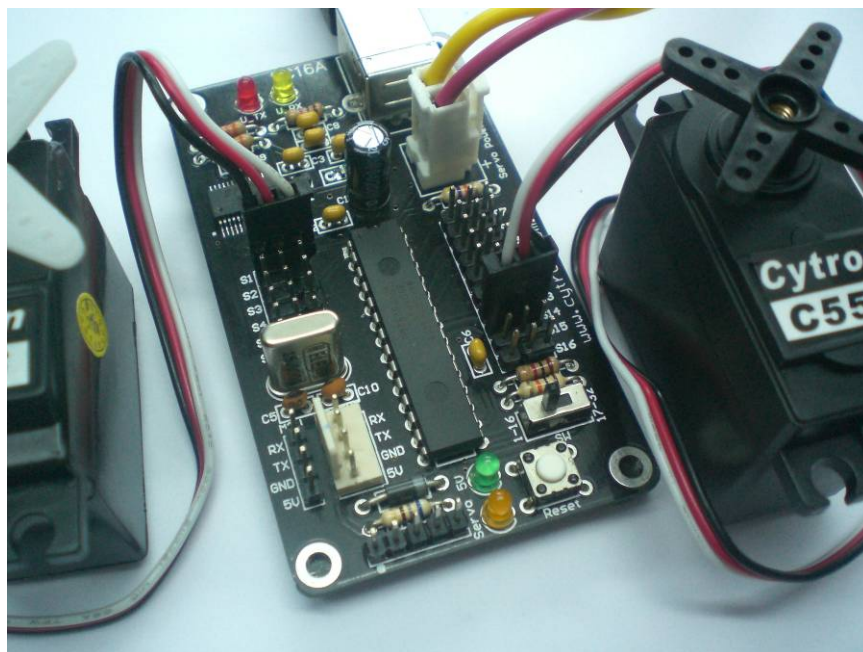




SC16A

SERVO CONTROLLER



User's Manual

V2.0

September 2008

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1. INTRODUCTION AND OVERVIEW

SC16A offers reliable yet user friendly RC Servo motor controller to hobbyist and students. It is designed to control 16 independent standard RC (Remote Control) servo motors simultaneously in a single board. Each servo signal pin is able to generate servo pulses from 0.5 ms to 2.5 ms, which is greater than the range of most servos, further allows for servos to operate 180 degrees. Through serial communication, SC16A can be daisy chain in 2 boards to offer independent control over 32 RC servo motors simultaneously. The host of SC16A can either be a PC desktop, Laptop with USB port, or microcontroller with UART interface. Both USB and UART interface present a flexible, fast and easy to use feature. With USB, it is plug and play, user is able to get it running within 5 minutes time.

It is designed with capabilities and features of:

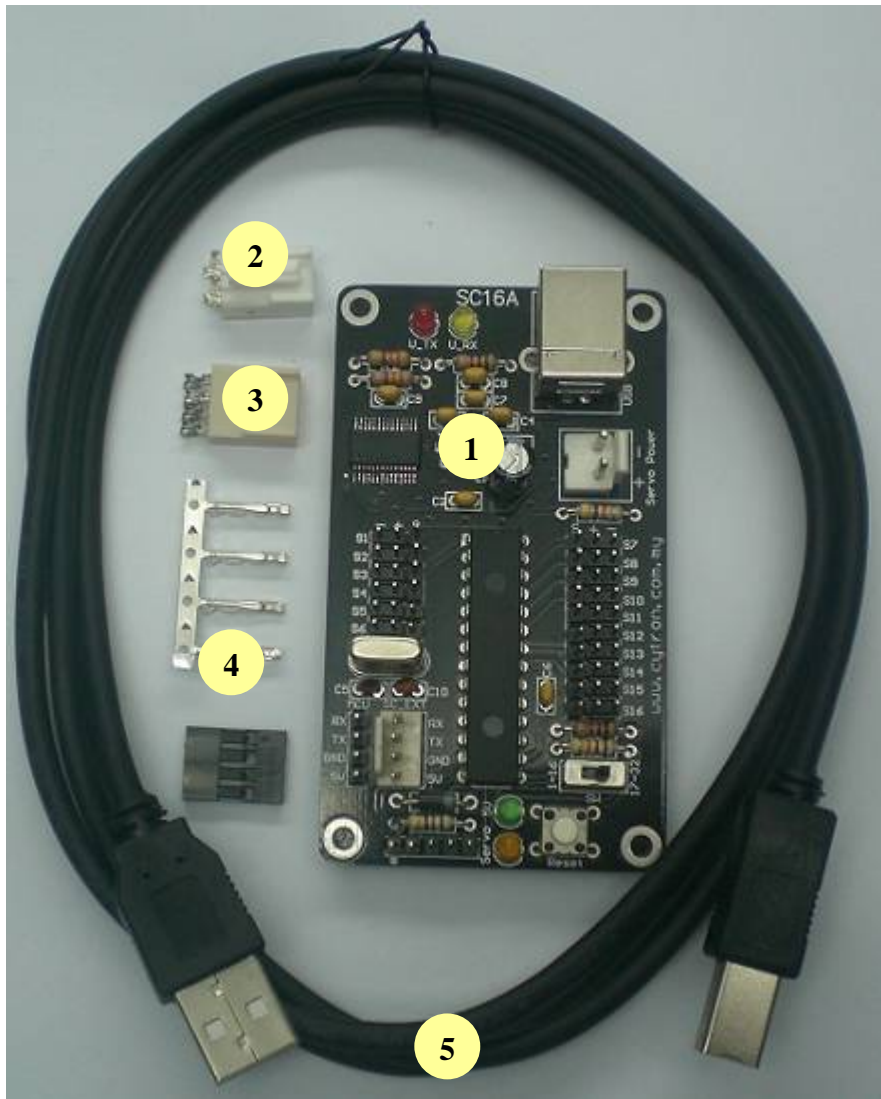
- **16 channels:** Servo driven independently
- **Extendable to 32 Channels:** Two controller linked together to drive 32 servos
- **Optional Position Reporting:** User may request position of an individual servo.
- **Optional Servo Ramping:** Choose one of 63 ramp rate (speed rate) for each servo.
- **Sample GUI for computer*:** User may control the servo via sample GUI software.
- **Resolution:** 1.367us.
- **UART:** 9600 baud rate
- **Servo pulse:** 0.5ms to 2.5ms.

* The sample GUI is provided free, therefore no further support is provided. It have been tested on Window XP Home, XP Professional and Vista Starter.

This document explains the method to use SC16A.

2. PACKAGING LIST

Please check the parts and components according to the packing list. If there are any parts missing, please contact us at sales@cytron.com.my immediately.



1. 1 x SC16A main board
2. 1 set of 3961 connector for power source (2 ways including iron pin)
3. 1 set of 2510 connector for expansion connection (4 ways including iron pin)
4. 1 set of 2561 connector for microcontroller connection (4 ways including iron pin)
5. 1 x B Type USB cable
6. USB driver, User's Manual and other necessary softcopy should be downloaded from www.cytron.com.my

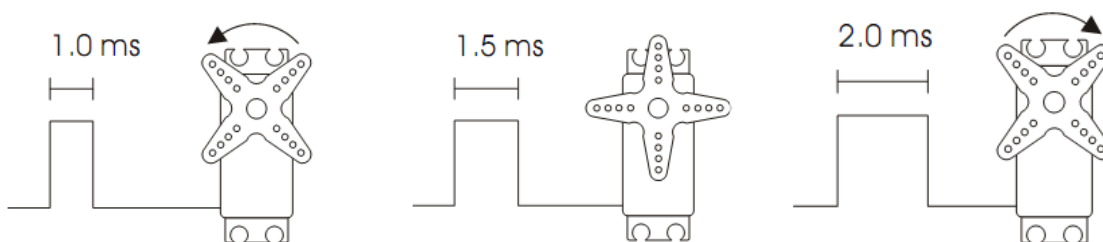
3. How RC Servo Motor works

Radio Control (RC) hobby servos are small actuators designed for remotely operating model vehicles such as cars, airplanes, and boats. Nowadays, servos are become more popular in robotics, creating humanoid robot, biologically inspired robot, robotic arm and etc. This is because its' ability to rotate and maintain and certain location, position or angle according to control pulses from a single wire. Inside a typical servo contains a small motor and gearbox to do the work, a potentiometer to measure the position of the output gear, and an electronic circuit that controls the motor to make the output gear move to the desired position. Because all of these components are packaged into a compact, low-cost unit, servos are great actuators for robots.

