

## TNG-3B FAQ

### 1. What's a TNG?

TNG is pronounced “thing” as in *The Cat in the Hat* by Dr. Seuss, and stands for “totally neat gadget”. TNG-3B is the third in an evolutionary line of simple data acquisition devices. TNG-3B is an input only device that streams analog and digital data to a host computer connected by an RS-232 serial port.

### 2. How does TNG-3B work?

TNG-3B continuously reads its 8 analog-to-digital converter (ADC) inputs and 8 digital input bits and transmits this information in 10-byte data blocks at 19.2k baud on its RS-232 compatible output line. The ADC resolution is 8 bits (0-255). The power to operate TNG-3B is derived from the RTS, DTR, and serial data lines.

### 3. How big is TNG3?

TNG3 is 2.82 inches wide, 4.7 inches long and 0.91 inches tall. This includes any connectors that protrude from the side of the box. The basic box is a PACTEC HML box (<http://www.pactecenclosures.com/index.lfml>)

### 4. How much does TNG3 weigh?

4.6 ounces plus or minus 0.1 ounce.

### 5. Where does the power come from?

TNG-3B derives its operating power from the serial port. The DTR, RTS, and both data lines are all used, and must be properly connected.

The power budget is consequently somewhat meager, but as TNG-3B is only used for input, the small amount of available power is rarely a problem. TNG-3B uses about 2 milliamps (mA) of current for its normal operation. An additional 2 mA is used when the test button is depressed. This leaves about 6 to 8 mA of power available for devices attached to TNG-3B.

The recommended power allocation is  $\leq 0.5\text{mA}$  for each analog input and  $\leq 250$  microamps ( $\mu\text{A}$ ) for each digital input.

Each digital input has an associated weak pull-up. So, in many cases, no additional pull-up resistor is required.

Remember, these are guidelines, not absolute requirements. We routinely use

sensors that consume more than 0.5mA. As a matter of practice, we try to keep all of our devices  $\leq 1$ mA. The power budget only becomes critical when using most or all of the TNG-3B inputs simultaneously.

## **6. What connectors plug into TNG-3B?**

The serial port connector on TNG-3B is a DB-9 female connector.

The analog inputs (8) use a 3.5 mm stereo phone jack.

The digital inputs (8) use a 2.5 mm mono phone jack.

## **7. Does TNG3 have any output capabilities?**

No. TNG-4 (not yet released) and future versions will have bidirectional capabilities.

## **8. How fast is TNG3?**

The standard unit is connected at 19.2k Baud (kbps). That's 19,200 bits or 1,920 bytes sent every second. TNG4 sends the data for all eight ADC channels and each digital input in a 10-byte data packet. Packets are sent continuously. At 19.2k Baud, that translates into 192 data packets sent every second.

Each analog channel is actually sampled 416 times per second. The result of each acquisition is added to the result of the previous acquisition and the sum is right-shifted one bit (divided by 2) to form the next result. This moving-average filter provides a limited low-pass filter. In practical terms, large voltage steps are not fully realized for 3-5 data packets, depending on the magnitude of the voltage step.

## **9. Can it go faster?**

Yes. By special order (\$50 premium), we can easily change the baud rate. Baud rates of 57.6k are easily attainable. It's not just a matter of changing the baud rate—everything else has to change proportionally. Tell us what you need ([support@sensyr.com](mailto:support@sensyr.com)).

Slower baud rates are also available by special order.

