# UM0759
# User manual

## L9958 evaluation board and graphical user interface (GUI)

## 1 Overview

This document was intended to explain how to work with L9958 GUI and ST10F276 evaluation board.

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# 2 System description

## 2.1 Introduction

The L9958 evaluation board is a standalone evaluation board for the L9958 devices.

The L9958 is an SPI controlled H-bridge, designed for the control of DC and stepper motors in safety critical applications and under extreme environmental

## 2.2 Main components

- L9958 device with 34x4 connectors can be connected to the MCU evaluation board
- Main GUI

**Figure 1. System connection**

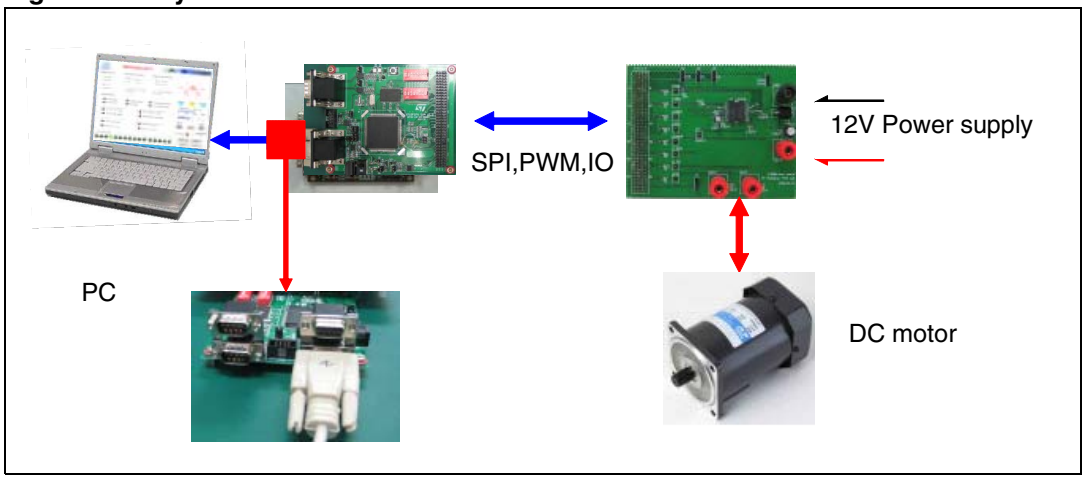
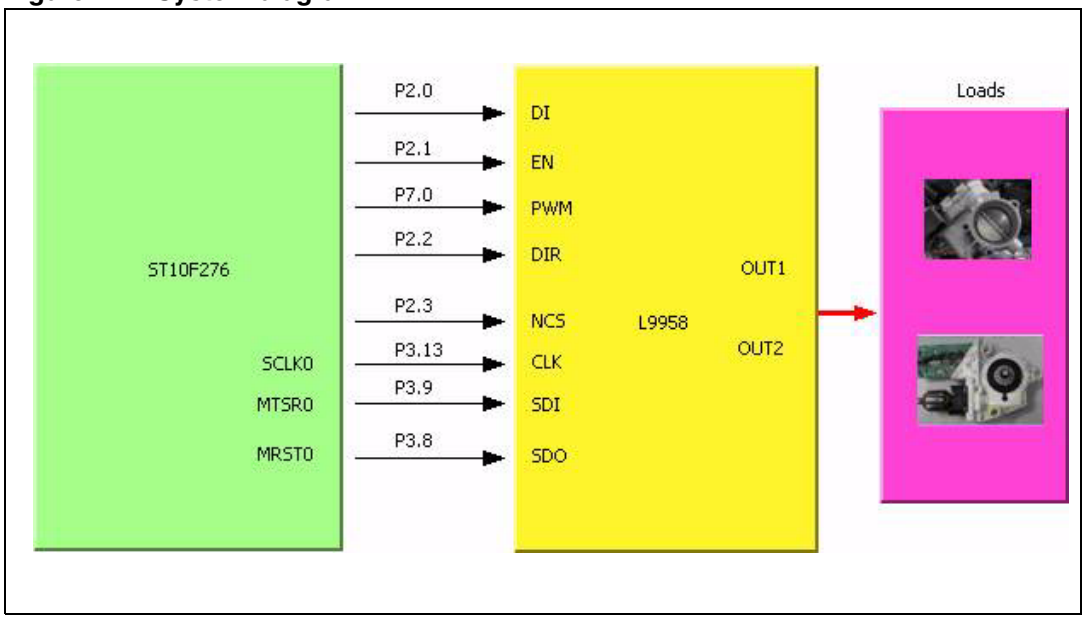



**Figure 2. System diagram**



# 3 General description

## 3.1 Hardware description

The L9958 evaluation board consists of a transil diode provide ISO pulse protection by clamping action, L9958 H-bridge IC for DC motor control, IO connector for MCU connection (compatible with ST10 MCU).

Schematics of the evaluation board can also be referred to for more details on the jumper configurations.

