TSM11

Integrated Step-Servo Motor

Hardware Manual
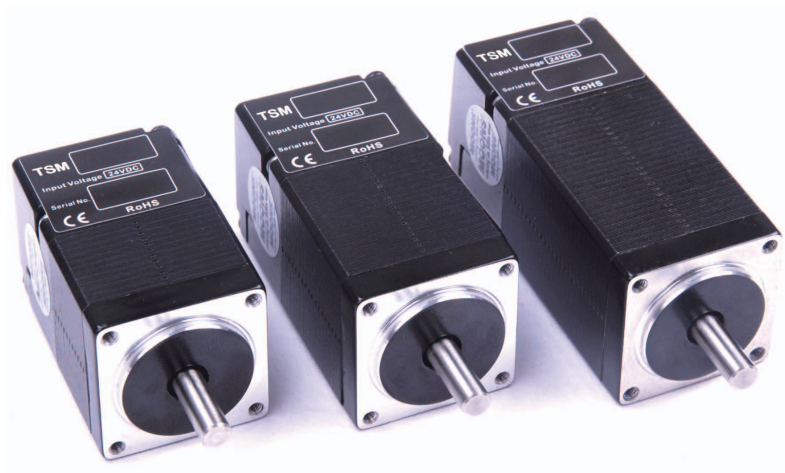
AMP & MOONS' Automation

Contents

The information in this manual applies to the following products:

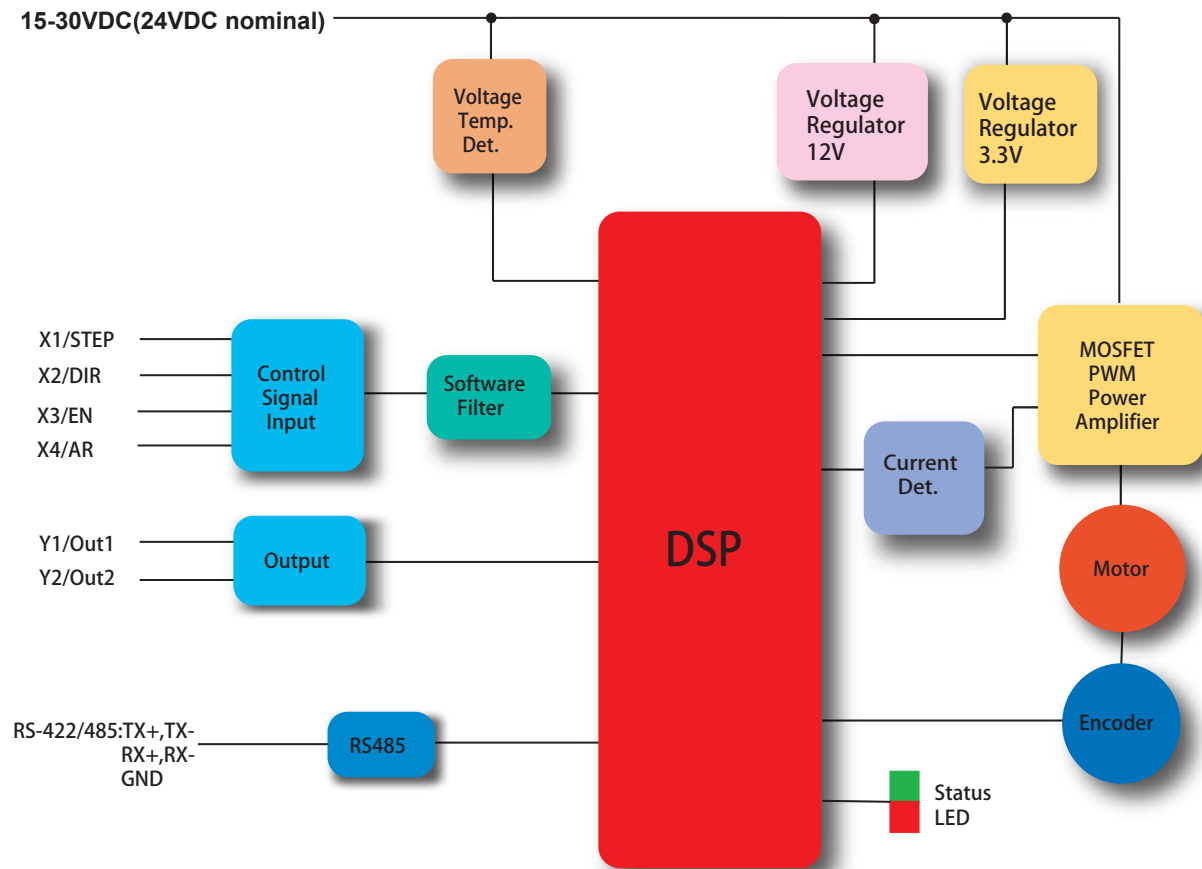| Model	Communication	
	RS-422/485	Modbus/RTU
TSM11S-1RM	✓	
TSM11S-2RM	✓	
TSM11S-3RM	✓	
TSM11Q-1RM	✓	✓
TSM11Q-2RM	✓	✓
TSM11Q-3RM	✓	✓

1 Introduction

Thank you for selecting the MOONS' TSM11 Integrated Motor. The Step-Servo is an innovative revolution for the world of stepper motor, it enhances the stepper motors with servo technology to create a product with exceptional feature and broad capability. TSM is MOONS' 3rd generation integrated Step-Servo and compact motor+drive+encoder+controller all-in-one solution. With improved technology, TSM upgrades significant key features based on 2nd generation SSM and operates more efficient and intelligent.
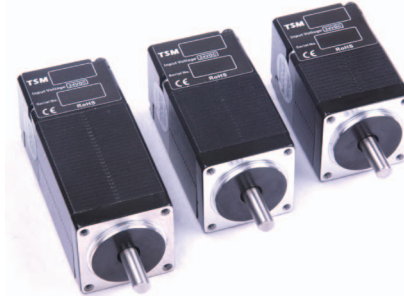
1.1 Features

- Programmable, micro-stepping digital step-servo motor and driver in an integrated package
- Operates from a 15 to 30 volt DC (24VDC nominal) power supply
- Control Modes:
    - Profile Position
        - * Step and Direction
        - * CW/CCW pulse
        - * A/B Quadrature (Encoder following)
        - * Serial Commanded Position
    - Profile Velocity
        - * I/O Controlled Velocity
        - * Serial Commanded Velocity
    - Torque Mode
        - * Serial Commanded torque mode
    - Q Programming (TSM11Q only)
- Communications:
    - RS-422/485, Modbus/RTU protocol
- Encoder feedback
- Available torque:
    - TSM11□-1RM up to 65mN.m
    - TSM11□-2RM up to 80mN.m
    - TSM11□-3RM up to 125mN.m
- I/O:
    - Digital Input filtering both hardware and software
    - 4 digital inputs, 5 to 24VDC, up to 1MHz
    - 2 digital outputs, 30VDC, 100 mA max
- Support multiple homing methods

1.2 Block Diagram

15-30VDC(24VDC nominal)

Voltage Temp. Det.

Voltage Regulator 12V

Voltage Regulator 3.3V

X1/STEP
X2/DIR
X3/EN
X4/AR

Control Signal Input

Software Filter

DSP

MOSFET PWM Power Amplifier

Current Det.

