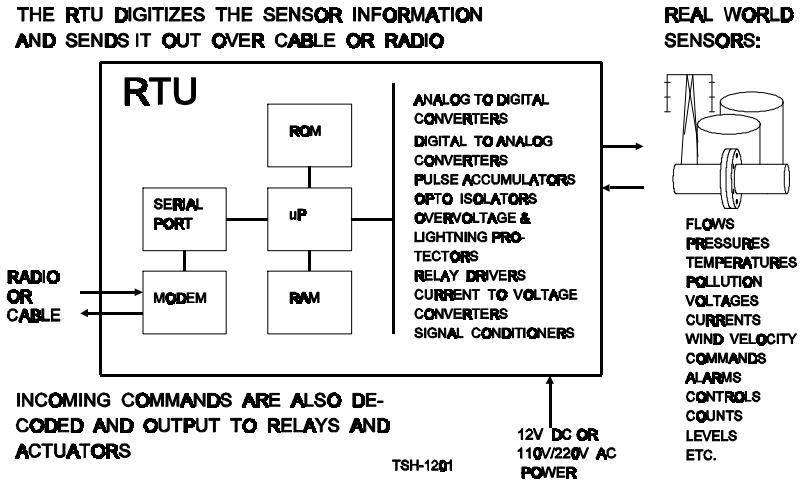
# CHAPTER 12, SENSORS AND ACTUATORS:

## 12.A FIELD INSTRUMENTATION:

All RTUs interface with real world field instrumentation inputs and outputs. The basic function of the RTU is to receive analog signals, digital signals and pulse metering current, voltage and contact inputs. The RTU digitizes these inputs into a form which can be transmitted over radio and cable networks to a central station or to another RTU.




The RTU also receives commands over the radio and cable networks from a central or from another RTU to generate real world analog, digital and pulse current outputs. These commands are received in digitized form and are converted by the RTU to currents matching the requirements of the field relays, actuators and controller inputs.

Additionally, the RTU can have many other functions such as flow calculations, generating alarms, data logging and others. These functions are described elsewhere in this Handbook.

There are six classes of Input/Output (I/O) signals:

## 12.B ANALOG INPUTS (A/Is):

This class of inputs come from transducers which convert flows, pressures, levels, temperatures, vibration levels, etc., to electrical signals that can be connected to the RTU. How are these signals generated.

A very simple (and crude) example would be a pressure transducer consisting of a membrane attached to a pipe. This membrane moves in and out as the pressure of the gas or liquid in the pipe varies. Attach a potentiometer to the membrane and a battery in series with the potentiometer. You would now get a voltage which is proportional to the pressure in the pipe. This voltage can be connected directly to the RTU and digitized and sent on to the central or to another RTU.

**WHAT KIND OF TRANSDUCERS TO USE?**

In the old days (before SCADA and telemetry) you bought a thermometer and installed it through the side of the water tank and you bought a level (or pressure) meter and installed it at the bottom of the tank. You then had your man Charlie go out and periodically read these meters and write the readings down on a piece of paper.

Modern temperature and level and pressure meters work the same way, except that they convert the readings to electric current signals and are therefore called transducers. A visual read-out, as with the old instruments, is an option that is seldom used. Today you don't walk out to the tank to read the meter; you sit in the air conditioned comfort of your control room and read the numbers on a computer screen from the transducers (in Mode-B operations) or on an annunciator panel (in Mode-C operations).

There are many advantages with this approach; the electric current signals from the transducers are converted by the RTUs to a language any computer can understand, display and print. The computer can also tabulate, store, trend and compare these numbers and perform complex control functions based on these readings.

There is a nearly endless list of analog transducers available and new ones are designed every day. A brief list of the kinds of transducers available could look like this (the list is by no means complete):

- **Flow transducers.**
- **Level transducers.**
- **Pressure transducers.**
- **Temperature transducers.**
- **Strain & force transducers.**
- **Turbidity, PH and conductivity transducers.**
- **Voltage, current, phase angle and watt transducers.**

Different transducers generate different types of electrical signals. The modern industry standard is the 4-20 mA loop signal. Here a 0% reading from the transducer is converted to 4 mA and a 100% reading to 20 mA.

