AND9474/D

MOSFET Power Module Application Note using the STK984-190-E

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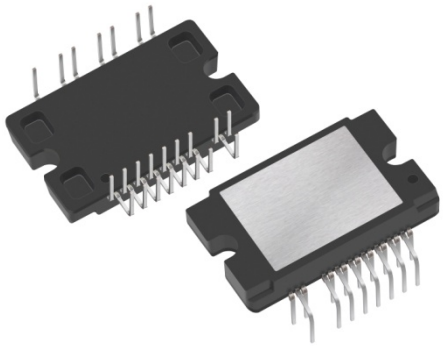
APPLICATION NOTE

1. Product synopsis

This application note provides practical guidelines for designing with the **STK984-190-E**.

The STK984-190-E is a MOSFET power module containing 6 MOSFETs in a three-phase bridge (B6) configuration and a seventh MOSFET used as a reverse battery protection switch. The compact module is 29.6 mm × 18.2 mm and is 4.3 mm high The MOSFET module uses a DBC substrate for excellent thermal performance. The module is suitable for 12 V automotive and industrial applications with motors rated up to 300 W.



DIP-S3

The key functions are outlined below:

- Three-phase MOSFET bridge with reverse battery protection switch.
- Device is PPAP capable.
- Compact 29.6 mm × 18.2 mm dual in-line package
- Motor power up to 300 W for 12 V systems.
- 40 V MOSFETs with 30 A continuous and 85 A pulse current ratings

A simplified block diagram of a motor control system is shown in Figure 1.

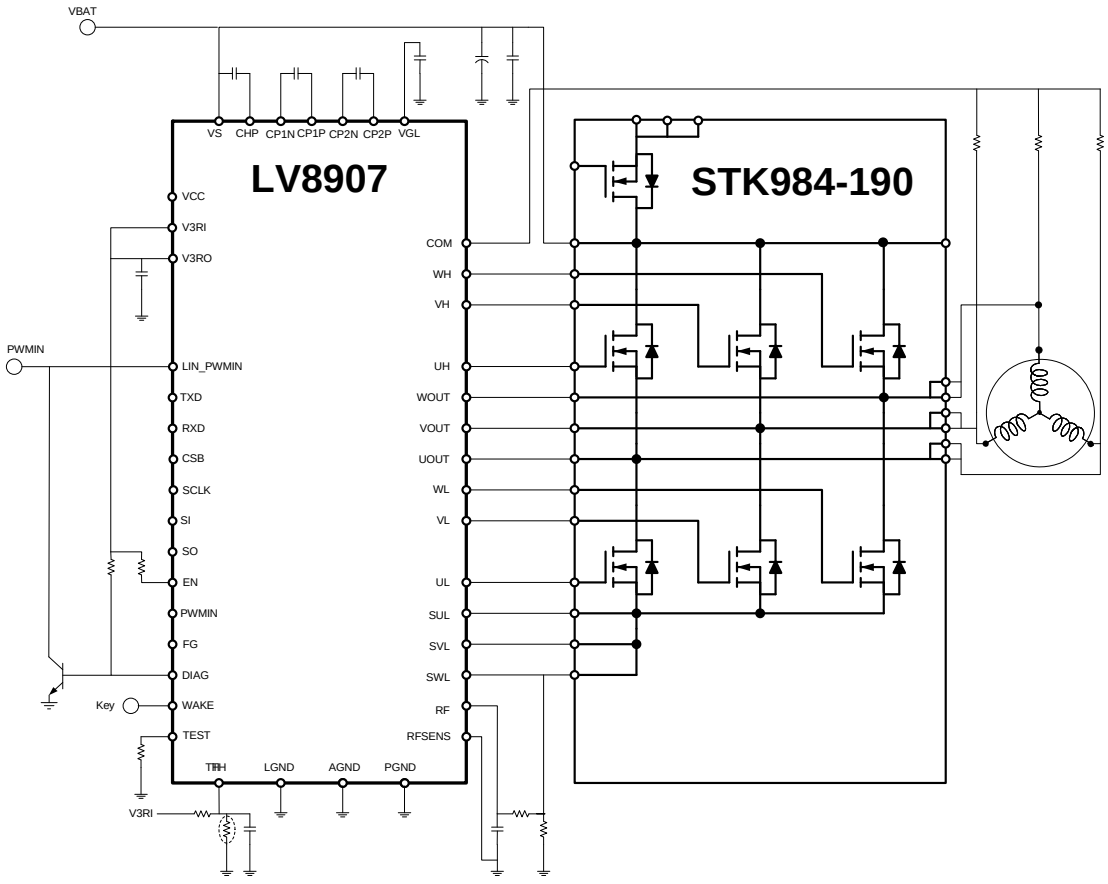


Figure 1. Motor Control System Block Diagram

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2. Product description

Table1 gives an overview of the device and. For package drawing, please refer to Chapter 5.

Device	**STK984-190-E**
Package	DIP-S3 – horizontal pins
Voltage (V_{DSS})	40V
Current (ID max)	30A
Peak current (ID pulse)	85A

Table 1. Device Overview

Table2 shows an internal block diagram.