Motor

Y1/Out1
Y2/Out2

Output

Encoder

RS-422/485:TX+,TX-
RX+,RX-
GND

RS485

Status LED

TSM11 Block Diagram

I/O Configurations

X1(5-24Volts)	X2(5-24Volts)	X3(5-24Volts)	X4(5-24Volts)	Y1(30V, 100mA)	Y2(30V, 100mA)
: Step	: Direction	: Enable	: Alarm Reset	: Fault Output	: Brake Output
: CW Step	: CCW Step	: General Purpose	: Change Speed	: General Purpose	: Motion Output
: A Quadrature	: B Quadrature		: General Purpose		: Tach Output
: CW Limit	: CCW Limit				: General Purpose
: CW Jog	: CCW Jog				
: Run/Stop	: General Purpose				
: General Purpose					

1.3 Safety Instructions

Only qualified personnel should transport, assemble, install, operate, or maintain this equipment. Properly qualified personnel are persons who are familiar with the transport, assembly, installation, operation, and maintenance of motors, and who meet the appropriate qualifications for their jobs.

To minimize the risk of potential safety problems, all applicable local and national codes regulating the installation and operation of equipment should be followed. These codes may vary from area to area and it is the responsibility of the operating personnel to determine which codes should be followed, and to verify that the equipment, installation, and operation are in compliance with the latest revision of these codes.

Equipment damage or serious injury to personnel can result from the failure to follow all applicable codes and standards. MOONS' does not guarantee the products described in this publication are suitable for a particular application, nor do they assume any responsibility for product design, installation, or operation.

Read all available documentation before assembly and operation. Incorrect handling of the products referenced in this manual can result in injury and damage to persons and machinery. All technical information concerning the installation requirements must be strictly adhered to.

It is vital to ensure that all system components are connected to earth ground. Electrical safety is impossible without a low-resistance earth connection.

This product contains electrostatically sensitive components that can be damaged by incorrect handling. Follow qualified anti-static procedures before touching the product.

During operation keep all covers and cabinet doors shut to avoid any hazards that could possibly cause severe damage to the product or personal health.

During operation the product may have components that are live or have hot surfaces.

Never plug in or unplug the Integrated Motor while the system is live. The possibility of electric arcing can cause damage.

Be alert to the potential for personal injury. Follow recommended precautions and safe operating practices emphasized with alert symbols. Safety notices in this manual provide important information. Read and be familiar with these instructions before attempting installation, operation, or maintenance. The purpose of this section is to alert users to the possible safety hazards associated with this equipment and the precautions necessary to reduce the risk of personal injury and damage to equipment. Failure to observe these precautions could result in serious bodily injury, damage to the equipment, or operational difficulty.

2 Getting Started

The following items are needed:

- A 15-30 volt DC power supply (24VDC is recommended), "Choosing a Power Supply" for help in choosing the right one
- Download **Step-Servo Quick Tuner** software from MOONS' website
- A PC running Windows XP, Vista, Windows 7 or Windows 8 (32-bit or 64-bit)
- A mating cable(for power, I/O and communication connection, included in package)
- A RS-485 converter

2.1 Installing Software

Before utilizing the TSM11 Integrated Motor and Step-Servo Quick Tuner Software in an application, the following steps are necessary:

- Install the Step-Servo Quick Tuner
- Launch the software by clicking Start Step-Servo Quick Tuner software...Programs...MOONS'.
- Connect the drive to the PC using RS-422/485, it is recommended to set up in a 4-Wire configuration (see "Connecting to a host using RS-422/485" below.)
- Connect the drive to the power supply. See instructions below.
- Apply power to the drive.
- The software will recognize the drive and display the model and firmware version. At this point, it is ready

2.2 Mounting Hardware

As with any integrated motor, the TSM11 must be mounted so as to provide maximum heat sinking and airflow. Keep enough space around the Integrated Motor to allow for airflow.

- Never use the TSM11 where there is no airflow or where other devices cause the surrounding air to be more than 40°C (104°F).
- Never put the TSM11 where it can get wet.
- Never use the TSM11 where metal or other electrically conductive particles can infiltrate the TSM11.
- Always provide airflow around the TSM11.

2.3 Choosing a Power Supply

The main considerations when choosing a power supply are the voltage and current requirements for the application.

2.3.1 Voltage Selection

The TSM11 is designed to give optimum performance at 24 VDC . The extended range of operation can be as low as 14VDC minimum and as high as 32 VDC maximum. When operating below 18VDC, the power supply input may require larger capacitance to prevent under-voltage and internal-supply alarms. Current spikes may make supply readings erratic. The supply input cannot go below 14VDC for reliable operation. Absolute minimum power supply input is 14 VDC.

Absolute maximum power supply input is 32VDC at which point an over-voltage alarm and fault will occur. When using a power supply that is regulated and is near the drive maximum voltage of 32VDC, a voltage clamp may be required to prevent over-voltage when regeneration occurs. The RC880 Regeneration Clamp is recommended for the TSM11 in this situation (see 3.1 Connecting the Power Supply below). When using an unregulated power supply, make sure the no-load voltage of the supply does not exceed the drive's maximum input voltage of 32 VDC.

TSM11 Max Duty cycle vs Speeds at 24VDC operation(40°C)

These charts show the duty cycle of the drive at various speeds and voltages. See also Section 4.4 on Drive/Motor Heating for more information
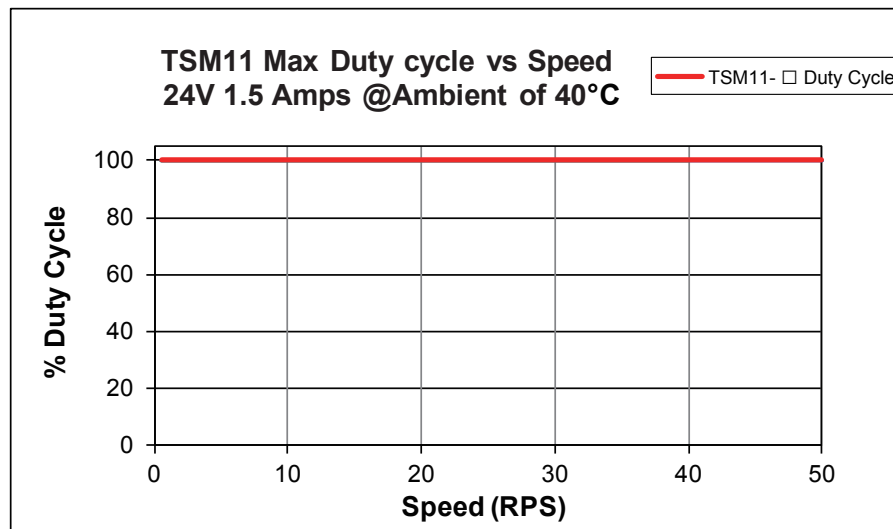
2.3.2 Current

The power supply current required by the TSM11 at 24VDC input is shown in the charts below.

Note that the supply current flowing into the TSM11 is less than the motor phase current. That's because TSM11's switching amplifier converts high voltage and low current from the DC power supply into the higher current and lower voltage required by the motor.

