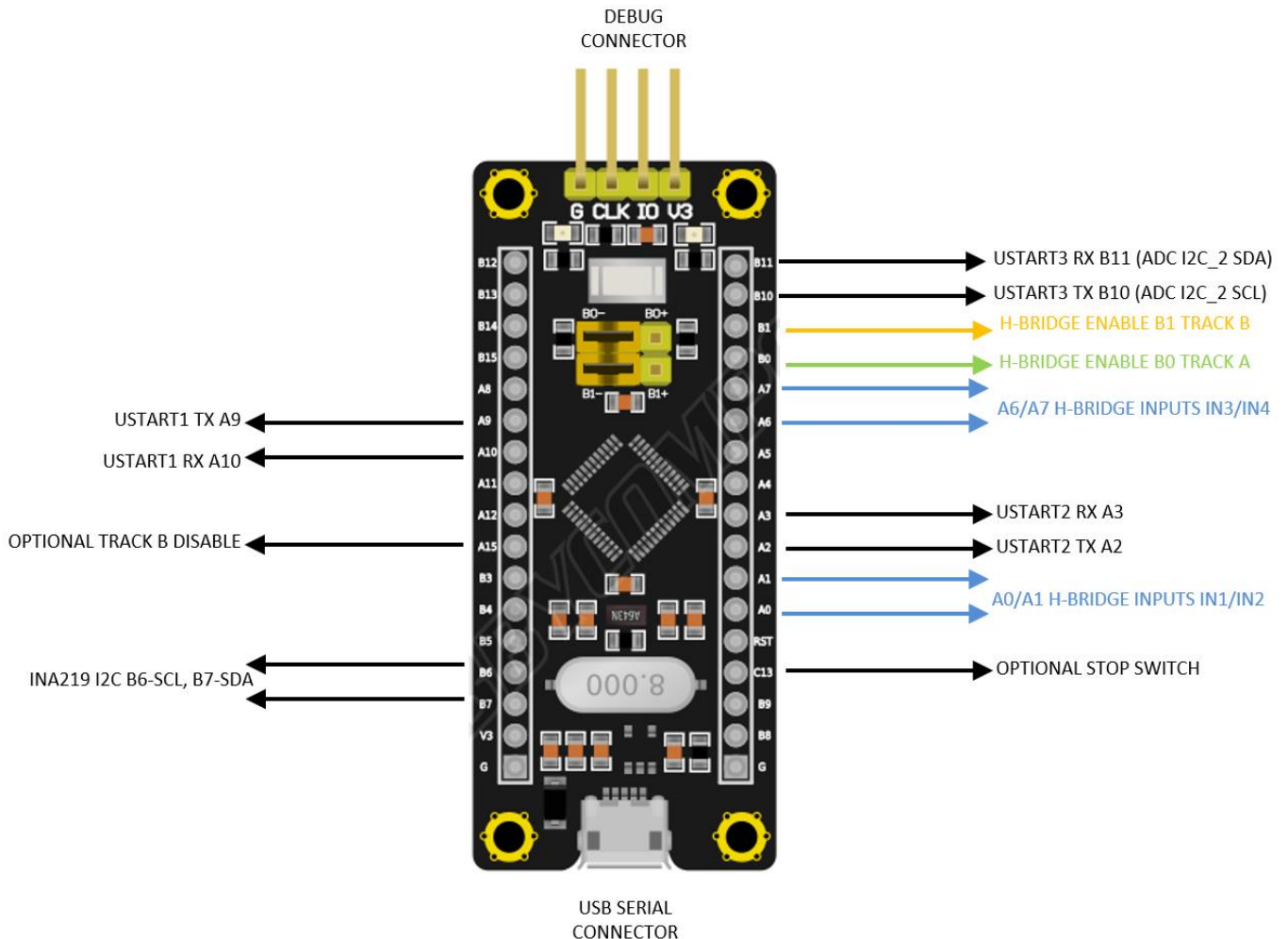
STM32F103 Pin	Connection	Notes
A0	L298N IN1 or IBT-2 LPWM Input	H Bridge DCC Command Input
A1	L298N IN2 or IBT-2 RPWM Input	H Bridge DCC Command Input
A6	L298N IN3 or IBT-2 LPWM Input	H Bridge DCC Command Input
A7	L298N IN4 or IBT-2 RPWM Input	H Bridge DCC Command Input
B0 <sup>2</sup>	L298N Motor Enable or IBT-2 L_EN and R_EN	Track A Enable
B1 <sup>2</sup>	L298N Motor Enable or IBT-2 L_EN and R_EN	Track B Enable
B6	INA219 SCL Input	I2C_1 Bus
B7	INA219 SDA Input	I2C_1 Bus
B10 <sup>1</sup>	ADS1115 SCL Input	Analogue control ADC I2C_2
B11 <sup>1</sup>	ADS1115 SDA Input	Analogue control ADC I2C_2
A9	USART TX	Connect to HC05 or FTDI
A10	USTART RX	Connect to HC05 or FTDI
B10 <sup>1</sup>	USART TX	Connect to HC05 or FTDI
B11 <sup>1</sup>	USTART RX	Connect to HC05 or FTDI

### NOTES:

1. B10/B11 can be used for either a USART connection or connection to the ADS1115 ADC for analogue potentiometer speed control.
2. The H-Bridge enable pins are now optional. If the H-Bridge can be turned off by setting both control inputs (IN1 & IN2) low then there is no need to connect B0 and B1 pins.

## STM32F103 Black Pill Board

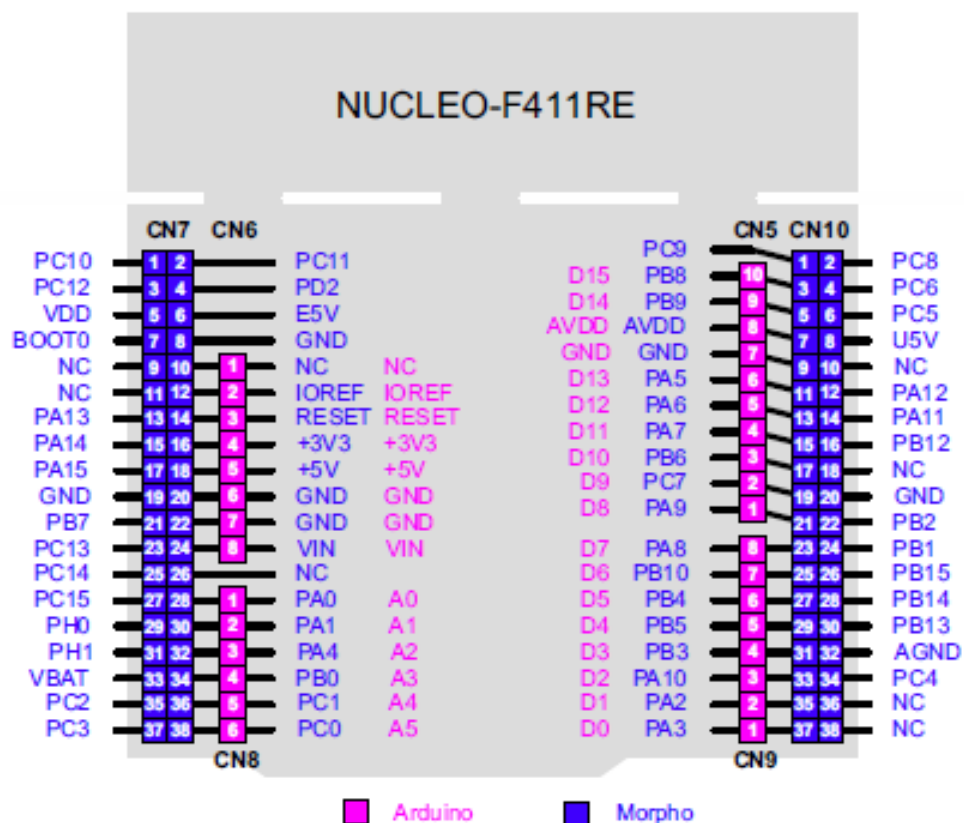
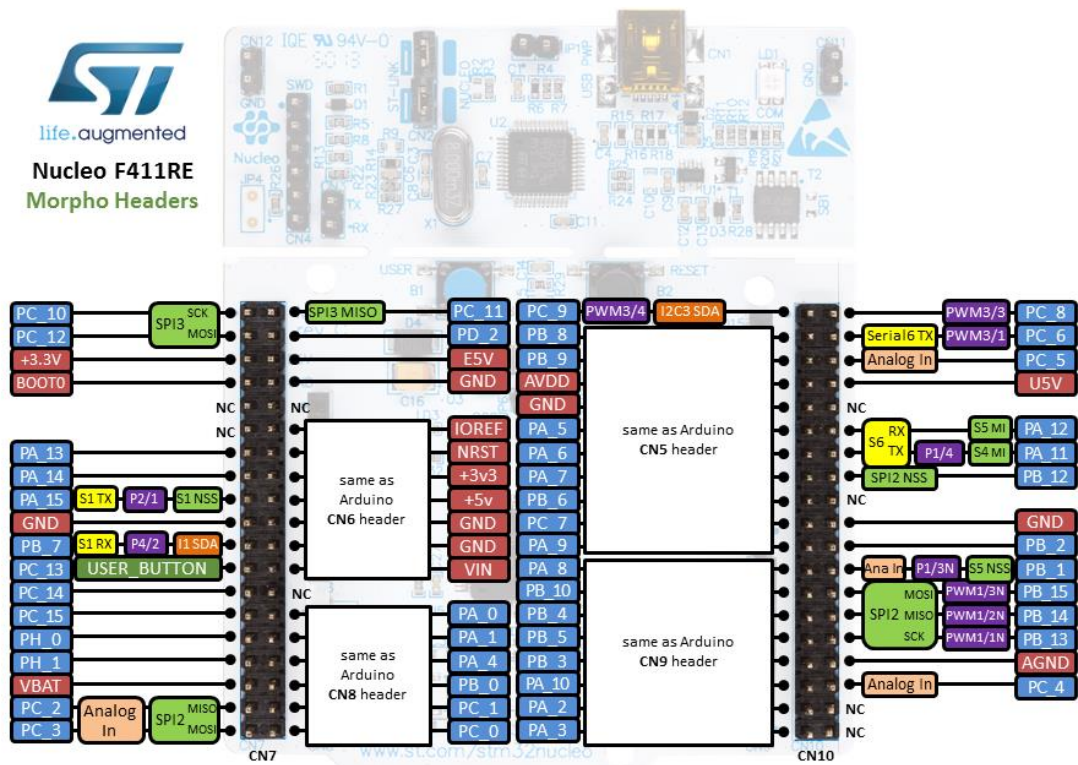
The following diagram shows all connections possible for a black pill board configured as an LC-DCC controller.



