CHAPTER 18, DESIGNING & SPECIFYING A SYSTEM

18.A SUMMARY:

It is our hope that this Handbook has given you a good overview on the techniques involved in designing and operating a SCADA and Telemetry System. We have tried to cover as much ground as possible in the space available. ScanData's building block RTU and software designs have done much to simplify what could otherwise be complex and bewildering subjects. As a help in designing your system, you may wish to follow the following outline procedure:

18.A.1 THE FIRST QUESTION A SYSTEM DESIGNER MUST ASK IS:

What kind of communication should be used?

- **Dialing the RTUs.**
- **Continuous communication with the RTUs over cable or radio.**

18.A.2 THE SECOND QUESTION IS:

What mode of operation?

- **Mode-A, dialing the RTUs.**
- **Mode-B, continuously scanning the RTUs.**
- **Mode-C (signal multiplexing)?**

18.A.3 THE THIRD QUESTION IS:

How many inputs and outputs (I/Os) do you need at each RTU?

18.A.4 THE FOURTH QUESTION IS:

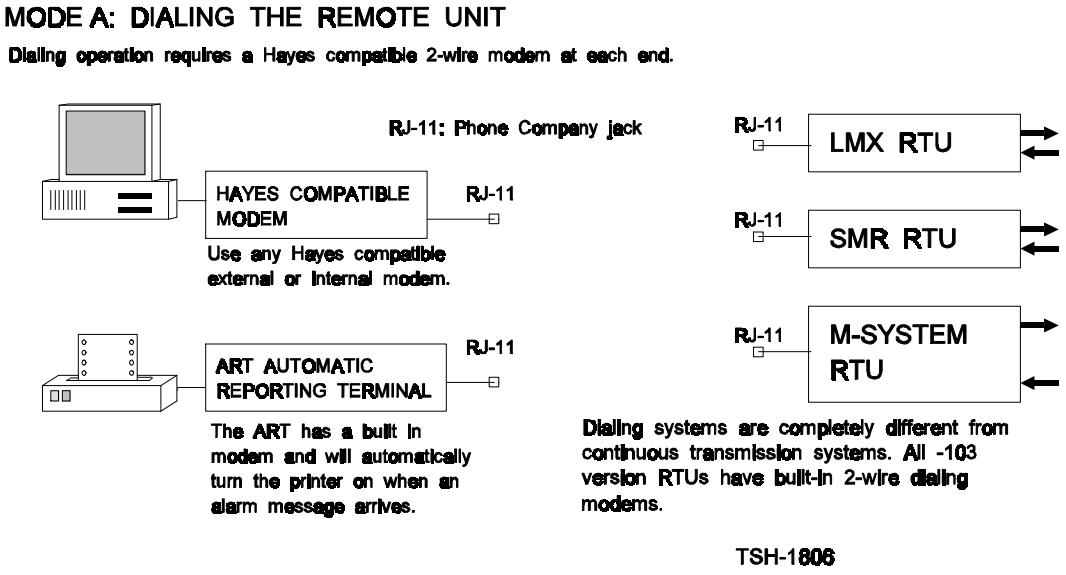
What kind of central station should be used? There are two main possibilities:

- **Using another RTU as a central, with inputs and outputs reflecting the far end RTU inputs and outputs (Mode-B, signal multiplexing).**
- **Using a Windows PC with operator's SCADA software.**

The ScanData RTUs will work in all of these modes. Simply select RTUs with the required I/O capacity, as described above. An operation with a mix of these modes is also possible.

18.B MODE-A (DIALING) DESIGN CONSIDERATIONS:

Remote installations may be located many miles from the supervisor's office. Installing proprietary cables or radio links may be impractical. The phone company may not have cable connections available for lease.



In these instances, dialing the RTUs may be the only practical solution.

The main advantages of dialing the RTUs are:

- **No line installation costs.**
- **You can access RTUs anywhere in the world.**

- **You can use your existing computer and Hayes compatible modem.**
- **The RTUs can log data and deliver it when dialed.**
- **You can use Voice Telemetry RTUs such as the VBX-7 to get a complete engineering report in your own pre-recorded voice.**

The main disadvantages of dialing the RTUs are:

- **The phone company charges you for each time you access an RTU.**
- **It is impractical to access the RTUs more than a few times a day or, at the most, a few times every hour.**
- **Continuous supervision of your remote sites is not possible.**

18.B.1 SELECTING AND SIZING THE RTUs:

Select ScanData VBX-7, LMR, LMX, SMR or M-system RTUs with the required I/O capacities.