Also note that the current draw is significantly different at higher speeds depending on the torque load to the motor. Estimating your current needs may require a good analysis of the load the motor will encounter.
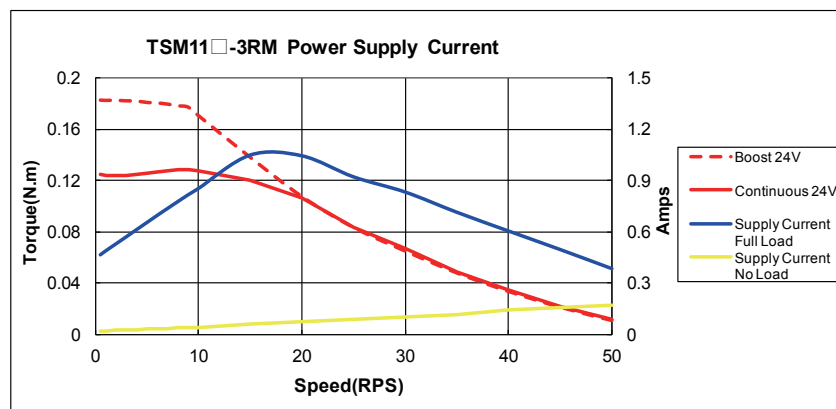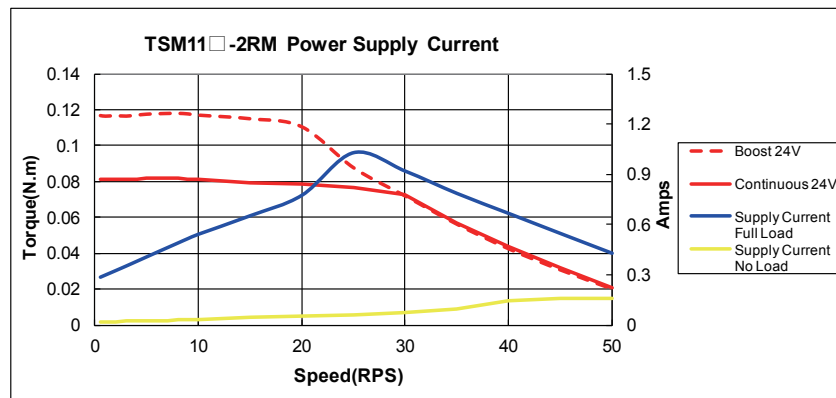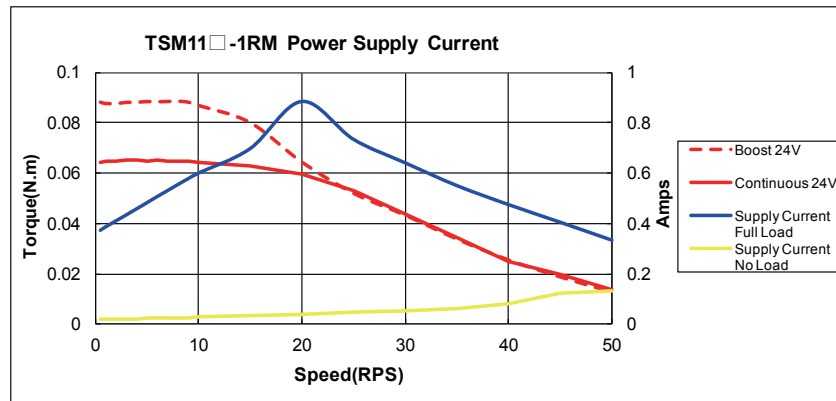
3 Installation/Connections

3.1 Connecting the Power Supply

Connect the power supply "+" terminal to the drive "+" terminal and the power supply "-" terminal

to the drive "-" terminal using AWG 26 wire. The TSM11 contains an internal fuse connected to the "+" terminal. This fuse is not user replaceable. If a user serviceable fuse is desired, install a 2 amp fast acting fuse in line with the "+" power supply lead.
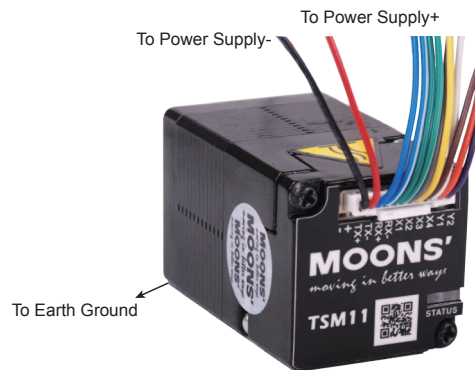
⚠ **Be careful not to reverse the wires. Reversing the connection may open the internal fuse and void the warranty.**

If a regulated power supply is being used, there may be a problem with regeneration. When a load decelerates rapidly from a high speed, some of the kinetic energy of the load is transferred back to the power supply, possibly tripping the over-voltage protection of a regulated power supply, causing it to shut down. This problem can be solved with the use of a MOONS' RC880

Regeneration Clamp. It is recommended that an RC880 initially be installed in an application. If the "regen" LED on the RC880 never flashes, the clamp is not necessary.
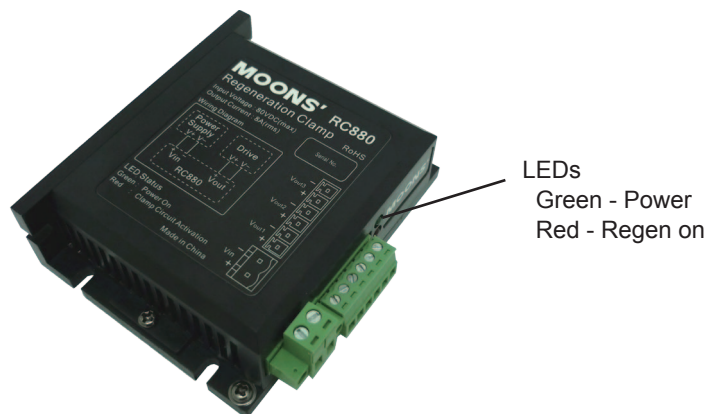
RC880 Regen Clamp

3.2 Connecting the TSM11 Communications

The TSM11 is available with RS-422/485 serial communication. Below are descriptions of how to interface RS-422/485 to a PC.

### 3.2.1 Connecting to a host using RS-422/485

RS-422/485 communication allows connection of more than one drive to a single host PC, PLC, HMI or other computer. It also allows the communication cable to be long (more than 300 meters or 1000 feet). The use of Category 5 cable is recommended as it is widely used for computer networks, inexpensive, easily obtained and certified for quality and data integrity.

The TSM11 can be used with either Two-Wire or Four-Wire RS-422/485 implementation. The connection can be point-to-point (i.e. one drive and one host) or a multi-drop network (one host and up to 32 drives).

Four-Wire Configuration

Four-Wire Systems utilize separate transmit and receive wires. One pair of wires must connect the host's transmit signals to each drive's RX+ and RX- terminals. The other pair connects the drive's TX+ and TX- terminals to the host's receive signals. The logic ground on each drive shares with the same potential of power ground (V-). So if all the drives on the RS-422/485 network are powered from the same supply it is not necessary to connect (V-) as the logic grounds. One drive's (V-) terminal should still be connected to the host computer ground.

Because the host in a four-wire system never needs to disable its transmitter, software is simplified. Some converters make this process very difficult to implement and can delay communications.
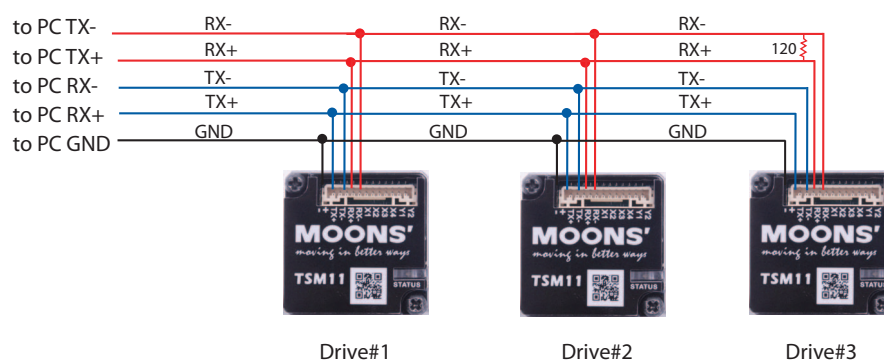
RS-422/485: 4-wire system diagram

NOTE: If the PC does not have an RS-422/485 serial port, a converter will be required.

NOTE: Send SCL Command "PR261" to the drive will enable the full duplex communication.

RS-232 to RS-422/485 4-wire Converter:

- **UT-202** is a recommended 'RS-232 to RS-422' converter from UTEK TECHNOLOGY (SHENZHEN) CO, LTD. (http://www.szutek.cn/) The connection is as follows. It only supports to establish the full-duplex (4-wire) RS-422 network. It can't be used in the half-duplex (2-wire) RS-485 network.

