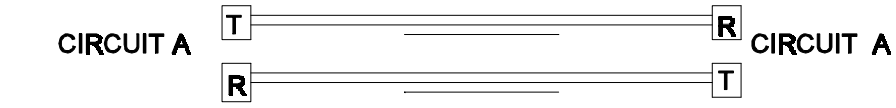
CHAPTER 11, NETWORKING RTUs.

11.A SUMMARY:

A simple telemetry system consists of two RTUs, talking to each other in Mode-C, multiplexing analog and digital signals from one site to another, using a 4-wire circuit:



Example of a single 4-wire circuit.

A 4-wire leased line or cable circuit must be terminated at each end with the proper terminating resistance, normally 600 ohms, at each end. T = transmit, R = receive.

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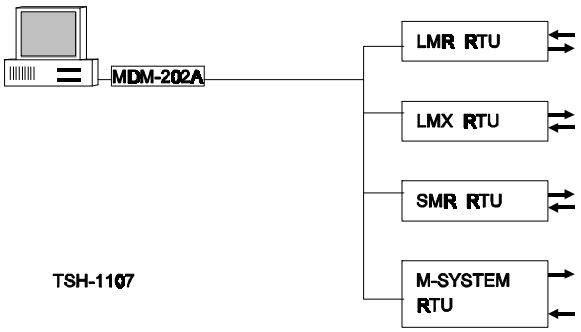
Another example of a simple system is a central station computer talking to several RTUs over a star or multi- drop network.



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In real life, things are often not that simple. Two RTUs may be needed at one end instead of one, multiple RTUs may have to be served by one cable branch or by one radio repeater, etc.

This involves multiple branching or networking of RTUs. This chapter deals with the different methods available for branching and networking RTUs in both cable and radio telemetry systems.

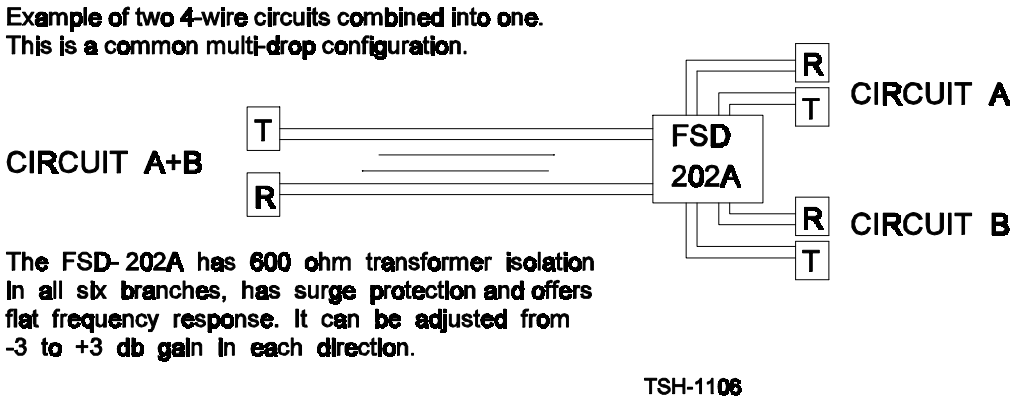
11.B A NETWORKING EXAMPLE:

A common requirement with Mode-B (scanning) SCADA systems is that the central station should be able to operate un-manned at times. Automatic alarms are then needed as there is no operator watching the computer screen. Often there is a requirement to have the central station also dial one or more telephone numbers and leave voice alarm messages.

This requirement is solved by branching off at the central station to an RTU placed next to the central station computer. The central station is then programmed to re-direct certain digital and alarm signals from the remote RTU digital inputs to the local RTU digital outputs, for connection to local alarm bells, lights, etc. This arrangement, in effect, links remote RTU digital inputs to the local RTU digital alarm outputs.

The branching is done at the point where the modem interfaces to the radio or to the cable.

What device can used for this branching? It has to branch the outgoing (transmit) circuits and combine the incoming (receive) circuits.



