Technical Brief
AN242 Rev A2

4-20mA Inputs for SCADA Applications

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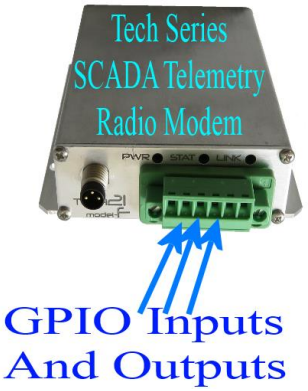
Summary

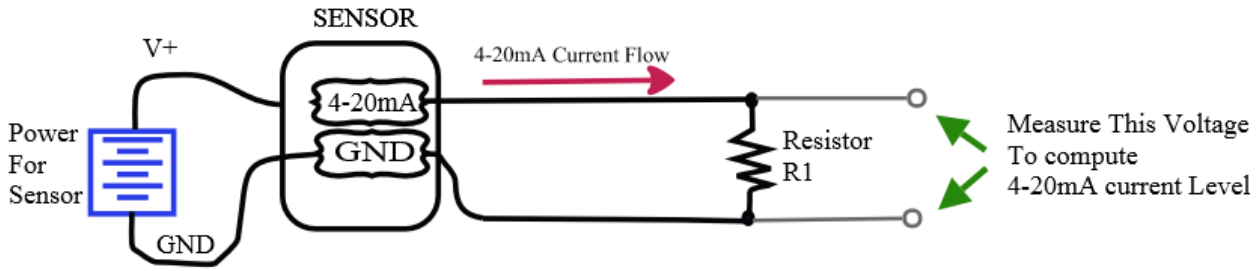
The SCADA industry has many sensors that put out ***4-20m***A current as them measure things such as temperature, water pressure, light brightness…

SCADA stands for Supervisory Control and Data Acquisition. The ***MRV-M21*** and ***MRV-M22*** data radios from Raveon Technologies are called the "*Tech Series*" modems. The *Tech Series* modems can read voltages, and with a resistor, they can read the level of 4-20mA current draw.



Tech Series Remote Terminal Features: Digital IO, Analog IO, Switched Power, Open Collector outputs, accelerometers, and others. The Analog inputs can read voltage and this Tech Note describes how to connect a 4-20mA sensor to a voltage measuring device like Raveon's GPIO interface or any other voltage sensor.