The USB connector is configured as a virtual communications port (VCP) so can be controlled using a Windows PC application. The USART connection can be connected to either an HC05 blue-tooth module or an FTDI USB serial adapter. Programming can be achieved by using a ST-LINK V2 USB programmer or by using USART1 and changing the boot jumpers (yellow in the above diagram).

## STM32F411RE Nucleo Board

The following diagram shows all STM32F411RE connections and the following table details connections used with the LC-DCC controller.



## STM32F411 Nucleo Board Connections

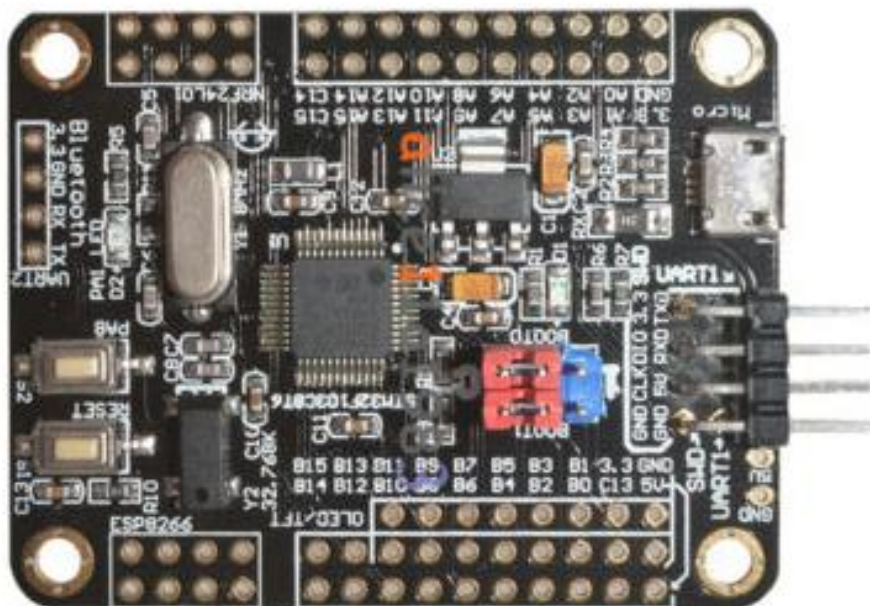
32F411RE PIN	Board Connection	Connection To
PA0	CN7 Pin 28	L298N IN1 Motor/Track A or IBT-2 RPWM
PA1	CN7 Pin 30	L298N IN2 Motor/Track A or IBT-2 LPWM
PA6	CN10 Pin13	L298N IN3 Motor/Track B or IBT-2 RPWM
PA7	CN10 Pin15	L298N IN4 Motor/Track B or IBT-2 LPWM
PC0 <sup>1</sup>	CN7 Pin 38	L298N ENA Enable or IBT-2 L_EN & R_EN
PC1 <sup>1</sup>	CN7 Pin 36	L298N ENB Enable or IBT-2 L_EN & R_EN
PB8	CN10 Pin 3	INA219 SCL
PB9	CN10 Pin 5	INA219 SDA
3.3V	CN7 Pin16	INA219 VCC or ADS1115
GND	CN10 Pin20	INA219 GND or ADS1115
GND	CN7 Pin8	L298N 0V or IBT-2 GND
5V	CN7 Pin18	IBT-2 VCC or Blue-tooth HC05 +5V
PA11	CN10 Pin14	USART6 Tx Data
PA12	CN10 Pin12	USART6 Rx Data
PA9	CN10 Pin21	USART1 Tx Data
PA10	CN10 Pin33	USART1 Rx Data
PC9	CN10 Pin 1	ADS1115 SDA
PA8	CN10 Pin 23	ADS1115 SCL

### NOTES:

1. The H-Bridge enable pins are now optional. If the H-Bridge can be turned off by setting both control inputs (IN1 & IN2) low then there is no need to connect PC0 and PC1 pins.

## STM32F103 WIFI Board & Connections

The following is the STM32F103 board required for use with the ESP8266 WIFI module.



The ESP8266 module is mounted on the connector labelled ESP8266 (bottom left in image above). The following connections are required to the H-Bridge and INA219 if connected.

BOARD PIN	Connection To
A9	L298N IN1 Motor/Track A or IBT-2 RPWM
A10	L298N IN2 Motor/Track A or IBT-2 LPWM
A6	L298N IN3 Motor/Track B or IBT-2 RPWM
A7	L298N IN4 Motor/Track B or IBT-2 LPWM
B0 <sup>1</sup>	L298N ENA Enable or IBT-2 L_EN & R_EN (optional)
B1 <sup>1</sup>	L298N ENB Enable or IBT-2 L_EN & R_EN (optional)
B6	INA219 SCL
B7	INA219 SDA
3.3V	INA219 VCC
GND	INA219 GND
GND	H-Bridge GND

### NOTES:

1. The H-Bridge enable pins are now optional. If the H-Bridge can be turned off by setting both control inputs (IN1 & IN2) low then there is no need to connect B0 and B1 pins.

## Status LED

All boards have a status LED used to indicate the state of the LC-DCC controller. The following table indicates the meaning of the LED flash sequence used on all boards.

LED Sequence	Meaning
On and off four times a second	Software or hardware fault detected
One second on one second off	Normal operation, one or both tracks are powered in either idle or operational state
One short flash once a second	Both tracks are powered off
Always on	Overload current has been detected and power removed from both tracks
Off	Controller is in service mode and no CV reading or writing is happening
Short on flash	Controller is in service mode and is reading or writing to a CV

## Optional GPIO Configuration Pins

The following two GPIO pins can be used to include a stop switch and a track B disable feature. Either GPIO by default is inactive but a switch or wire link can be used to ground either pin and so active them. The following table details which pins to use:

<b>STM3232F411RE NUCLEO</b>	<b>STM32F103 BLUE PILL</b>	<b>STM32F103 WIFI</b>	<b>STM32F103 BLACK PILL</b>	<b>Function when pin grounded</b>
PC14	PC14	PB15	PA15	Track B disabled, only read at power up or reset
PC13	PC15	PB14	PC13	Generate a stop all followed by track power off

If either function is not required then no connection to the M3 or M4 is needed as internal pull-up resistors hold the pins high.

The disable track B feature allows Windows and Android software to tailor the track power control buttons when only one H-Bridge output is used.

The pin used for the stop switch on the Nucleo board is the same as is connected to the user push button blue switch on the board. This switch connects the input pin to ground when pressed. This switch can be used as the stop switch or another normally open switch can be connected to pin PC13 and GND.