This method has a number of advantages. One is that if the wire or the transducer is broken the signal becomes 0 mA and you know something is wrong. Another is that variations in the loop power supply and variations in resistance of the transducer leads have no effect on the accuracy of the measurements.

The 4-20 mA loop is the much preferred way to enter process variables into RTUs. It is rapidly becoming the world standard. Scan-Data manufactures converters that change different transducer outputs to 4-20 mA currents. Transducers which generate 4-20 mA are often referred to as loop transmitters or simply transmitters.

**WHAT IS THE 4-20 mA LOOP?**

The best transducers are those which convert the measurements to the industry standard 4-20 mA loop signals. As ASCII (American Standard Code for Information Interchange) has become the standard computer interface protocol so has the 4-20 mA instrument loop become the industry standard for instrumentation analog measurements.

In addition to being a world standard, there are many other advantages with the 4-20 mA instrument loop. It is capable of high accuracy. Breaks in the cable or in the sensor cause 0 mA in the loop, signaling an invalid reading. Variations in the cable resistance and in the loop power supply have no influence on the accuracy of the loop.

The loop consists of four components: One is the transmitter (or transducer) which generates the signal. The second is the DC power supply (normally 24V DC) which powers the loop. The third is the 2 wires which transmit the reading. The fourth component is the receiver or receivers. Several receivers can be connected into one loop without affecting accuracy. For instance, you may wish to temporarily insert a chart recorder to locally record the reading of a pressure or flow transmitter. Simply break the loop and insert the recorder. When you are through just connect the two wires back together again. The loop accuracy will not be affected.

All ScanData RTUs are capable of performing as 4-20 mA loop transmitters and receivers. To check and calibrate all aspects of the 4-20 mA loop, use the ScanData CAL 4/20 calibrator instrument.

A complete 4-20 mA loop consists of a loop transmitter (the transducer), a DC loop supply (normally +24V) and a loop receiver.

The Analog Input (A/I) at the RTU is one type of loop receiver. It normally consists of a 125 or a 250 ohm resistor. The RTUs can be set up to supply the loop power or they can work with an external loop power supply. Please specify when ordering.

Use the ScanData CAL-4/20 calibrator to measure and calibrate all 4-20 mA loops. It allows operation in four modes: Reading a transmitter, reading and powering a transmitter, calibrating a receiver and reading & powering a receiver.

**HOW ACCURATE IS THE 4-20 mA LOOP?**

The 4-20 mA loop is capable of great accuracy. The reason is that variations in loop supply voltage and variations in wiring resistance have absolutely no effect on the readings.

What can cause errors are leakage currents to ground. The loop must be connected to ground in only one place, normally at one end of the receiver. Most RTUs have one side of their 4-20 mA input tied to ground.

How good should the loop isolation be? The total span of the 4-20 mA loop is 16 mA, or 0.016 A. One tent of one percent of this is 0.000016 A, or 16 uA. This means that a leakage current to ground anywhere in the loop of 16 uA would cause an error of one tenth of one percent.

What resistance to ground will cause a leakage current of 16 uA? At 12V the resistance would be 12/0.000016 = 750,000 ohms. This means that you should keep your loop isolation considerably better than 1 megohm. Every part of the loop, all the additional receivers connected to the loop such as chart recorders, etc., and the power supply, all should have an isolation resistance to ground better than one megohm.

Luckily, there are a variety of 4-20 mA isolators available at reasonable costs that you can use if you have ground leakage problems or if more than one receiver has one end tied to ground.

All ScanData RTUs can accept a 4-20 mA signal, as well as 1-5V and certain other currents and voltages.