The ScanData FSD-202-A splitter and combiner (multidrop) amplifier is designed for this type of service. It is connected to the modem line input and output terminals. It works on both radio and cable circuits. It splits the modem's line output 2-wire into two 2-wire circuits, one to the cable or radio as before and one to the RTU. It also combines the two incoming 2-wire circuits, one from the RTU and one from the cable or radio into one 2-wire for the modem's line input.

A further refinement of having a local RTU at the master station would be to connect a VTM-7 voice telemetry and alarm dialer to the digital outputs of the local RTU. You can program the VTM-7 to dial up to six different telephone numbers on up to 20 alarm conditions. It will dial these numbers and leave voice alarm messages with each one.

11.C NETWORKING WITH CABLE SYSTEMS:

Networking RTUs that operate over cable always involves different branching approaches. The requirements when branching and combining 4-wire circuits are quite strict; you cannot simply tie two 4-wire circuits together. That would cause severe impedance mis-match and signal loss and could introduce DC unbalance and unwanted currents.

The branching and combining device should offer transformer isolation in all six branches with a good 600 ohm impedance match. It should branch in the transmit direction and combine in the receive direction. It should preferably have 0 gain (or better, adjustable gain) in all six branches and also have adequate surge protection in all six branches. The ScanData FSD- 202A meets all these requirements.

There are basically two methods of networking cable systems. One is using the star network configuration and the other is using the multi-drop network configuration.

THE FSD-202A SPLITTER AND COMBINER (MULTI-DROP) AMPLIFIER

The ScanData FSD-202A splitter and combiner (multi-drop) amplifier is designed to branch and combine 4-wire circuits in star and multi-drop configured cable networks.

The FSD-202A is mounted on a 4" x 6" PC board with four threaded 4/40 spacers placed at each corner. Matching enclosures are available. It is designed to operate in harsh environments and has the HardCoat(tm) moisture barrier coating with automatic color change fault detection.

Six pairs of screw connectors connect to the incoming and outgoing circuits. Another screw connector pair connects to a +12V power supply. Current consumption at 12V: 30 mA.

The FSD-202A contains a -12V power supply and a summing amplifier to combine the two 2-wire transmit pairs into one 2-wire pair and a splitter amplifier to split the 2-wire receive pair into two 2- wire pairs.

The gains of the summing amplifier and of the two splitter amplifier branches are individually adjustable. The hybrid balance is also adjustable but this should only be done with the proper telephone line test equipment.

The FSD-202A uses six 600 ohm telephone type transformers, one in each leg, for impedance matching and isolation. Each transformer is individually surge protected.

11.C.1 STAR NETWORKS:

An example of a star network could be one where the central station modem has to be connected to, say, sixteen RTUs over cable circuits. One solution would be to first branch out from the modem into two 4-wire circuits, using some suitable branching device like the FSD-202A.

Then to branch these two out into four, these four into eight and finally these eight into sixteen. If you had sixteen RTUs placed geographically around the central and

4-wire cables running from each RTU into the central like spokes in a wheel, this configuration may be the one you would use. This branching problem, or variations thereof, are quite common.

You can look at it another way: When you start to resolve your problem in this example, you have sixteen 4-wire circuits facing you at the central station location, all to be connected to a single 4-wire modem.

Combining each incoming pair of 4-wire circuits with an FSD-202A into one gives you eight 4-wire circuits to deal with. Combining these by pairs into four, then into two, then into one gives you one 4-wire circuit that you can connect to your modem.

Looking at the problem from a branching viewpoint or a combining viewpoint, therefore, gives the same result.

How do you branch and combine these 4-wire circuits? Use the FSD- 202A combiner and splitter amplifier mentioned above and described in the sidebar. It combines two 4-wire circuits into one in the receive direction and splits one 4-wire circuit into two in the transmit direction.