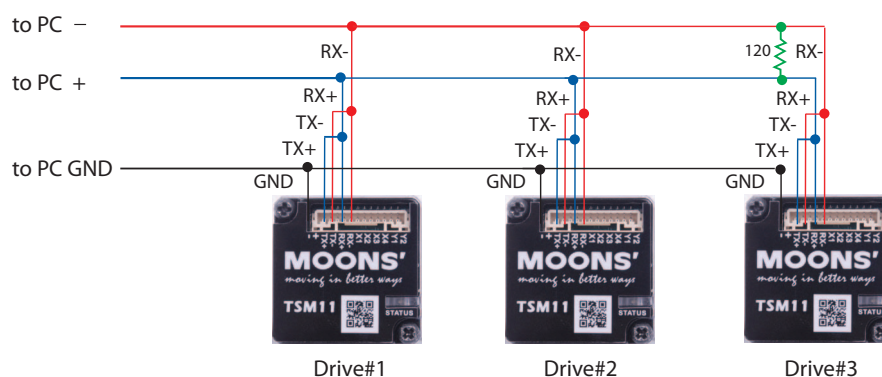| DB9 Male (PIN)	Converter Output	Drive
1	T/R+	RX+
2	T/R-	RX-
3	RX+	TX+
4	RX-	TX-
5	GND	GND

USB to RS-422/485 4-wire Converter

- **UT-890** is a recommended 'USB to RS-422/485' converter from UTEK TECHNOLOGY (SHENZHEN) CO, LTD. (http://www.szutek.cn/) The connection is as follows. It supports to establish either the half-duplex (2-wire) RS-485 network or the full-duplex (4-wire) RS-422 network.

DB9 Male (PIN)	Converter Output	Drive
1	T/R+	RX+
2	T/R-	RX-
3	RX+	TX+
4	RX-	TX-
5	GND	GND

Two-Wire Configuration

In a 2-wire system, the host must disable its transmitter before it can receive data. This must be done quickly before a drive begins to answer a query. The TSM11 includes a transmit delay parameter that can be adjusted to compensate for a host that is slow to disable its transmitter. This adjustment can be made over the network using the TD command, or it can be set using the Step-Servo Quick Tuner software. It is not necessary to set the transmit delay in a four wire system.

RS-422/485: 2-wire system diagram

NOTE: If the PC does not have an RS-422/485 serial port, a converter will be required.

NOTE: DO NOT send SCL Command "PR261" to the drive with two-wire configuration.

RS-232 to RS-422/485 2-wire Converter:

• **UT-201** is a recommended 'RS-232 to RS-485' converter from UTEK TECHNOLOGY (SHENZHEN) CO, LTD. (http://www.szutek.cn/) The connection is as follows. It only supports to establish the half-duplex (2-wire) RS-485 network. It can't be used in the full-duplex (4-wire) RS-422 network.

DB9 Male (PIN)	Converter Output	Drive
1	T/R+	RX+
2	T/R-	RX-
3	T/R+	TX+
4	T/R-	TX-
5	GND	GND

USB to RS-422/485 2-wire Converters

• **UT-890** is a recommended 'USB to RS-422/485' converter from UTEK TECHNOLOGY (SHENZHEN) CO, LTD. (http://www.szutek.cn/) The connection is as follows. It supports to establish either the half-duplex (2-wire) RS-485 network or the full-duplex (4-wire) RS-422 network.

DB9 Male (PIN)	Converter Output	Drive
1	T/R+	RX+
2	T/R-	RX-
3	T/R+	TX+
4	T/R-	TX-
5	GND	GND

3.2.2 Assigning Addresses

Before the entire system is wired, each drive will need to connect individually to the host computer so that it can be assigned a unique address.

Once the drive has been connected to the PC as described above, launch the Step-Servo Quick Tuner software. Apply power to the drive. If a drive has already been configured, click the Upload button so that the Step-Servo Quick Tuner settings match those of the drive. Click on "Step 1: configuration" button and select the SCL (Stream Command) mode. Under control mode setting, Node ID settings, The numerals 0..9 or the special characters ! " # $ % & ' ( ) * + , - . / : ; <= > ? @ may be used as addresses. Make sure each drive on the network has a unique address. On a 2-wire network, the Transmit Delay may also need to be set. Most adapters work well with10 milliseconds. Once the address has been assigned, click Download to save the settings to the drive.

3.3 Inputs and Outputs

The TSM11 has four high speed (1 MHz) digital inputs, 5 to 24VDC logic:

X1/Step can be used as Step, CW Step, A Quadrature, CW Limit, CW Jog, Run/Stop or general purpose input

X2/Direction can be used as Direction, CCW Step, B Quadrature, CCW Limit , CCW Jog or general purpose input

X3/Enable can be used as Enable, general purpose input

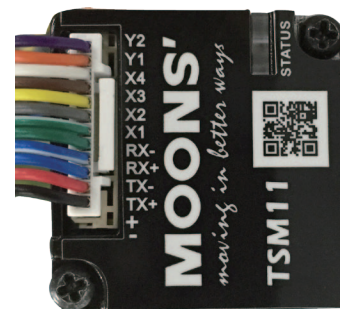X4/Alarm Reset can be used as Alarm reset, Change speed general purpose input

The TSM11 has two digital outputs, 30VDC, 100 mA max:

Y1/FAULT can be used as fault output or general purpose output.

Y2/BRAKE can be use as brake, in position, tach out or general purpose output.

3.3.1 Connector Pin Diagram

| Pin No.	Name	Description
1	Y2	Open drain outputs with freewheeling diode (30 VDC 100 mA in max.)
2	Y1	
3	X4	Digital inputs (input high voltage 5-24 VDC, input low voltage below 1 VDC, signal frequency 1 MHz in max.)
4	X3	
5	X2	Digital inputs (input high voltage 5-24 VDC, input low voltage below 2 VDC, signal frequency 1 MHz in max.)
6	X1	
7	RX-	RS-422/485 interface differential signals
8	RX+	
9	TX-	
10	TX+	
11	+	V+ power supply (typ. 24 VDC)
12	-	V- power ground (GND)

Note: All digital inputs & outputs are referenced to the power ground – (V-).

3.3.2 X1/Step & X2/Dir Digital Inputs

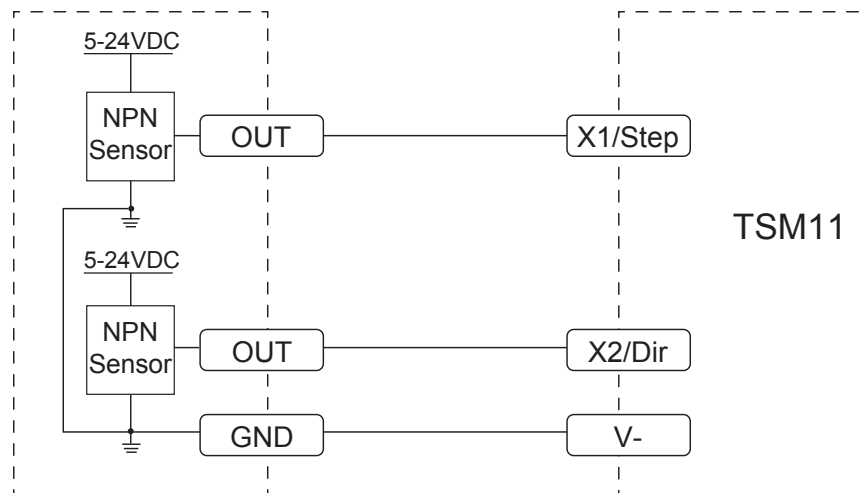The diagram below shows how to connect the X1/Step & X2/Dir Inputs to commonly used device.