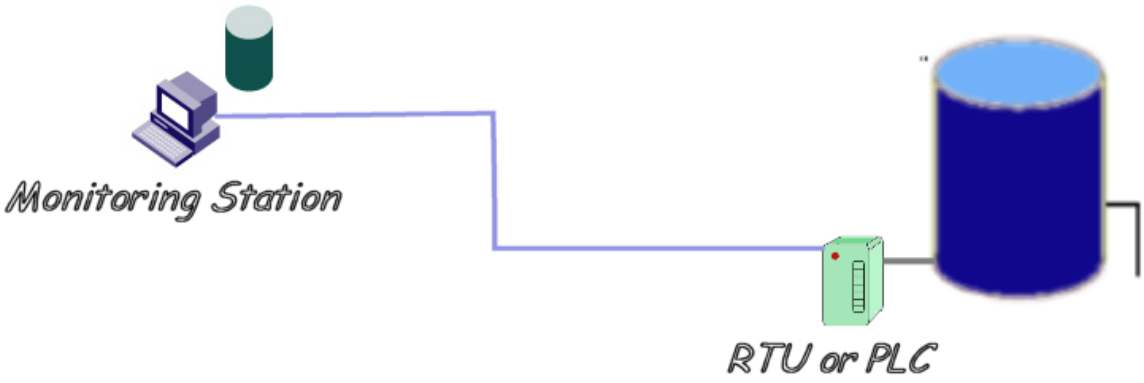
Measuring 4-20mA



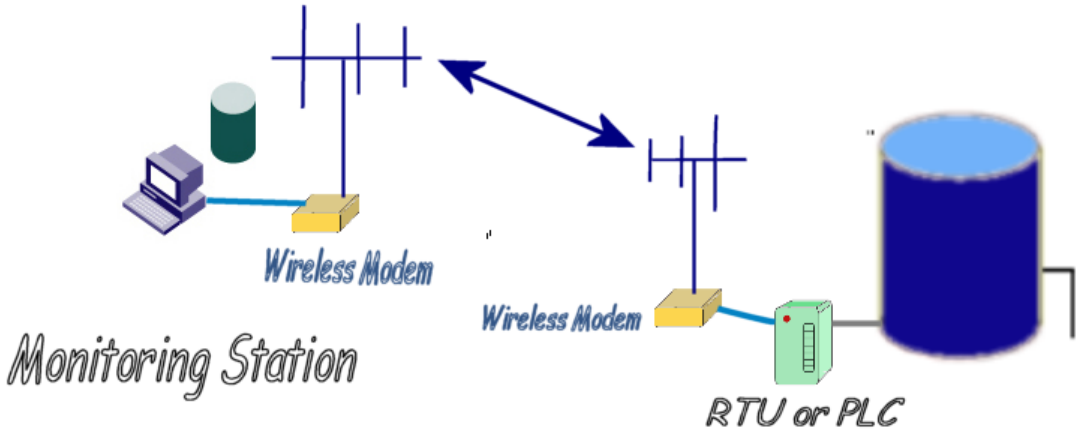
Wireless SCADA

In a wired SCADA system, a device or sensor is monitored by some type of computer or other human-to-machine interface. The user may have something as simple as an LED indicator, or as complex as a computer server for the operator. The human interface communicates to another electronic device that is remotely located at the monitored location. Often this remote device is a Remote Terminal Unit (RTU) or Programmable Logic Controller (PLC).

Typical SCADA System



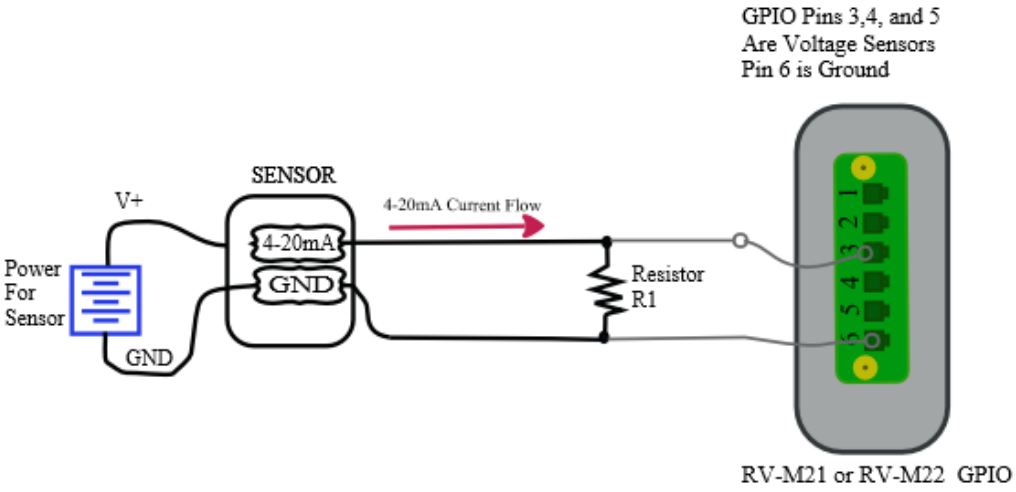
When the distance between the monitoring station and the device being monitored (the water tank above) is not trivial, than a wireless link between the two sites becomes a logical means of connecting them. The RTU monitors the digital and analog parameters in the field, and transmits data to the central Monitoring Station using a SCADA protocol.



Measuring with Tech Series GPIO

Wiring

To Setup a 2-40mA sensor on a Tech Series GPIO interface, wire the 4-20mA sensor to GPIO as shown here.



The 4-20mA current goes into resistor R1 that you need to add to the GPIO front panel.

4-20mA Math

V = R X A (Voltage = Resistance times Current)

120 ohm resistors are commonly used in 4-20mA loads to convert to voltage. Here is a list of voltage ranges for various resistors used to convert 4-20mA:

Resistance in ohms	Voltage at Various Current Levels into the Resistor				
	List of Various Current inputs to the Resistor				
	4mA	*8mA*	*12mA*	*16mA*	*20mA*
120	0.48V	0.96V	1.44V	1.92V	2.40V
220	0.88V	1.76V	2.64V	3.52V	4.40V
470	1.88V	3.76V	5.64V	7.52V	9.40V
680	2.72V	5.44V	8.16V	10.88V	13.60V
750	3.00V	6.00V	9.00V	12.00V	15.00V
1000	4.00V	8.00V	12.00V	16.00V	20.00V

The Maximum input voltage to the GPIO voltage input sensor is slightly less than the DC input voltage to the radio modem. Must users use 12V input or 24V input.