11.C.2 MULTI-DROP NETWORKS:

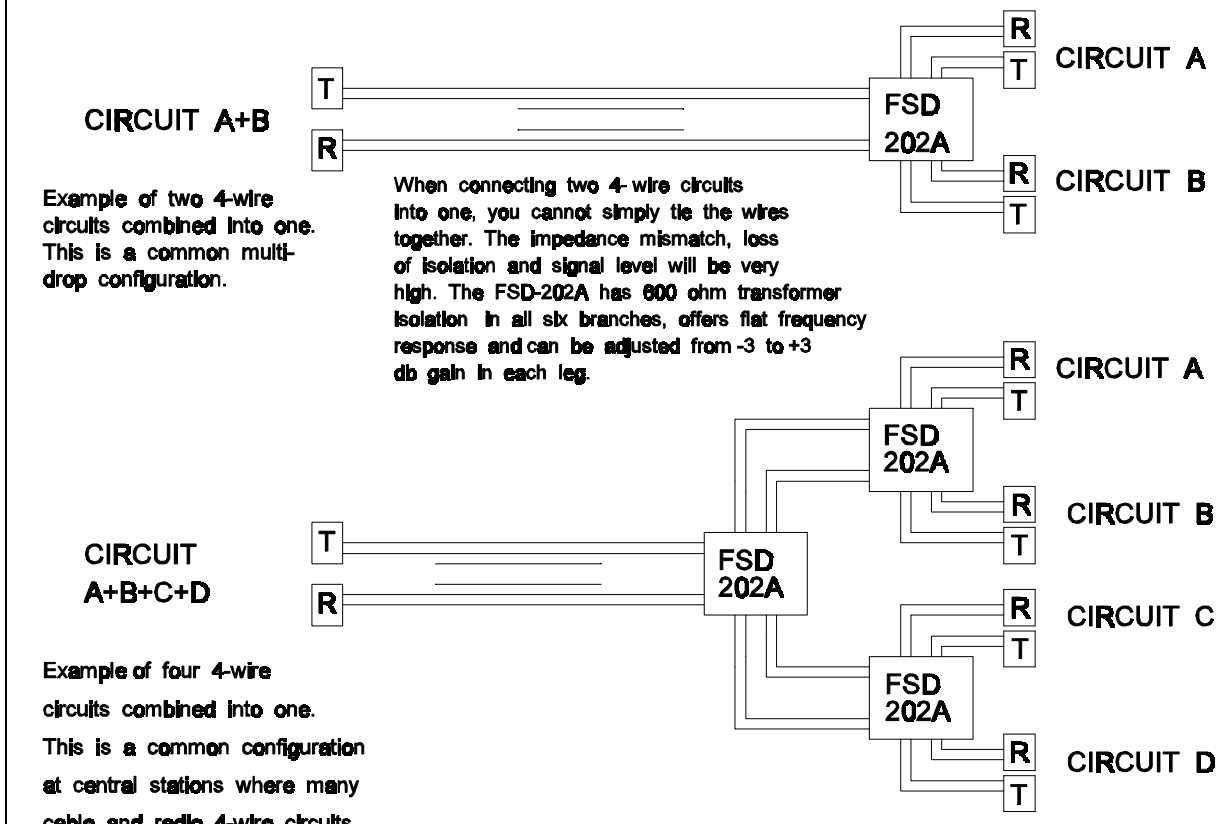
Having cables running from each one of your RTUs into the central like spokes in a wheel is often very wasteful of cable and cable trenching costs. Having a single 4-wire cable running along the rim of the wheel, connecting to all the RTUs on the rim, Christmas tree light style, is often a much more cost effective solution as far as cable laying costs are concerned. You use much less cable. This cable running along the rim can simply continue on to the central station. One cable run does it all.

This is a typical multi-drop network. The cable multi-drops or branches off at each RTU. You would still need an FSD-202A at each RTU, with one branch going to the RTU and the other continuing along the rim. In fact, you will use as many FSD-202A amplifiers whether you choose the star network or the multi-drop network.