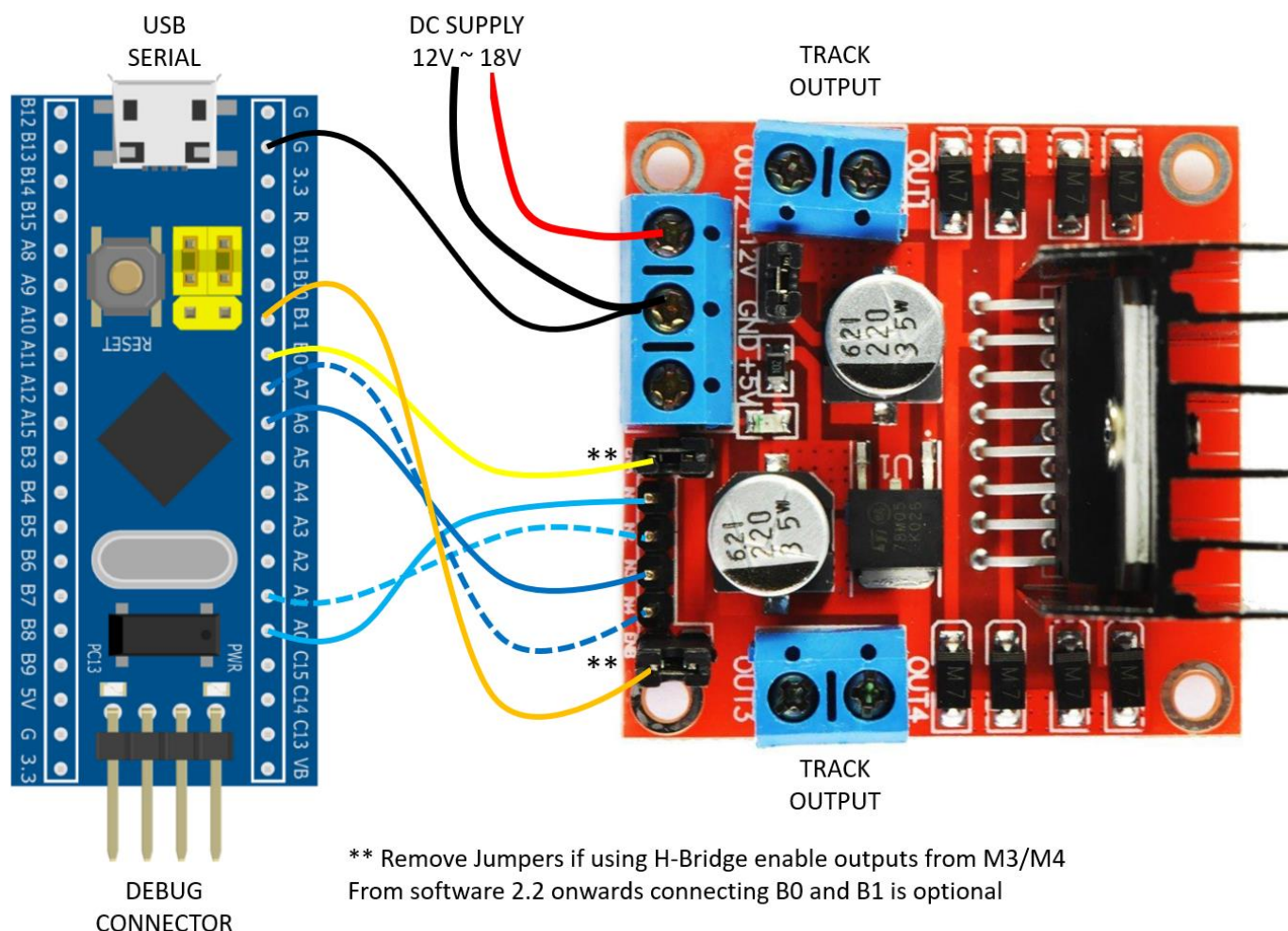
The stop switch functions in the following manner:

- In service mode, pressing the switch will remove power which can only be reinstated by using either the Windows or Android applications.
- If an overload has been detected then power can be reapplied by pressing the switch for about one second.
- If either track A or B is powered then pressing the switch for one second will remove power from both tracks.
- If both tracks are off then pressing the switch for one second will reinstated track power.
- A short press of the switch in operational or idle mode will generate an emergency stop broadcast packet.

## Example Configurations

### Cheapest smallest LC-DCC Controller

The cheapest and smallest LC-DCC controller that can be built is shown in the following connection diagram. This design can run trains and accessories and provide CV programming from a Windows PC connected via the USB interface. There is no overload detection or the ability to read CVs.



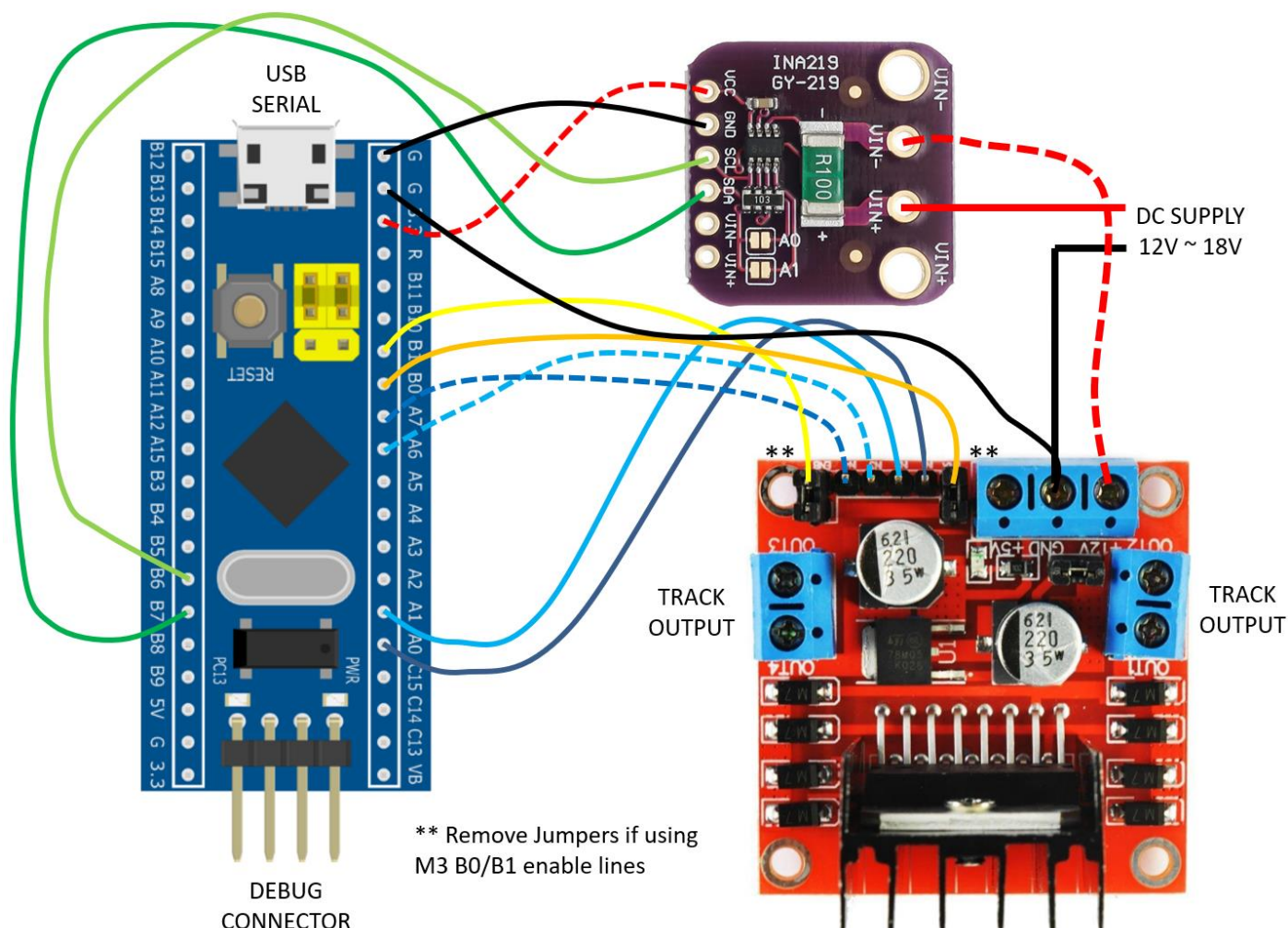
The following is the required wiring for the above design.

STM32F103	L298N	NOTES
A0	IN1	A0 DCC Packet Data connected to IN1
A1	IN2	A1 DCC Packet Data connected to IN2
A6	IN3	A6 DCC Packet Data connected to IN3
A7	IN4	A7 DCC Packet Data connected to IN4
B0	ENA	This is the TRACK A enable line and is optional
B1	ENB	This is the TRACK B enable line and is optional

From software 2.2 onwards there is no need to connect the H-Bridge enable lines to the M3/M4 processor pins. The L298N enable jumpers can be left connected.