Besides signal wire, a RC servo has other two leads: power and ground. The control signal is a continuous stream of pulses that are 1 to 2 milliseconds long, repeated approximately fifty times per second, as shown below.

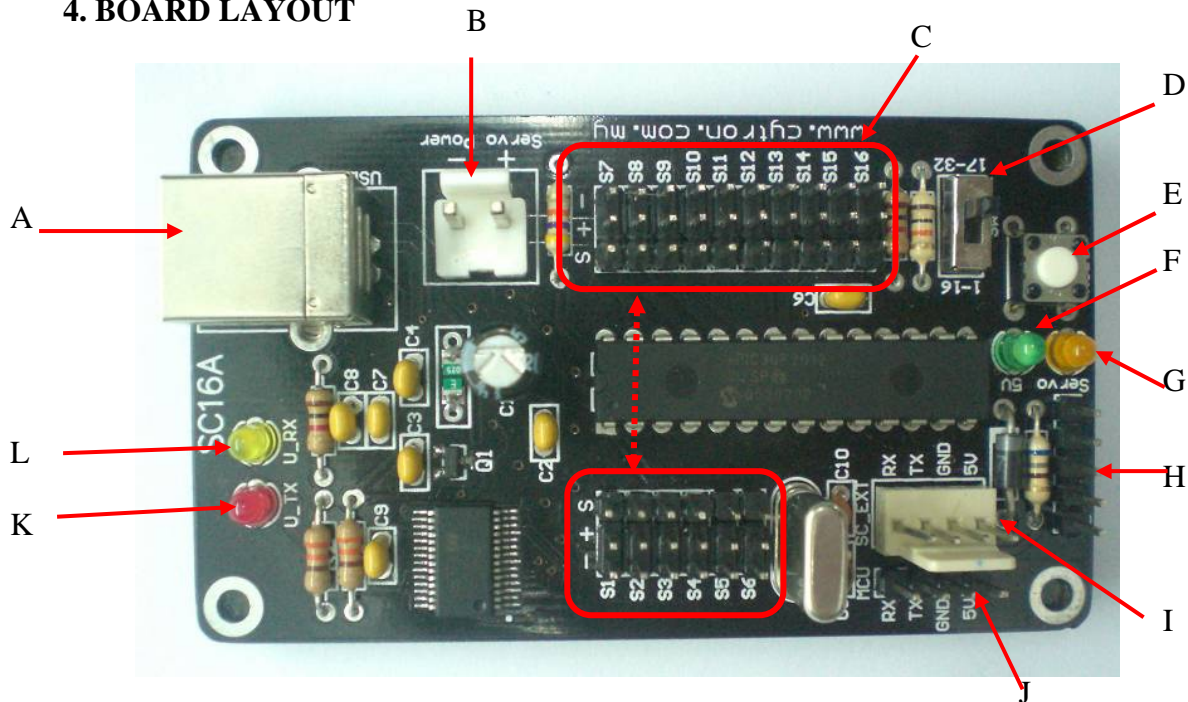


The width of the pulses determines the position to which the servo moves. The servo moves to its neutral, or middle, position when the signal pulse width is 1.5 ms. As the pulse gets wider, the servo turns one way; if the pulse gets shorter, the servo moves the other way. Typically, a servo will move approximately 90 degrees for a 1 ms change in pulse width. However, the **exact correspondence between pulse width and servo varies from one servo manufacturer to another.**



SC16A is designed to simultaneously generate 16 independent servo control signals. The servo controller can generate pulses from 0.5 ms to 2.5 ms, which is greater than the range of most servos, and which allows for a servo operating range of over 180 degrees.

4. BOARD LAYOUT



Label	Function	Label	Function
A	B type USB port socket	G	Small Orange LED (servo power)
B	Servo motor power source connector	H	Manufacturing test point
C	Servo motor ports	I	Expansion link connector
D	SC16A selection slide switch	J	4 way header pin
E	SC16A Reset button	K	Small red LED
F	Small green LED (5V)	L	Small yellow LED

A - is for USB connection to PC desktop or laptop. Please connect the B type of USB cable to this socket.

B – is 2 way 3961 connector for servo motor power source, please connect the power supply properly to the provided connector and check the polarity before plug in.

C – are 16 servo motor ports. Each port consists of 3 header pin. 16 ports are distributed to both side of dsPIC controller. S1 - S6 at the left side while S7 – S16 at right side. The signal pin is closest to dsPIC (middle of board). Both sides of servo motor port are labeled at the top. Please follow the label for connecting servo port to SC16A, 'S' for signal.

D – is a slide switch to configure SC16A for expansion mode. For single board usage, the slide switch should be pushed towards middle of board (1-16). If SC16A is used in expansion, one of SC16As must be configure to expansion board, the slide switch should be pushed towards edge of board (17-32).

E – is Reset button for SC16A. Pressing this button will stop all pulses generation and return SC16A to initial stage if after released. Without pulses generation, all servo connected to SC16A will not rotate, is free run.

F – is a small green LED to indicate 5V for dsPIC operation.

G – is a small orange LED to indicate power for servo motor. It should illuminate if power source is connected properly.

H – is 5 ways header pin reserve for manufacturing test point. DONOT connect or short these pin.

I – is a 4 ways 2510 connector for expansion board link. It will be used if user requires to expand SC16A for 32 servo motors.

J – is a 4 ways header pin for user to connect power and signal wire from microcontroller host. Please be cautions during making connection to this header, **wrong polarity will damage servo controller.**

K – is a small red LED, this LED is indicator for on board USB converter's Tx indicator. It will illuminate if there is activity on Tx line. It will only works if SC16A is connected to computer through USB

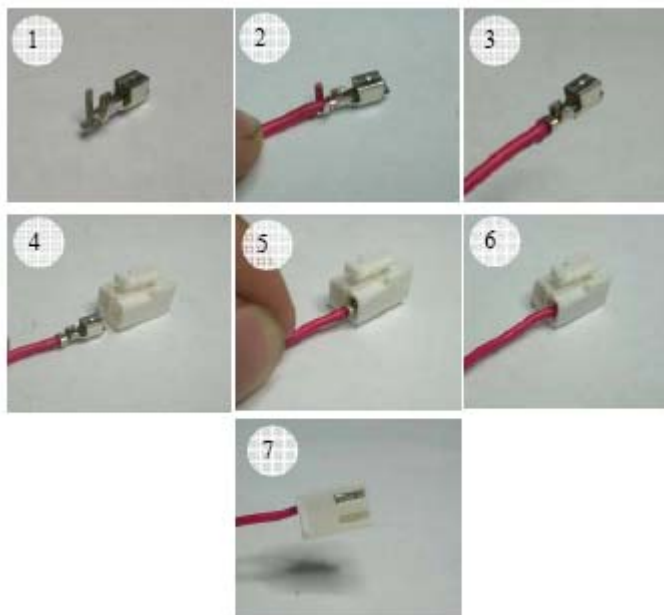
L – is a small red LED, this LED is indicator for on board USB converter's Rx indicator. It will illuminate if there is activity on Rx line. It will only works if SC16A is connected to computer through USB

5. INSTALLATION (HARDWARE)

SC16A is designed to control RC servo motor. Following steps will guide user in using SC16A. The controller can either be a microcontroller with UART interface or PC desktop/Laptop with USB port.

