BASIC ELECTRONICS FOR FIELD MEASUREMENT

Rick Heuer
Emerson Process Management
Daniel Division – Houston, Texas

Introduction

Try this at home. We are professionals. If you are able to install your own TV dish satellite system and a wireless home network for PCs, you have a head start on installing and maintaining electronic field measurement equipment.

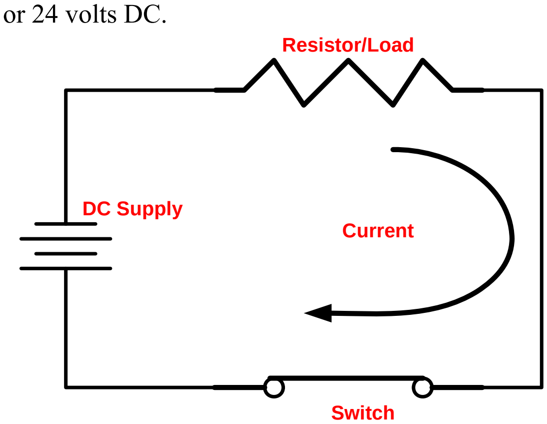
Today's Measurement Technicians and Engineers are required to operate and maintain a variety of Hi-Tech field measurement equipment. Most of the field instrumentation is tightly integrated in a complete system functional environment. The larger the metering station, the more complex the system.

The goal of this paper is to provide an introductory to electronics based on current field measurement technology.
Basic field duties would include:
calibration, data collection, configuration, orifice plate changes, communication checks and maintenance.

Some of the basic types of wire connections include *power*, *analog signals* and *digital signals*. Each of these play unique circuitry roles and require different knowledge of their intended operation.

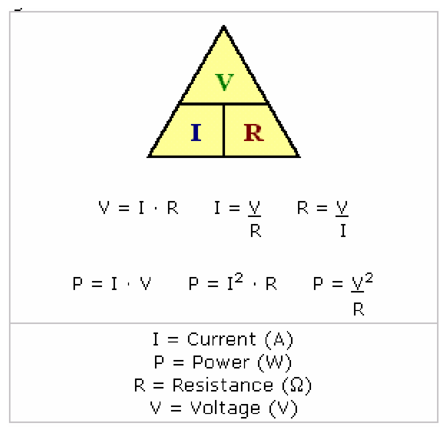
Power

Current flows from one terminal to another only when there is a completed circuit. The device being powered must have enough current and voltage to insure proper operation (Inrush). Most Field electronics operate off of 6, 12 or 24 volts DC.



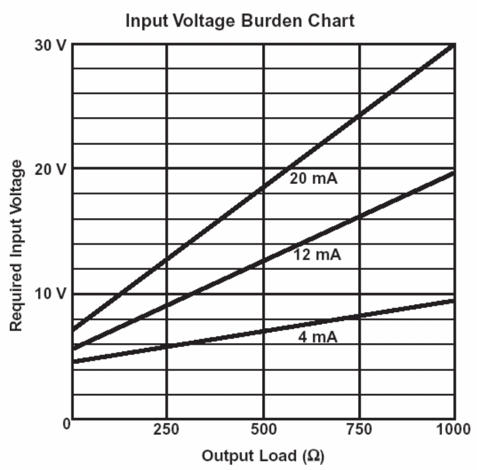
Electronics Formulas

V = I * R
I = V / R
R = V / I
Where V is Voltage (Volts), I is current (Amps), R is Resistance (OhmsΩ)
P = Power (Watts) where as:
P = I² * R
P= E * I



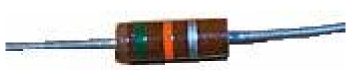
Analog Signals

Some of the more common things encountered is calculating 4 to 20 mA instrument loops. Loop loading can be seen on the Input Burden Chart below. This chart shows the maximum number of 250Ω loads a device can power, based on loop voltage levels. This applies to both analog inputs and analog outputs.



Current to voltage basics

Most RTUs, PLCs and flow computers convert current style transmitters into voltage for use in the analog to digital process. Current output devices are still common due to only two or three connection wires and their ability to locate thousands of feet between devices.