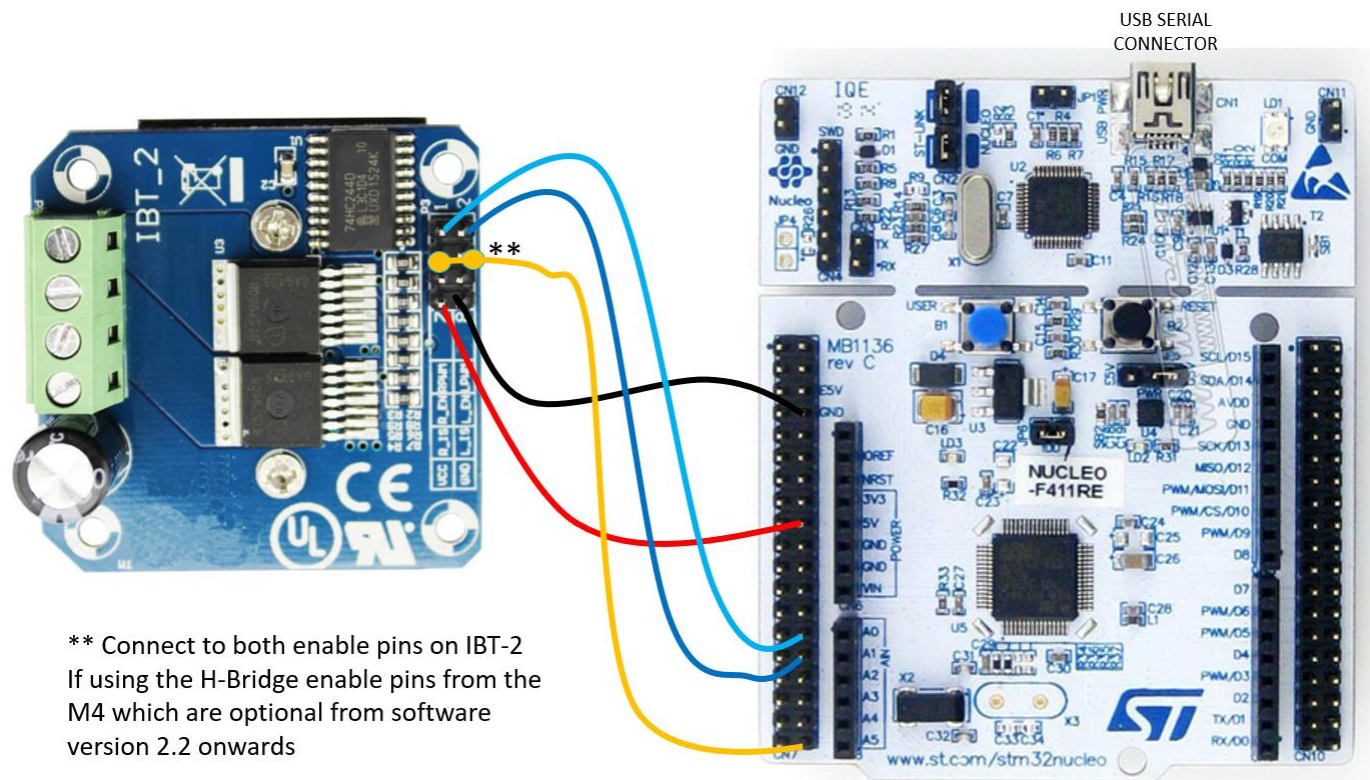
## Standard STM32F103 Controller with INA219

The following connection diagram shows the basic M3 design with an INA219 current monitor. This design can program and read CV values, control trains and accessories and detect current overload.



## High Power STM32F411 Controller

The following connection diagram is for a 10.0 amp capable LC-DCC controller with train and accessory control utilising only track A control.



\*\* Connect to both enable pins on IBT-2  
If using the H-Bridge enable pins from the M4 which are optional from software version 2.2 onwards

# Blue Tooth Configuration

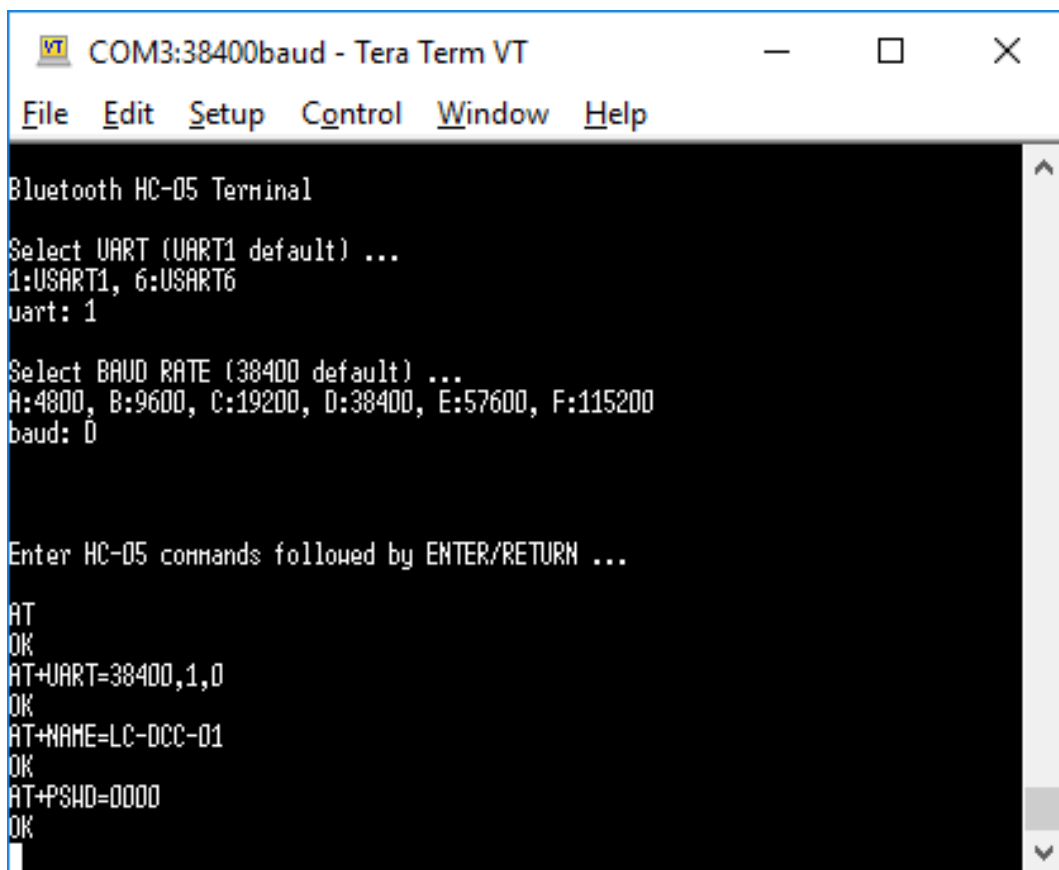
## HC-05

This section describes the blue tooth configuration of the HC05 module.

The module must be configured to operate at 38400 baud, one stop bit and no parity. This configuration is achieved by connecting the STM F411RE or F103 to a PC via the USB cable; connecting the Bluetooth module to a suitable UART on the M3 or M4 processor; loading the STM F411RE or F103 with the binary file bt\_terminal\_m4.bin or bt\_terminal\_m3.bin and running tera term on the PC.

The Bluetooth module must be configured in AT mode. To put the Bluetooth module into AT mode, hold down the button near the connector before turning on the STM F411RE or F103 board. The red LED on the Bluetooth module should flash once every two seconds in AT mode.

Enter the following on the tera terminal, note the name and password (pin code PSWD) can be changed from the example. If there is no OK response to the **AT** command then the Bluetooth module is not in AT mode or you have entered an invalid command. The BT terminal program allows back space to be used to correct commands as the command is only sent to the Bluetooth module when the ENTER/RETURN key is pressed.



```
COM3:38400baud - Tera Term VT
File Edit Setup Control Window Help

Bluetooth HC-05 Terminal

Select UART (UART1 default) ...
1:USART1, 6:USART6
uart: 1

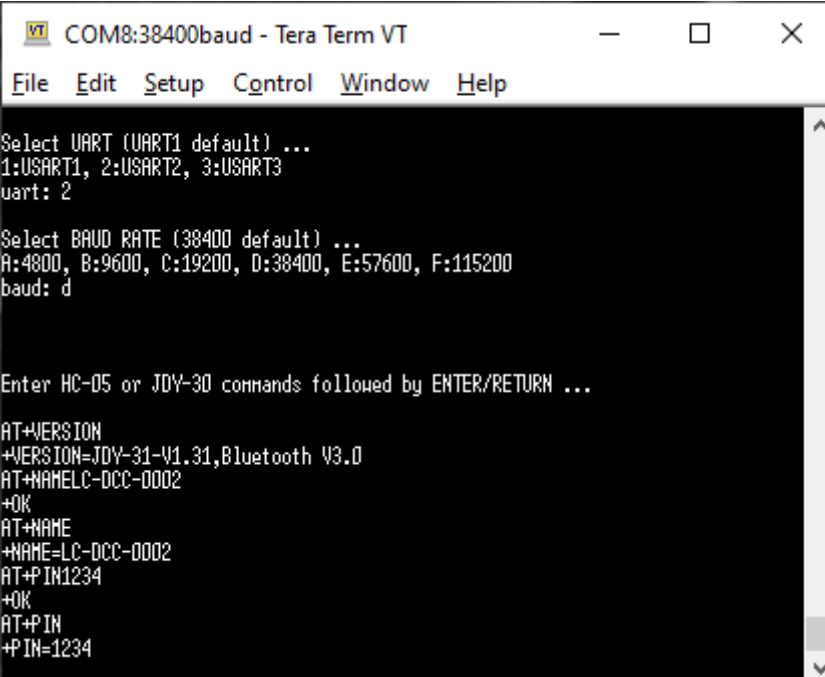
Select BAUD RATE (38400 default) ...
A:4800, B:9600, C:19200, D:38400, E:57600, F:115200
baud: 0

Enter HC-05 commands followed by ENTER/RETURN ...

AT
OK
AT+UART=38400,1,0
OK
AT+NAME=LC-DCC-01
OK
AT+PSWD=0000
OK
```

Note sometimes double quotes are required around parameters. If an error is reported try adding double quotes, i.e. AT+PSWD="0000" etc.