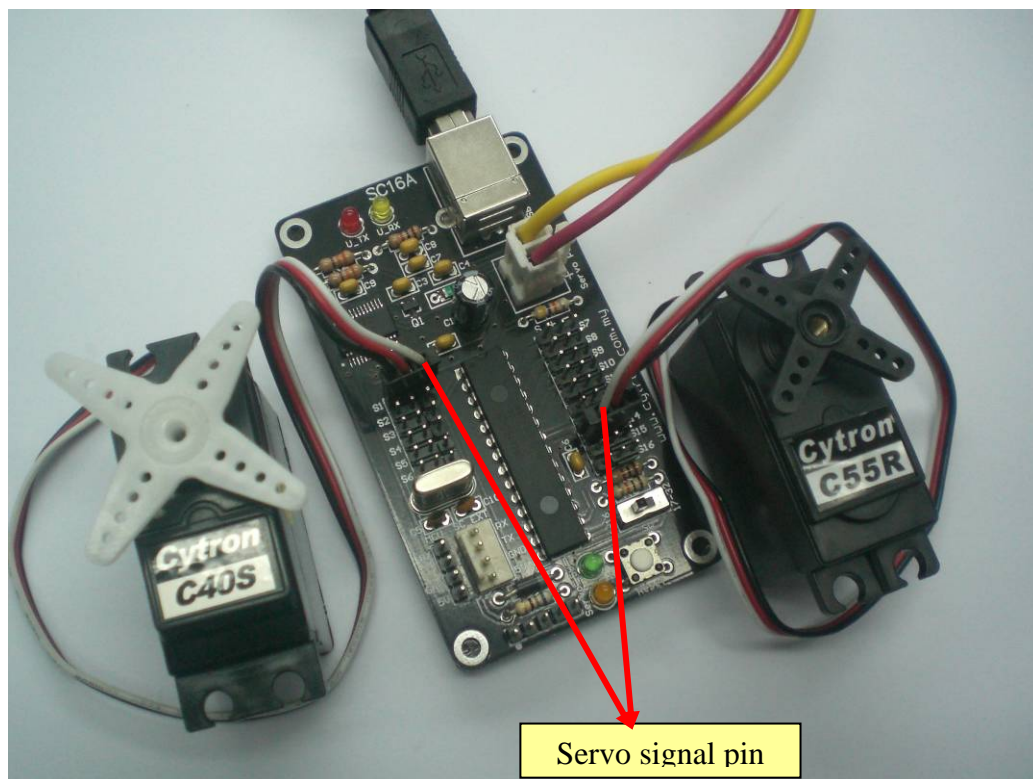
5.1 Setting up SC16A

- a. Servos are typically powered by independent power source ranging from 4.8V to 9V (standard is 4.8V to 6.0V). This power source is normally battery or adaptor. The power source should be connected to 3961 connector as shown in following photo.
 - Servo power indicator LED (orange) will light on if the power source is connected correctly.
 - The power source should be able to provide several ampere of current if many servos are expected to have loading simultaneously.



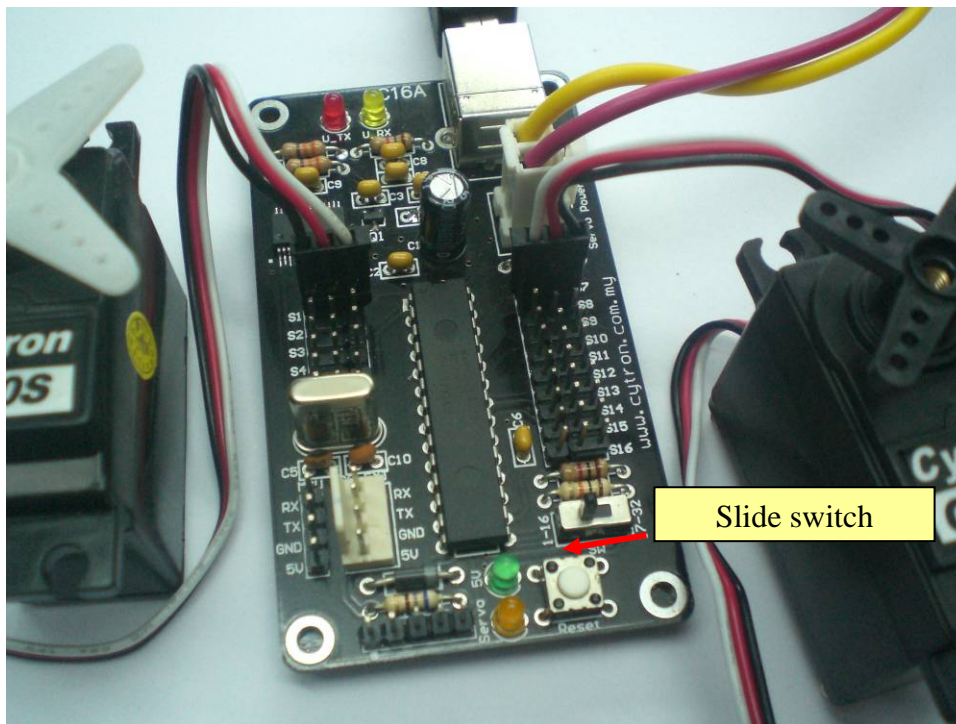
Caution: Always ensure the Power source for servo is connected correctly before servo motor is connected to SC16A, else all servo motor will be damaged.

- b. User must ensure the power source is connected correctly before plug-in servo to SC16A. Servo cable may be plugged to any servo port on SC16A. When connecting servos, be careful because the servo header pins (connector) are not polarized and it is possible to plug in a servo backwards. **ENSURE** the connection of servo is correct; else the servo may be destroyed. The signal (usually white, orange or yellow) wire should be closest to controller chip (farthest from the edge of the board), and the black wire should be closest to the edge of the board. Some servo connectors have a polarizing nub that indicates the signal lead; that notch should be on the pin farthest from the edge of the PCB. The function of each pin is being label at the top of servo motor port, please follow the label.



- c. Do remember the label (S1 to S16) of each servo motor to ease the program development in later stage.

- d. For basic connection (16 servos maximum), please ensure the slide switch (SW) is being pushed towards middle of SC16A (1-16).

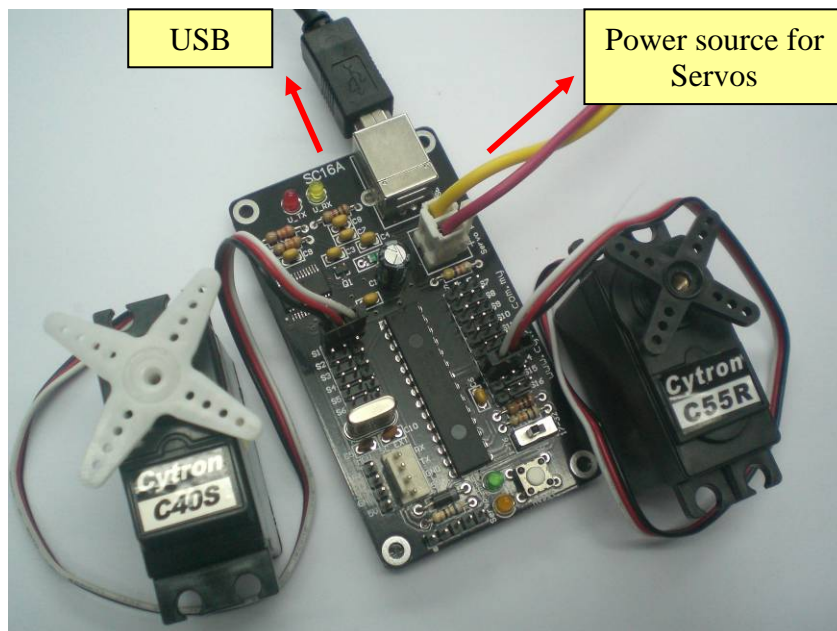


- e. SC16A needs its own power; it can either come from USB power or other microcontroller board power. However, the standard power source is 5V for SC16A.
- f. Following steps will further explain the hardware setup for PC desktop/Laptop, Microcontroller and also expansion mode.