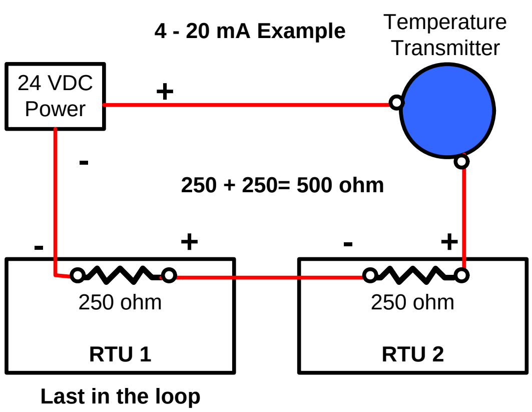


Typical Resistor

4mA x 250Ω = 1 V

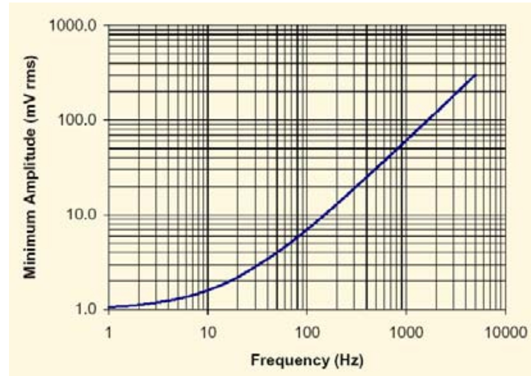
20mA x 250Ω = 5 V

The 4 – 20mA example shows how a single transmitter signal can go to two RTUs (Remote Terminal Unit)



Frequency/Pulse

Turbine meters and gas ultrasonic meters have pulse or frequency type outputs. They are best measured by using an oscilloscope. This allows you to view the amplitude and frequency of the signal. Un-amplified signals are usually small amplitude sine waves. Amplified device outputs are more than likely a square wave. The chart below gives an example of the millivolt input to frequency ratio on the input of a preamp. This shows that a high frequency (Noise) small amplitude signal would be filtered out.



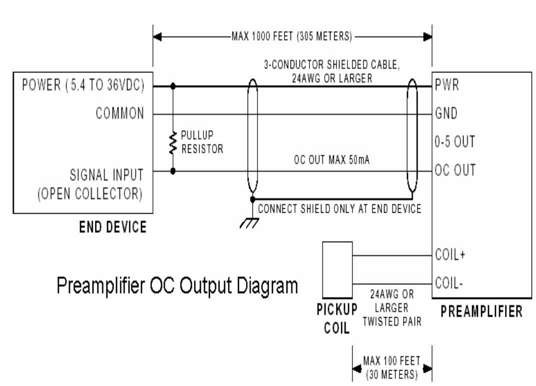
Preamp Frequency Input Graph

Relays

Relay type circuits are magnetically operated switches. A wetting voltage usually DC is applied to the coil windings which produce a magnetic field used to open or close the relay switch. Relay terminals are referred to as "Normally Open", or "Normally Closed". Relays can be used to turn on or off different actuations such as: Solenoid valves, gas samplers, and radios.

Open Collector

Some signal inputs and outputs may require a "pull-up" resistor to source the voltage. These are mostly referred to as "Open Collector". Check the specifications to insure proper resistor sizing. The resistor has to be sized to allow only enough current to flow through it. The drawing below shows a turbine meter preamp using a "OC", termination.



Digital Signals

Digital signals are normally low level, low voltage input types. They are typically looking for a voltage transition between 0 and 5 volts DC. Some digital signal types are as follows:

- Digital Inputs are normally used as status type inputs that sense a voltage level transition. This could be from a valve limit switch. The signal is a low to high voltage level transition.

Sometimes they can be "OC" type for use with long distance connections.

- Digital Outputs are normally used to trigger an event like a smart gas sampler. This output could also be "OC" type. The signal is a low to high voltage level transition.
- Communications are digital in nature because they carry the binary (Computer Talk) information needed for data transfer. While there are many different hardware formats for carrying data, RS232 is still the most common device interface today. The table shows the connector pin out for two types of common cables.