Note: X1/Step & X2/Dir inputs have been pulled up to power supply input +, typ. 24 VDC

Note: If the input voltage is between 5-24 VDC, or the input is not connected, the logic state of that input is HIGH. If the input voltage is below 2 VDC, the logic state of that input is LOW.
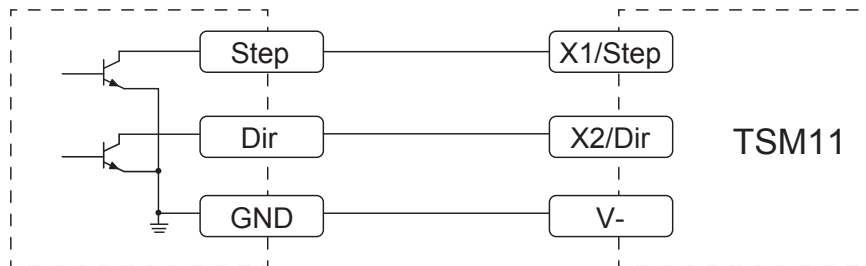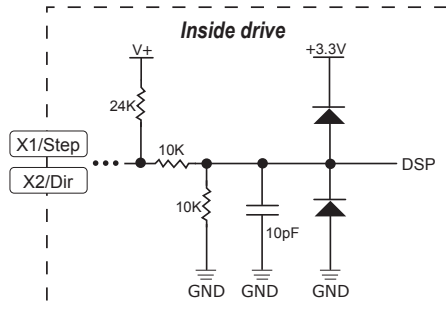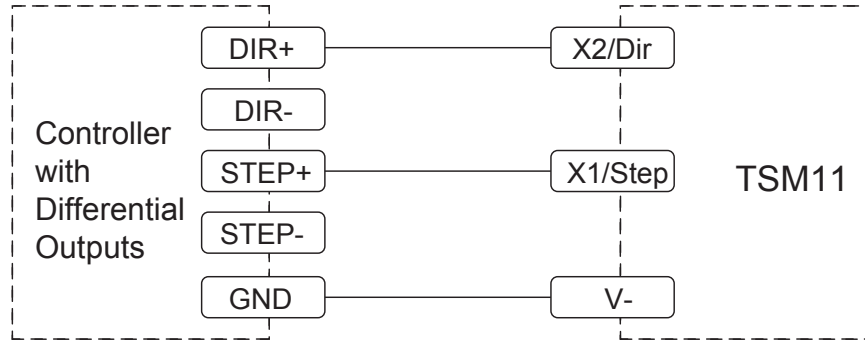

Connecting to Controller with Sinking Outputs
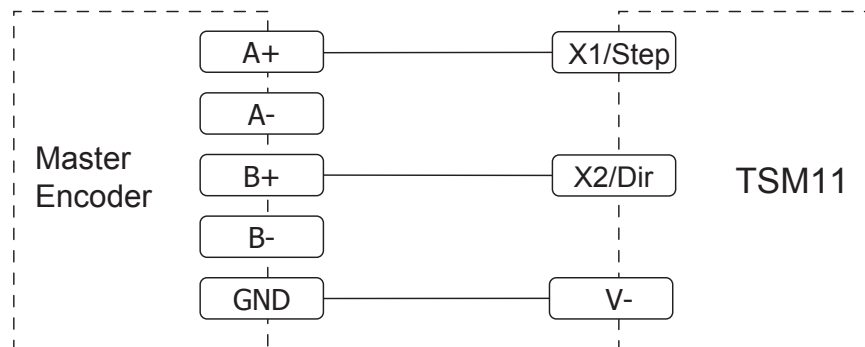Note: Souring Outputs are not compatible to inputs X1/Step and X2/Dir

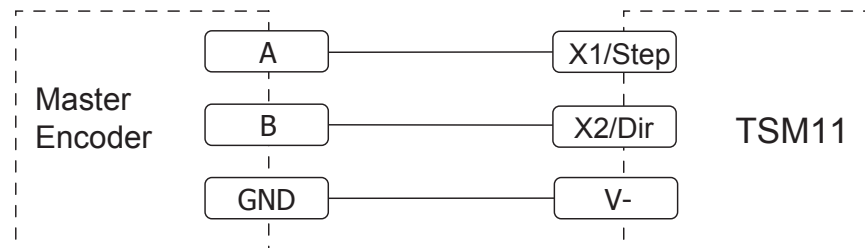Connecting to NPN type Proximity Sensor
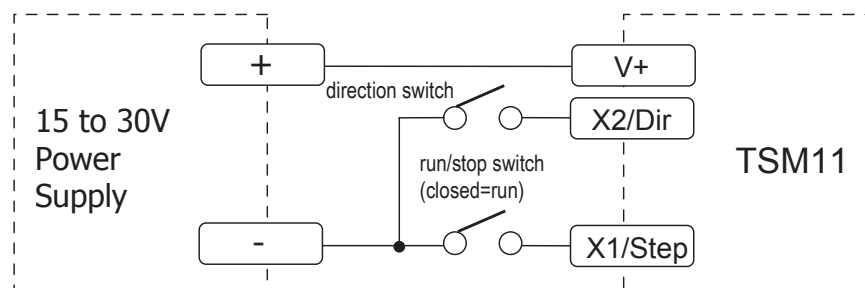Note: PNP type Proximity Sensor is not compatible to inputs X1/Step and X2/Dir

Connecting to Controller with Differential Outputs

Wiring for Encoder Following with Differential Outputs

Wiring for Encoder Following with Single-ended Sinking Outputs

Using Mechanical Switches

MOONS'

3.3.3 X3/EN & X4/AR Digital Inputs

The diagram below shows how to connect the X3/En & X4/AR Inputs to commonly used device.

Note: X3/En & X4/AR inputs have been internally pulled up to logical supply +3.3 VDC

Note: If the input voltage is between 5-24 VDC, or the input is not connected, the logic state of that input is HIGH. If the input voltage is below 1VDC, the logic state of that input is LOW.
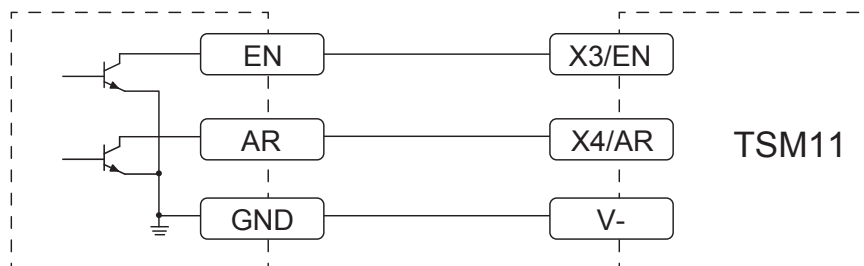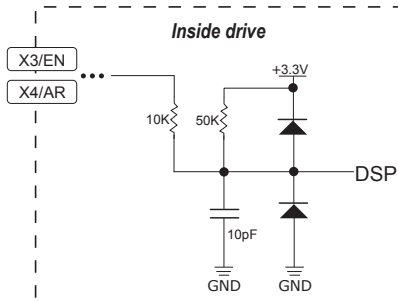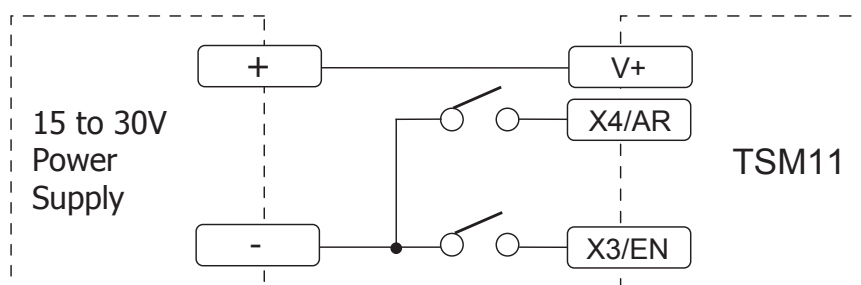