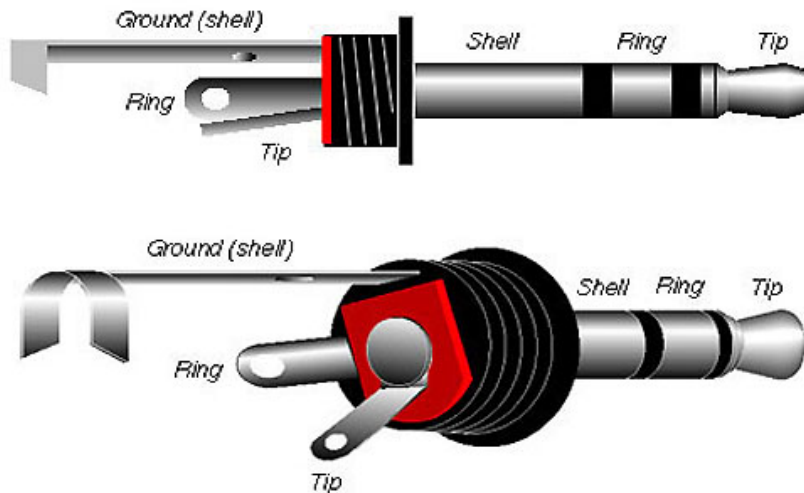
Once selected, the baud rate remains fixed.

## **10. How do I attach an analog sensor?**

The output of your sensor eventually has to be connected to a 3.5mm stereo plug. The tip is +5VDC. The ring is the input signal. Ground is connected to the shell. See Figure 1, below.

The sensor output should be in the 0-5VDC range. Negative voltages are not allowed, nor are voltages exceeding 7V.

### Components of the 1/8" Stereo Plug



**Figure 1: 3.5mm Stereo Plug for Analog Inputs**

### 11. Is TNG-3B electrically isolated?

No. There's no electrical isolation between the computer, TNG-3B, and the devices attached. That is, unless an attached device has electrical isolation built in.

### 12. Can I measure voltages higher than 5V?

Yes. You have to use a voltage divider circuit to attenuate the input so that it's within the allowed range. Be advised that if part of the attenuator fails, the TNG-3B input could be subjected to a voltage that could exceed the allowed maximum. Worse yet, so could your computer (possible, but unlikely).

### 13. Can I measure negative voltages?

This is trickier than the previous question. You can use the 5V available on the stereo connector to pull up the negative voltage into the appropriate range, just be sure that no negative voltage appears on the input. This includes times when the TNG-3B is powered down. We really recommend an active attenuation circuit with input protection for this task.

### 14. How do I attach a digital input device?

The digital inputs are usually used with switches, but any TTL-compatible output

can be connected to a TNG-3B digital input. Tip is signal; ring is ground. If you need to terminate the line, put an appropriate resistor (50, 75, 100 Ohms) between tip and ring.

**15. How often can a digital input change?**

As fast as it wants. The real question is how fast can an input change and have the changes register reliably in the host computer. The answer is  $<1/200^{\text{th}}$  the baud rate.

Here's the reasoning: Each data packet is 10 bytes. Each byte requires 10 baud clocks to send (8 data bits, 1 start bit, and 1 stop bit). The typical baud rate is 19.2k baud. Divide that by 10 for bits, and by 10 again for bytes per packet, and you get 192 packets per second. The fastest square wave (50% duty cycle) you can see is 96 cycles per second.

In actuality, 96 Hertz is the upper limit. Two independent oscillators will drift in phase relative to one another. At 96 Hz, TNG-3B will occasionally miss an up or down transition. 50 Hz is a more practical upper limit.

**16. How can I connect TNG3 to digital signals that aren't TTL-compatible?**

Yes, but you have to implement some variety of level-shifter circuit external to TNG-3B.

**17. How do I connect the TNG3 to my computer?**

Use the included cable to connect a serial port on your PC to TNG-3B. This assumes that the host computer uses standard 9-pin connectors. There are adaptors that allow you to convert the 9-pin connector to a 25-pin connector. Beware of adaptors that are also null-modem adaptors. Null-modem adaptors swap not only map the 9-pin connector to the 25-pin connector, but also swap certain signal pairs.

**18. What are the LED and pushbutton switch for?**

When TNG-3B is functioning properly, pressing the yellow pushbutton switch near the serial connector will cause the LED to light. This means that TNG-3B is powered, connected to the computer, and the processor is running. The TNG-3B processor reads the state of the switch and lights the LED based on that state.