### 3.1.1 Main feature of the L9958 evaluation board

**Figure 3. L9958 evaluation board top view**

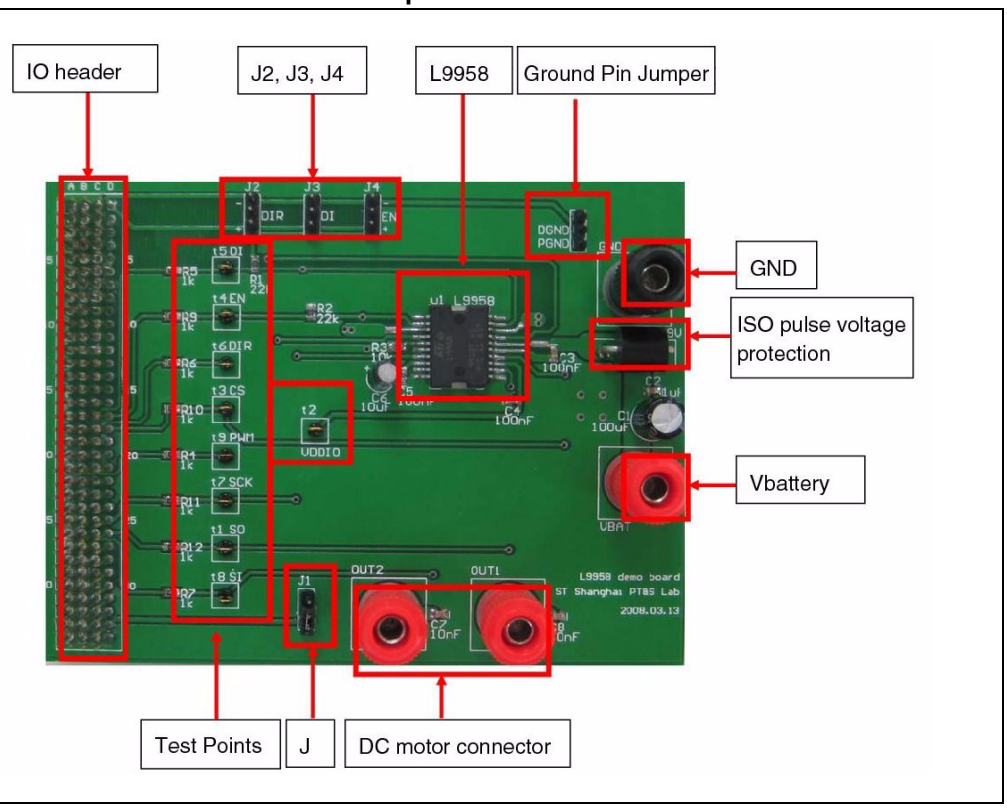


**Figure 4. L9958 evaluation board back view**

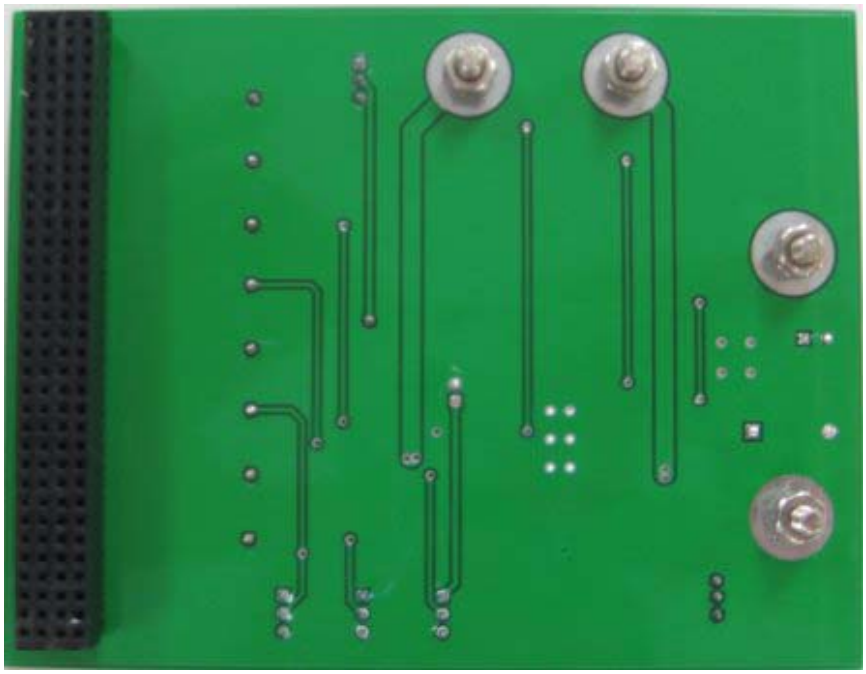
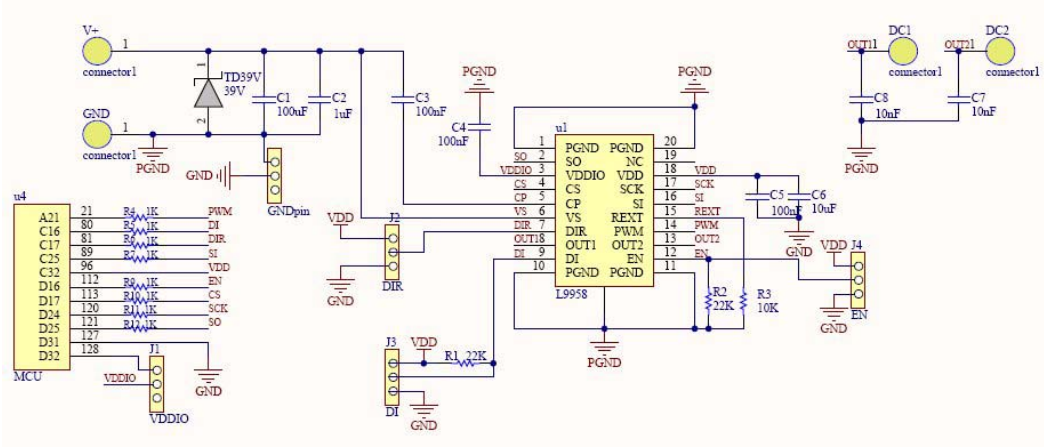


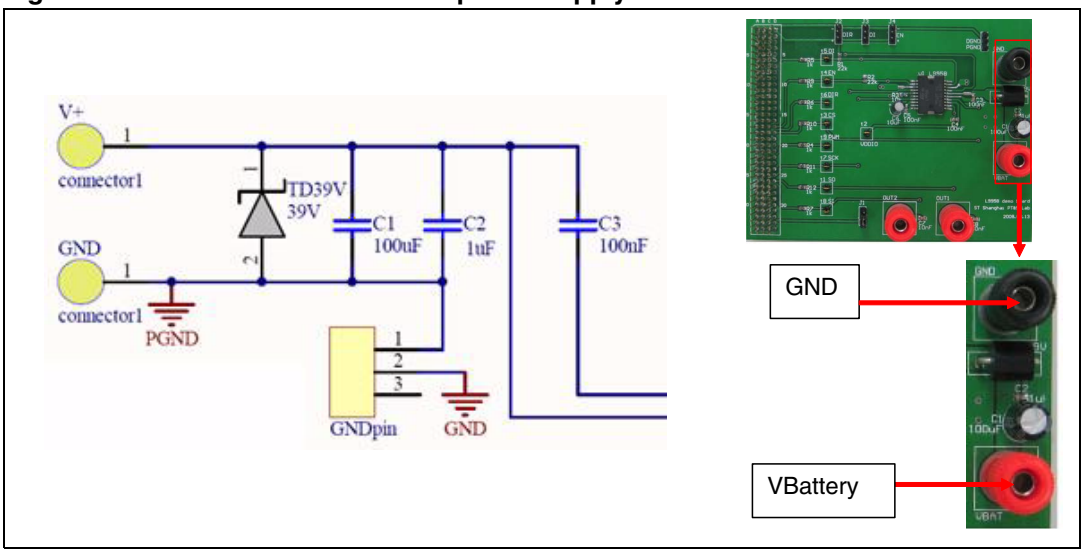
**Figure 5. L9958 evaluation board application circuit**



### 3.1.2 Battery power supply

There is one battery supply connectors on the board, with a trasil diode for ISO pulse voltage protection (39 V). C1, C2 is designed for power supply filter purpose and C3 is the charge pump capacitor. See below the schematic of this part.