5.2 Connecting SC16A to Computer

One of the main concerns in controlling servo is the hard work needed to get start. However, with SC16A, getting start is easy as 1 2 3. SC16A offer an USB to serial converter onboard to enable USB Plug and Play function. No RS232 (serial port, DB9) is needed on PC desktop/Laptop to test SC16A. This will save tremendous work and time. Simply plug SC16A to USB port of computer (PC or Laptop), install driver (1st time user only) and there is an extra virtual COM port. After installation of GUI for SC16A (provided free), user can start playing with servo motor in no time. Only power source for servo motor is needed if SC16A is connected to PC. Anyway, the power of USB is isolated from the 5V pin (external supply). In other words, **USB power is not able to supply power for microcontroller board.**

- a. Simply connect USB cable (B type) to SC16A USB socket as shown in following figure, another end (A type) to PC desktop/Laptop.

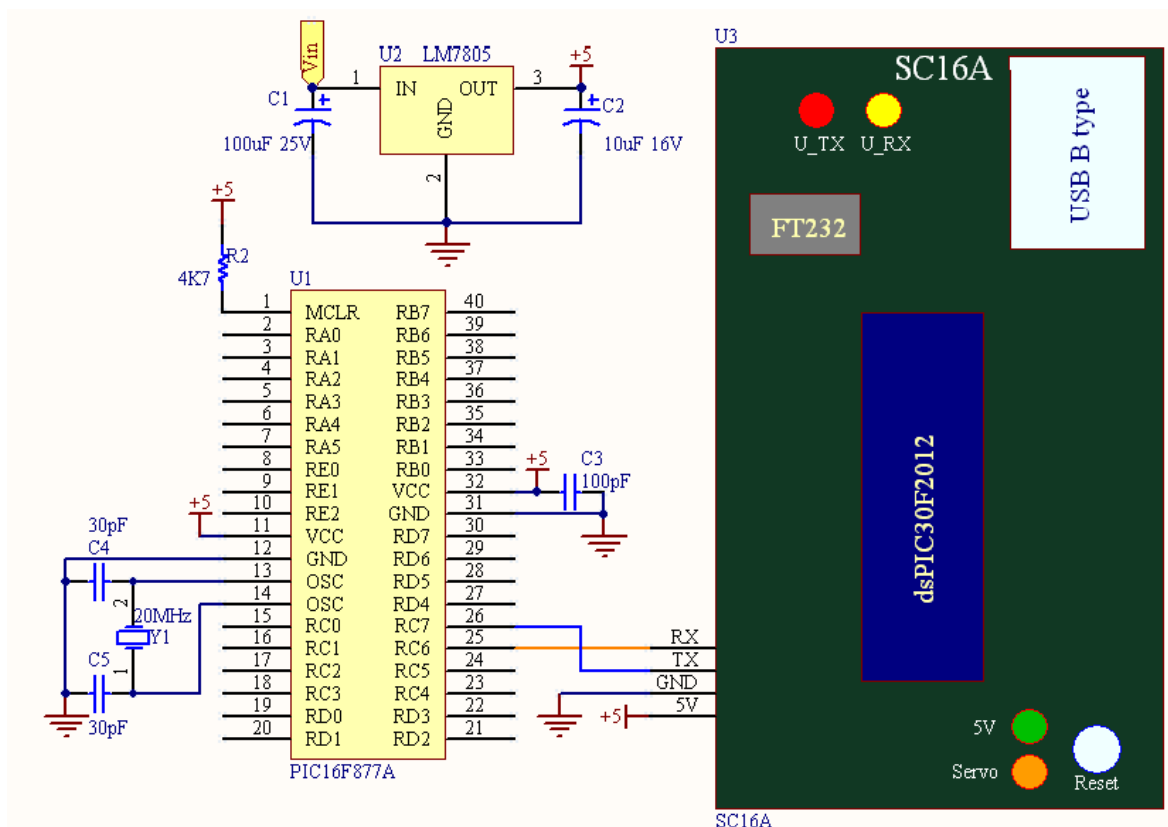


- b. Please refer to document named “USB Driver Installation Guide” for USB to UART driver installation. USB driver needed can be downloaded from SC16A product page at www.cytron.com.my
- c. After plug in SC16A’s USB cable to computer and installation of driver, user is ready to control servo motor from computer.
- d. Please beware that, only one host can be connected to SC16A at a moment. Either computer or a microcontroller. DONOT connect two hosts (computer and microcontroller) to a SC16A at the same time.

Caution: Only one host should be connected to SC16A, either computer (through USB cable) or microcontroller (through UART).

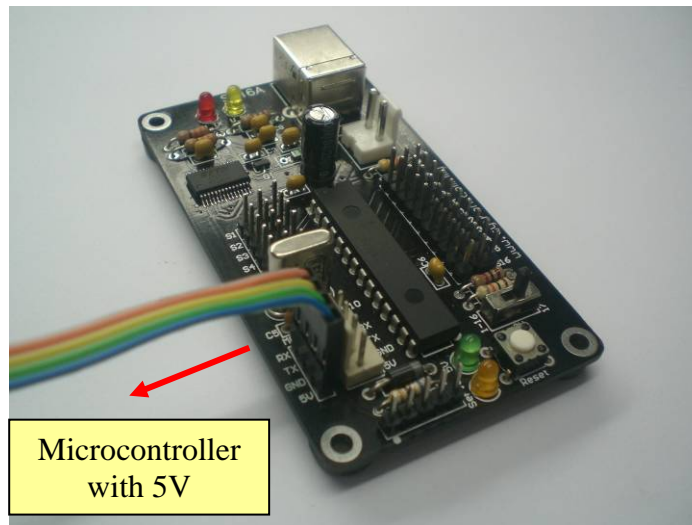
5.3 Connecting SC16A to Microcontroller

Another concern of user is for embedded system to control servo motors. For microcontroller to interface with SC16A, the minimum requirement will be TTL UART (Universal Asynchronous Receiver and Transmitter) and 5V supply. 5V will not be an issue since most of embedded or microcontroller system is 5V powered, tapping the 5V from host system will be reasonably easy. As for UART, a minimum of Transmit pin is required to send command to SC16A.



- a. Please refer to the sample schematic to interface SC16A to microcontroller. Following sample schematic shows PIC16F877A interface to SC16A. No restriction to what type or brand of microcontroller can be used, as long as it has UART peripheral.
- b. Although SC16A come with Tx pin, it is an alternative for user to connect if positioning report is needed. Thus minimum wires from the host, microcontroller to SC16A are 3 wires. Please use proper connector to connect the wires. Following figure show an example of wire interface to SC16A. It uses 4 ways 2561 socket. **Please ensure the cable**

is not connected in wrong direction, wrong connection will spoilt SC16A and worst the host or microcontroller.