The following screen shows example dialog with a JDY 31. Note the JDY 31 default baud rate is 9600.



```
COM8:38400baud - Tera Term VT
File Edit Setup Control Window Help

Select UART (UART1 default) ...
1:USART1, 2:USART2, 3:USART3
uart: 2

Select BAUD RATE (38400 default) ...
A:4800, B:9600, C:19200, D:38400, E:57600, F:115200
baud: d

Enter HC-05 or JDY-30 commands followed by ENTER/RETURN ...

AT+VERSION
+VERSION=JDY-31-V1.31,Bluetooth V3.0
AT+NAMELC-DCC-0002
+OK
AT+NAME
+NAME=LC-DCC-0002
AT+PIN1234
+OK
AT+PIN
+PIN=1234
```

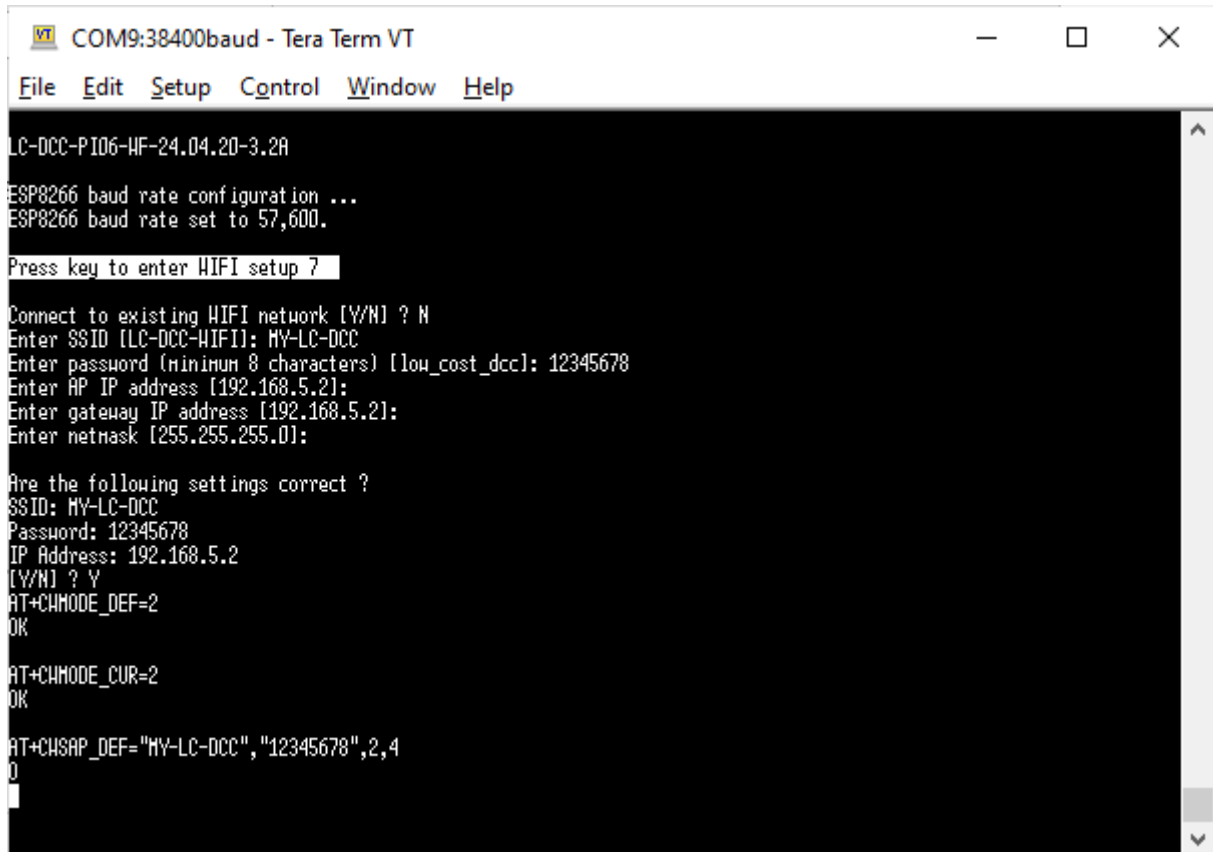
Note the JDY 30/31 is always in **AT command mode** until the blue-tooth is connected. To set the JDY 31 baud rate you must use the command **AT+BAUD6** for 38400 baud.

## BT Terminal Notes

The BT terminal M3/M4 application allows easy setup for the HC-05 and JDY 31. The application has been updated to allow the ESC key to be used to restart the USART and BAUD rate selection process. The ESC can be pressed at any time. The letters used for baud rate selection can now be in either upper or lower case.

## WIFI Configuration

To configure the ESP8266 WIFI module you must connect to the STM32F103 board micro USB connector with a USB cable and a PC. On the PC run a terminal emulator such as tera-term with the serial connection set to 38400 baud 8 data bits and one stop bit. Once the tera-term is configured either reset the STM232F103 or disconnect then reconnect the USB cable between the PC and STM32F103, the following will (highlighted) appear on the tera-term screen:



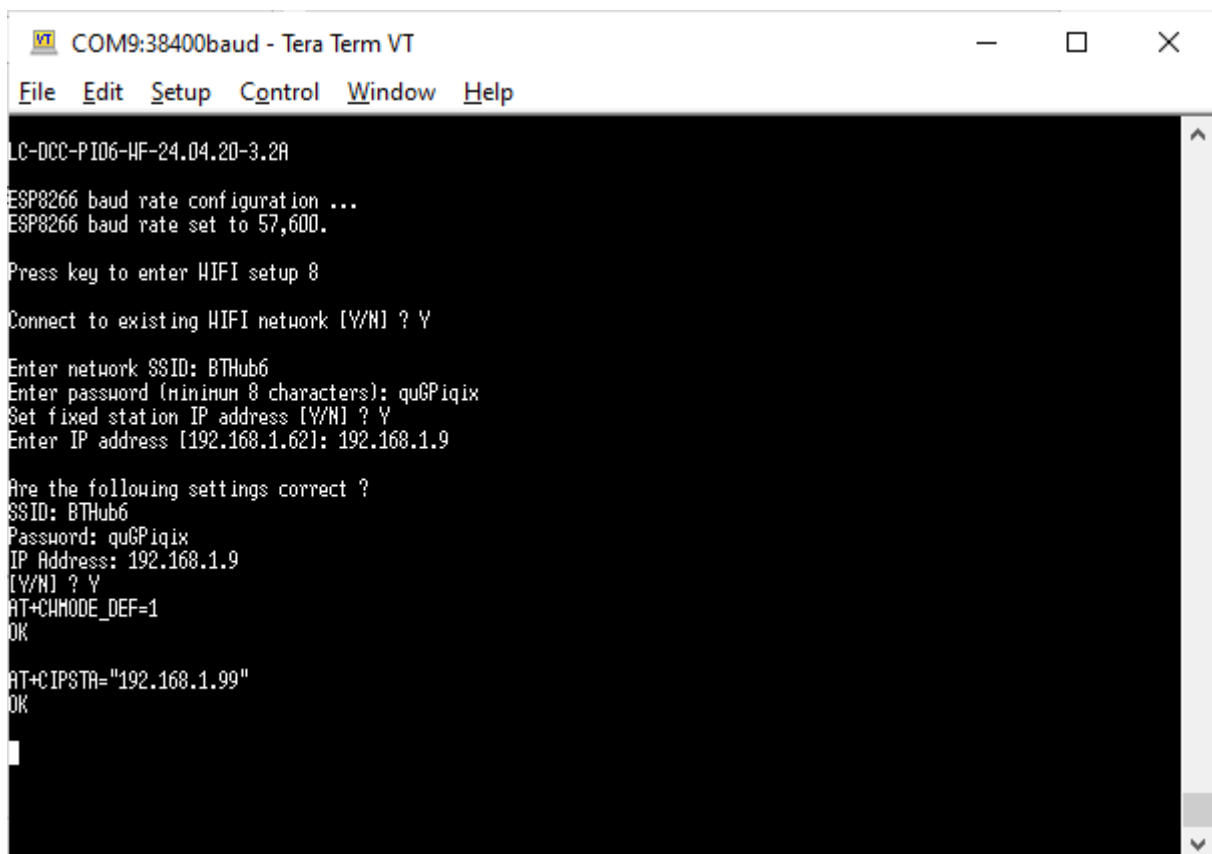
```
COM9:38400baud - Tera Term VT
File Edit Setup Control Window Help

LC-DCC-PI06-WF-24.04.20-3.2A
ESP8266 baud rate configuration ...
ESP8266 baud rate set to 57,600.
Press key to enter WIFI setup ?
Connect to existing WIFI network [Y/N] ? N
Enter SSID [LC-DCC-WIFI]: MY-LC-DCC
Enter password (minimum 8 characters) [low_cost_dcc]: 12345678
Enter AP IP address [192.168.5.2]:
Enter gateway IP address [192.168.5.2]:
Enter netmask [255.255.255.0]:

Are the following settings correct ?
SSID: MY-LC-DCC
Password: 12345678
IP Address: 192.168.5.2
[Y/N] ? Y
AT+WMODE_DEF=2
OK
AT+WMODE_CUR=2
OK
AT+WSAP_DEF="MY-LC-DCC","12345678",2,4
0
```