**Figure 6. L9958 evaluation board power supply**

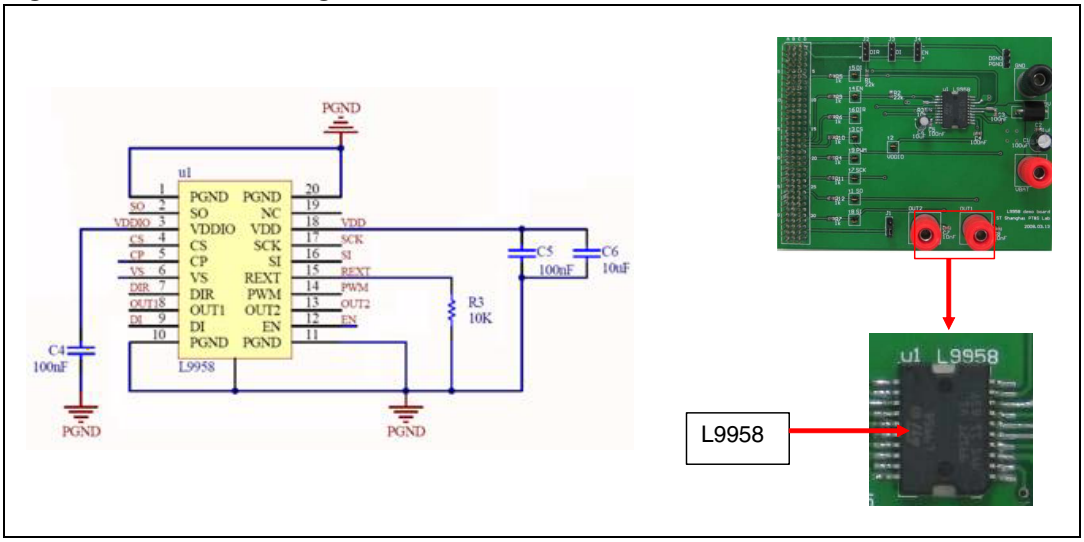



### 3.1.3 L9958 H-bridge DC motor driver

There is L9958 H-bridge DC motor driver on the board, can achieve PWM control, SPI diagnostic, DC motor drive functions.

C4,C5,C6 is designed as decoupling capacitor for VDDIO and VDD.

**Figure 7. L9958 H-bridge DC motor driver overview**

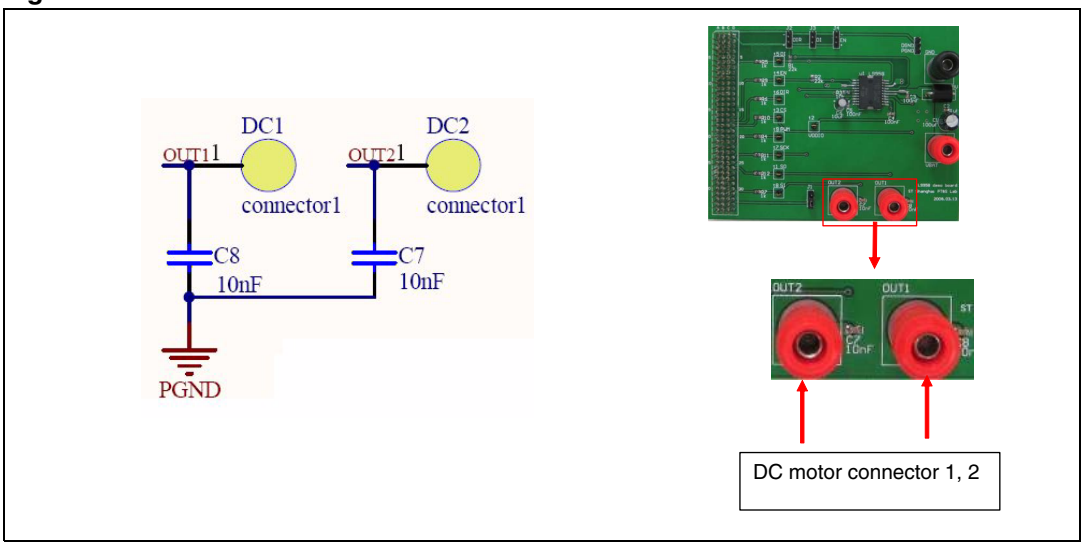


### 3.1.4 DC motor connector

There are two connectors on the board can be directly connect to DC motor, C7, C8 is designed for ESD purpose for DC motor drive.

See below the schematic of this part

**Figure 8. L9958 evaluation board DC motor connector**




### 3.1.5 Jumpers

There are 5 jumpers on the board for VDDIO connection, Power ground, Digital ground configuration as well as DIR,DI,EN connection for L9958 input digital signal

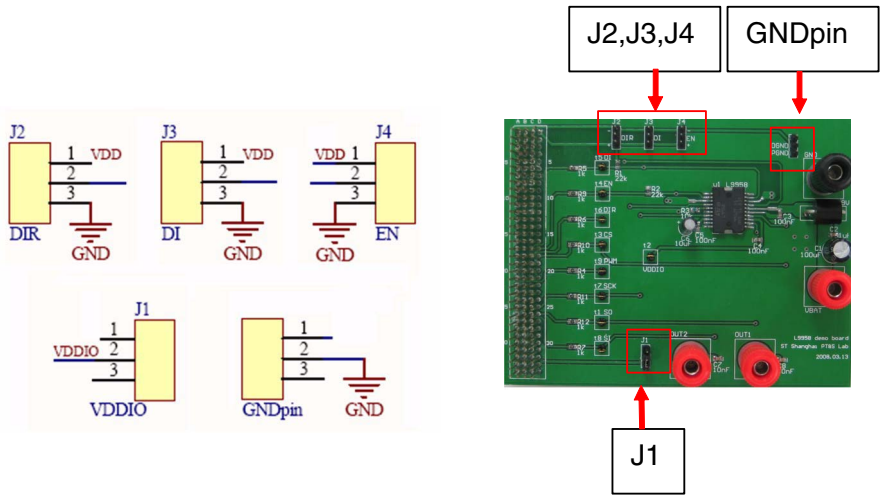
**Table 1. Jumpers**

| Type | | Description |
|---|---|---|
| J1 |  | Connect L9958 VDDIO to D32 (ST10 5V) |
| J2 |  | DIR is connected to 5V |
| |  | DIR is connected to GND |
| |  | DIR is controlled by C17 |
| J3 |  | DI is connected to 5V |
| |  | DI is connected to GND |
| |  | DI is controlled by C16 |