Do you need voice telemetry RTUs? If so, select the VBX-7 RTUs.

Do you need dial out capability? If so, select the programmable SMR or M-system RTUs.

Do you need flow computing and/or other advanced programmable capabilities? Then select the SMR or M-system RTUs.

How do you wish to access the RTUs? If you have selected the VBX- 7 voice telemetry RTUs, you need no extra equipment other that a regular phone to access the RTU.

If you select ASCII (American Standard Code for Information Interchange) RTUs, such as the ScanData LMR, LMX SMR or M-system, the best way to access the RTUs is over a PC 386 or 486 computer or laptop. Use a communications program such as Procom or access the RTUs automatically over the AutoAcc(tm) or ScadaMaster(tm) programs. ScanData has detailed technical descriptions available for these programs.

Do you wish the RTUs to dial out on alarms or at pre-set times? If you don't want to have a computer ready, on line, waiting to be dialed by the RTUs, use the ScanData ART, Automatic Reporting Terminal. It connects to the telephone line and to a printer. When an RTU dials in, the ART will answer the call, turn the printer AC power on and cause a print out of the incoming RTU message. When the RTU terminates the call, the ART will turn the printer AC power off and wait for the next call.

18.C MODE-B (CONTINUOUS COMMUNICATION) DESIGN CONSIDERATIONS:

Many industrial installations, such as pipe lines, water and waste systems and others require constant supervision, an instant update of all information and command execution without delay. A petroleum pipe line, for instance, needs constant updating of the pressures and flows along the line. When the operator at the central station console sends a command, to stop a pump or to open a diverter valve, this command has to be sent out immediately.

A dialing system would be too slow for this type of application. Continuous communication is the only way to go.

The main advantages of having continuous communications with the RTUs are:

- **Continuous supervision of any remote installation.**
- **Virtually instant update of all analog and digital values and all alarms.**
- **A central station can automatically control remote processes as the time lag between input and output is small.**
- **No need for extra intelligence in the RTU for logging, dialing instructions, etc.**

The main disadvantages of continuous communication systems are:

- **The line costs, either for your own radio, your own cables or phone company leased lines may be high.**

18.C.1 USING PROPRIETARY CABLES

Many utilities and others have cables running throughout their working areas. If you can find two workable pairs connecting to all your SCADA or Telemetry sites you can probably connect your central station and RTU modems onto these pairs. See Chapter 11, Networking RTUs, for details on how to connect up your system.

You can lay new cables for your system, provided that right of way, trenching and cable costs are within your budget. Sometimes cables are strung between poles to avoid trenching costs. This practice invites lightning damage, however.

As a general observation, a good proprietary cable system, well maintained, is without a doubt the best communication system you can use for your Telemetry and SCADA system.

4-wire systems are preferred, as each pair (incoming and outgoing) can be independently amplified, using the FWA-4 amplifier. The level at any point in the cable should not be allowed to drop below -25 dbm. The attenuation in an 22 AWG cable for instance, is 1.8 db per mile.

18.C.2 USING PHONE COMPANY LEASED CABLES

Most local phone companies have extensive cable runs throughout their territory. These cables were almost always laid with a large amount of excess capacity, as it is hard to predict how an urban area would develop. Many phone companies had a rule that any cable laid should be sufficient for to cover real estate developments for at least twenty years into the future.

You can lease pairs from the phone company if they have cables running along your intended route. The lease of cable pairs is fixed and covered by government regulations. It is generally based on a per mile monthly fee.

18.C.2.a USING SATELLITE COMMUNICATIONS

VSAT (Very Small Aperture Transmission) satellite communication is a viable option for larger RTUs and for important systems such as major petrochemical pipe lines. A VSAT terminal gives you direct RS-232 communication with any other VSAT terminal in the system.