To configure the ESP8266 press any key when prompted. You can configure the ESP8266 as an access point or as a station. Most configurations have default values (displayed between [] brackets); to accept a default value simply press the return key.

Connect to an existing network . . .



```
COM9:38400baud - Tera Term VT
File Edit Setup Control Window Help

LC-DCC-PI06-WF-24.04.20-3.2A
ESP8266 baud rate configuration ...
ESP8266 baud rate set to 57,600.

Press key to enter HIFI setup 8

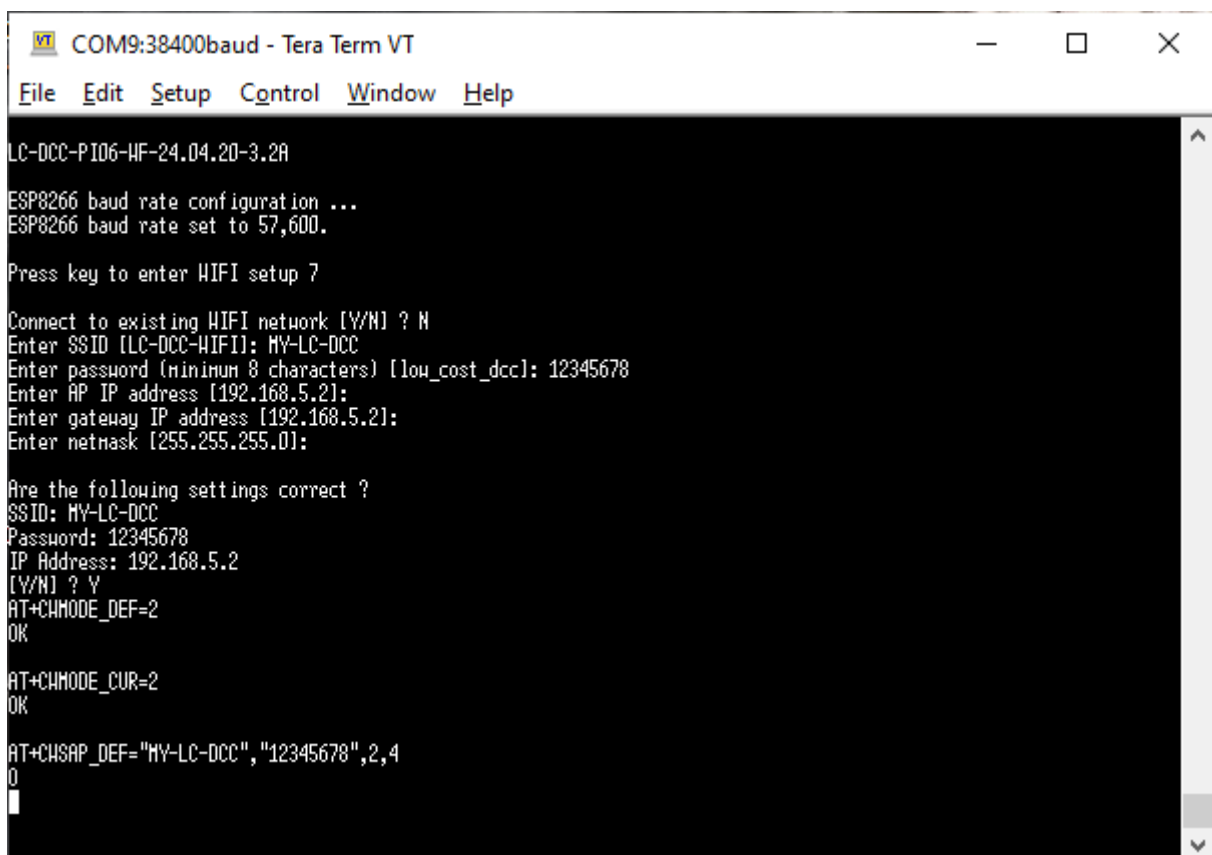
Connect to existing HIFI network [Y/N] ? Y

Enter network SSID: BTHub6
Enter password (minimum 8 characters): qu6Piqix
Set fixed station IP address [Y/N] ? Y
Enter IP address [192.168.1.62]: 192.168.1.9

Are the following settings correct ?
SSID: BTHub6
Password: qu6Piqix
IP Address: 192.168.1.9
[Y/N] ? Y
AT+CHMODE_DEF=1
OK

AT+CIPSTA="192.168.1.99"
OK
```

Create a WIFI access point with ESP8266 . . .



```
COM9:38400baud - Tera Term VT
File Edit Setup Control Window Help

LC-DCC-PI06-WF-24.04.20-3.2A
ESP8266 baud rate configuration ...
ESP8266 baud rate set to 57,600.

Press key to enter HIFI setup 7

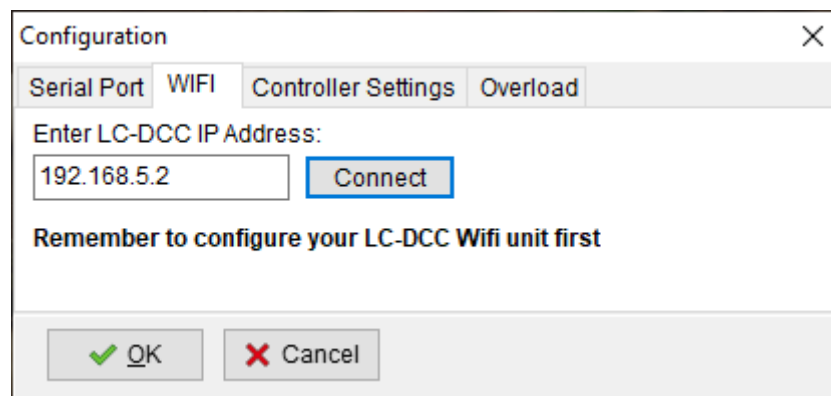
Connect to existing HIFI network [Y/N] ? N
Enter SSID [LC-DCC-HIFI]: MY-LC-DCC
Enter password (minimum 8 characters) [low_cost_dcc]: 12345678
Enter AP IP address [192.168.5.2]:
Enter gateway IP address [192.168.5.2]:
Enter netmask [255.255.255.0]:

Are the following settings correct ?
SSID: MY-LC-DCC
Password: 12345678
IP Address: 192.168.5.2
[Y/N] ? Y
AT+CHMODE_DEF=2
OK

AT+CHMODE_CUR=2
OK

AT+CHSAP_DEF="MY-LC-DCC", "12345678", 2, 4
0
```

The IP address chosen is the one required when connecting to the LC-DCC WIFI controller from one of the LC-DCC software applications as shown in the following display from the Windows/Linux application:



The image shows a 'Configuration' dialog box with a close button (X) in the top right corner. It has four tabs: 'Serial Port', 'WIFI', 'Controller Settings', and 'Overload'. The 'WIFI' tab is selected. Inside the dialog, there is a label 'Enter LC-DCC IP Address:' followed by a text input field containing '192.168.5.2' and a 'Connect' button. Below this, a message reads 'Remember to configure your LC-DCC Wifi unit first'. At the bottom, there are 'OK' and 'Cancel' buttons.