Table 1. Jumpers (continued)

| Type | | Description |
|---|---|---|
| J4 |  | EN is connected to 5V |
| |  | EN is connected to GND |
| |  | EN is controlled by D16 |
| GNDpin |  | GND is connected to PGND |
| |  | GND and PGND not connected |

Figure 9. L9958 evaluation board jumpers



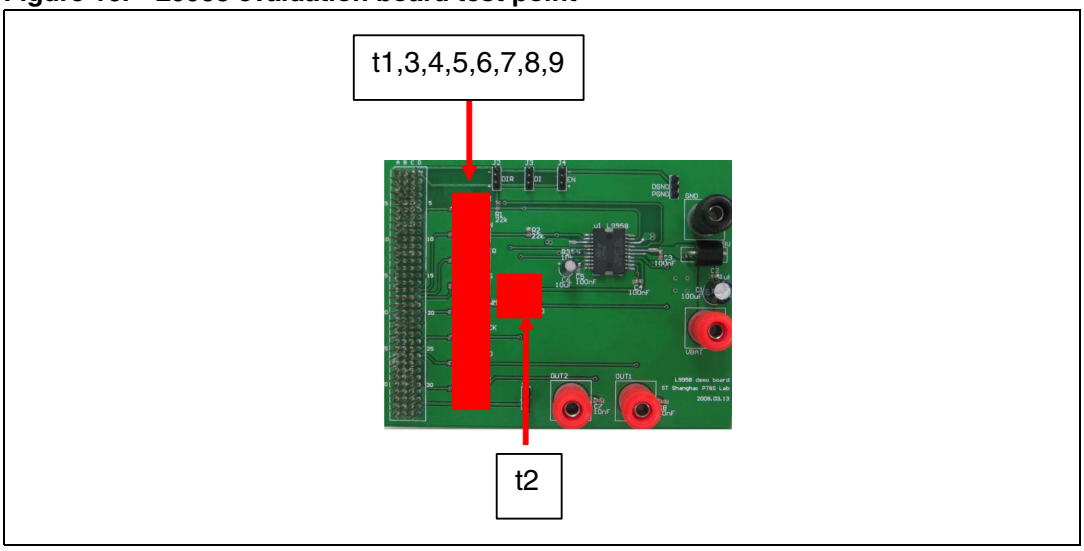
### 3.1.6 Test points

There are 9 test points on the board.

**Table 2. Test points**

| Test points | Definition | Description |
|---|---|---|
| t1 | SO | L9958 SPI Dout |
| t2 | VDDIO | L9958 VDDIO |
| t3 | CS | L9958 SPI CS signal |
| t4 | EN, | L9958 enable signal |
| t5 | DI | L9958 DI signal |
| t6 | DIR | L9958 H-bridge direction control |
| t7 | SCK | L9958 SPI clock signal |
| t8 | SI, | L9958 SPI Din |
| t9 | PWM | L9958 PWM input signal for H-bridge control |

**Figure 10. L9958 evaluation board test point**




### 3.1.7 I/O header

The 34×4 I/O header allows access to control or diagnostic I/O from the MCU.

Below is the I/O header pin mapping, see appendix A.

### 3.1.8 BOM of L9958 evaluation board

**Table 3. Bill of material**

| Comment | Description | Designator | Footprint | Quantity |
|---|---|---|---|---|
| 100µF 50V | 100uF | C1 | Cap (50V 100µF) | 1 |
| 1µF | Capacitor (Semiconductor SIM Model) | C2 | C0805 | 1 |
| 100nF | Capacitor (Semiconductor SIM Model) | C3, C4, C5 | C0805 | 3 |
| 10µF | Capacitor | C6 | RAD-0.1 | 1 |
| 10nF | Capacitor (Semiconductor SIM Model) | C7, C8 | C0805 | 2 |
| connector1 | - | DC1, DC2, GND, V+ | Connector1 | 4 |
| Jpin | DI, DIR, EN, VDDIO | GNDpin, J1, J2, J3, J4 | Jpin | 5 |
| 22k | Semiconductor resistor | R1, R2 | 2012[0805] | 2 |
| 10k | Semiconductor resistor | R3 | 2012[0805] | 1 |
| 1k | Semiconductor resistor | R4, R5, R6, R7, R9, R10, R11, R12 | 2012[0805] | 8 |
| testpoint | - | t1, t2, t3, t4, t5, t6, t7, t8, t9 | testpoint | 9 |
| 39V | - | TD39V | transil diode | 1 |
| L9958 | - | u1 | PowerSO20 | 1 |
| connector2 | X1 | u4 | HDR34X4 | 1 |

## 3.2 ST10F276 evaluation board configuration

The ST10F276 is configured as 64 MHz CPU clock, and the configuration is shown in following table:

**Table 4. ST10F276 configuration**

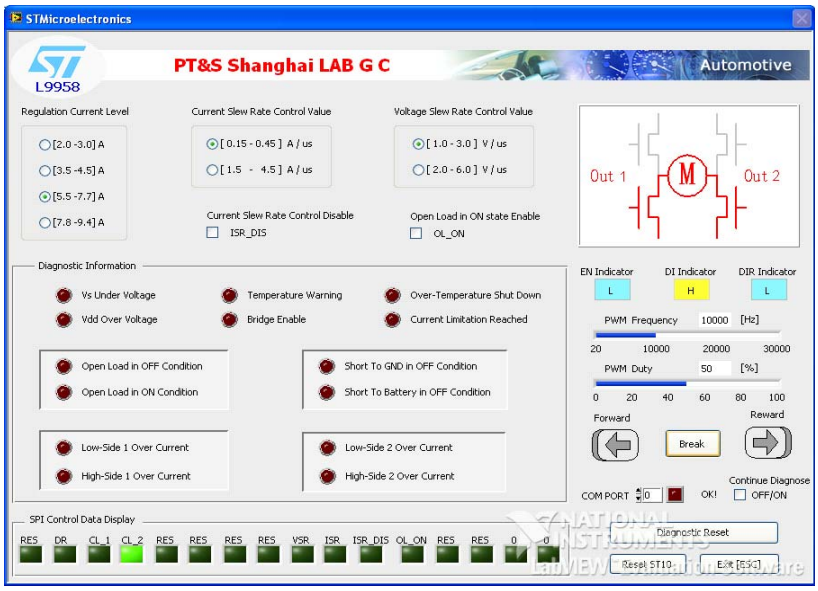
| B1 | B2 | B3 | B4 | B5 | B6 | B7 | B8 |
|---|---|---|---|---|---|---|---|
| **S3 configuration** | | | | | | | |
| off | off | off | off | off | off | on | off |
| **S4 configuration** | | | | | | | |
| on | off | on | on | on | off | on | off |

Connect PC COM port to ST10 UART0, PC COM port can be configured by GUI.