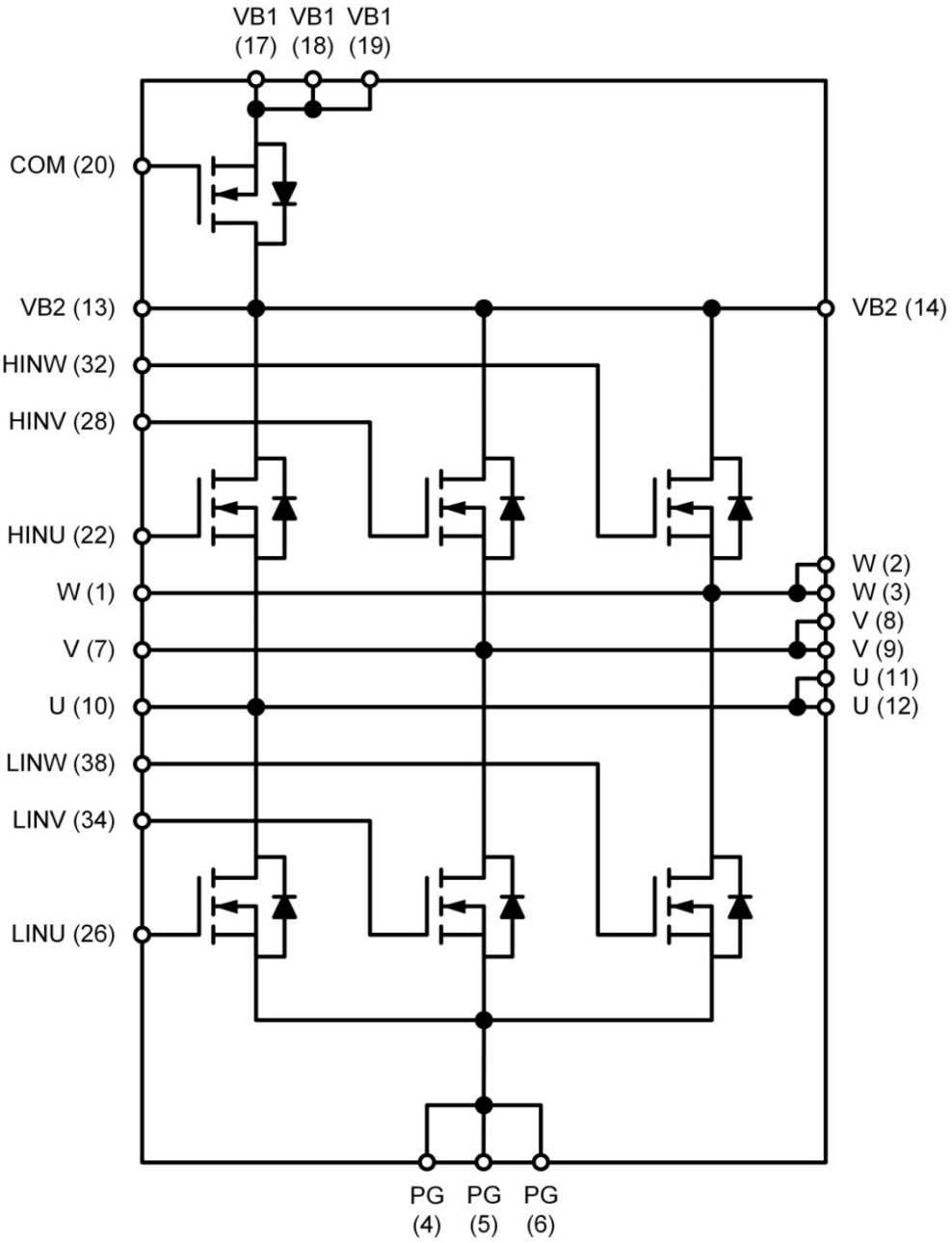


Figure 2. Internal Block Diagram

3. Performance test guidelines

The methods used to test some datasheet parameters are shown in Figures 3 to 5.

3.1. Switching time definition and performance test method

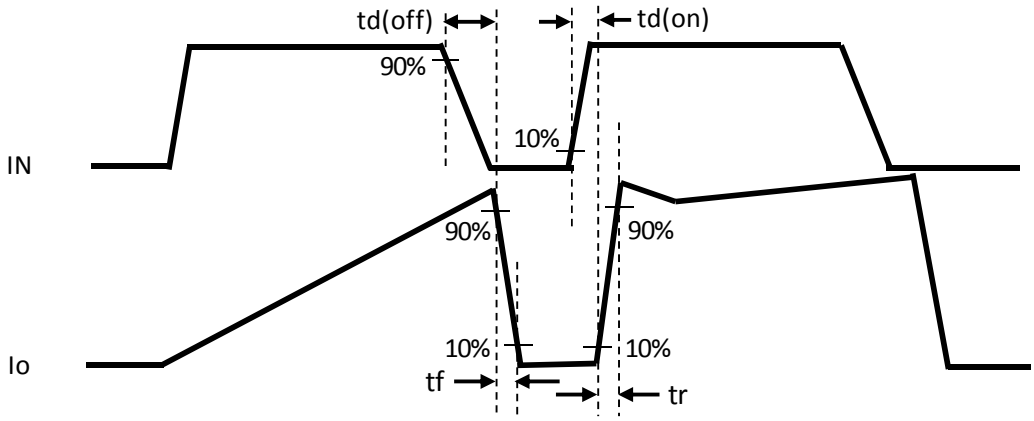


Figure 3. Switching Time Definition

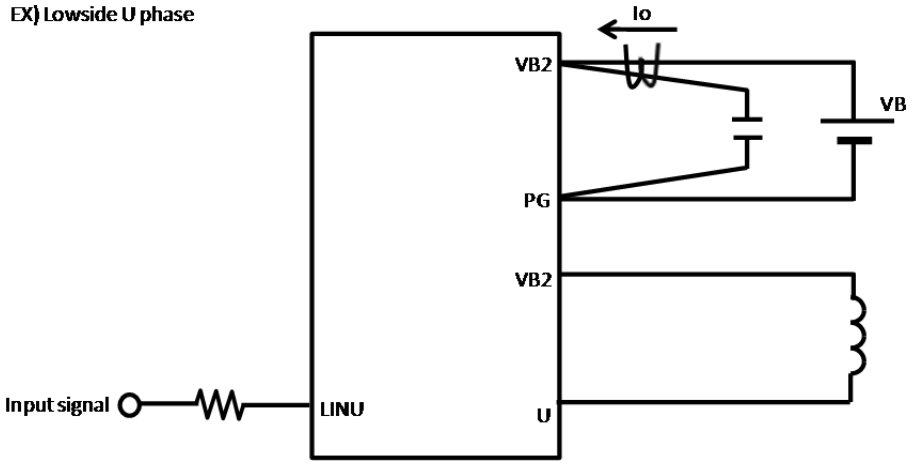


Figure 4. Evaluation Circuit (Inductive load)

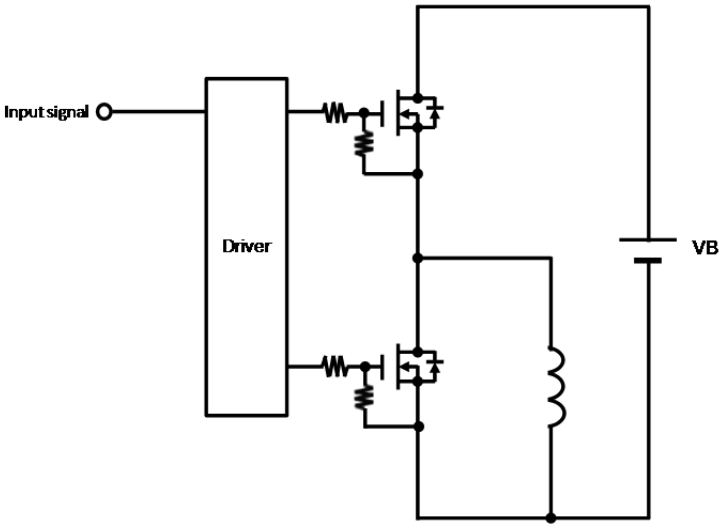


Figure 5. Switching Loss Measurement Circuit

4. PCB design and mounting guidelines

This chapter provides guidelines for an optimized design and PCB layout as well as module mounting recommendations to appropriately handle and assemble the PM.