### 12.B.1 RTUS WITH INTERNAL LOOP SUPPLY:

RTUs can be delivered with or without an internal loop supply. To determine if you have an RTU with an internal loop supply, power up the RTU and measure across the analog input terminals with a tester. If you read 12V or 24V, the RTU has an internal loop supply and you can connect your transducer direct to the RTU input. If not, you need an external loop supply which should be well isolated (see the sidebar).

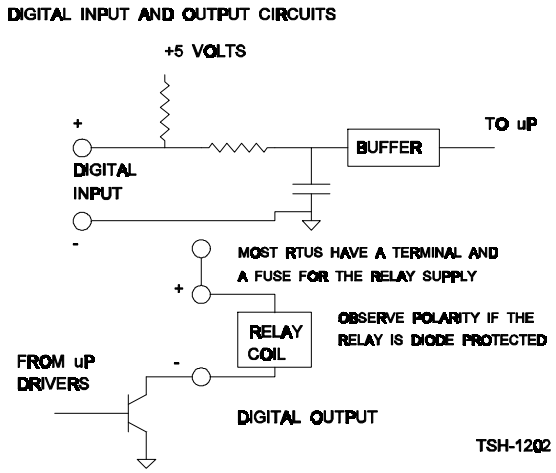
## 12.C DIGITAL INPUTS (D/Is):

This class of inputs come from switches and contacts which are **'ON'** if a certain condition occurs, otherwise **'OFF'**. For instance, **'HIGH TANK LEVEL'** can generate an **'ON'**. So can **'DOOR OPEN'**, **'FIRE ALARM'**, **'HIGH SO2 LEVEL'**, **'HIGH TURBIDITY'**, **'LOW DIESEL FUEL'**, etc.

The preferred method is to have these conditions generate a 'dry' contact, in other words shorting a relay contact or a wire pair that is not connected to anything else but the switch.

The RTU input normally consists of a 10K resistor connected to +5V, followed by a voltage spike protection circuit, a noise filter and a Schmitt trigger. This means that the RTU can accept either a dry contact or a +5V level input.

If you measure across the RTU digital input you will find +5V. When the dry contact connected to this input closes, you will see 0V.




## 12.D PULSE INPUTS (P/Is):

This class of inputs typically come from pulsing flow meters that deliver pulses which are proportional to flow. These pulses are accumulated (counted) in the RTU and the count is reported by the RTU as total accumulated flow. This is similar to how a pump in a gas station reports the total flow to the purchaser.

The pulses from the flow meter are normally at a +5 volt level. Some flow meters deliver dry contact closures. The ScanData RTUs can handle both. The design of the pulse input circuits include filtering and surge protection and are similar to the design of the digital input circuits.

One word of caution: Many pulsing flow meters generate pulses of a very high frequency, 10,000 Hz or more. These are too high to be counted. The resulting accumulated pulse count report would increase too rapidly to be meaningful.

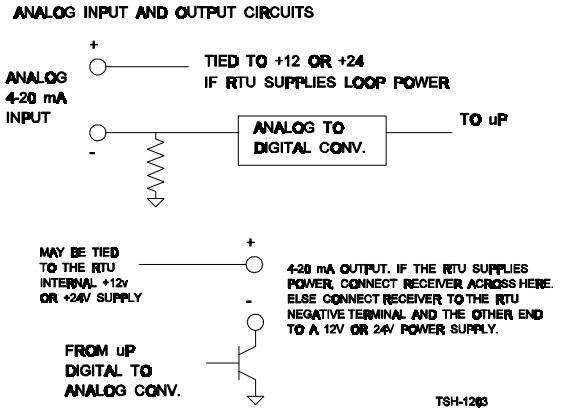
For example, if your car's odometer counted numbers in a rapid blur you would become confused. Anyway, you would probably not be interested in how many 1/4 inches you have driven.

These high frequency pulses are sometimes converted to analog 4-20 mA values and reported as instantaneous flow rate, instead of accumulated flow. The problem with that is that the flow rate may vary rapidly between readings, causing errors in calculating the correct accumulated flow.