Configuration

Serial Port WIFI Controller Settings Overload

Enter LC-DCC IP Address:

192.168.5.2 Connect

Remember to configure your LC-DCC Wifi unit first

OK Cancel

## Overload Detection

The LC-DCC system provides overload detection when an INA219 is fitted. This is achieved by monitoring the current using the INA219 and disabling the H Bridge drive if a current that is too high is detected. By default, the INA219 can measure a maximum of 3.2 amps. This can be increased by adding extra shunt resistors to the INA219.

The overload current is set via the Windows or Android applications.

## Multi User Operation

The LC-DCC system can support multiple users at any one time via either WIFI or multiple serial or Bluetooth connections.

The users cannot share engines and only one user can change the DCC controller state from idle to operational or service mode. Only one user can perform service mode operations.

The user that is first to select either operational or service mode is considered the state owner and only he or she can change the state of the DCC controller.

Once a user has selected an engine address and sent any command (speed/stop/function) he or she owns that address until the DCC controller returns to the idle state.

If a user attempts to control an already owned engine the Windows or Android application will indicate the engine address is locked.

Engine locking can be turned on or off using the Windows or Android application configuration window. The same is true for accessory locks. These options allow one user multiple connections to the DCC controller so walk about mode can be used.

## Analogue Operation

If an ADS1115 is connected to the specified I2C interface on the M3 or M4 processor then up to four trains can be controlled by using potentiometers connected to the ADS1115.

The potentiometers must be set to read maximum voltage at power up otherwise they will not be enabled by the LC-DCC system. The potentiometers must be centred (zero speed position) before they become active after either an emergency stop operation or when an engine address is programmed for a potentiometer.

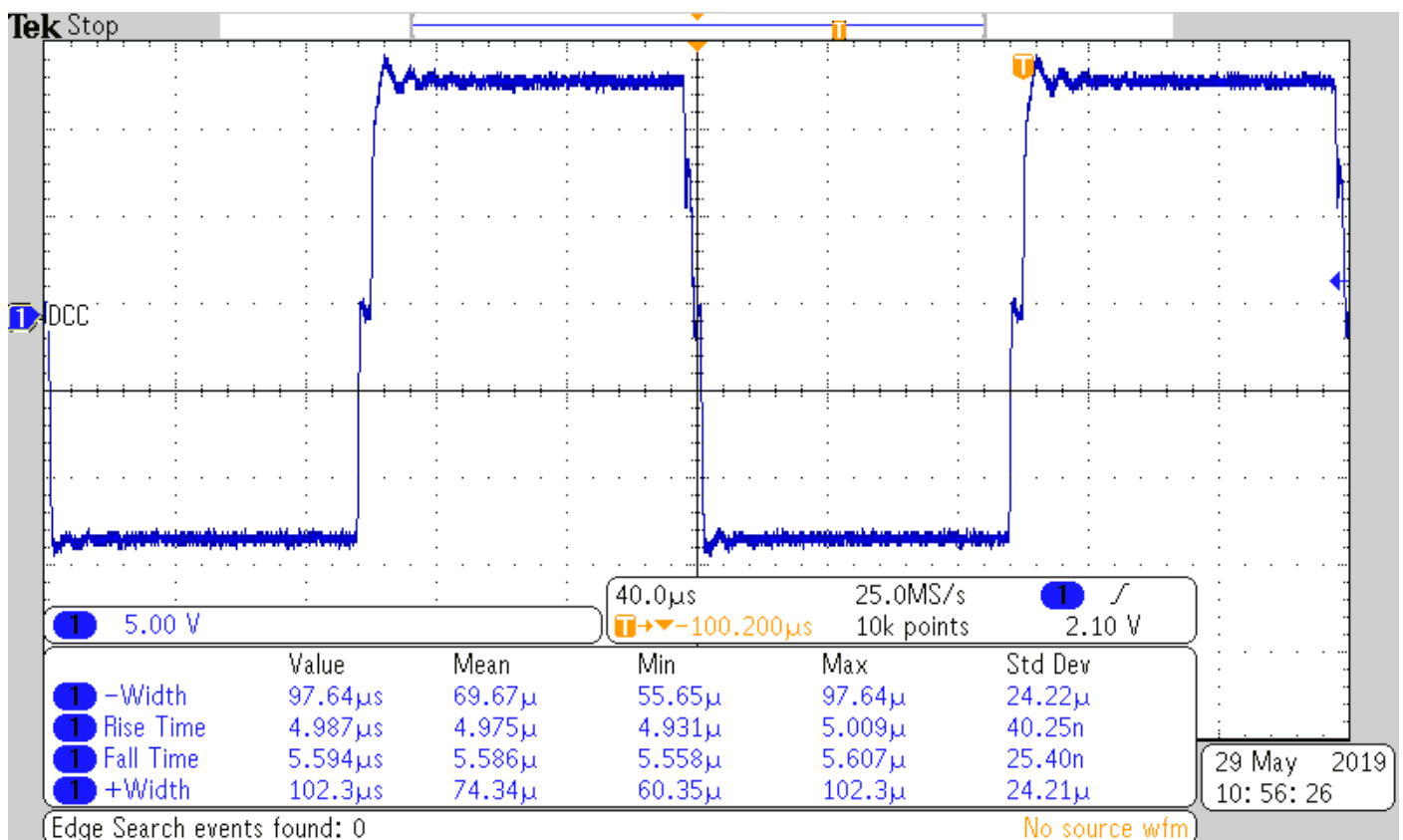
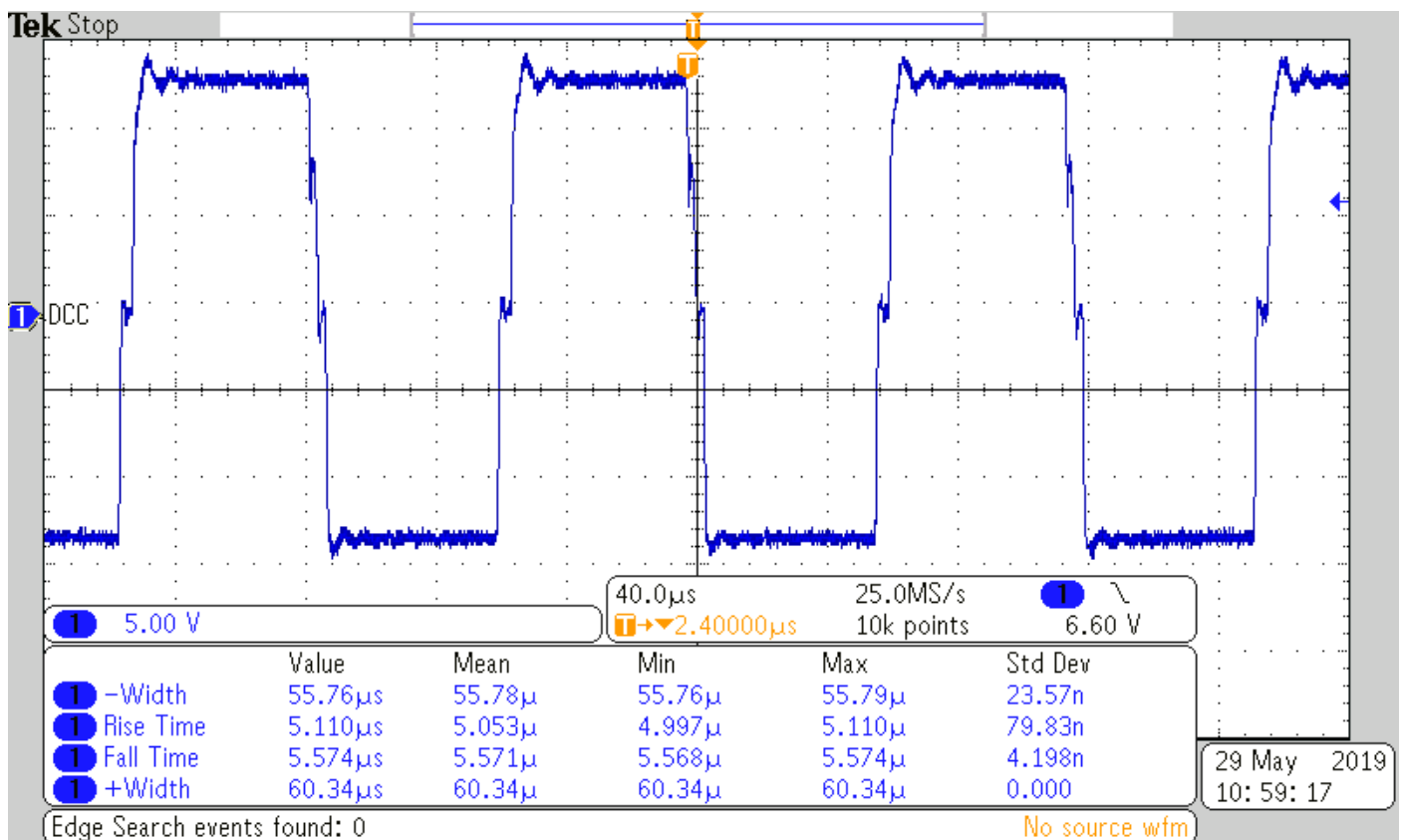
## VBAT