## 3.3 Evaluation GUI description

The L9958 GUI consists of five fields, three control fields: SPI menu select, motor control command field, function configuration field; two indication field: SPI diagnosis indicator and EN, DI, DIR indicator.

**Figure 11. L9958 GUI general view and the default value**




### 3.3.1 RUN and STOP L9958 GUI

The L9958 GUI was automatically running when opened. At this time, the default value was shown as *Figure 11*.

User can stop and exit the GUI via click “Exit” key: Exit [ESC] or press “ESC” key on keypad.

### 3.3.2 Configure L9958 GUI

#### SPI menu select field

This field was used to select SPI command. The SPI command was sent to L9958 by ST10 via SPI. The SPI configuration protocol was shown as below, more details, please refer to L9958.

**Table 5. SPI configuration protocol**

| Bit | Name | Description | Config. value after reset |
|---|---|---|---|
| 0 - LSB | RES | Reserved | — |
| 1 | DR | Diagnostic Reset Bit | 0 |
| 2 | CL_1 | Bit1 for Regulation Current Level | 0 |

Table 5. SPI configuration protocol (continued)

| Bit | Name | Description | Config. value after reset |
|---|---|---|---|
| 3 | CL_2 | Bit2 for Regulation Current Level | 1 |
| 4 | RES | Reserved | — |
| 5 | RES | Reserved | — |
| 6 | RES | Reserved | — |
| 7 | RES | Reserved | — |
| 8 | VSR | Voltage slew rate control value | 0 |
| 9 | ISR | Current slew rate control value | 0 |
| 10 | ISR_DIS | Current slew rate control disable | 0 |
| 11 | OL_ON | Open load in ON state enable | 0 |
| 12 | RES | Reserved | — |
| 13 | RES | Reserved | — |
| 14 | 0 | “0” to be written | — |
| 15-MSB | 0 | “0” to be written | — |

### Diagnostic reset bit

Description: Diagnostic Reset bit, more details, please refers to L9958 datasheet.

Value: Diagnostic Reset Disable → Clicked → 1
Diagnostic Reset Enable → Un-Clicked → 0

Default: Diagnostic Reset Enable → Un-Clicked → 0

SPI command Bit: b1

### Open load in ON state enable

Description: Open load in ON state Enable bit, more details, please refer to L9958 datasheet.

Value: Open load in ON state Enable → Clicked → 1
Open load in on state Disable → Un-Clicked → 0

Default: → Open load in ON state Disable → Un-Clicked → 0

SPI-DIN Bit: b11

### Current slew rate control disable

Description: Current Slew Rate Control Disable bit, more details, please refers to L9958 datasheet.

Value: Current Slew Rate Control Disable → Clicked → 1
Current Slew Rate Control Enable → Un-Clicked → 0

Default: Current Slew Rate Control Enable → Un-Clicked → 0

SPI-DIN Bit: b10

### ISR

Description: Current Slew Rate Control Value bit, more details, please refers to L9958 datasheet.

Value: [0.15 - 0.45] A/µs → ISR=1
[1.5 - 4.5] A/µs → ISR=0

Default: [1.5 - 4.5] A/µs → ISR= 0

SPI-DIN Bit: b9

### VSR

Description: Voltage Slew Rate Control Value bit, more details, please refer to L9958 datasheet.

Value: [1 - 3] V/µs → VSR=1
[2 - 6] V/µs → VSR=0

Default: [2 - 6] V/µs → VSR=0

SPI-DIN Bit: b8

### Current regulation level

Description: Current Regulation Level bit, more details, please refers to L9958 Datasheet.

Value: [2.0 - 3.0] A → CL_1=0, CL_2=0
[3.5 - 4.5] A → CL_1=1, CL_2=0
[5.5 - 7.7] A → CL_1=0, CL_2=1
[7.8 - 9.4] A → CL_1=1, CL_2=1

Default: [2.0 - 3.0] A → CL_1=0, CL_2=0

SPI-DIN Bit: b2 b3

### SPI IN display

Description: Corresponding SPI IN command was displayed

Value: b0 b1 b2 b3 b4 b5 b6 b7 b8 b9 b10 b11 b12 b13 b14 b15

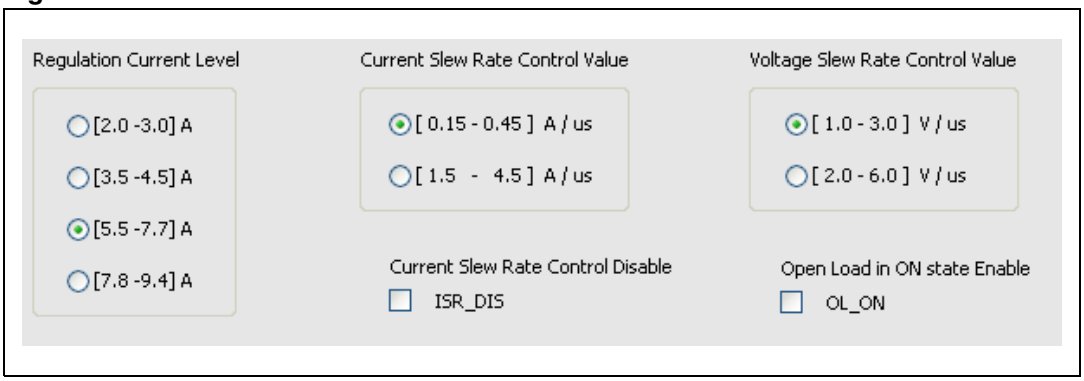
Reset Value: 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0

*Note: bit 0, bit4-bit7, bit12-bit15 was fixed as '0 ' according to L9958 SPI protocol shown as Figure 5, more details, please refer to L9958 Datasheet.*

### Configuration example

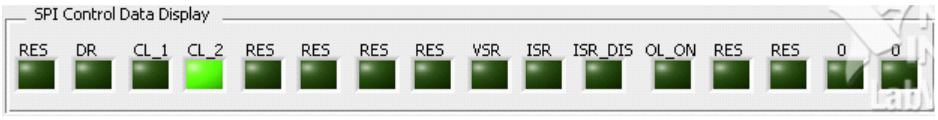
Click the button means set the bit. Unclick the button means reset the bit.

**Figure 12. SPI control area**




After configured SPI menu, the configured SPI command will be displayed at "SPI Control Data Display" area and automatically sent to L9958.