4.1. Application (schematic) design

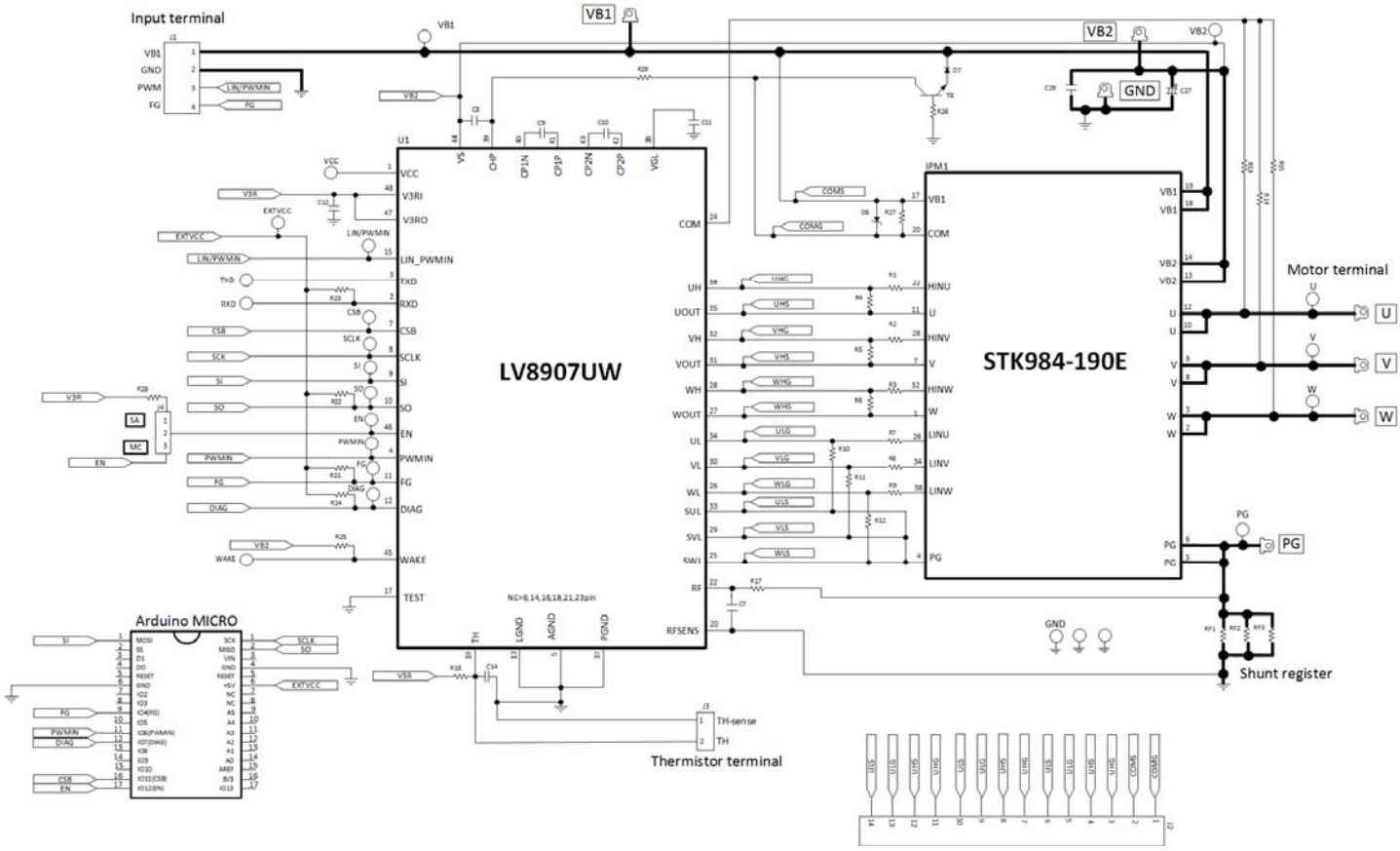


Figure 6. Application Circuit

4.2. Pin by pin design and usage notes

This section provides pin by pin PCB layout recommendations and usage notes. A complete list of module pins is given in Chapter 5.

VB1, VB2
PG

DC Power supply terminal for the inverter block and reverse battery protect switch. Voltage spikes could be caused by longer traces to these terminals due to the trace inductance, therefore traces are recommended to be as short as possible. In addition a snubber capacitor should be connected as close as possible to the VB terminal to stabilize the voltage and absorb voltage surges.

U, V, W

These are the output pins for connecting the 3-phase motor. They share the same GND potential with each of the high-side control power supplies. Therefore they are also used to connect the GND of the bootstrap capacitors. These bootstrap capacitors should be placed as close to the module as possible.

HINU, LINU
HINV, LINV
HINW, LINW
COM

These pins are the control inputs for the power stages. The inputs on HINU/HINV/HINW control the high-side MOSFETs of U/V/W, the inputs on LINU/LINV/LINW control the low-side MOSFETs of U/V/W, and the input on COM controls the MOSFETs of reverse battery protect switch. The input logic is active HIGH.

MOSFETs control signals must include a dead-time to avoid shoot-through at the power stage.

External pull-down resistor with a value of 100kΩ is recommended to prevent erroneous switching caused by noise induced in the wiring. Additionally external gate resistor with a value of 10 to 51Ω is recommended as electrostatic countermeasure and switching noise reduction.

4.3. Heat sink mounting and torque

If a heat sink is used, insufficiently secure or inappropriate mounting can lead to a failure of the heat sink to dissipate heat adequately.

The following general points should be observed when mounting PM on a heat sink:

1. Verify the following points related to the heat sink:
   - There must be no burrs on aluminum or copper heat sinks.
   - Screw holes must be countersunk.
   - There must be no unevenness in the heat sink surface that contacts PM.
   - There must be no contamination on the heat sink surface that contacts PM.