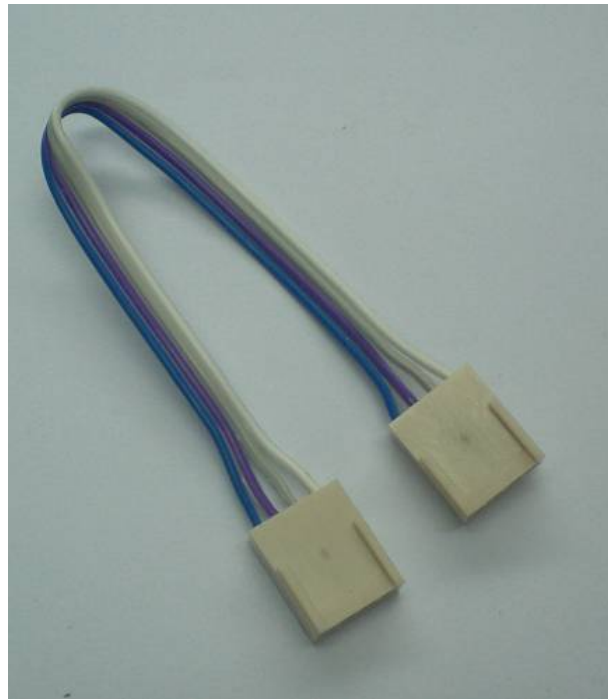


- c. In this setup, SC16A will share 5V power source from host or microcontroller board. If 5V power source is ON and connection is correct, the small green LED (5V) will light ON to indicate controller is powered.
- d. The hardware interface for SC16A to microcontroller host is ready. However in order to control servo from microcontroller, user is require to write program for microcontroller sending command according to protocol in software section.

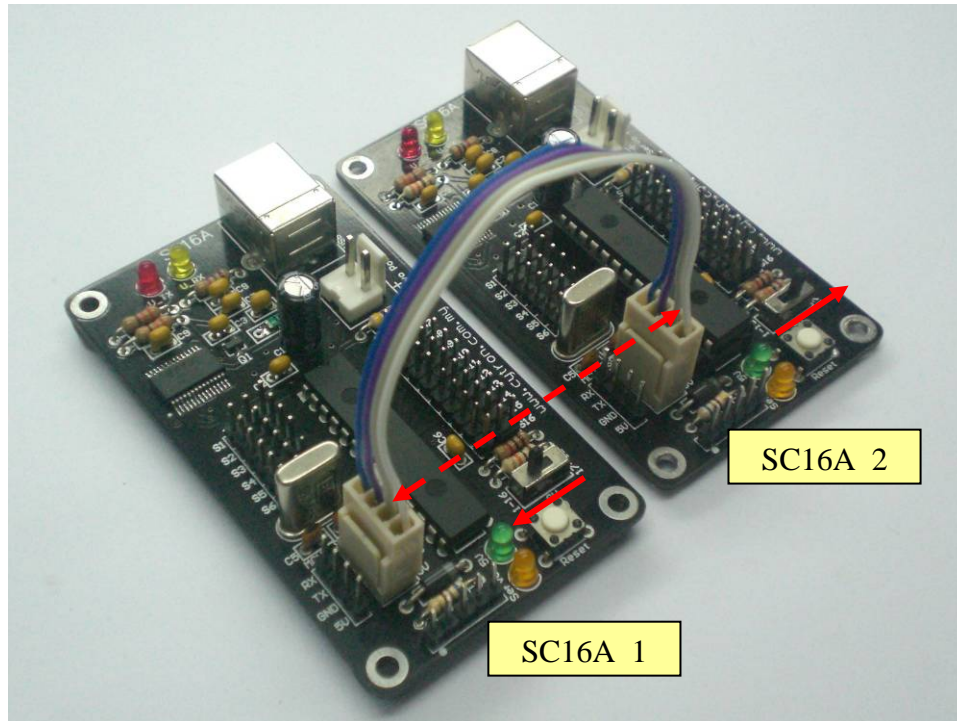
5.4 Expanding SC16A for 32 Channels

SC16A provides the flexibility to be expanded and control 32 channels of servo motor simultaneously. In some application, more than 16 servos are required. No worries, 2 units of SC16A can be combined for expansion mode to control 32 servos. Following steps will guide user to setup SC16A for expansion mode.

- a. Two units of SC16A are needed.
- b. Setup both SC16A according to steps in section 5.1. User may share the same power source for servo motor. However, please ensure power source is capable to supply higher current since more servos are used.
- c. Create a back to back 4 ways cable for interlink between two SC16As. Following figure shows the cable connection. Please ensure the polarity is correct.



- d. Link up both SC16A with the cable. Following figure shows the sample connection. Please ensure the 2510 connector is being connected, **DONOT connect to header pin**, the header pin is only use for connection to host, microcontroller.



- e. The slide switch “SW” for SC16A_1 (board 1) should be pushed towards inside board (1-16), while for SC16A_2 (board 2) should be pushed towards outside board (17-32).
- f. For SC16A_2, servo connected at “S1” will be recognized as “S17” in software. This applied to the rest of servo port on SC16A_2. Every label should be added with 16 during software development.

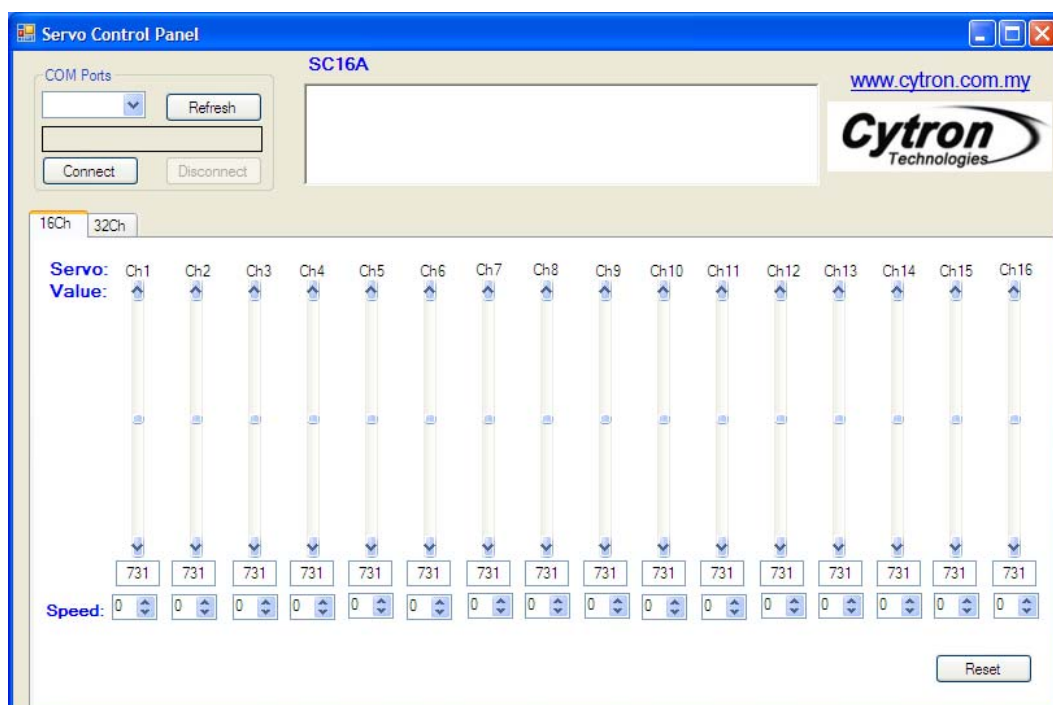
6. INSTALLATION (SOFTWARE)

There are 2 software options for SC16A. The simplest way is to use the sample GUI program provided by Cytron Technologies which need to be installed on computer, while another program is the sample program for PIC16F877A to control servo through SC16A.