RS-232

DTE (Computer) **DB9**

Pin# DB9	RS-232 Signal Names
#1	Carrier Detector (DCE)
#2	Receive Data (Rx)
#3	Transmit Data (Tx)
#4	DTE Ready/Data Terminal Ready (DTR)
#5	Signal Ground/Common (SG)
#6	DCE Ready/Data Set Ready (DSR)
#7	Request to Send (RTS)
#8	Clear to Send (CTS)
#9	Ring Indicator (RI)

DTE (Computer) **DB25**

Pin# DB25	RS-232 Signal Names
#1	Shield to Frame Ground
#2	Transmit Data (Tx)
#3	Receive Data (Rx)
#4	Request to Send (RTS)
#5	Clear to Send (CTS)
#6	DCE Ready/Data Set Ready (DSR)
#7	Signal Ground/Common (SG)
#8	Carrier Detector (DCE)
#20	DTE Ready/Data Terminal Ready (DTE)
#22	Ring Indicator (RI)

Ethernet

Ethernet connectivity is being used for most plant type operations involving line power flow computers. This is a very common network medium that is spreading to more complex field measurement scenarios. Most RTUs, Gas Chromatographs and Gas Ultrasonic meters have Ethernet ports. Simply follow the instructions needed for setting up your laptop's Ethernet port.

Fieldbus

Connecting a set of measurement transducers to a flow computer has been traditionally an analog world. There is the low power 1 to 5vdc method and the 4 to 20 mA method for line powered applications. Fieldbus changes this in two ways. A standard set of wires and connectors are used between devices and a common communication protocol is used. Less field wiring is needed and device interchangeability is added. Device interrogation is done digitally now instead of analog. Process variables along with performance diagnostics are now available at the device level.

Smart Multivariable Process Transmitter

Protocols

The de facto standard for flow computer protocol is EFM (Daniel/ENRON) Modbus ASCII or RTU. All major vendors offer some variation of this. This was the first step toward vendor interchangeability. The next step is the use of higher level protocols based from the internet standards.

Troubleshooting & Checkups

In a perfect world there would be; As -built drawings, Make & Model of equipment lists and of course, the manuals. For each measurement station!

Most manuals can be found on the vendors website. Other useful information as to support contacts, software upgrades/patches and FAQs (Frequently Asked Questions) is also online.

Field Checks

1. Are there Lights, LCD, or other health indications?
2. How's the Power?
3. Check the Fuses.
4. How's the system grounding? (Another lengthy discussion)

The *best* way to verify correct operation is to interrogate the device by using it's diagnostic modes. A laptop PC or PDA is needed. Some new technology even has predictive diagnostics, integrated documentation, calibration management and device configuration.

Field Electronic Examples
Smart Transducers, Digital Valve Controllers, Ultrasonic meters, Turbine meters, radios, gas chromatographs, odorizers, sample systems, radios and power systems.

Digital Valve Controller

Some Field Technician Tools

- Portable Laptop Computer with device software
- Cables
- Digital Voltmeter
- Transducer Calibration Test equipment

NOTE:
Some of the new electronic instrumentation has micro-termination connectors. This means that normal screwdrivers will not work. Ensure that you have the necessary tools before you are on location.

Area Classifications
If the equipment is installed in a hazardous area for measuring natural gas or liquid hydrocarbons, it must meet certain safety requirements. In the Americas, U.L. or CSA type ratings are required.

Sanity Checks and Procedures
Remember to shut down and start up electronic measurement & control equipment properly. Some valves and regulators will need to be placed in manual operation until the electronics are brought back online.

Failure to operate and maintain the equipment in the manner it was designed for, might have undesired consequences. Results of this could be inaccurate measurement accounting and deliveries or worse.

Before you attempt to work on any equipment, make sure that the area is safe. *Safe from a hazardous area perspective and by general electrical safety precautions.*

Cautions such as, but not limited to:

- Working on (Hot) powered equipment while standing in water.
- Turning process control equipment off without setting proper manual, override or bypass conditions.

Conclusion
As measurement devices and techniques change, so must the skill level of the Technician or Engineer. Training is a necessity and not a luxury. OJT (On the Job Training) in the measurement of natural gas does not lend itself to good results. Make sure there is a sound knowledge of the device's operation. Especially when it relates to custody and gas control operations. Many times if an RTU or flow computer has to be configured, repaired or replaced, a software cold start or program memory re-flash will be required. Simply removing power will not work anymore! Learn the essentials.