**Figure 13. SPI control data display**

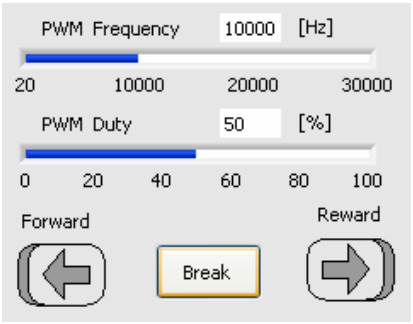



More information about SPI configuration protocol, please refer to L9958 datasheet.

### Motor control command field

This field was purposed for controlling motor command: PWM duty-cycle, PWM Frequency, motor direction control and break control.

**Figure 14. Motor control command field**




### Disable/EN switch

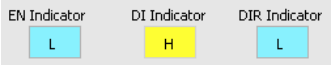
The EN and DI input signal of L9958 to make the bridge tri-state or on-state is controlled by


key,


key and


key.

When toggle these keys, DIR, EN and DI is automatically controlled by PC software, and the




will display the status of EN, DIR, DI pins.

The control logic is shown in *Table 2*: more information, please refer to L9958 datasheet.

**Table 6. EN/DI/DIR switch map**

| Switch | EN | DI | DIR | Bit "ACT" | Bridge status |
|---|---|---|---|---|---|
| Forward | EN Indicator H | DI Indicator L | DIR Indicator H | Bridge Enable "1" | On-state |
| Break | EN Indicator L | DI Indicator H | DIR Indicator H | Bridge Enable "0" | tri-state |
| Reverse | EN Indicator H | DI Indicator L | DIR Indicator L | Bridge Enable "1" | On-state |
| Break | EN Indicator L | DI Indicator H | DIR Indicator L | Bridge Enable "0" | tri-state |

**PWM duty-cycle and frequency control**

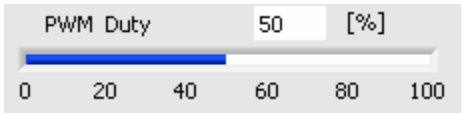
- PWM Duty-cycle control

  Range: [0, 100] %

  Step: 1

  Default: 50 %

**Figure 15. PWM duty**



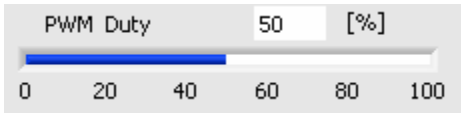

- PWM frequency control

  Range: [20, 30000] Hz

  Step: 1

  Default: 10000Hz

**Figure 16. PWM frequency control**



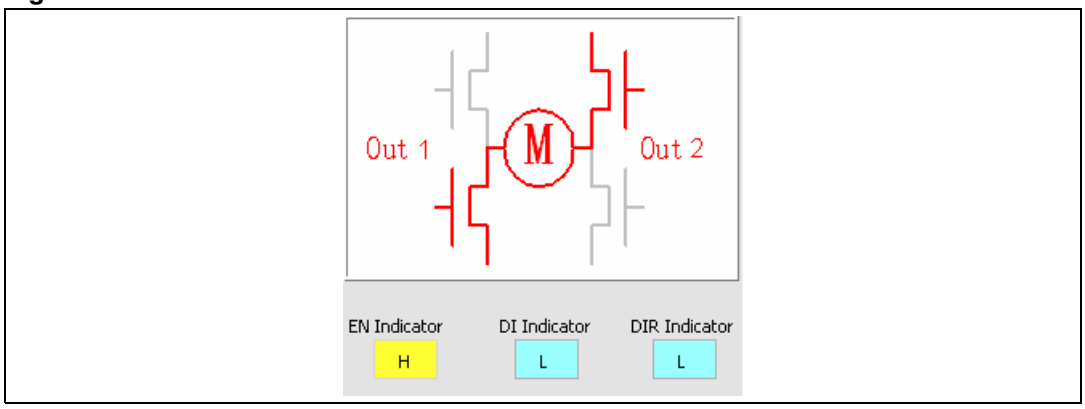

To adjust PWM control bars will change the duty-cycle and frequency of L9958's PWM input signal. But if the motor was freewheeling, the action clicking the control roll didn't change the current status, PWM duty-cycle unchanged.

### Reverse key

The key only works at CLICKED (Rising edge), that is to say the un-clicked action (fall edge) didn't change the direction status. When the "Reverse Key" was clicked, the DIR input signal of L9958 becomes LOW.

From the GUI side, when "Reverse Key" was clicked, the "BREAK" or "Forward Key" was reset, and the motor display field was shown as below:

**Figure 17. Reverse direction of motor control**

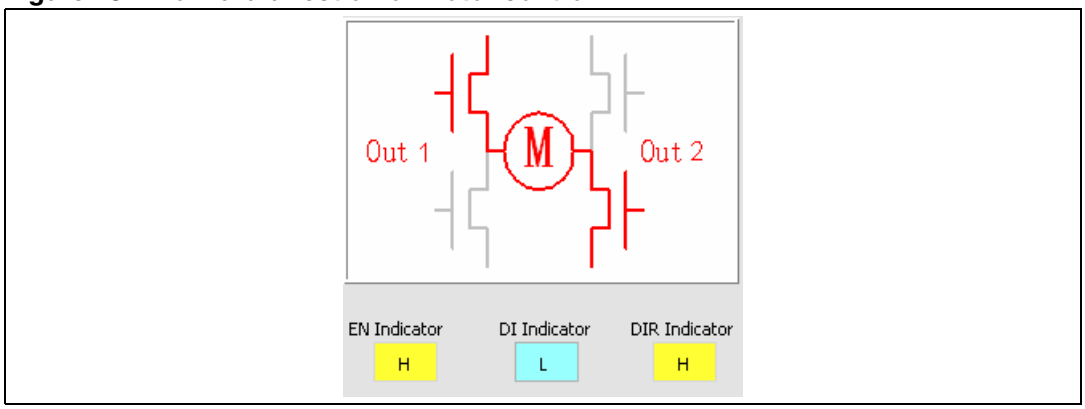



### Forward key

The key only works at CLICKED (Rising edge), that is to say the un-clicked action (fall edge) didn't change the direction status. When the "Forward Key" was clicked, the DIR input signal of L9958 becomes HIGH.

From the GUI side, when "Forward Key" was clicked, the "BREAK" or "Reverse Key" was reset, and the motor display field was shown as below:

**Figure 18. Forward direction of motor control**

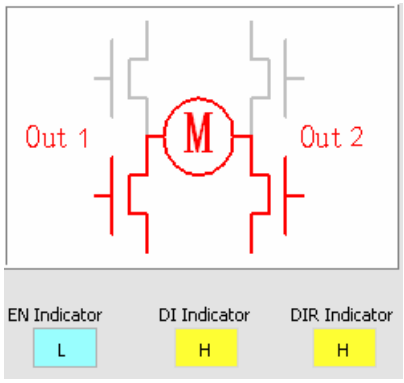


### BREAK key

The key only works at CLICKED (Rising edge), that is to say the un-clicked action (fall edge) didn't change the direction status. When the "BREAK" was clicked, the duty-cycle of L9958 PWM was 0%, PWM=0, the status of bridge was freewheeling Low (as *Table 2* above).