Connecting to Controller with Sinking Outputs
Note: Souring Outputs are not compatible to inputs X3/EN and X4/AR
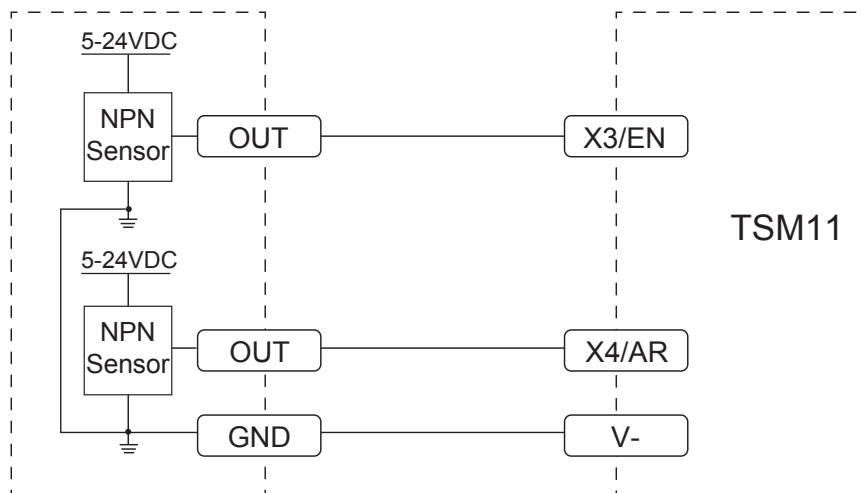
Connecting to NPN type Proximity Sensor
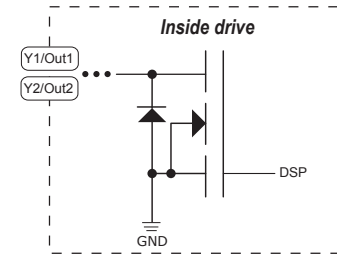Note: PNP type Proximity Sensor is not compatible to inputs X3/EN and X4/AR

Using Mechanical Switches

3.3.4 Programmable Output

The TSM11 has two digital outputs:

Y1/FAULT can be used as fault output or general purpose output.

Y2/BRAKE can be use as brake, in position, tach out or general purpose output.

Diagrams of various connection types as follows:

Note: Do not connect the output to more than 30 volts. The current through the output terminal must not exceed 100mA.
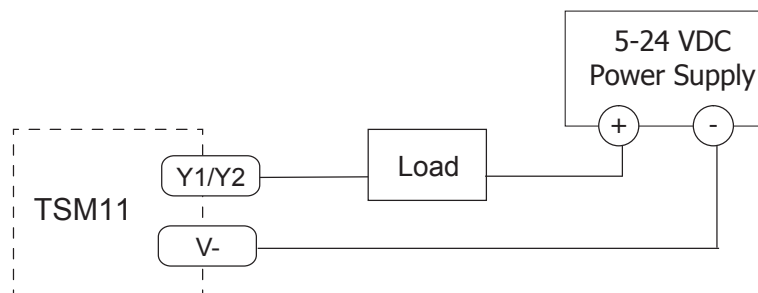
Connecting a Sinking Output
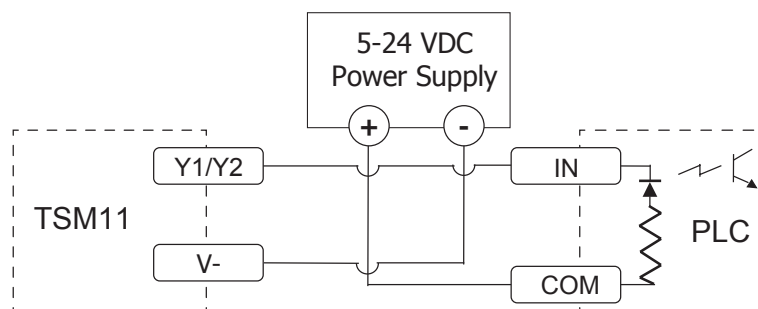
Connecting a sinking output with PLC's input
Note:Y1 and Y2 can not be used as sourcing output.