**19. When I push the test button, the LED doesn't light. Why?**

This indicates one of two things: TNG-3B isn't powered up, or there's too much current load on TNG-3B.

The DTR and RTS lines of serial port must be asserted for TNG-3B to be powered. If you are sure that DTR and RTS are asserted, and nothing else is connected to TNG-3B, it's possible that TNG-3B has died. It's also possible that there's some problem with your serial port. Reboot. Try another port or another computer.

If there are devices attached to TNG-3B, disconnect them all. If the LED lights after disconnecting the attached devices, check each of the previously attached devices by themselves. If any one device fails the test, it's drawing too much current. If no one device fails the test, then the total current draw exceeds the available current.

**20. Is a cable included?**

Yes, a 6-foot 9-pin D-style extension cable is included with your purchase.

**21. How long a cable can be attached?**

Up to 50 feet or so. At higher baud rates, this is reduced to about 10 feet. The quality of the cable you use has a large influence.

**22. How can I make my own serial cable?**

Sure. Connect pins 2, 3, 4, 5, and 7. Pin 5 is ground. Pin 4 is DTR. Pin 7 is RTS. Pin 2 is for data coming from TNG-3B. Pin 3 is for data coming from the computer into TNG-3B.

**23. Can I get more power?**

Yes. Construct a special cable that connects RTS and DTR to an external power source of 6-9 volts. Better yet, use a PVN012 photoMOS relay or its equivalent switched by the DTR line to turn on the external voltage source.

A much less acceptable solution would be to apply an external, regulated 5V source to the 5V line of one of the analog input jacks.

**24. Can TNG-3B operate at voltages other than 5V?**

We can make a 3.3V or 3V TNG-3B by special order (\$50). The analog input range is correspondingly reduced.

**25. Can I get more analog resolution—10 bits, 12 bits?**

This is a possibility. We have not yet worked out a backwards-compatible protocol for the additional data. The extended resolution would decrease the data

rate. Contact SenSyr, LLC for more information ([sales@sensyr.com](mailto:sales@sensyr.com)).

**26. Can I use more than one TNG-3B on the same computer?**

Yes. You can have as many TNG-3B units as you have serial ports.

**27. Is there a USB TNG?**

Not yet. We are working on it, though. We have used TNG-3B successfully with a number of different USB to RS-232 adaptors. Strangely, we have recently received reports of some USB adapters that work fine with TNG-3B on one system and not at all on others.

**28. What software is available?**

NeatTools, a graphical programming language, is downloadable as freeware at <http://www.pulsar.org/2k/neattools/>

A Windows .dll is available at <http://www.pulsar.org/int/tibor/tng3drv.html>

**29. Can I use LabView with TNG-3B?**

TNG-3B is compatible with the LabView™ programming language available from National Instruments, Inc. (<http://www.ni.com>).

Some example VIs and some demo programs are available for download at [www.sensyr.com](http://www.sensyr.com)

**30. I want to collect data with my own program. What's the data format?**

Each data packet is as follows:

From TNG-3B:

Separator Byte: AAh (10101010) alternating with 55h (01010101).

Analog Channel 1 (8-bits)

Analog Channel 2

Analog Channel 3

Analog Channel 4

Analog Channel 5

Analog Channel 6

Analog Channel 7

Analog Channel 8

B-Port Digital Data (8 bits)

### **31. I think that it's dead. What do I do?**

Double check everything. Check your connections. Check your software. Reboot the computer. Try it on another computer. If, after all that, you still think it's dead, contact SenSyr ([support@sensyr.com](mailto:support@sensyr.com)).

### **32. What sensors are available?**

See [www.sensyr.com](http://www.sensyr.com).

### **33. Are TNG3's inputs protected in any way?**

The analog and digital inputs have some diode transient protection built into the microcontroller. Additionally, the analog inputs have a 100 Ohm series resistor.