6.1 Sample Program for Computer

To ease user in using SC16A, Cytron Technologies has developed a GUI (Servo Control Panel) for user to control SC16A from USB port. Following steps will guide user to install Servo Control Panel and use it.

- g. Extract the zipped file named “Servo Control Panel.zip”. This file can be downloaded from Cytron website (www.cytron.com.my).
- h. Double click on “setup.exe” to install the GUI.
- i. A shortcut will be created at Window’s start up menu. To activate the GUI, go to *start -> All Programs -> Cytron Technologies -> Servo32Ch*.
- j. Before any setup at *Servo32Ch* can be done, please ensure hardware installation of SC16A is being setup correctly, USB cable and power to servo motor is connected. Besides, USB driver is a must to be installed.
- k. After Servo Control Panel is activated, a window will pop out, following figure show the window.



1. Ensure the USB is connected to computer, click the “Refresh” icon. Choose the COM Ports by clicking the side bar, choose the last COM port. Normally, the extra virtual COM port will be the largest number port after driver installation. Click on it.

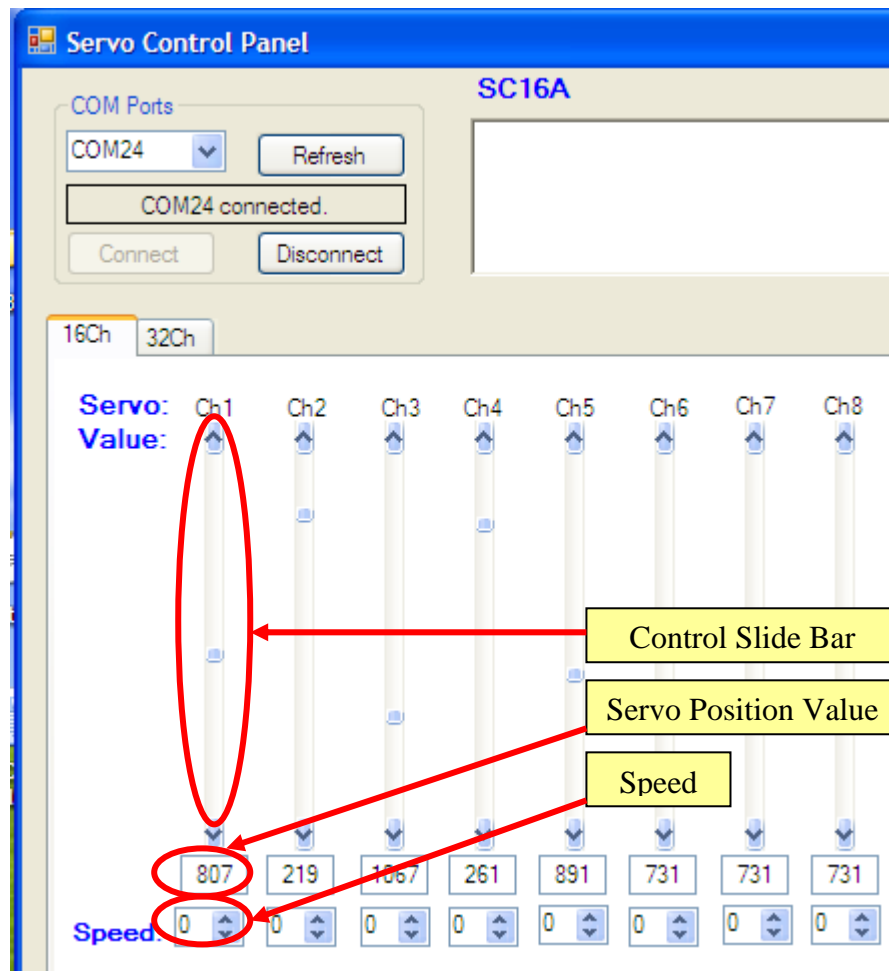


- m. Click the “Connect” icon and Servo Control Panel will show “COMXX connected”



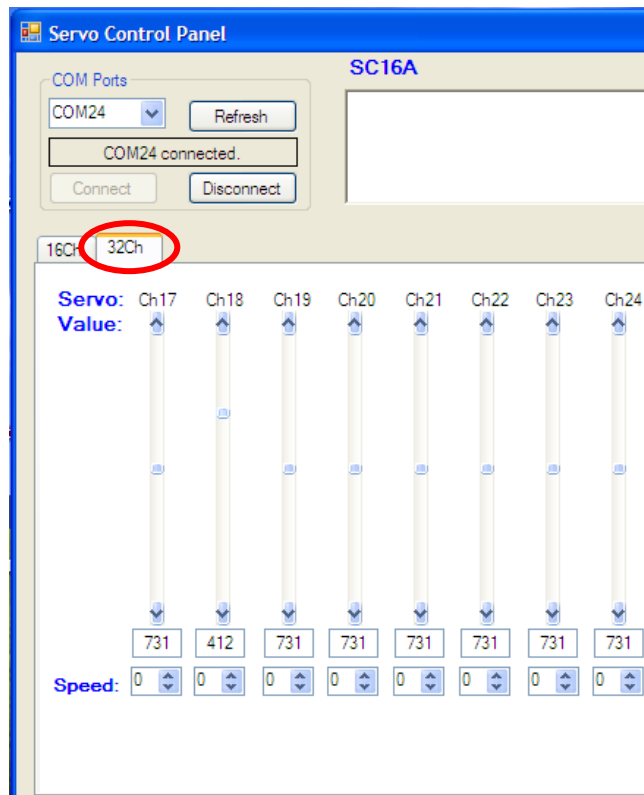
- n. Now, Servo Control Panel is ready to control the servo motor on SC16A, please ensure the power for servo motor is connected properly.

- o. User may drag the corresponding sliding bar to control particular servo motor. The value at the bottom of each slide bar is position value where user may copy to microcontroller host after finalizing the servo position at computer. This help user to save more time and shorten the development time.

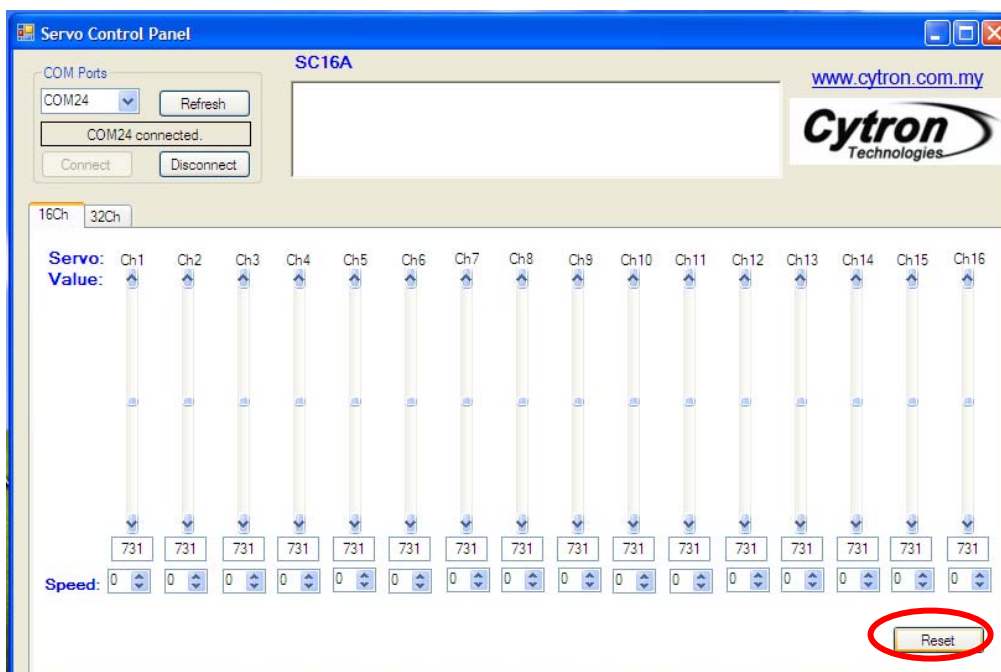


- p. Furthermore, user may set the speed at the bottom of position value at each slide bar. The default value for speed is “0” which represent fastest speed. For further details of speed, please refer section 7.3.
- q. Please take note that position reporting is not implemented of Servo Control Panel.