Driving a Relay

4 Reference Materials

4.1 Mechanical Outlines (Unit:mm)

Model	"L"
TSM11□-1RM	43.8
TSM11□-2RM	52.9
TSM11□-3RM	64.1

4.2 Technical Specifications

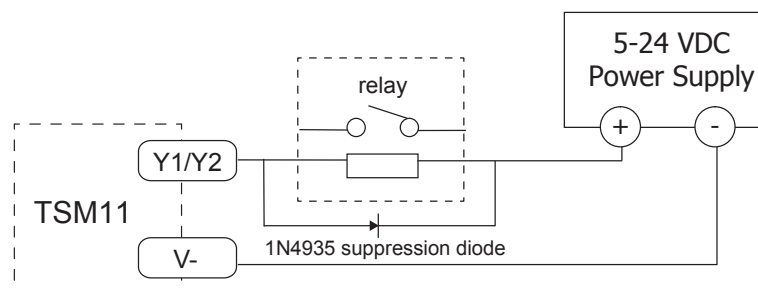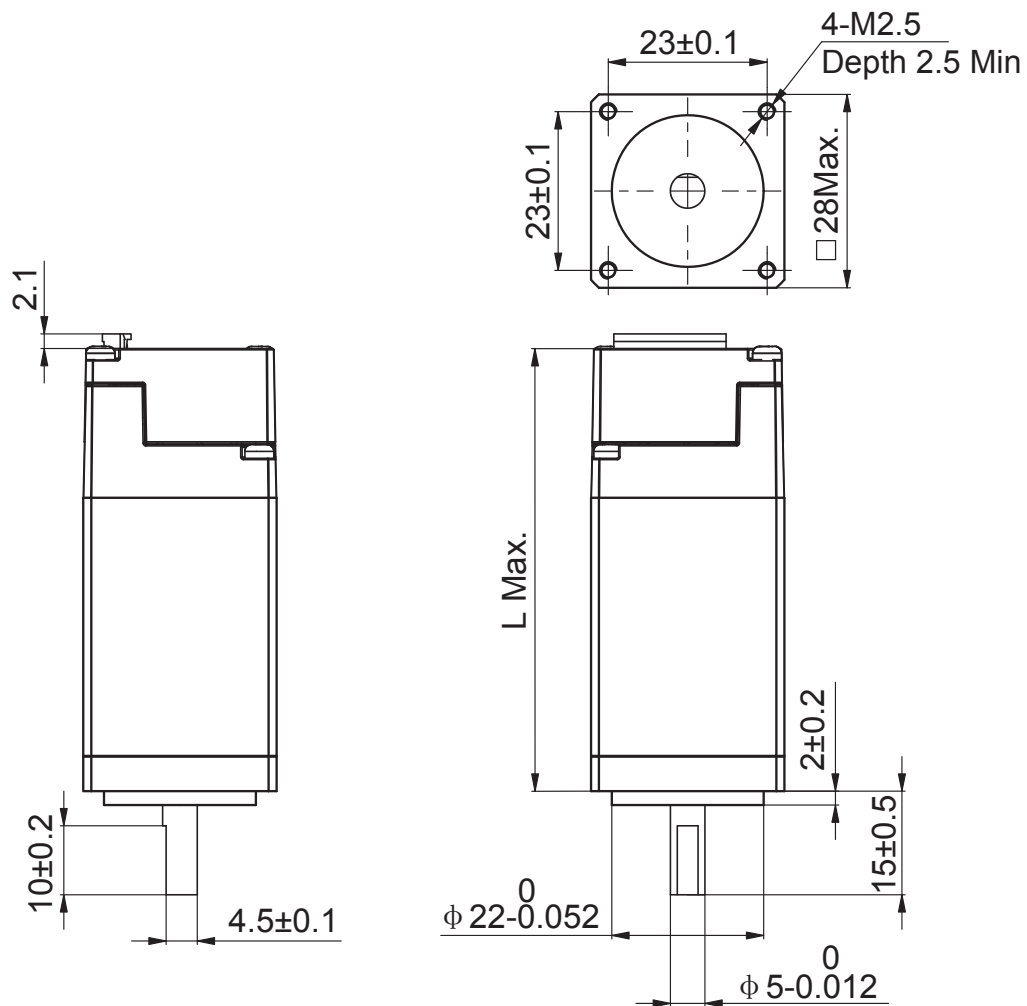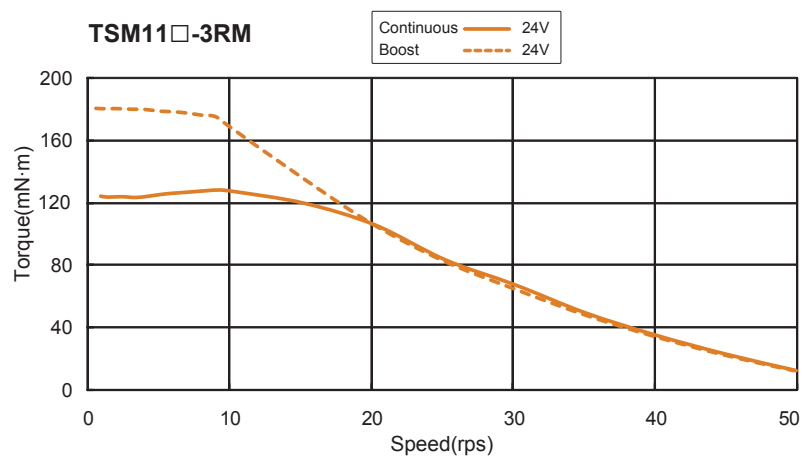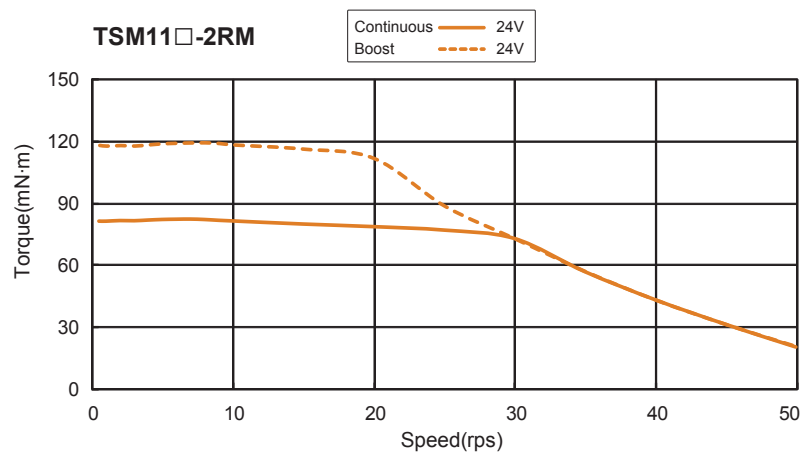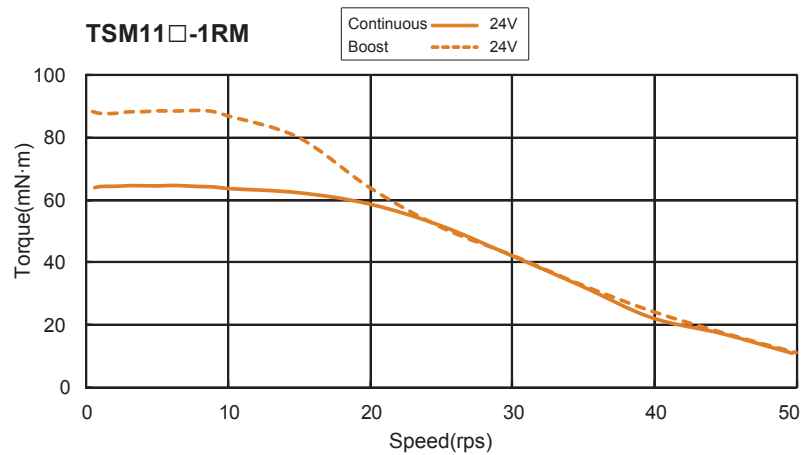| Power Amplifier	
Amplifier Type	Dual H-Bridge, 4 Quadrant
Current Control	4 state PWM at 20 KHz
Output Torque	TSM11□-1RM up to 65 mN.m TSM11□-2RM up to 80 mN.m TSM11□-3RM up to 125 mN.m
Power Supply	External 24 VDC power supply required
Input Voltage Range	15 - 30 VDC min/max (nominal 24 VDC)
Protection	Over-voltage, under-voltage, over-temp, internal motor shorts (phase-to-phase, phase-to-ground)
Ambient Temperature	0 - 40°C (32 - 104°F) when mounted to a suitable heatsink
Humidity	90% non-condensing
Controller	
Current Control	Advanced digital current control provides excellent high speed torque
Microstep Resolution	Software selectable from 200 to 51200 steps/rev in increments of 2 steps/rev
Speed Range	Speeds up to 60 rps
Distance Range	Over 10,000,000 revolutions (at 200 steps/rev)
Noise Filtering	Programmable hardware digital noise filter. Software noise filter
Serial Commanding	Supports Serial Command Language (SCL)
Encoder Feedback	4096 counts/rev encoder feedback
Non-Volatile Storage	Configurations are saved in FLASH memory on-board the DSP
X1/Step	Input: 5 - 24 VDC, single-ended signals, max. pulse frequency 1MHz Functions: Step, CW Step, A Quadrature, CW Limit, CW Jog, Run/Stop, general purpose input; adjustable bandwidth digital noise rejection filter Connect with NPN type output ONLY
X2/Direction	Input: 5 - 24 VDC, single-ended signals, max. pulse frequency 1MHz Functions: Dir, CCW Step, B Quadrature, CCW Limit , CCW Jog, general purpose input; adjustable bandwidth digital noise rejection filter Connect with NPN type output ONLY
X3/Enable	Inputs: 5 - 24 VDC, single-ended signals, max. pulse frequency 1MHz Functions: Enable, general purpose input Connect with NPN type output ONLY
X4/Alarm Reset	Inputs: 5 - 24 VDC, single-ended signals, max. pulse frequency 1MHz Functions: Alarm reset, Change speed, general purpose input Connect with NPN type output ONLY
Y1/FAULT	Open drain output, maximum current 100mA with maximum voltage of 30VDC Functions: Fault detection, general purpose
Y2/BRAKE	Open drain output, maximum current 100mA with maximum voltage of 30VDC Functions: Brake, In Position, Tach Output, general purpose
Communication Interface	RS-422/485
Weight	TSM11□-1RM: 118 g TSM11□-2RM: 168 g TSM11□-3RM: 218 g
Rotor Inertia	TSM11□-1RM: 9 g•cm^2 TSM11□-2RM: 12 g•cm^2 TSM11□-3RM: 18 g•cm^2

4.3 Torque Speed Curves

Note: all torque curves were measured at 20,000 steps/rev.