To avoid this, ScanData manufactures a pulse divider, the PDI, which divides the pulses from the flow meter by 10, 100, 1,000 or 10,000, thus allowing an accurate reporting of the actual accumulated flow instead of introducing errors in measurements by reporting the fluctuating instantaneous flow rate.

## 12.E ANALOG OUTPUTS (A/Os):

Analog outputs correspond to far end analog inputs from another RTU in Mode-C operation or from a computer generated loop current command in Mode-B operation.




This class of outputs is almost always in the 4-20 mA form. This output current is used to drive motorized valve positioners, PLC setpoint inputs, meters, chart recorders and other process control devices.

Here the RTU output acts as the loop 4-20 mA loop transmitter. A loop transmitter normally requires an external loop power supply. The RTU can be supplied with a transmitter loop power supply, on special order. Please specify when ordering.

To find out if the RTU analog output has an internal transmitter loop supply, measure across the analog output terminals with a tester. If you read 12V or 24V, the RTU has an internal loop supply and you can connect your receiver(s) directly across the RTU terminals.

Use the ScanData CAL-4/20 to very accurately measure and calibrate all aspects of the 4-20 mA loops.

## 12.F DIGITAL OUTPUTS (D/Os):

Digital outputs correspond to far end digital inputs from other RTUs in Mode-C operation or from computer generated relay output commands in Mode-B operation.

This class of outputs is normally in the form of an open transistor relay drivers, capable of driving up to 100 mA and up to 48V DC. Interposing relays are used to interface with AC control circuits or other control circuits that require higher voltages and currents. Some process industry digital inputs can connect directly to

the RTU transistor output.

The RTU can be equipped with a relay driver voltage source. Measure from each digital output terminal to ground with a tester. If you read +12V or +24 volts from either terminal, the RTU has an internal relay driver source and you can connect your relay coil (rated at that voltage) directly across the RTU terminals. If the relay coil has a back diode connected across it (the recommended practice) you must observe proper polarity when connecting the relay coil to the RTU terminals.

## 12.G PULSE OUTPUTS (P/Os):

There may be instances where it is necessary to transmit pulse counts from one point to another in Mode-C operation. ScanData has a custom program which allows one or more of the digital output circuits in an RTU to output pulses which correspond exactly in number to the pulses input at the RTU at the other end.

The pulses are transmitted as a count, not as individual pulses which could be lost if there was a temporary gap in the transmission or a noise hit on the radio. This count is received and added to the existing count (if any) in the receiving RTU. The receiving RTU bleeds out this existing count at a pre-set rate. In this way no pulses are lost, which is of great importance, especially in custody transfer systems.

ScanData has delivered a number of these pulse count transmission systems. It is a very effective way to transmit metering pulses in Mode-C operation.

## WHERE CAN I GET MORE INFORMATION?

The following descriptions, pertinent to this chapter, are included in the DESCRIPT directory on the SCADAtech(TM) CD:

| | |
|---|---|
| pri-0901.pdf | Design Guide and Price List. |
| pdi-1007.pdf | Metering pulse divider module, divide by 10, 100, 1,000. |
| app-1115.pdf | How the 4-20mA instrumentation loop works. |
| dsi-1362.pdf | DIN rail snap in relays. |
| asi-1365.pdf | Analog signal and pulse interface module summary. |
| cal-0945.pdf | 4-20mA calibrator technical description. |
| calc0920.pdf | CAL 4-20 calibrator fact sheet. |
| iti-1504.pdf | 4-20mA current isolators. |
| spg-1109.pdf | 4-20mA trip point generator. |
| v2c-1496.pdf | 4-20mA to voltage and voltage to 4-20mA converters. |
| ips-1495.pdf | 5V, 12V and 24V isolated DC power supplies. |

An easy way to get the latest and most recently updated versions of these descriptions is to go on our WEB site:

**www.scan-data.com**

When you are there, click on the blue button near the bottom of the WEB page that says **Technical Information.** Then click on the description # you need.

Another good source for information on the 4-20mA instrument loop is:

**www.4-20maloop.com**