### **34. The unused TNG3 analog input channels all read as 5V. Why?**

There's a 100 Ohm resistor connected to +5V for each analog input channel that's connected to the input when nothing is plugged into the jack. The jack is a switched jack. If allowed to float, signals on adjacent used channels can appear on unused channels.

### **35. How do I convert an ADC value to a voltage?**

The analog to digital converter (ADC) in the PIC microcontroller transforms an analog input voltage in the zero to 5 volt input range into a digital number, a single byte (character). The byte value is in the range 0 through 255, inclusive. To transform a byte value into a voltage, use the following formula:

$$\text{Volts} = \text{ADC value} * (5/255)$$

For example, an ADC value of 128 corresponds to a voltage of 2.51 volts.

### **36. How do I convert an ADC value to a physical unit?**

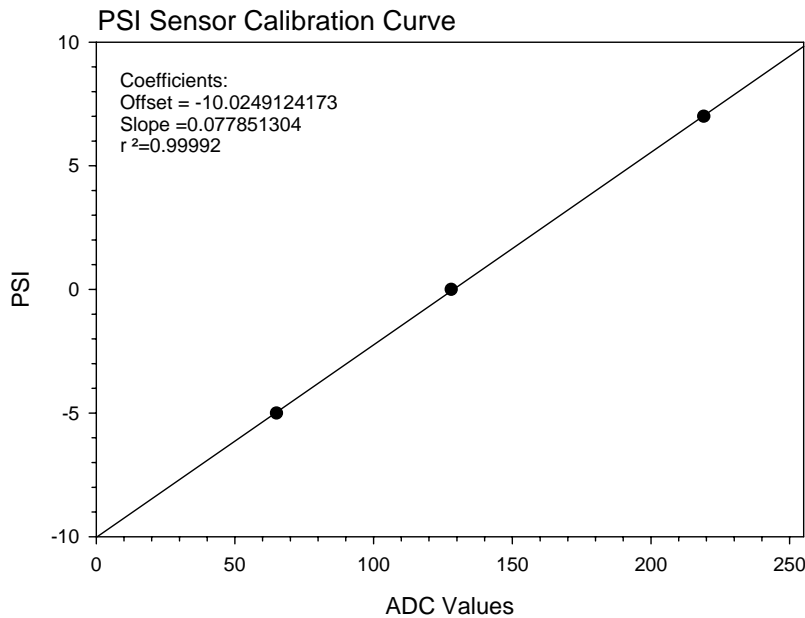
This is similar to the previous question, but usually requires a calibration step. The ADC has a built-in calibration to voltage. Things are not quite so easy for most sensors and transducers connected to TNG3. Just as the ADC maps input voltages to an 8-bit number, real-world physical units such as pressure, force, and temperature to ADC values.

Assuming that the transducer/sensor has a linear output, determine the ADC value for each of two (or more) sensor values. Ideally, you should use values near each extreme. Fit a straight line to this calibration data, and now you can read inputs in the physical units of the sensor.

I prefer a three-point calibration whenever feasible, as a straight line can be drawn through *any* two points. The third point serves as a sanity check.

Also, be careful of calibration points that might fall outside the conversion range (even if just by a small amount) of the A/D converter. This can throw your calibration curve way off.

For example, let's say there's a pressure sensor that has an output span of 0 to 5V for a physical input span of  $\pm 10$  PSI. We calibrate at three points: 0 PSI, -5 PSI, and +7 PSI. The corresponding ADC values are 128, 65, and 129, respectively. This yields the following calibration curve:



**Figure 2: PSI Sensor Calibration Curve Example**

Using the coefficients of the calibration curve, we can easily convert any ADC value to PSI by multiplying each ADC value by 0.0778513 and then subtracting 10.025 PSI from the result.

Nonlinear sensors, like thermistors, can also be calibrated, but the curve fitting techniques are more difficult. More calibration points are required. Also, the resolution of such a sensor depends on where the reading falls on the curve.