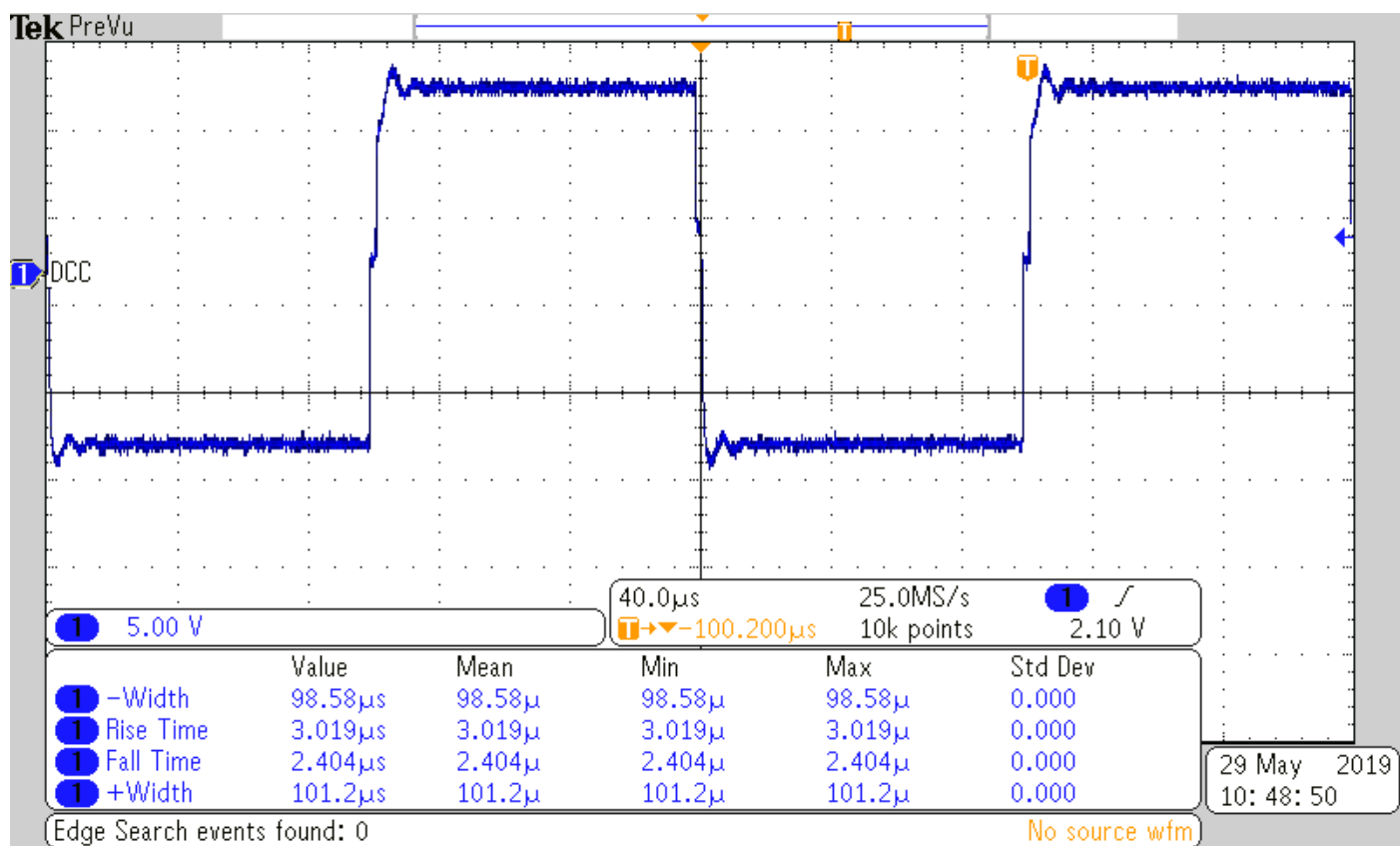
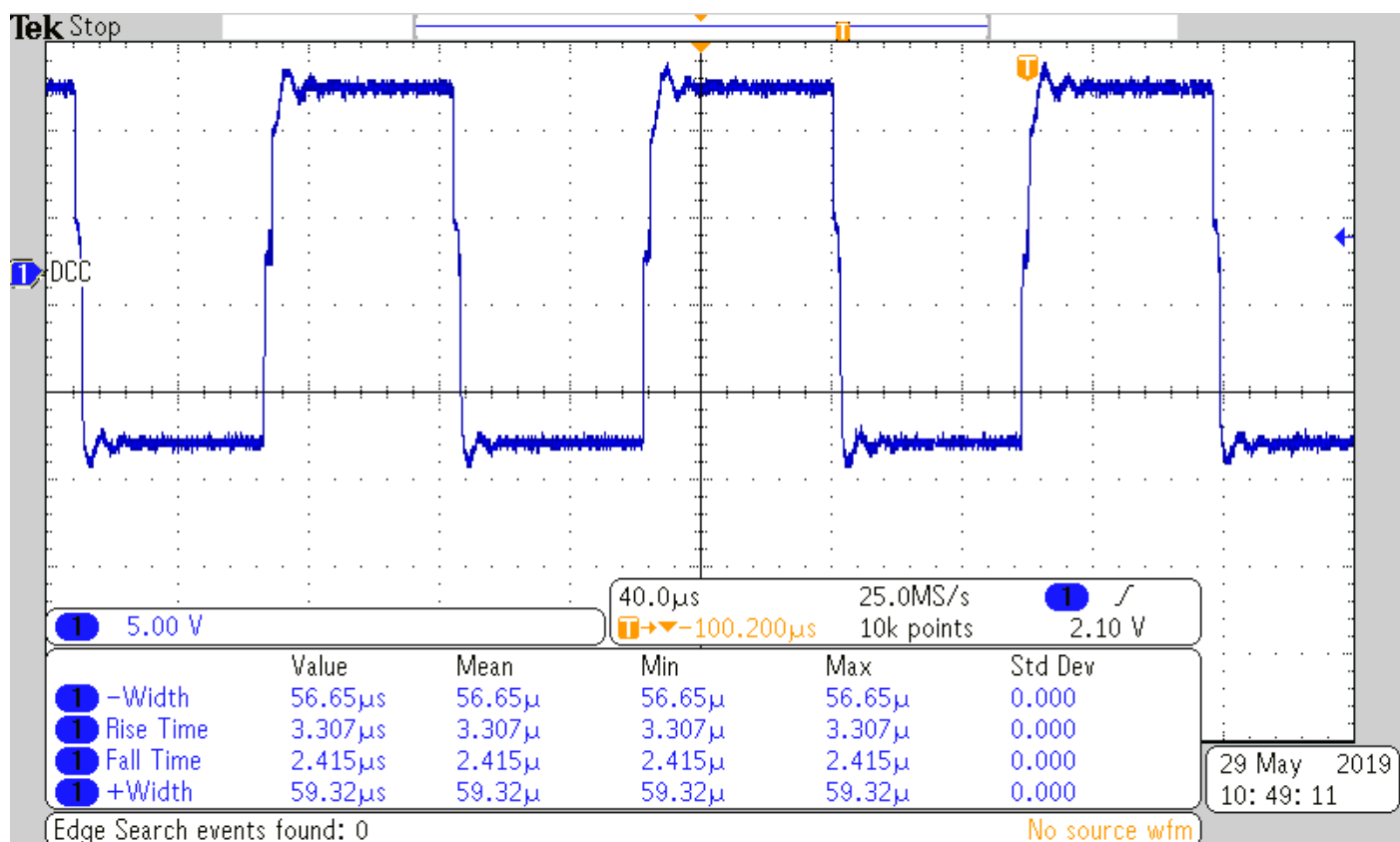
On both the STM32F103 Blue Pill board and the STM32F411RE nucleo board there is an option to connect a 3.0 volt battery that will preserve settings even when the power is switched off on the processor board. The software uses

this to save the configuration of the four potentiometers and the controller unlock code. This means that once a controller is configured to use the ADC and potentiometers no tablet or PC is required to use the controller solely with the potentiometers. On the STM32F411RE board a link resistor must be removed to use the VBAT option.

## DCC Waveforms

IBT-2 Output 15V supply, 15 Ohm load





## Version Change History

### **April 2020**

Added WIFI LC-DCC controller build information.

### **December 2019**

Added JDY 30/31 blue-tooth information.

### **November 2019**

Added extra ADS1115 support to allow up to eight potentiometers. Added off switch and track B disable. Add LED status information.

### **June 2019**

Added blue tooth configuration.

### **May 2019**

Added DCC IBT-2 and L298N waveform examples. Updated how ADC potentiometers work.

### **April 2019**

Added suggested ADC potentiometer value. Corrected STM32F411 Nucleo board connections table.

### **March 2019**

Initial version.