2. Highly thermal conductive silicone grease needs to be applied to the whole back (aluminum substrate side) uniformly, and mount PM on a heat sink. If the device is removed, grease must be applied again.

3. For a good contact between the PM and the heat sink, the mounting screws should be tightened gradually and sequentially while a left/right balance in pressure is maintained. Either a bind head screw or a truss head screw is recommended. Please do not use tapping screw. We recommend using a flat washer in order to prevent slack.

The standard heat sink mounting condition of the STK984-190-E is as follows.

Item	Recommended Condition
Pitch	26.0±0.1mm (Please refer to Package Outline Diagram)
Screw	diameter : M3 Screw head types: pan head, truss head, binding head
Washer	Plane washer The size is D:7mm, d:3.2mm and t:0.5mm JIS B 1256
Heat sink	Material: Aluminum or Copper Warpage (the surface that contacts PM) : −50 to 50 μm Screw holes must be countersunk. No contamination on the heat sink surface that contacts PM.
Torque	Temporary tightening : 50 to 60 % of final tightening on first screw Temporary tightening : 50 to 60 % of final tightening on second screw Final tightening : 0.4 to 0.6Nm on first screw Final tightening : 0.4 to 0.6Nm on second screw
Grease	Silicone grease. Thickness : 50 to 100 μm Uniformly apply silicone grease to whole back. Thermal foils are only recommended after careful evaluation. Thickness, stiffness and compressibility parameters have a strong influence on performance.

Table 2. Heat Sink Mounting

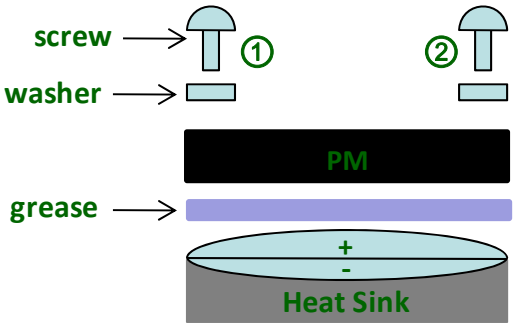


Figure 7. Mount PM on a Heat Sink

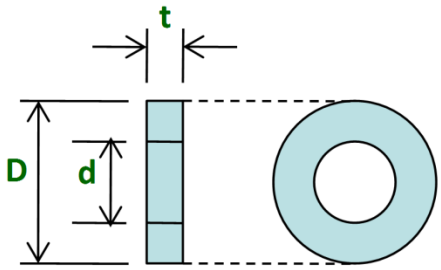


Figure 8. Size of Washer

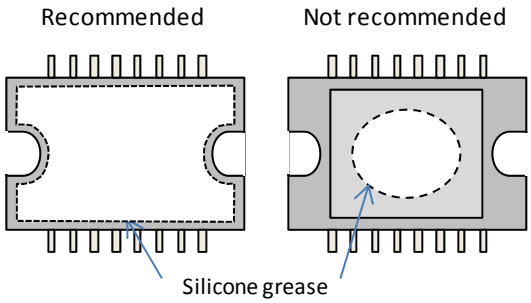


Figure 9. Uniform Application of Grease Recommended

Steps to mount an PM on a heat sink
1st: Temporarily tighten maintaining a left/right balance.
2nd : Finally tighten maintaining a left/right balance.

4.4. Mounting and PCB considerations

In designs in which the PCB and the heat sink are mounted to the chassis independently, use a mechanical design which avoids a gap between PM and the heat sink, or which avoids stress to the lead frame of PM by an assembly that slipping PM is forcibly fixed to the heat sink with a screw.

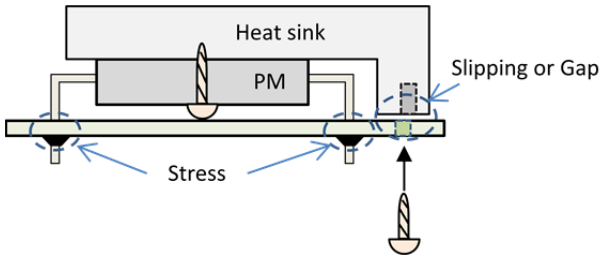


Figure 10. Fix to Heat Sink 1

Maintain a separation distance of at least 1.5 mm between the PM case and the PCB. In particular, avoid mounting techniques in which the PM substrate or case directly contacts the PCB.

Do not mount PM with a tilted condition for PCB. This can result in stress being applied to the lead frame and PM substrate could short out tracks on the PCB. If stress is given by compulsory correction of a lead frame after the mounting, a lead frame may drop out.

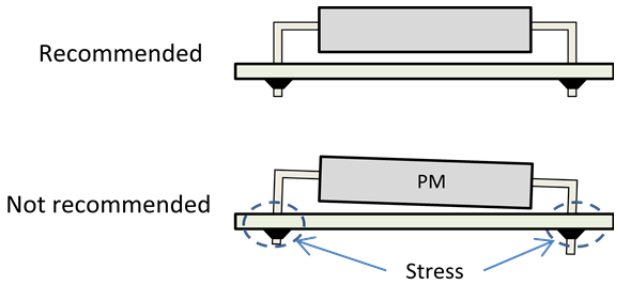


Figure 11. Fix to Heat Sink 2

Since the use of sockets to mount PM can result in poor contact with PM leads, we strongly recommend making direct connections to PCB.

Mounting on a PCB

1. Align the lead frame with the holes in the PCB and do not use excessive force when inserting the pins into the PCB. To avoid bending the lead frames, do not try to force pins into the PCB unreasonably.
2. Do not insert PM into PCB with an incorrect orientation, i.e. be sure to prevent reverse insertion. PMs may be destroyed or suffer a reduction in their operating lifetime by this mistake.
3. Do not bend the lead frame.

