# TNG-servo Board

The TNG-servo board accepts SPI-protocol data to control the position of Futaba-style hobby servo motors. Up to eight servos can be controlled from a TNG-4 interface device through its SPI expansion port. Multiple (up to 8) TNG-servo boards can be daisy-chained together. Each board can be addressed individually. That's 64 motors!

The TNG-servo board uses a PIC16F73 microcontroller IC to control the hobby servo motors by means of pulse width modulation (PWM). In other words, the rotational position of the hobby servo is proportional to the duty cycle length of the control pulse. Each motor is sent about 62.5 pulses per second. The pulse width of each motor can be varied from approximately 1 microsecond to 3000 microseconds in 1 microsecond steps. The power-up default is a 1500 microsecond pulse width—the "neutral" position for most servo motors. Most common servos have a hysteresis of 8 microseconds.
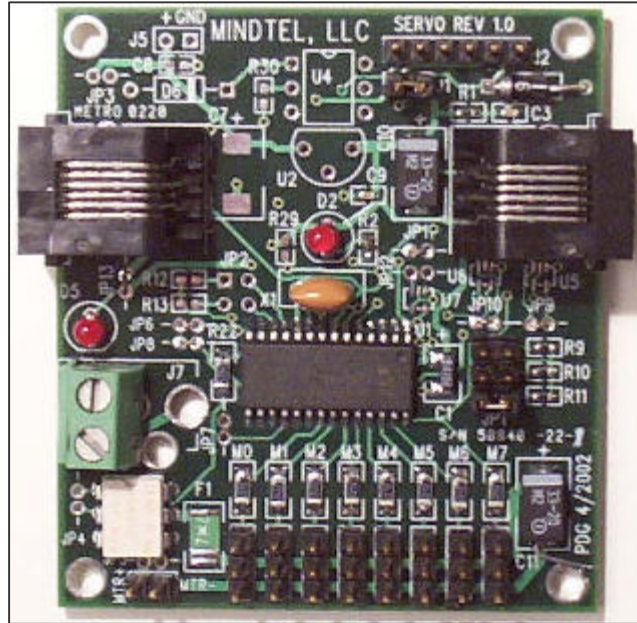
SPI Communications protocol:

The communications protocol is as follows:
1. Sync Byte: (FFh[255])
2. Address/Command Byte.
   form: xybbbmmm where
   x   = 1 if turning motors on.
   y   = 1 if turning motors off.
   bbb   = board base address (0-7). These bits are the same as the address selector jumpers (R9, R10, and R11).
   mmm = motor number (0-7).
3. Servo position high byte.
4. Servo position low byte.

The servo position is the pulse width time in microseconds.

If using a TNG-4/CM (command mode) as a data source, the 4 byte message should be prefixed with the following hex bytes: 99 04. These two bytes instruct TNG-4 to send a 4-byte SPI message using PORT C.2 as the chip select line.

Data Connection:

The data input connector is the modular jack on the left (J9) in the picture above. The modular jack on the right (J8) is used for daisy-chaining TNG-servo boards. The data cable between TNG-4 and TNG-servo or two TNG-servo boards should have the modular plug prong on both ends of the cable on the same side of the cable.

The interface is powered by +5V and ground delivered on the first and last pins of the input connector when connected to TNG-4. Alternative power schemes are possible (see below). The SPI protocol uses three lines: CLOCK, DATA, and CS-. The TNG-servo board will flash the D2 LED when it receives a valid SPI message compatible with its base address.

The base address is set by the jumpers adjacent to resistors R9, R10, and R11. The least significant address bit corresponds to the least significant bit of the board address. An open jumper corresponds to a "zero" for that position. The board address is enumerated at power-up.

Motor Connections:

The motors are powered independently from the interface and TNG-4. DC voltages less than 20V are acceptable, provided that voltage is compatible with the servo motor. A 5 to 6 volt power supply is typical. The motor power is applied through the green screw-terminal connector. The positive terminal is the one closest to the bottom edge of the TNG-servo board. A self-resetting fuse at F1 limits sustained current to 0.75 A (not on all boards).

Motor power is controlled by the PhotoMOS relay at U3. Motor power is active when the LED at D5 is on. The PhotoMOS relay can switch up to 2 amps. No PWM pulses are sent to the motors when the motor power is off (default).

TNG-4, TNG-servo, and motor power must have their grounds connected at some point. This ideal location for this connection depends on the particular system. When the TNG-servo is powered through TNG-4, TNG-4 and TNG-servo grounds are automatically connected.