From the GUI side, when "BREAK" was clicked, the "Reverse Key" or "Forward Key" was reset, and the motor display field was shown as below:

**Figure 19. Freewheeling direction of motor control**




### “Diagnostic reset" button

The action clicked the "Diagnostic Reset" button ( Diagnostic Reset ) will only reset SPI Menu field and SPI Diagnosis Indication field to the default value shown as Figure 3.

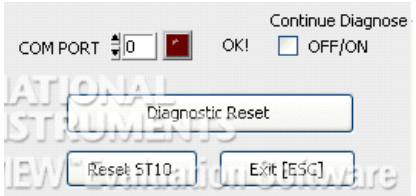
### "Reset ST10" button

The action clicked the "Reset ST10" button ( Reset ST10 ) will soft reset ST10 and configure ST10 DIO, SPI and CC.

### Function configuration field

The function configuration field consists of four parts: Port Configuration, Rx Error, Exit button, Continue Diagnosis switch, as shown below:

**Figure 20. Function configure field**



### Port configuration

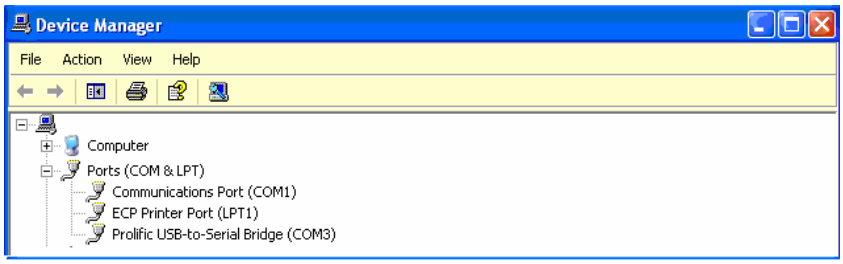
Com port ( COM PORT 0 ) can be changed by user, according the used COM port number of PC.

After modified the com port number, user must click the reset key Reset ST10 to reset and configure the ST10 evaluation board.

Port number: (COM Number - 1)

Baud rate: 38400 (default)

**Figure 21. COM number map on PC**




Example: For COM1: "0" port number should be selected ( COM PORT 0 )

For COM3: "2" port number should be selected ( COM PORT 2 )

If the port configuration failed, when select Continue Diagnosis OFF/ON , COM PORT 0 ERROR! happened:

Notes: when this error appeared, please do below actions:

- Configure the Port number correctly
- Clicked the "Reset ST10" button to reset the L9958 GUI and ST10 configuration

## 3.3.3 Rx error

The Rx error turned red ( COM PORT 0 ERROR! ) indicate below receive error:

- Receive timeout
- Receive error
- Received frame incorrect

## 3.3.4 "Exit" button

The "Exit" button ( Exit [ESC] ) was only used to stop and exit the L9958 GUI.

## 3.3.5 "Continue diagnosis" switch

If the "Continue Diagnosis" was clicked ( Continue Diagnosis OFF/ON ), the L9958 GUI enters automatic diagnosis mode, the current SPI menu configuration will be sent to L9958 continuously to do the continuous diagnosis. When continuous diagnosis was selected, "SPI send" also works.

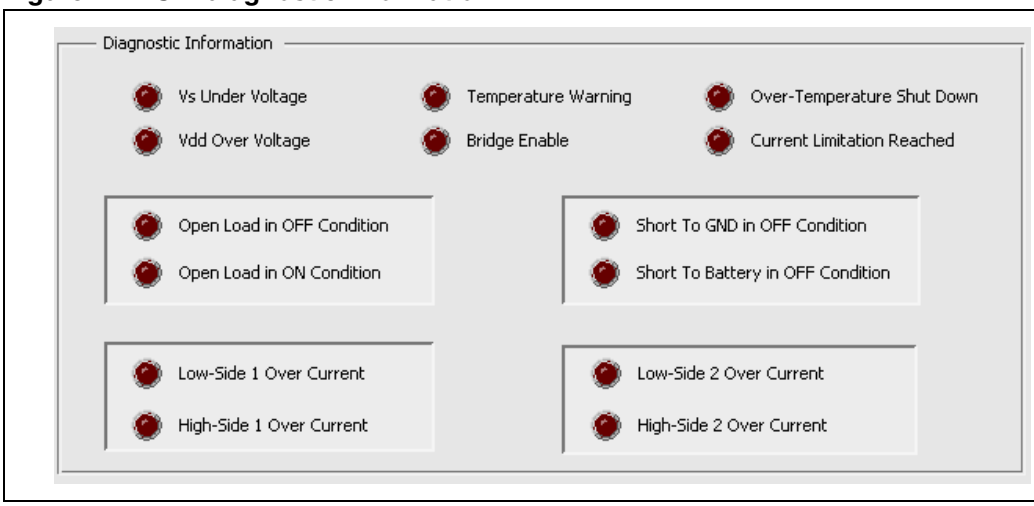
### 3.3.6 SPI diagnosis indication

This field will indicate the diagnosis status. SPI diagnosis word will displayed at SPI Diagnosis Indication field. The diagnostic protocol was referred below:

**Table 7. SPI diagnostic protocol**

| Bit | Name | Description | Status after reset |
|---|---|---|---|
| 0-LSB | OL_OFF | Open load in OFF condition | 0 |
| 1 | OL_ON | Open load in ON condition | 0 |
| 2 | VS_UV | Vs undervoltage | 0 |
| 3 | VDD_OV | Vdd overvoltage | 0 |
| 4 | ILIM | Current limitation reached | 0 |
| 5 | TWARN | Temperature warning | 0 |
| 6 | TSD | Over-temperature shutdown | 0 |
| 7 | ACT | Bridge enable | 1 |
| 8 | OC_LS1 | Over-current on low side 1 | 0 |
| 9 | OC_LS2 | Over-current on low side 2 | 0 |
| 10 | OC_HS1 | Over-current on high side 1 | 0 |
| 11 | OC_HS2 | Over-current on high side 2 | 0 |
| 12 | Null | Not used | – |
| 13 | Null | Not used | – |
| 14 | SGND_OFF | Short to GND in OFF condition | 0 |
| 15-MSB | SBAT_OFF | Short to battery in OFF condition | 0 |

**Figure 22. SPI diagnostic information**

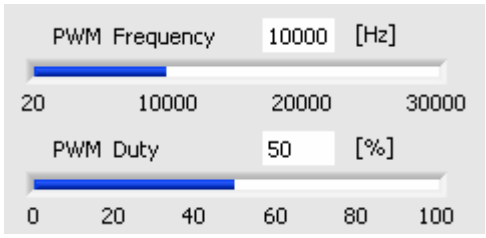



For more diagnostic information, Please refer to L9958 datasheet in detail.