Change the Calibration to read Current.

The Tech Series Radios have a voltage calibration command to set the actual reading for a particular voltage input. You can re-calibrate it by putting the current into the resistor, and then calibrate the voltage.

For example, if you have a 470 ohm resistor, and you put in 12mA into the resistor, there will be 5.64 volts going into the GPIO pin. If you issue the GVOLT command, it will get the voltage reading and display the voltage. Or you can issue a MODBUS command to read the voltage. It will show about 5.6 volts, but it is 12mA.

So, you can issue the CALADC 12000 command to calibrate the "voltage" input on the analog to digital converter (ADC) in the modem in millivolts. 12000 is 12000mV which is 12V. Once you calibrate it this way, and ask the voltage with a MODBUS command or the GVOLT command, it will tell you with that 12mA you have 12 volts (1200mV). So you now calibrate 12mA to read as 12.00 or 12000 in a voltage register.

Tech Series Features for SCADA Applications

Reliable Long Range Connectivity. 19200bps in 25kHz channel, 9600bps in 12.5kHz.

Remote status monitoring including DC voltage, packet error statistics, modem "up time", and receiver signal strength.

Easy to use. Plug-in, Turn-on, and GO. Transmit data in = Receive data out.

A myriad of IO options. The front interface of the Tech Series M21 is fully field-reconfigurable. The following front panel interfaces are available and interchangeable:

• RS-232	[S]	5T835	(RS232 serial data communications interface with flow control)
• USB	[U]	5T837	(USB Serial interface)
• RS-485	[T]	5T836-1	(Serial communications for RS-485)
• RS-422	[F]	5T836-2	(Serial communications for RS-422)
• GPIO	[G]	5T833	(General Purpose IOs, Digital, switch DC, Open C, Analog in.)
• Analog	[A]	5T838	(Analog input and output with FM mod/de-mod)
• FIO	[D]	5T832-1	(Flexible IO with Digital Inputs, Digital Outputs)

Low current draw. The M21 wireless modems draw less than 90mA in the receive mode.

The M21 is a **Modbus Gateway**, to send MODBUS messages to remote devices.

Wide input voltage with high-efficiency switching voltage regulator.

Packetized AND Streaming Data. Integrated Packetized data protocol with error correction and built-in Streaming Real-Time operation. User selectable.

Save Money. GPIO and **FIO** interfaces save you lots of cost, wires, and time to implement, so the Tech Series radio can be your Remote Terminal Unit itself.

Store-and-forward repeating operation. This feature option can extend the range over thousands of square miles.

Small size. Extruded aluminum enclosure is small, and very rugged.

16 bit addressing for up to 65,525 different unique device addresses per channel. Radio channels may be shared with no interference between users.

Supports **group and broadcast** transmissions. Network mask allows groups of any size.

ARQ error correction and retransmission capability. Totally transparent to the application.

Easily to configure. *Raveon* modems are configured using "AT" commands through the modem's serial port. Raveon also provides free of charge, *Radio Manager*, a easy-to-use PC program with a graphical user interface to configure and program all Raveon Radios.

RS-232, RS-422, or RS-485 serial port. Programmable serial baud rates up to 115200 make the *M21* radio modem compatible with most every PLC, PC, and HMI device made.

Programmable over-the-air data rates. With the *M21* radio modem, you can choose how your system will work. Set the OTA data slower for extended communication range, or set it fast for lowest latency. *Your choice*.

SkyLine compatibility mode for use in older Sonik radio systems.

Integrated Sensors

Built into the M21 modems are many features and commands that can be used as sensors for SCADA, telemetry, and remote control without having to attach an external sensor.

For many SCADA systems, the Tech Series GPIO interface is the ideal interface to monitor remote devices or control them. The ones with serial interfaces such as RS-232, USB, and RS485 can be connected to a SCADA controller or HMI to communicate with a remote Tech Series radio modem that has the GPIO interface.

The following commands in the M21 are powerful SCADA and telemetry features.

Commands for SCADA and Telemetry

This is a list of commands the Tech Series products have that can be used for reading a voltage or 2-30MA current input to a voltage sensor on the GPIO pin. See Application Note AN234 for all SCADA command for all features.