TSM11□-1RM

Continuous	24V
Boost	24V

TSM11□-2RM

Continuous	24V
Boost	24V

TSM11□-3RM

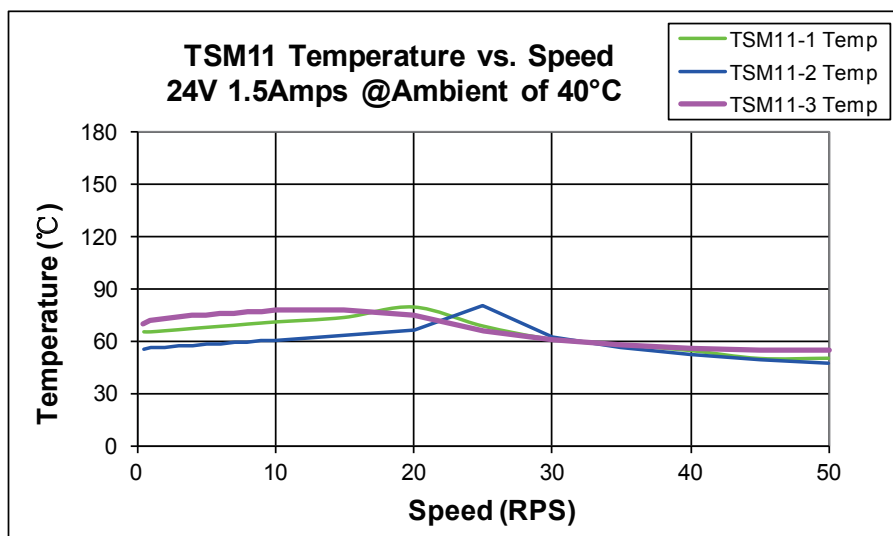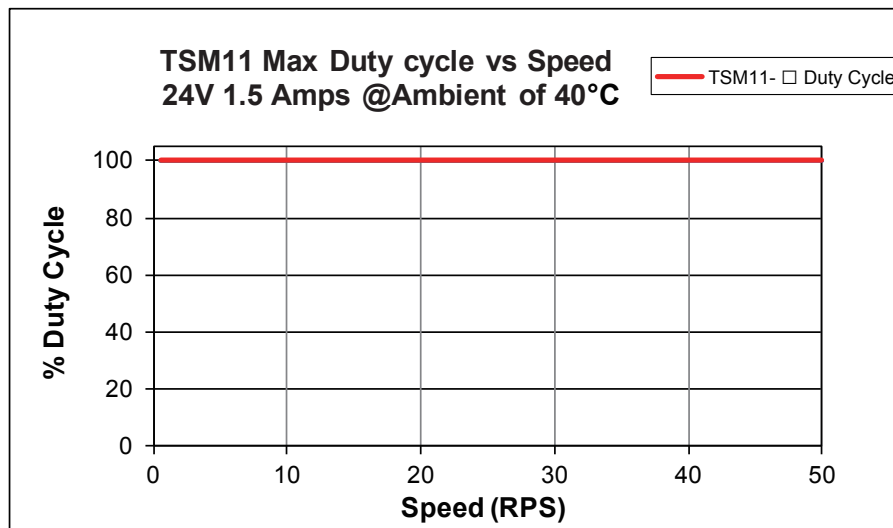|	
Continuous	24V
Boost	24V

4.4 Drive/Motor Heating

Step motors convert electrical power from the driver into mechanical power to move a load. Because step motors are not 100% efficient, some of the electrical power turns into heat as it passes through the motor. The amount of heating is not so much dependent on the load being driven as on the motor speed and power supply voltage. There are certain combinations of speed and voltage at which a motor cannot be continuously operated without damage occurring to the motor.

A step motor typically reaches its maximum temperature after 30 to 45 minutes of operation. A motor that runs for one minute and then rests for one minute is said to have a duty cycle of 50%. Five minutes of running and five minutes of rest is also a 50% duty cycle. However, one hour of running and one hour of rest has the effect of 100% duty cycle as the motor will reach full and possible excessive temperature during the first hour. The actual temperature of the motor depends on how much heat is conducted, convected or radiated out of it.

The curves below result from measurements made in a 40°C (104°F) environment with the motor mounted to an aluminum plate sized to provide a surface area consistent with the motor power dissipation. Results may vary.

TSM11 Max Duty cycle vs Speed
24V 1.5 Amps @Ambient of 40°C

TSM11 Temperature vs. Speed
24V 1.5Amps @Ambient of 40°C

5 Troubleshooting

LED Error Codes

The TSM11 uses bi-color LED to indicate status. When the motor is enabled, the green LED flashes slowly. When the green LED is solid, the motor is disabled. Errors are indicated by combinations of red and green flashes as follows:

LEDs
Green - Power
Red - Alarm

	Code	Error
🟢	Solid green	Motor Disabled
🟢🟢	Flashing green	Motor Enabled
🔴🟢	1 red, 1 green,	Motor Stall
🔴🟢🟢	1 red, 2 green	Can't move(disabled)
🔴🔴🟢	2 red, 1 green	CCW Limit
🔴🔴🟢🟢	2 red, 2 green	CW Limit
🔴🔴🔴🟢	3 red, 1 green	Drive Over Temp
🔴🔴🔴🟢🟢	3 red, 2 green	Internal Voltage out of range
🔴🔴🔴🔴🟢	4 red, 1 green	Supply Voltage High
🔴🔴🔴🔴🟢🟢	4 red, 2 green	Supply Voltage Low
🔴🔴🔴🔴🔴🟢	5 red, 1 green	Over Current
🔴🔴🔴🔴🔴🟢🟢	5 red, 2 green	Current Foldback
🔴🔴🔴🔴🔴🔴🔴🟢	7 red, 1 green	Communication Error

6 Mating Connectors and Accessories

6.1 Mating Cable (included in package)
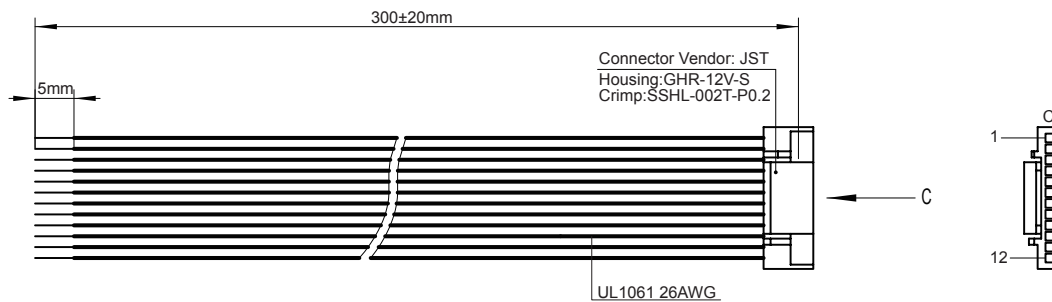
Mating Connector Diagram

Pin No.	1	2	3	4	5	6	7	8	9	10	11	12
Color	Purple	Orange	White	Brown	Yellow	Gray	Green/White	Green	Blue/White	Blue	Red	Black
Define	Y2	Y1	X4	X3	X2	X1	RX-	RX+	TX-	TX+	+	-

This cable is for power, I/O and communication connection, included in package.

Cable P/N: 1109-030

Housing: GHR-12V-S (JST)

Crimp: SSHL-002T-P0.2 (JST)

6.2 Accessories (Sold Seperately)

RS-485 converter:

RS-232 to RS-422 four-wire Converter P/N: UT-202

USB to RS-422 four-wire Converter P/N: UT-890

RS-232 to RS-485 two-wire Converter P/N: UT-201

USB to RS-485 two-wire Converter P/N: UT-890

Converters are from UTEK (http://www.szutek.com/)

DC Power Supplies:

24 V, 150 W switching power supply P/N: MF150A24AG-V

Regeneration Clamp for use with high inertial loads: RC-880

MOONS'

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