- r. For expanded mode where more than 16 servo motors are required, please setup SC16A according to 5.4. Please use 16Ch to control servo motor on SC16A_1 board, while 32Ch to control servo motor on SC16A_2 board.



- s. Right bottom corner offer a “Reset” icon which provide fast reset to all servo motors to the center position.



6.2 Sample program for PIC16F877A

Most servo motor is being used as actuator for humanoid, legged mobile robot and many other applications. All these developments are based on embedded controller, which is microcontroller or microprocessor. Considering this reason, Cytron Technologies has also developed two samples embedded program using PICC Lite for PIC16F877A. Following steps will guide user to use the sample program.

- a. The 1st sample program (SC16A+16F.zip) can be downloaded from Cytron website (www.cytron.com.my), the link under SC16A page.
- b. Extract the file into hard disc.
- c. Ensure the hardware interface for microcontroller to SC16A is setup properly. Besides, the power for servo motor is also needed. Please refer to section 5.3 for example of schematic.
- d. There are 2 files available for user, SC16A+16F.c and SC16A+16F.hex. For fast testing, user may load SC16A+16F.hex to PIC16F877A and plug into microcontroller board that was being completed in step c.
- e. The sample program is based on SK40B startup kit. Power up the board, it will further power the SC16A. Press and release RESET button on SK40B, followed by pressing SW1 button.
- f. If all connections and setups are correctly done, every servo on SC16A will turn from left to right and return to left.
- g. Please refer to SC16A+16F.c for details on method to send command to SC16A.
- h. The 2nd sample program (SC16A+16F+Pos.zip) can be downloaded from Cytron website (www.cytron.com.my), the link under SC16A page.
- i. This sample program shows the sample of using positioning report to control particular servo motor.
- j. Please follow step from b to f.
- k. Sample source code for PIC16F877A is compatible for PIC16F876A. Cytron Technologies developed based on PIC16F877A is because PICC Lite does not support PIC16F876A.

7. GETTING STARTED

7.1 Using SC16A with Computer

After installation of sample GUI and USB driver, user is ready to use SC16A with computer. Setup SC16A according to steps in 5.1. Plug USB B-type connector to SC16A and the other end to computer's USB port. Double click on the sample GUI icon to open a window shown. Following steps guide user to control servo from computer.

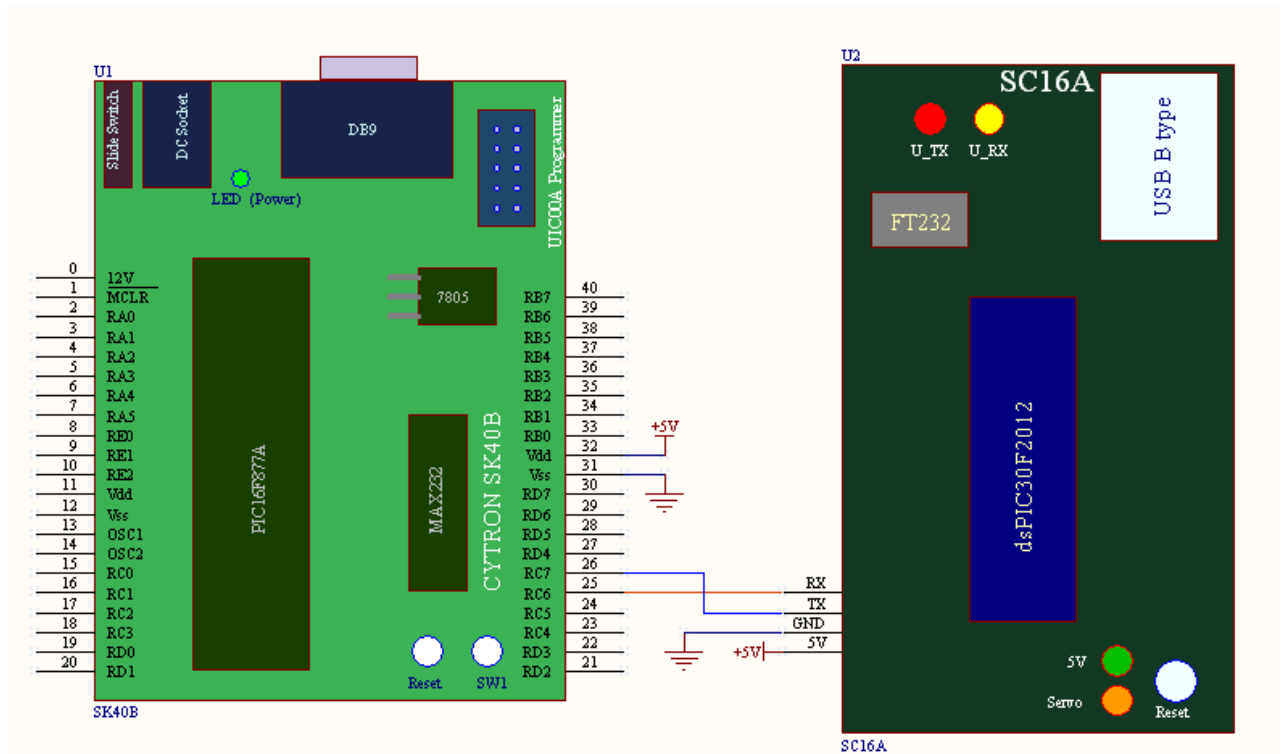
- a. Before the GUI is able to control servos on SC16A, connection must be made. Click on COM port, choose the last COM port, click connect. Please follow the steps under section 6.1
- b. Once the status shows connected. User is free to drag the bar of each servo label. If every setup is correct, corresponding servo will rotate accordingly. User may record the decimal value for particular angle or position of servo. This feature help to save development time, especially during gates setting, body or arm moving sequence. Please do utilize this GUI.

7.2 Using SC16A with Microcontroller

More work will be needed if microcontroller is used as host of SC16A. This section will show sample of using SK40B + PIC16F877A as host of SC16A.

- a. Setup up SK40B with PIC16F877A. Load the sample program using UIC00A or any other programmer.
- b. Setup SC16A according to steps in section 5.1.
- c. Connect Vcc(5V), Gnd(0V) and RC6/Tx (pin 25) to SC16A respectively.
 - i. (SK40B) **RC6 to RX** (SC16A)
 - ii. (SK40B) RC7 to TX (SC16A) – optional, if position report is needed.
 - iii. (SK40B) **Vss to GND** (SC16A)
 - iv. (SK40B) **5V to 5V** (SC16A)

- d. Power up SK40B, press and release RESET button of SK40B. Followed by pressing SW1 button on SK40B.
- e. If all connections and setups are correctly done, every servo on SC16A will turn from left to right and return to left.



- f. Please refer to sample program files for details of method to send command to SC16A.

7.3 Protocol of SC16A

There are two protocols for SC16A. The 1st protocol is important which is used to send command to SC16A, further control a particular servo to a position with a defined speed. 2nd protocol is for host to request the current position of servo.