Commands in the Tech Series Modems GPIO Voltage input

Command	Command Description	Parameters	Default Settings
GOUT	**GOUT** Get the output bit register in hexadecimal format. Example: will return 00**C3** if bits 0, 1, 14, 15 are set(1) and all other clear (0).	Returns Hex value, 16 bits max.	
GVOLT	**GVOLT X** Get/read the voltage on an input X.	Returns floating point, 3 decimal places. .	
IOPIN	**IOPIN XX M** Set the GPIO bits on the Tech Series GPIO front panel to inputs or outputs. **XX** parameter are the hexadecimal representation of the pins being configured. M is the mode for the XX pins. Mode M values: **A**:Digital TTL Input, **B**:Digital TTL Output. **C**:Open Drain MOSFET output, **D**:DC Power switch output. **E**:Analog Input	XX=Hex 00-FF M=(A,B,C,D)	A

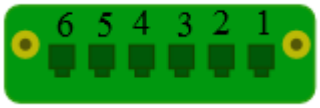
MODB	**MODB x** Enable or disable the MODBUS communication feature. 0=disable. 1=MODBUS RTU mode. 3=MODBUS TCP (If available on the product)	X: 1-3 0=No MODBUS	0

The Tech Series SCADA features support custom “safe zones” and alert you automatically if the sensor detects conditions outside of that range. Some safe zone settings can report: On, OFF, XX number of transitions, pulses per second, pulses per minute.

General Purpose IO (GPIO)

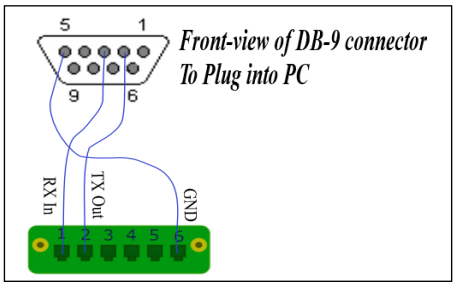
The M21 and M22 *Tech Series* radio modems have a GPIO interface option and telemetry software built into the modem, so that the User can use standard telemetry apps and MODBUS to communicate to the M21 GPIO to monitor, manage, and control devices using the Tech Series radio modem’s GPIO interface.

The GPIO has serial IO and general purpose IO functions that are software configurable. The GPIO pins are as show here:



Pin #	*Name*	*Direction*	*Function*	*Level / Specification*
1	**RX**	In	Serial data Input	RS232
2	**TX**	Out	Serial Data Output	RS232
3	**IO0**	I/O	I/O Pin 0	Configurable General Purpose IO (GPIO). Does not support DC Switched output mode (D).
4	**IO1**	I/O	I/O Pin 1	Configurable General Purpose IO (GPIO)
5	**IO2**	I/O	I/O Pin 2	Configurable General Purpose IO (GPIO)
6	**GND**	-	Ground	Connect to earth ground.

An RS232 serial cable can be connected to pins 1, 2, and 6 to configure the internal radio modem and MIMIC mode features. Here is a wiring diagram for the RS232 DB9 connector to be wired to the GPIO connector.



Or contact Raveon to have the device pre-configured when it is purchased.

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Configuring the GPIO for Telemetry

The GPIO Front panel option on the Tech Series enclosures is a flexible General Purpose IO feature. The 3 IO pins can be configured for various IO options.

- **A**: Digital TTL Input, 3.3V digital signal. Most GPIOs don't incorporate this. Contact Raveon sales to order GPIO version with this feature enabled.
- **B**: Digital TTL Output. Most GPIOs don't incorporate this. Contact Raveon sales to order GPIO version with this feature enabled.
- **C**: Open Drain MOSFET output,
- **D**: DC Power switch output.
- **E**: Analog Input. This is the input to use to measure 4-20mA with a resistor on the input pin.

The radio will auto-detect the GPIO board and set all necessary parameters to enable it. By default, the IO pins are set to digital inputs. When configuring the pins, make sure nothing is connected to them until the IO pins are all properly configured.

IOPIN XX M is the command to set the GPIO bits on the Tech Series GPIO front panel to inputs or outputs.

XX parameter are the Hexadecimal representation of the pins being configured. For example, to configure bits 0 and 1, XX should be set to 3. FYI: GPIO pin #4 is called IO2 and is designates as XX bit 1, which is XX=02.

7	6	5	4	3	2	1	0
					IO2	IO1	IO0
128	*64*	*32*	*16*	*8*	*4*	*2*	*1*

M is the mode for the XX pins. Mode M values:

- **A**: Digital TTL Input,
- **B**: Digital TTL Output.
- **C**: Open Drain MOSFET output,
- **D**: DC Power switch output.
- **E**: Analog Input

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