18.C.3 USING RADIO LINKS

All Scan-Data data radios can transmit and receive at 1,200 Baud, the normal transmission speed for these systems. Spread Spectrum radios can use even higher baud rates.

You have basically three main frequency choices when purchasing equipment for your own radio system.

18.C.3.a USING THE 49 MHz LICENSE FREE BAND

Equipment in this band will go about 1/4 mile, but you are sharing the frequency with an increasing number of other users. This band is ideal for applications that go only short distances and are in limited access areas.

A good application example for a 49 MHz data radio link is where you have to cross a road. Using two ScanData LDR-A radios would eliminate the trenching and cable laying costs.

18.C.3.b USING THE 150 or 450 MHZ BAND WITH AN FCC LICENSE

Once you have an FCC operating license you can be almost certain of interference

free operation in your designated area. 450 MHz data radio communications can be very reliable if the equipment is installed properly. High gain antennas and tall towers allow you to span long distances with equipment in this band.

RADIO OPERATING LICENSES.

To go long distances you need radios such as the LDR-V 150 MHz or LDR-U 450 MHz data radios which will operate up to 50 miles, as long as there is line of sight between the two antennas. A quick way to find out if you have line of sight, by the way, is to shine a flashlight at one site and look for the light from the other site, on a dark night.

These high power data radios will need an operating license from FCC or from the Communications Department or Ministry of Communication in the country of operation. Many companies such as utilities and others already have frequency assignment licenses that can be used. If not, there are many engineers who specialize in helping to obtain FCC licenses. The nearest FCC office will give you a list of these engineers on request.

Designing an efficient, long range radio communication system with repeaters, towers and high gain antennas is a complex undertaking involving path surveys, antenna and tower designs, repeater station terrain purchases and other specialized tasks that are best solved by professionals specializing in this type of work.

18.C.3.c USING LICENSE FREE SPREAD SPECTRUM RADIOS

Spread spectrum data radios operate in the 920 MHz and 2.4 GHz bands. They can communicate over distances of several miles. This is a shared frequency band, and one never knows who else is on the band.

Interference is minimized, however, as these radios use 'frequency hopping'. This means that the radios constantly and rapidly change operations from one frequency to another, staying on each frequency for only a few moments. The transmitter and the receiver(s) all hop between the same frequencies, in synchronization.

The ScanData LDR-S Spread Spectrum Data radios can be set to a number of different frequency bands. Setting the radios to operate on another band is a simple matter of setting a dip switch in each radio.

18.D SELECTING AND SIZING THE RTUs

You have two major choices to make when selecting RTUs. Choose between report and command only RTUs or fully programmable RTUs.

18.D.1 REPORT AND COMMAND RTUs

Most systems require the transmission of reports and commands only. The

intelligence, if any, is contained in the central station software or in inexpensive programmable controllers installed next to the RTUs.

This is, by far, the most economical approach to systems design. Software changes, if needed, are easily made in the central station. Automatic control changes are made with equal ease in the remote controller where the result of the adjustments can be easily observed.

A typical example would be with a water distribution company. The central station software handles the display, logging and printing of data. The remote controllers handle the starting and stopping of the pumps, continuously or only in case of a communication failure.

The software in the central station is accessible from the keyboard and a technician at any remote station can adjust the remote controller, set the levels for start and stop, etc., and immediately check the results of the adjustments.

18.D.2 PROGRAMMABLE RTUs

Programmable RTUs are used to calculate gas flow, to dial out at given times or on certain conditions, to log data and to perform other functions where programming instructions to the RTU are necessary.

18.D.3 SELECT RTUs WITH SUFFICIENT I/O CAPACITY

After you have decided whether to use report and command only RTUs or programmable RTUs, select RTUs with the necessary I/O capacities.

Select among the following ScanData RTUs:

RTU TYPE:	I/O CAPACITY:	PROGRAMMABLE:
LMR	2 A/I, 2 D/I, 2 D/O, 2A/O, 1 P/I	NO
LMX	8 A/I, 24 D/I, 8 D/0, 2A/O, 6 P/I	NO
M-SYSTEM	UP TO 4,000 POINTS, ANY MIX	YES
SLR	1 P/I	NO
SMR	6 A/I, 4 D/I, 4 D/O, 3 P/I	YES
VBX-7	2 A/I, 16 D/I, 2 D/O, 1 P/I	YES

Make sure the field instrumentation matches the RTU inputs and outputs. The standard analog input and output configuration is the 4-20 mA loop. The standard digital input configuration is dry contact or 0-5 V. The standard digital output configuration is a relay driver. The standard pulse input configuration is dry contact or 0-5 V.