## 3.4 Test results

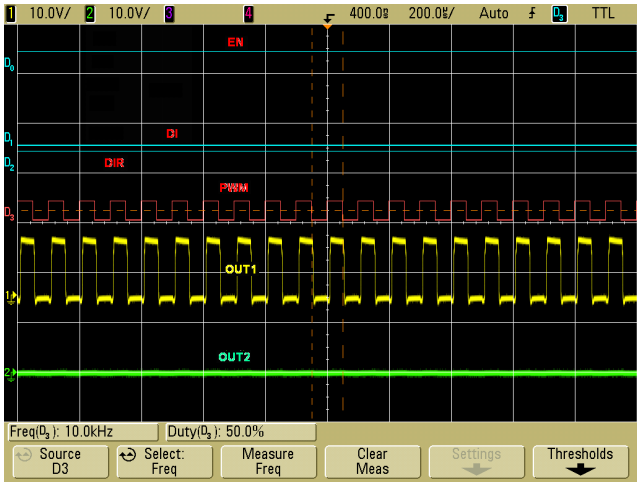
PWM control signal settings:

**Figure 23. PWM settings for motor control**




- Motor Control → Forward Control:

**Figure 24. The wave form of motor forward control**




- Motor Control → Reverse Control:

**Figure 25. The wave form of motor reverse control**

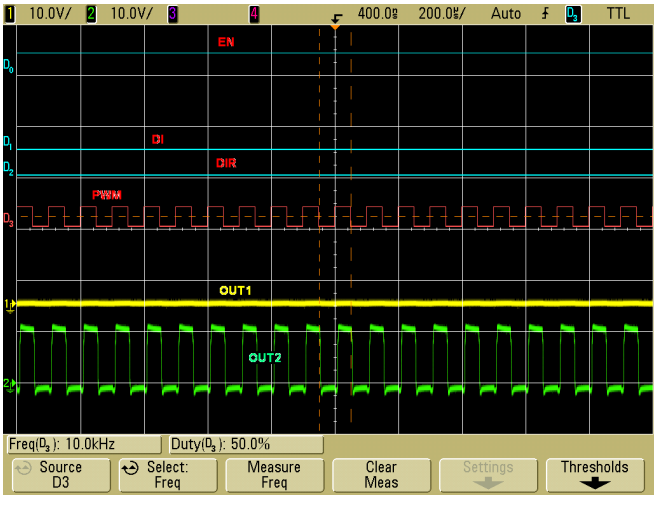


**Table 8. Partly diagnostic testing result**

| Item | Operation | SPI status register bit | Diagnostic information | Result |
|---|---|---|---|---|
| Open Load In OFF Condition | Open load | BIT 0 | Open Load in OFF Condition | pass |
| Open Load In ON Condition | Open Load in ON state Enable<br>OL_ON<br>& turn on the OUT1,2 | BIT 1 | Open Load in ON Condition | pass |
| Vs Under Voltage | Vbat<3.6V | BIT 2 | Vs Under Voltage | pass |
| Current Limitation Reached | Short circuit | BIT 4 | Current Limitation Reached | pass |
| Bridge Enable | Turn on OUT1,2 | BIT 7 | Bridge Enable | pass |
| High-Side 1 Over Current | DIR=1,EN=1,DI=0,PWM=1<br>CONNECT OUT1 to GND | BIT9 | High-Side 1 Over Current | pass |
| Low-Side 2 Over Current | DIR=1,EN=1,DI=0,PWM=1<br>CONNECT OUT2 to Vbatt | BIT8 | Low-Side 2 Over Current | pass |
| High-Side 2 Over Current | DIR=0,EN=1,DI=0,PWM=1<br>CONNECT OUT2 to GND | BIT11 | High-Side 2 Over Current | pass |
| Low-Side 1 Over Current | DIR=0,EN=1,DI=0,PWM=1<br>CONNECT OUT1 to Vbatt | BIT10 | Low-Side 1 Over Current | pass |
| Short To GND in OFF Condition | Connect OUT1 to GND | BIT14 | Short To GND in OFF Condition | pass |
| | Connect OUT2 to GND | | | |
| Short To Battery in OFF Condition | Connect OUT1 to Vbat | BIT15 | Short To Battery in OFF Condition | pass |
| | Connect OUT2 to Vbat | | | |

# Appendix A

## A.1 ST10 configuration

CPU Frequency: 64 MHz

1. ASC

   For ST10F276, ASC0 can be initialized;

   Baud Rate: 38400, 8 bit data asynchronous, 1 stop bit,

2. SSC

   Frequency: 1 MHz, 16 bit Data-Width, LSB first, Low level at idle, transmit at rising edge

   /CS line: 2.3

## A.2 Pin out

Pin connection between ST10F27x evaluation board and L9958 demonstration board.

**Table 9. ST10F276 pin out for L9958 board**

| Function | Name | GPIO | PIN | F27x_SH(1) |
|---|---|---|---|---|
| EN/DI | DI | P2.0 | Pin 47 - GPIO | C17 |
| | EN | P2.1 | Pin 48 – GPIO | D17 |
| Direction control | DIR | P2.2 | Pin 49 – GPIO | C18 |
| | PWM | P7.0 | Pin 19 – POUT0 | A22 |
| SPI signals | /CS | P2.3 | Pin 50 – GPIO | D18 |
| | SCK | P3.13 | Pin 80- SCLK0 | D25 |
| | SI | P3.9 | Pin 76-MTSR0 | C26 |
| | SO | P3.8 | Pin 75-MRST0 | D26 |
| UART signals | TxD1 | P8.7 | Pin 16-TxD1 | B21 |
| | RxD1 | P8.6 | Pin 15-RxD1 | A21 |
| | TxD0 | P3.10 | Pin 77-TxD0 | C11 |
| | RxD0 | P3.11 | Pin 78-RxD0 | D11 |

1. F276_SH is the board made by ShangHai BPT&S Lab APG China (ST10F27X EVA v1.0).

# 4 Revision history

Table 10. Document revision history

| Date | Revision | Changes |
|---|---|---|
| 28-Jul-2009 | 1 | Initial release. |

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