4.5. Cleaning

PM has a structure that is unable to withstand cleaning. Do not clean independent PM or PCBs on which an PM is mounted

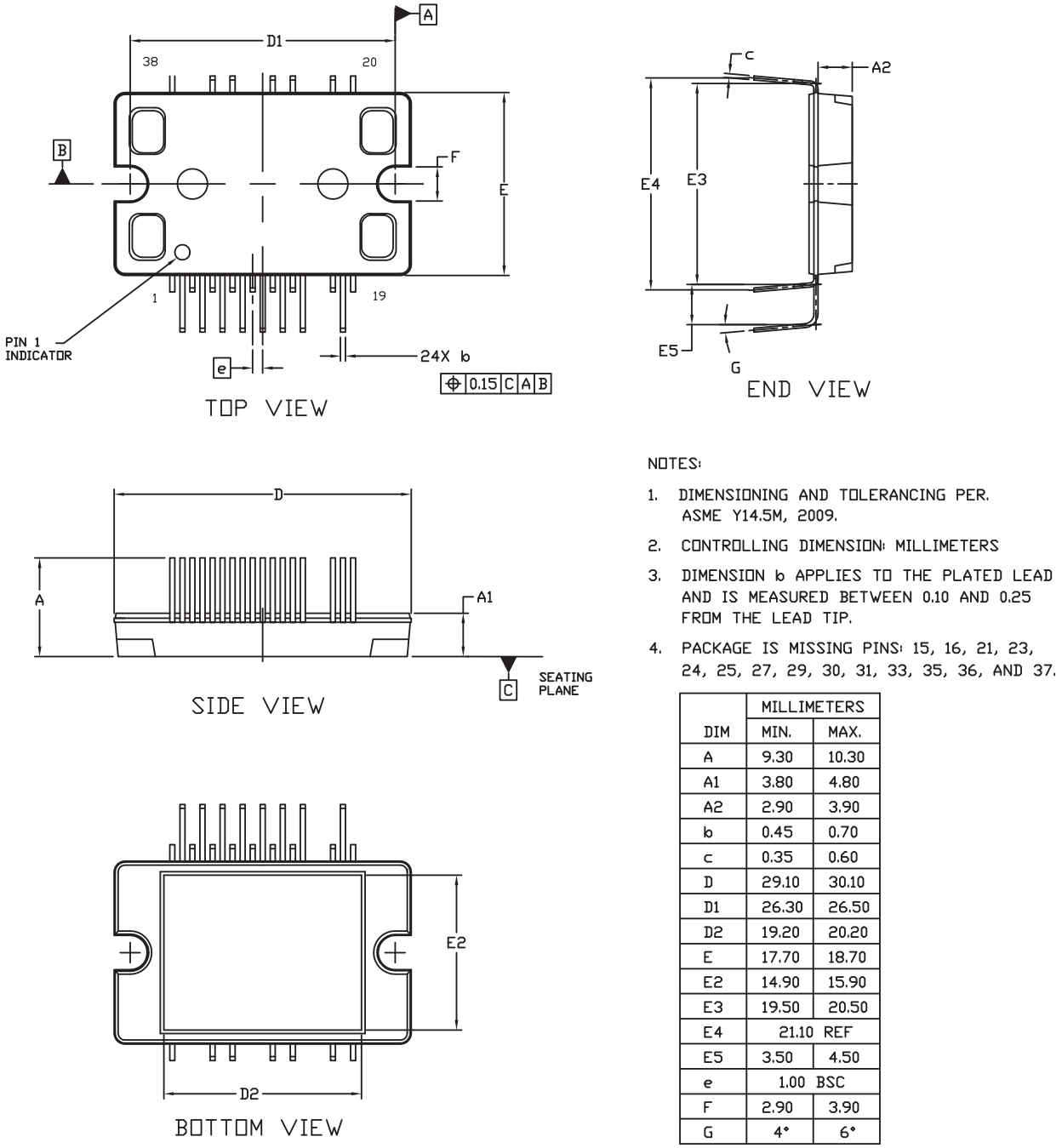
5. Package Outline

The package of STK984-190-E is DIP-S3. (Double-inline-package)

5.1. Package outline and dimension

The tolerances of length are +/– 0.5mm unless otherwise specified.

MODULE SPCM24 29.6x18.2 DIP S3
CASE MODBL
ISSUE A



NOTES:

1. DIMENSIONING AND TOLERANCING PER. ASME Y14.5M, 2009.
2. CONTROLLING DIMENSION: MILLIMETERS
3. DIMENSION b APPLIES TO THE PLATED LEAD AND IS MEASURED BETWEEN 0.10 AND 0.25 FROM THE LEAD TIP.
4. PACKAGE IS MISSING PINS: 15, 16, 21, 23, 24, 25, 27, 29, 30, 31, 33, 35, 36, AND 37.

	MILLIMETERS	
DIM	MIN.	MAX.
A	9.30	10.30
A1	3.80	4.80
A2	2.90	3.90
b	0.45	0.70
c	0.35	0.60
D	29.10	30.10
D1	26.30	26.50
D2	19.20	20.20
E	17.70	18.70
E2	14.90	15.90
E3	19.50	20.50
E4	21.10 REF	
E5	3.50	4.50
e	1.00 BSC	
F	2.90	3.90
G	4°	6°

Figure 12. Package Outline

5.2. Pin Out Description

Pin	Name	Description
1	W	W Phase Output
2	W	W Phase Output
3	W	W Phase Output
4	PG	Power Ground
5	PG	Power Ground
6	PG	Power Ground
7	V	V Phase Output
8	V	V Phase Output
9	V	V Phase Output
10	U	U Phase Output
11	U	U Phase Output
12	U	U Phase Output
13	VB2	Positive Supply for 3-phase bridge
14	VB2	Positive Supply for 3-phase bridge
17	VB1	Positive Supply to reverse battery protect switch
18	VB1	Positive Supply to reverse battery protect switch
19	VB1	Positive Supply to reverse battery protect switch
20	COM	Gate of reverse battery protect switch
22	HINU	High side gate phase U
26	LINU	Low side gate phase U
28	HINV	High side gate phase V
32	HINW	High side gate phase W
34	LINV	Low side gate phase V
38	LINW	Low side gate phase W

Note: Pins 15, 16, 21, 23, 24, 25, 27, 29, 30, 31, 33, 35, 36, 37 are not present

6. Evaluation Board

The evaluation board consists of BLDC motor driver LV8907ZUW, communication interface Arduino MICRO and the minimum required components.