A wide variety of signal converters, conditioners and isolators is available to simplify the connections between the field wiring and the RTUs. See Chapter 12, Sensors and Actuators, for more information.

18.E SELECTING BETWEEN MODE-B (COMPUTER OPERATION) AND MODE-C (MULTIPLEXING RTU) CENTRAL STATION

Telemetry and SCADA systems can use either a computer or an RTU at the central site to talk to the RTUs.

A computer (Mode-B operation) gives the operator graphic screens which portray the conditions at each RTU. Commands to the RTUs are sent out over the keyboard.

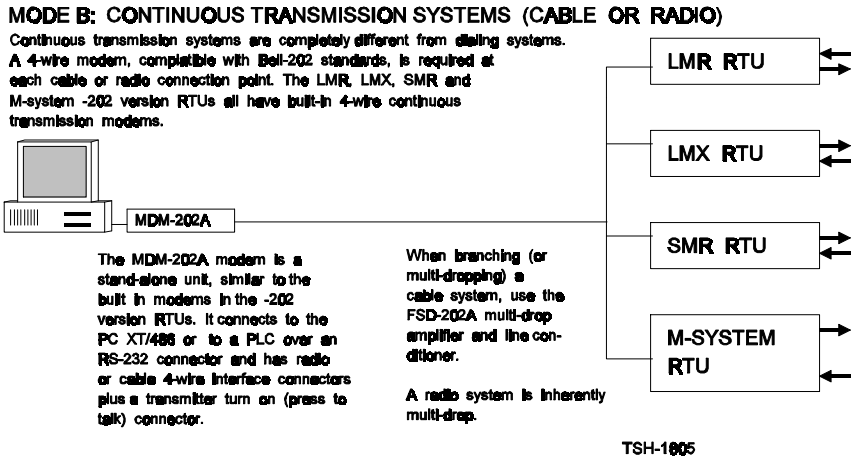
An RTU at the central (Mode-C operation) outputs all analog and digital signals into real world values (currents and relay closures) which can be connected into an annunciator board or to other displays. Commands to the RTUs are sent out over switches and potentiometers mounted on the annunciator board.

18.E.1 MODE-B SYSTEMS

In a Mode-B system a computer is used to communicate with and control all the RTUs in the system. You have basically two choices:

The first is what kind of computer to use. Today most systems use the very capable PC 386/486 and, lately, the Pentium class of computers. These machines are very capable and are continuously being improved.

The second choice is what kind of central station software to use. Use the cost effective ScadaGraph(TM) if there is no need for animation and pull down menus. Else use any of the commonly available central station industrial supervisory programs. The ScanData RTUs are compatible with most of these. Use an MDM-202A modem to connect between your computer's serial port and the cable or radio system.

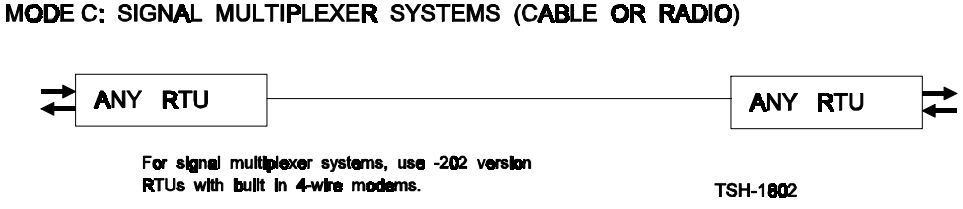


18.E.2 MODE-C SYSTEMS

In a Mode-C system an RTU is used to communicate with all the remote RTUs. All analog and digital signals input at the remote RTUs are output at the central RTU as 4-20 mA for the analog far end inputs and relay closures for the far end contact inputs.

The central RTU accepts 4-20 mA inputs to be sent to the far end RTU analog outputs and dry contact inputs to be sent to the far end RTU digital outputs.