The TNG-servo board is 2½ inches tall by 2¼ inches wide. There are four 0.125" mounting holes on TNG-servo. The left-right spacing is 2 inches. The up-down spacing is 2¼ inches. These plated-through holes are all connected to TNG-servo ground (not motor ground), and may serve as a convenient place to facilitate a motor ground to TNG-servo ground connection. The populated board weighs 0.85 ounce. Power consumption is about 10 mA, exclusive of motor power consumption.

The Futaba-style hobby motors use a 3-pin connector—motor control, motor +, and motor ground (or -). The connector is placed on the desired 3-position header on the TNG-servo board such that the motor control line (white or yellow) is connected to the top pin.

<u>**Alternative Board Configurations**</u>:

The TNG-servo board supports a plethora of different configuration that could be useful in different circumstances:

1. The firmware can be modified to suit specific requirements (within the hardware limitations of the device and board).
2. The board can be powered from motor power instead of TNG-4 power.
3. The board can be powered independently from either TNG-4 or motor power.
4. If the applied board power exceeds 5 volts, an on-board regulator can be implemented.
5. The SPI lines can be terminated.
6. Buffer IC's (Fairchild TINY logic: U5, U6, and U7) can be added to drive the SPI lines of daisy-chained TNG-servo boards.
7. The photoMOS relay can be eliminated. This would leave the motors powered continuously (pulses would not be sent to motors until a "power on" command was received).
8. The TNG-servo board can be configured to receive RS-232 instead of SPI. Daisy-chaining of boards is still possible.

<u>**Code examples**</u>:

99 04 FF 83 06 40: Send a 4-byte SPI message using Port C bit 2 as the chip-select line. The message is the FF sync byte, followed by the address byte (board 0, motor 3), followed by the position bytes (1600 µs).

99 24 FF 87 05 14: Send a 4-byte SPI message using Port D bit 6 as the chip-select line. The message is the FF sync byte, followed by the address byte (board 0, motor 7), followed by the position bytes (1300 µs).

99 74 FF A5 05 DC: Send a 4-byte SPI message using Port D bit 1 as the chip-select line. The message is the FF sync byte, followed by the address byte (board 2, motor 5), followed by the position bytes (1500 µs).
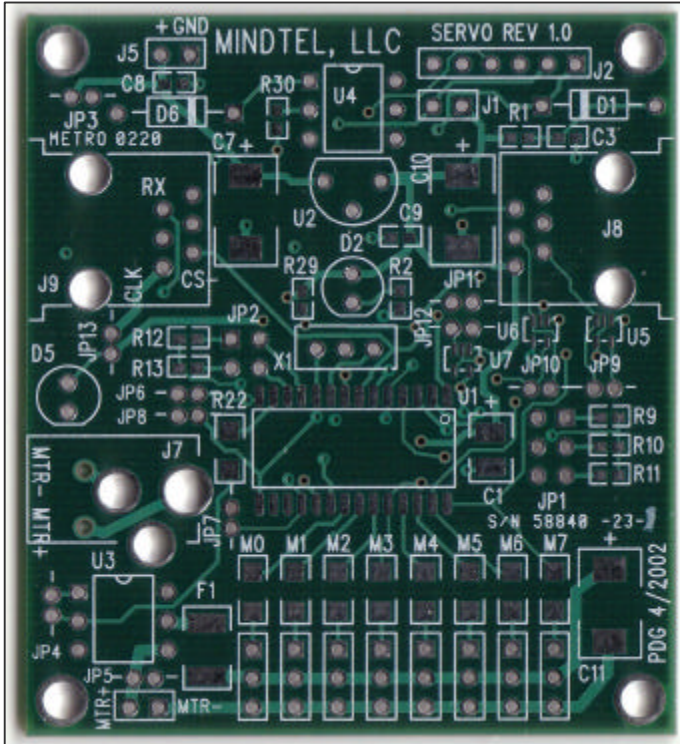
Programming Procedure:

Remove the jumper at J1. Connect the programmer to the TNG-servo at header J2 using the special in-circuit serial programming cable. Pin 1 of J2 is to the far right.

Make sure that the programming software is correctly configured. You are programming a PIC16F73 microcontroller. Enable the watchdog timer. Enable the power-on timer and brown out interrupt. Use the HS clock option (do NOT use LP or XT options).

Erase the chip prior to programming the device. Program the device using full code protection.

Remove the programming connector and replace the J1 jumper. Test the board.