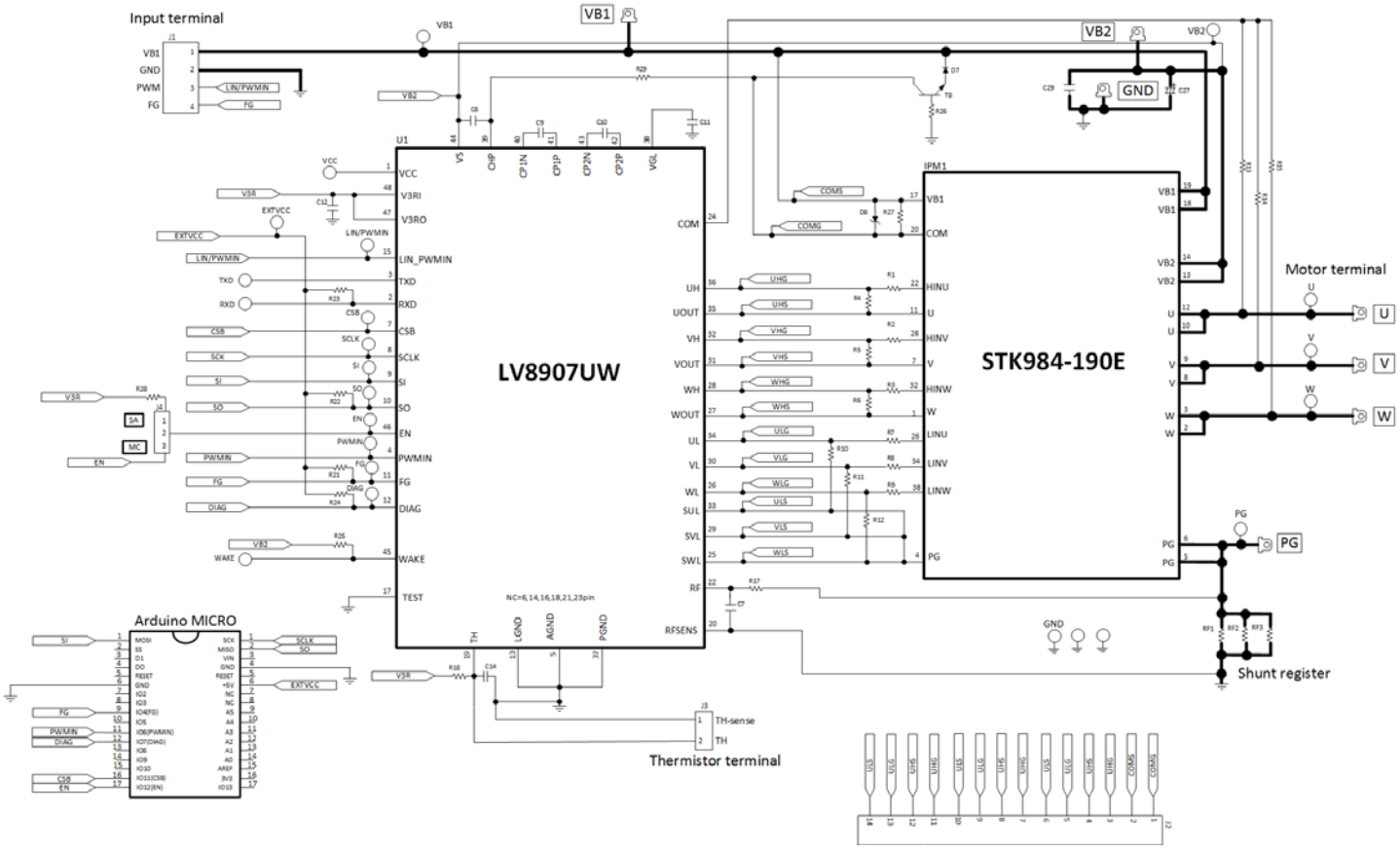
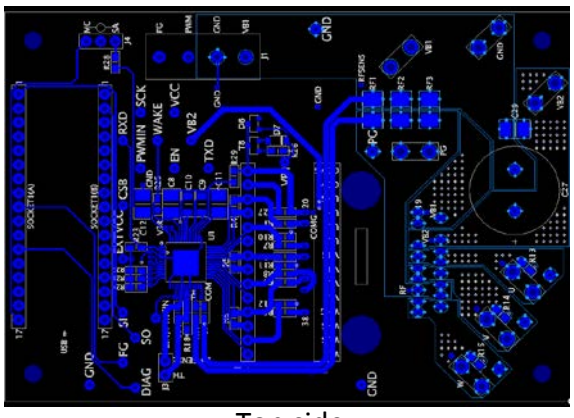
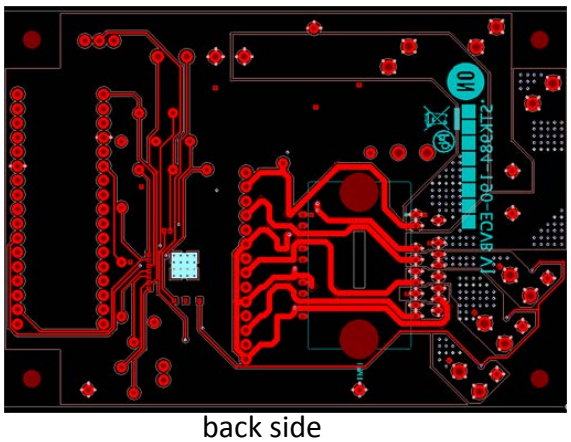