Mode-C systems are often used to interface with annunciator panels and other read out arrangements. Analog signals input at the far end RTUs are shown as analog 3- or 4-digit values and dry contact condition and alarm inputs are shown as light or dark lamps. Control signals from panel mounted potentiometers and switches are output at the designated far end RTUs as analog 4-20 mA currents and relay drivers.



The central RTU, in addition to accepting and sending analog and digital signals

to the far end RTUs, can also re-direct signals from one remote RTU to another RTU or RTUs.

18.F SELECTING A PROTOCOL

The days of the proprietary, secret protocols are over. There were endless problems with expansions and interconnections with this approach. Today, RTUs, PLCs, computers and other equipment connect freely to each other over some form of non secret (open) ASCII protocol. Two of the most common open protocols are:

- **CAP, Compressed ASCII protocol, the most convenient for programmers.**
- **GOULD MODBUS, the most widely used.**

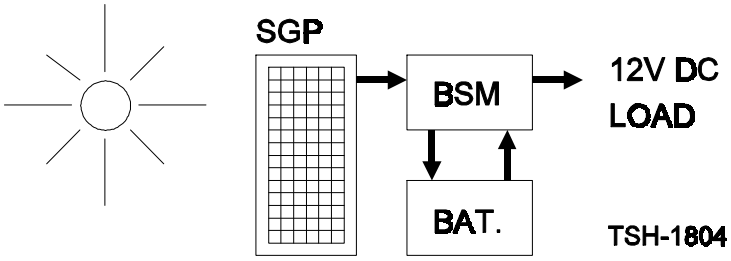
All ScanData RTUs can communicate in both of these protocols.

18.G SELECTING THE POWER SUPPLIES

If 110V or 220V AC is available at the station, the question often becomes: should 12V DC or 24V DC be used as the station primary and standby power?

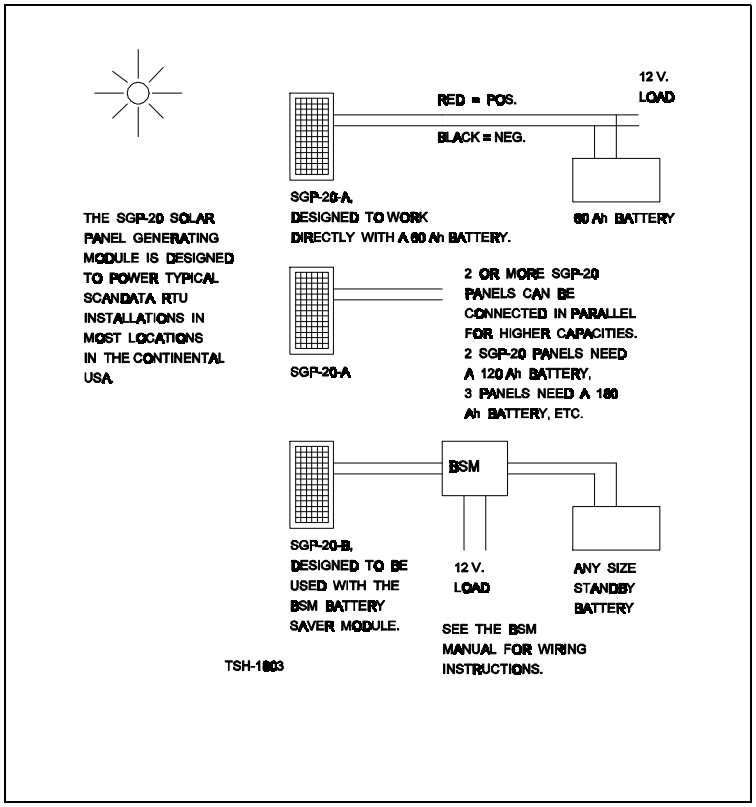
Many RTUs and most data radios need 12V DC. Many analog transducers (4-20 mA transmitters) need 24V. It is not economical to use two power supplies and two standby batteries.

A good solution to this problem is to select 12V DC for the station's primary and standby power. 12V batteries are cost effective and commonly available. Use the ScanData C24 12V to 24V converter for your analog transducer loop supply.