Of course, the 2nd protocol is alternative to user, if position reporting is not a requirement, it can be ignored. If position reporting is required, please do remember to connect the Tx pin of SC16A to Rx pin of host.

Position and Speed Command

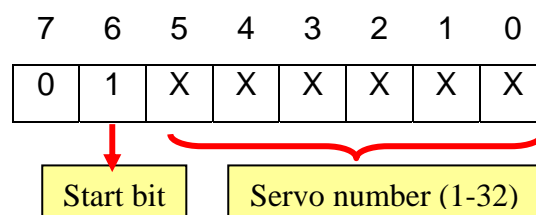
Both computer and microcontroller actually send command to SC16A serially. This section explains the protocol to send command.

- a. The command is being sent in packet format. Each packet consists of 4 bytes.
 - i. 1st byte: Start byte + Servo motor number
 - ii. 2nd byte: Position (Higher 6 bit)
 - iii. 3rd byte: Position (Lower 6 bit)
 - iv. 4th byte: Speed
- b. A packet of 4 bytes must be sent in order to control each servo. Thus to control 16 servos in an instant, a total of 64 bytes must be sent.
- c. SC16A is being setup to disable every servo on start up. Not pulses will be generated upon power up or reset. Pulses will only be generated for particular servo port if corresponding command is received by SC16A.

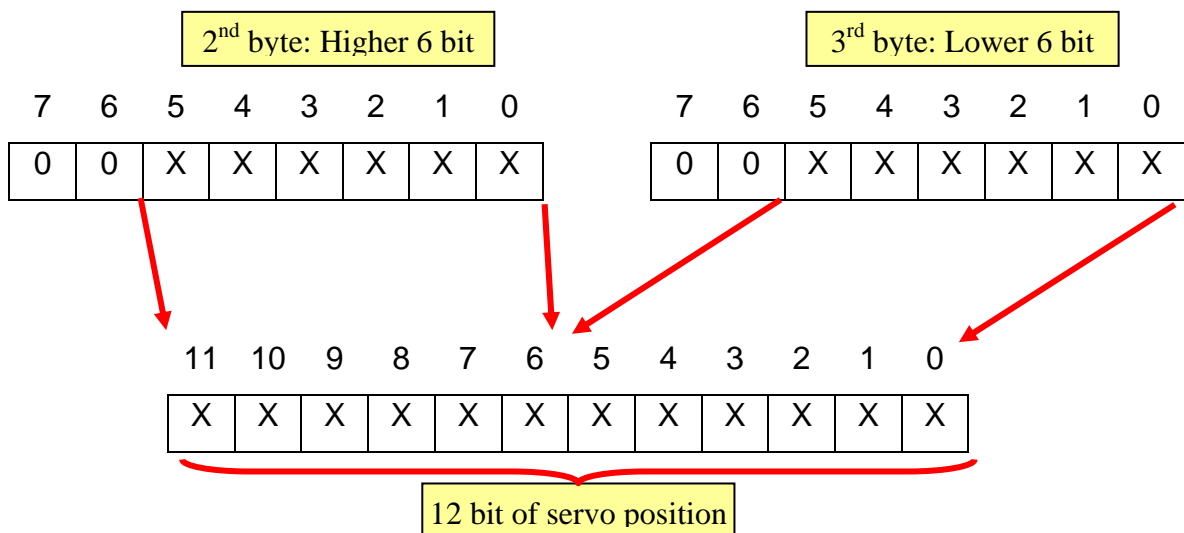
d. SC16A translate four bytes of data into three parameter:

Byte	Binary	Hexadecimal	Decimal
1st Byte	0b01XXXXXX	0x41 to 0x60	65 to 96
2nd Byte	0b00XXXXXX	0x00 to 0x3F	0 to 63
3rd Byte	0b00XXXXXX	0x00 to 0x3F	0 to 63
4th Byte	0b00XXXXXX	0x00 to 0x3F	0 to 63

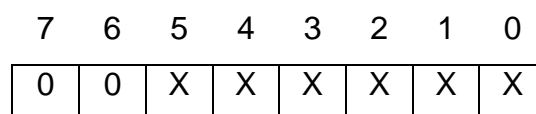
i. 1st byte is combination of start bit and servo number.



ii. 2nd and 3rd byte combined to provide 12 bit data of servo position.



iii. 4th byte represents the speed of servo rotation.



- e. The 1st byte is combination of start bit and servo number. 6th bit must be “1” to indicate this byte is 1st byte of SC16A command.
- f. 2nd and 3rd byte will be combined to form a 12 bit Servo Position; 0-1463. The resolution of SC16A is 1.367us. It will start from 0.5ms and increase the duty cycle of pulses according to value of Position. Thus, following formula show the duty cycle of pulses generated:

$$\begin{aligned} \text{Duty cycle} &= (\text{resolution} \times \text{Servo Position}) + 0.5\text{ms} \\ &= (1.367\text{us} \times \text{Servo Position}) + 0.5\text{ms} \end{aligned}$$

- g. 4th byte determines the speed of servo rotation for each servo independently. The higher value, the faster servo will rotate to its Position. However, value of ‘0’ will disable the speed, thus provide normal speed, the servo motor will rotate according to its own maximum speed. 63 ramp rates allow the user to set the speed of each servo. Decimal value ‘1’ indicates that the servo will run at slowest speed and decimal value ‘63’ will run at fastest speed. At each 20ms interval, the current servo position will increase or decrease with the speed value depending on whether the position is greater or lesser than the new position.

The speed of servo motor is depending on the brand of servo motors. Therefore, different type of servo would result in different speed. For Cytron C36S servo, the approximate time of speed range from 0 degree to 180 degree of rotation is shown as follows:

0 = 0.3 seconds	40 = 3.60 seconds
1 = 2.0 minutes	50 = 2.80 seconds
10 = 14 seconds	60 = 2.2 seconds
20 = 7.0 seconds	63 = 1.9 seconds
30 = 4.14 seconds	

- h. For more details, user may refer to sample source code provided. Comments are being provided in the sample code to help user understanding.

Position Reporting Command

This section explains the position reporting command.

- a. If position report is needed, the host (computer or microcontroller) should send this command to SC16A. The command is being sent in packet format. Each packet consists of 2 bytes.
 - i. 1st byte: Start byte, '@' or 0x40 in Hex.
 - ii. 2nd byte: Start bit + Servo motor number.

Byte	Binary	Hexadecimal	Decimal
1st Byte	0b0100000	0x40	64
2nd Byte	0b01XXXXXX	0x41 to 0x60	65 to 96

- b. 1st byte is start byte which indicate the user to request the position of servo. 2nd byte is combination of start bit and requesting servo number.
- c. After receive this command, SC16A will send out a packet format which consists of 3 bytes.

Byte	Binary	Hexadecimal	Decimal
1st Byte	0b01XXXXXX	0x41 to 0x60	65 to 96
2nd Byte	0b00XXXXXX	0x00 to 0x3F	0 to 63
3rd Byte	0b00XXXXXX	0x00 to 0x3F	0 to 63

- i. 1st byte: Start byte + Servo motor number
- ii. 2nd byte: Position (Higher 6 bit)
- iii. 3rd byte: Position (Lower 6 bit)

Please refer back to Position and Speed Command section (d) to (f) for the description of these 3 bytes.

- d. User is requires to receive and process these 3 bytes. User may refer to sample source code provided. Comments are being provided in the sample code to help user understanding. Please refer to sample program named "SC16A+16F+Pos.c".

8. WARRANTY

- Product warranty is valid for 6 months.
- Warranty only applies to manufacturing defect.
- Damage caused by misuse is not covered under warranty.
- Warranty does not cover freight cost for both ways.

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