Figure 13. Evaluation Board Schematic



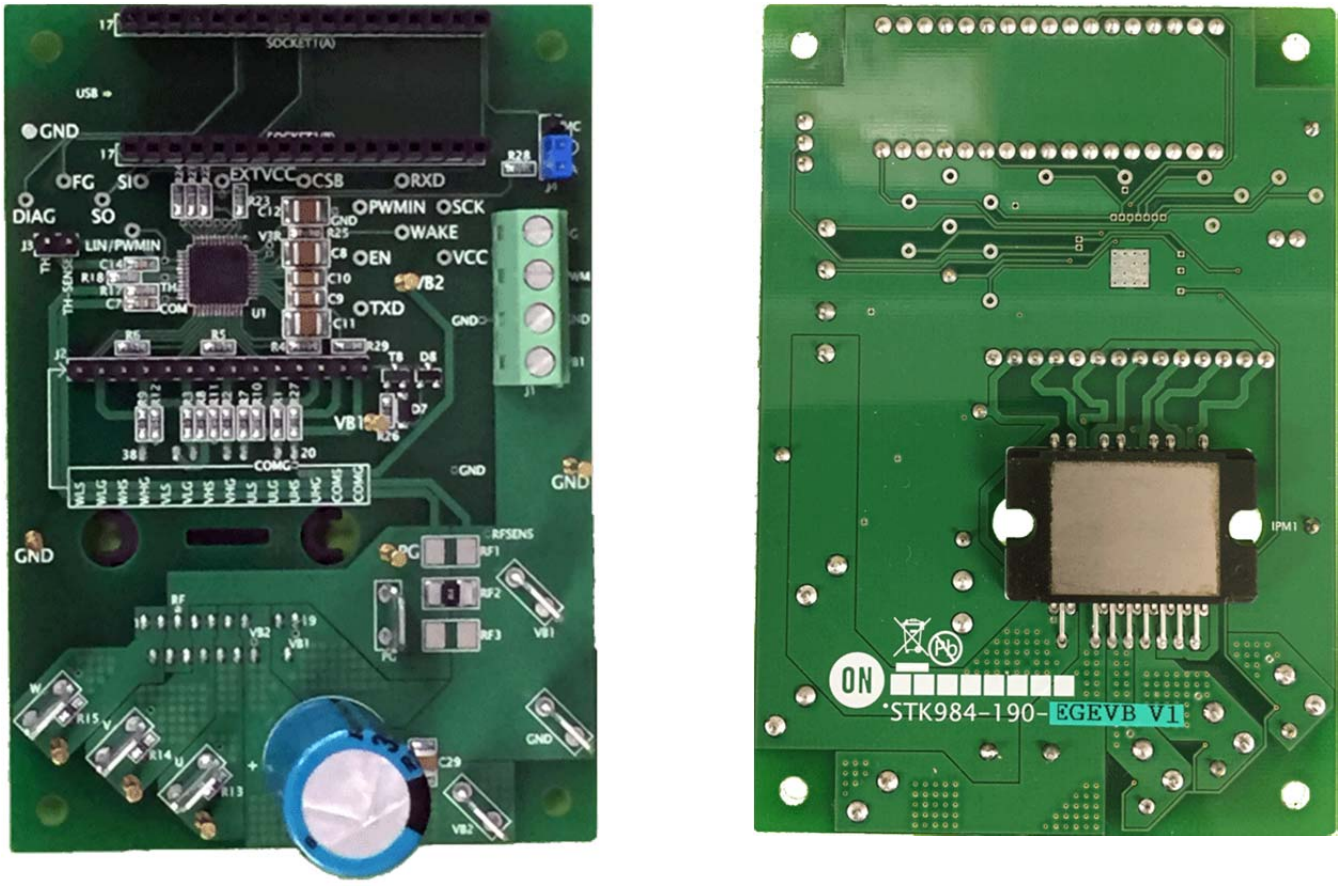
Top side



back side

Length : 70mm	Rigid double-sided substrate (Material : FR-4)
Side : 100mm	Both sides with resist coating
Thickness : 1.6mm	Copper foil thickness : 35um

Figure 14. PCB Layout (Top view)



Top view

Bottom view

Figure 15. Top and Bottom Views of Evaluation Board

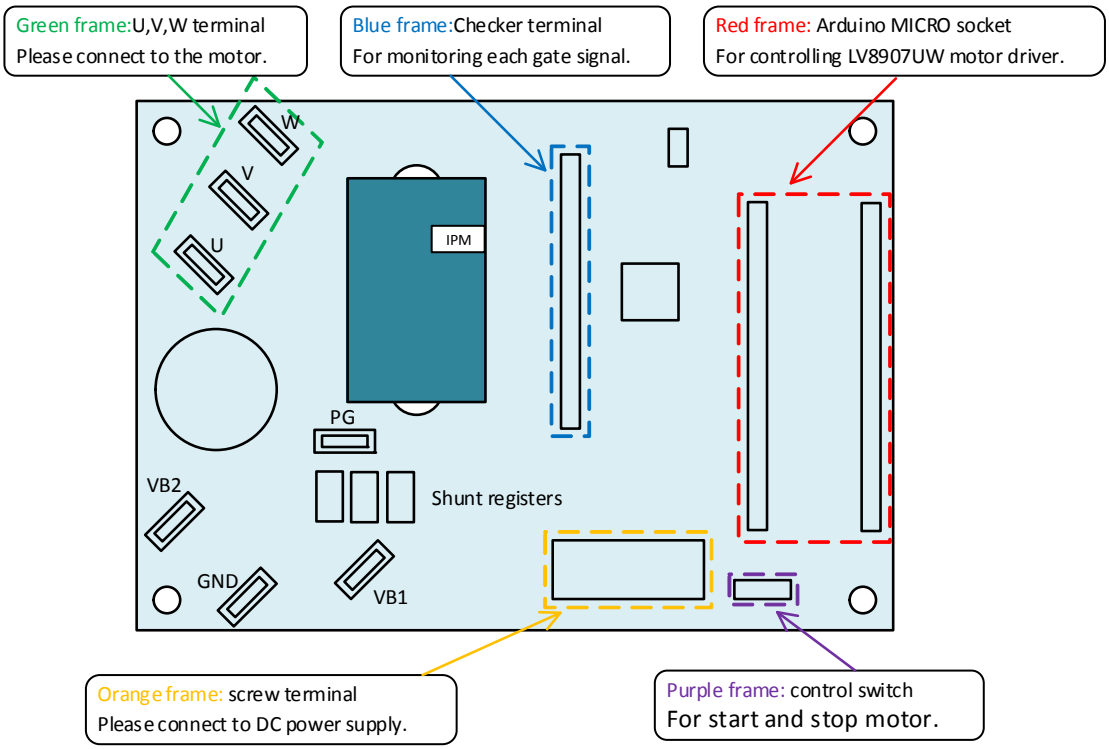


Figure 16. Pin Description

OPERATION PROCEDURE (Basic usage)