For stations with stand by operating batteries, the use of a battery discharge monitor such as the ScanData BSM Battery Saver Module is highly recommended. In the event of a prolonged AC power failure, the BSM disconnects the battery before it is destroyed so that it will be automatically recharged when power is finally restored. Station standby batteries operating without the BSM can be completely discharged and ruined during a long power outage. Then they will not take a charge and will have to be replaced.

If 5V, 12V or 24V DC, 110V or 220V AC voltage is available at the station, use one the many power converters that Scan-Data manufactures. See the MORE INFORMATION section at the end of this chapter.



If no power at all is available at the station, use one or more solar generating panels. These panels can be effective in places like in the southwest and less effective in the north, where there are long periods without sunshine.

Another solution for stations without AC power but where natural gas is available, is to use gas fired electric generators or thermo electric (ionic) generators. These are available in different sizes and capacities.

18.H SELECTING LIGHTNING PROTECTION

A quick lightning protection primer:

- **Every above ground wire will, sooner or later, pick up lightning energy. Thats why communication cables are buried underground.**
- **You don't need a lightning strike to pick up energy, as Ben Franklin found out when flying his kite under a cloud.**
- **Lighthing energy must be conducted to ground the shortest way possible, else it will find alternate routes through the equipment it is to protect.**

- **Lightning energy wave fronts are very steep and will couple to any other wire nearby.**
- **Placing electronic devices and lightning protectors next to each other, sharing the same ground, is to invite disaster.**
- **Lightning protectors should be placed near ground, at the lowest point in the system, and have a solid short direct ground connection.**
- **Wires from the lightning protector to the equipment should be buried for at least 20 feet before it is run up to the equipment.**

RTU failures from causes other than faulty lightning protection and over voltage abuses are rare. Today's solid state components are very reliable and have a long life.

ScanData protects each RTU board with a 2-part epoxy protective coating called HardCoat(tm) which prevents moisture and corrosive gas damage. This coating also helps anchor the components which avoids lead fatigue and breakage during shipping and operation in stations with heavy vibration, such as gas compressor stations. The coating also signals overheating and component failures by changing color from blue to yellow or brown.

In spite of these protective measures, lightning protection is the major cause of RTU damage. Every effort should be made, therefore, to install proper lightning protection equipment and to use proper installation techniques that minimize lightning protection damage.

Lightning protection can briefly be divided into two parts:

- **Conduct the lightning energy into ground by the shortest path possible, before it reaches the equipment.**
- **Protect sensitive circuits by shorting remaining lightning energy to ground as much as possible.**

It is always best to conduct as much of the lightning discharge energy as possible into the ground before it reaches the station equipment. Lightning energy always follows the shortest path. A good practice is to run all outside cabling down to ground before it enters the station. A lightning arrester connected to a solid ground should be placed at the lowest point, before the cabling enters the building.

This rule should be followed for all station cabling, including the sensor and actuator cabling, power supply cables and especially for communication wiires.

Remember that the very high currents and sharp wavefronts of lightning discharges couple very easily to any other conductor, even if relatively far away. Running station cabling parallel to lightning arrester wires is to invite trouble. A metal pipe line is a classic example of a device which will generate very heavy magnetic fields during a thunderstorm.

Over voltage protection is also available for all ScanData RTU inputs and outputs.

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.

gui-0980.pdf How to design SCADA and Telemetry systems.

acp-1045.pdf 110V/220V AC to 12V DC regulated power supply.

pwm-1366.pdf DIN rail mountable power modules..

ips-1495.pdf Isolated 12V to 5V, 12V and 24V converters.

bsm-0892.pdf Standby battery saver module.

cvt-1006.pdf 12/24V and 24/12V power converter modules.

app-1104.pdf How to send multiple analog and digital signals over cable & radio.

app-1105.pdf How to add automatic control to RTUs.

app-1112.pdf How to select data radios.

app-1319.pdf How to distribute SCADA data over the WEB.

app-1323.pdf How to arrange for stable RTU power supplies.

app-1336.pdf How to select M-system modules.

app-1561.pdf RTU and PLC communication methods.

lsp-1476.pdf Lightning strike I/O protectors.

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.