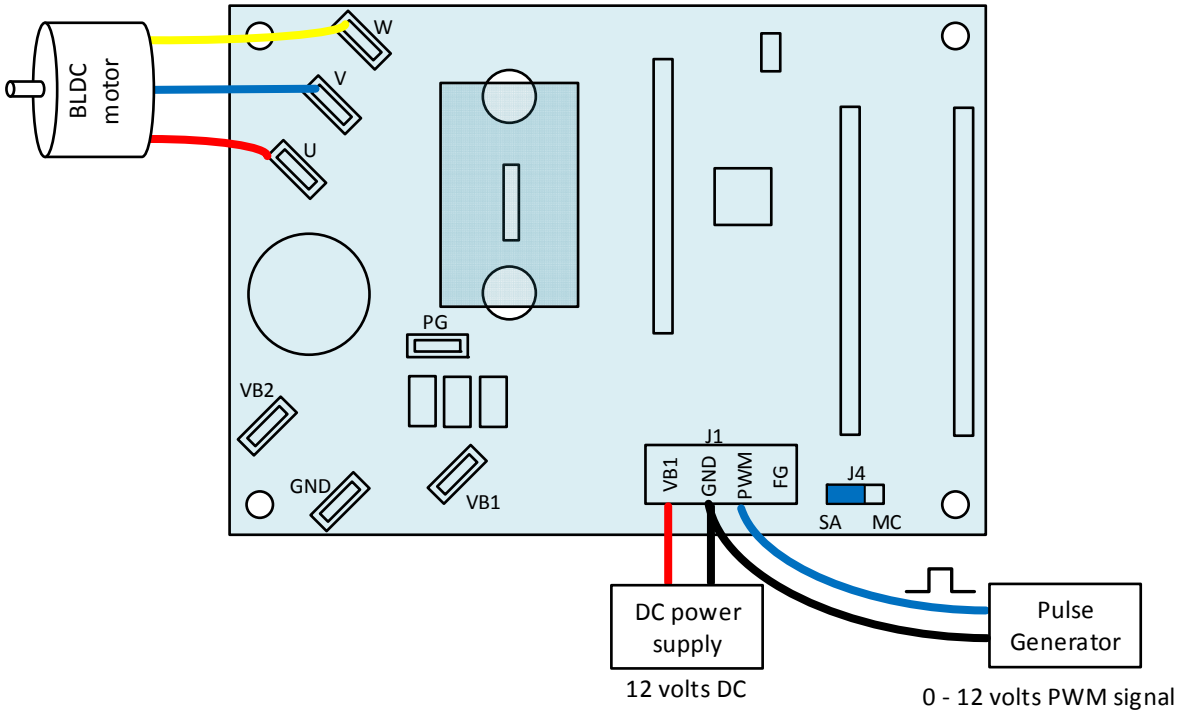


Figure 17. Connection (Basic)

Operating procedure

Step 1: Connect a power supply and pulse generator to J1.

Step 2: Connect a motor to U, V and W TAB terminal.

Step 3: Put short socket at SA side of J4.

Step 4: Turn on the power supply and supply 12 volts.

Step 5: Turn on the pulse generator and supply PWM signal. (Recommended duty ratio is 50%)

(PWM signal requirement - amplitude: 0 -12 volts, frequency range: 5.3-1000Hz, duty ratio; 15 - 85%)

Step 6: Spin up the motor, motor speed can be manipulated with the PWM signal's duty ratio.

OPERATION PROCEDURE (Advanced usage use fully function of LV8907UW)

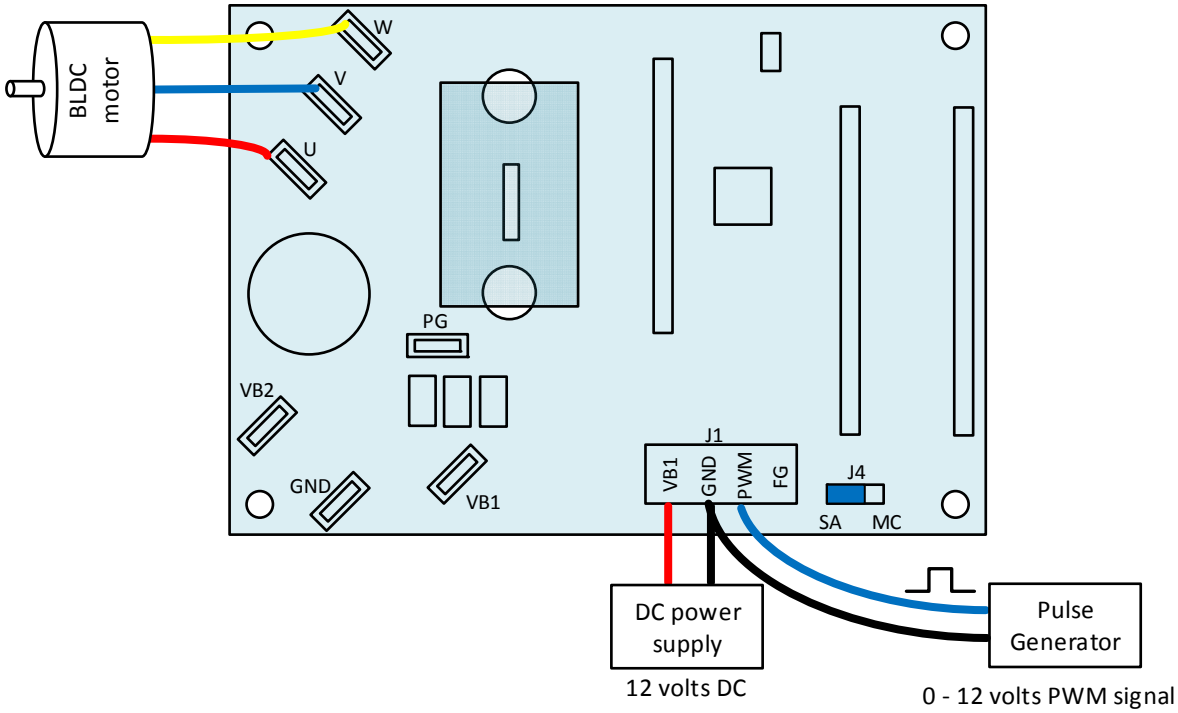


Figure 18. Connection (Basic)

Before using advanced feature, preparations are necessary.

Get Arduino MICRO by yourself. (Please see Arduino MICRO information on the Arduino web site)

https://www.arduino.cc/en/Main/ArduinoBoardMicro

Download LV8907UW PC based graphical user interface (GUI) software and USER GUIDE from LV8907UWGEVK (LV8907UW evaluation board) web site.

http://www.onsemi.jp/PowerSolutions/evalBoard.do?id=LV8907UWGEVK

PC must be installed GUI software and USB driver and Arduino MICRO must be installed firmware.

Please read detail instructions in LV8907UWGEVK USER GUIDE to use LV8907UW GUI.

Operating procedure

Step 1: Install the Arduino MICRO on the socket.

Step 2: Connect the Arduino MICRO and PC via USB type B Micro cable.

Step 3: Connect a power supply and pulse generator to J1.

Step 4: Connect a motor to U, V and W TAB terminal.

Step 5: Put short socket at MC side of J4.

Step 6: Turn on the power supply and supply 12 volts.

Step 7: Turn on the pulse generator and supply PWM signal. (Recommended duty ratio is 50%)

(PWM signal requirement - amplitude: 0 -12 volts, frequency range: 5.3-1000Hz, duty ratio; 15 - 85%)

Step 8: Use GUI to manipulate LV8907UW.

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