When you lease cables from the telephone company they will give you multi-drop configurations where needed. You may elect to rent multi-drop amplifiers from the phone company or buy your own FSD-202A units.

11.C.3 COMBINING STAR AND MULTI-DROP NETWORKS:

Many networks use a combination of star and multi-drop. This is no problem, as long as all cable runs are properly terminated with their correct impedance, either by connecting them into an RTU or central station modem or into an FSD-202A unit. The importance of properly terminating cable systems cannot be overstressed. Inadequate terminations will invariably cause grief.



Example of two 4-wire circuits combined into one. This is a common multi-drop configuration.

When connecting two 4-wire circuits into one, you cannot simply tie the wires together. The impedance mismatch, loss of isolation and signal level will be very high. The FSD-202A has 600 ohm transformer isolation in all six branches, offers flat frequency response and can be adjusted from -3 to +3 db gain in each leg.

Example of four 4-wire circuits combined into one. This is a common configuration at central stations where many cable and radio 4-wire circuits have to work into a single 4-wire modem.

Any amount of 4-wire circuits can be combined into one, using the FSD-202A multi-drop amplifier and line conditioner.

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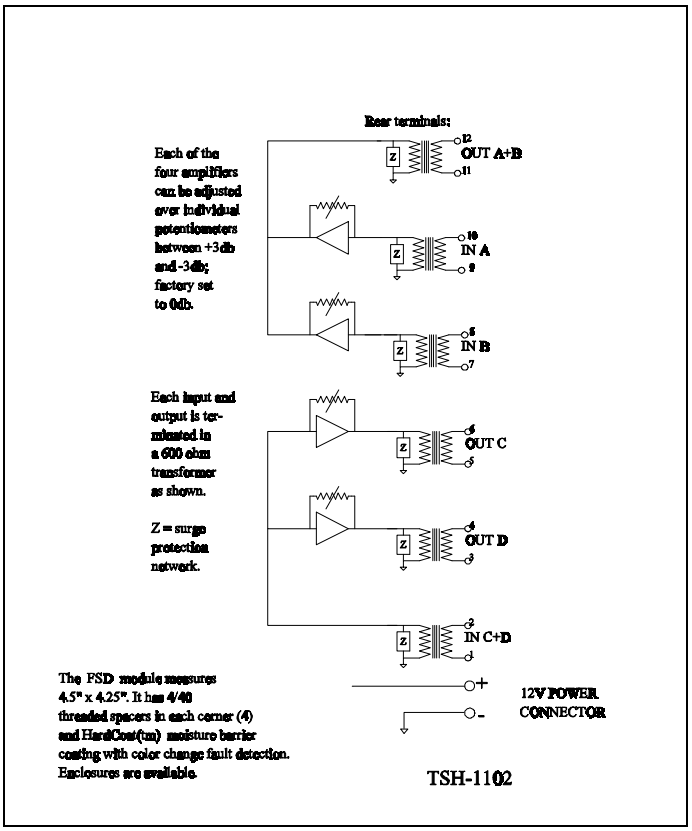
11.C.4 WHAT IF YOU ONLY HAVE A SINGLE 2-WIRE PAIR LEFT?



There are sometimes instances where there is only one 2-wire cable run left. You may be using old cables and there are just not enough pairs left. And you need a 4-wire cable to do the job. What to do?

You can convert a 4-wire circuit to a 2-wire circuit at one end of the 2-wire run and convert it back to 4-wire at the other end. This approach has some pitfalls but if you only have that one pair left it is worth a try.

First you to make sure that your 2-wire pair can send signals both ways. If it has one or more amplifiers in it, it will only pass signals one way. Leased phone company circuits often have these amplifiers in them. The

THE 4W2-A 4-WIRE TO 2-WIRE CONVERTER

The ScanData 4W2-A 4-wire to 2-wire converter is designed to convert cable 4-wire circuits (one pair for transmit and one pair for receive) into a 2-wire send and receive circuit. It is mounted on a 4" x 6" PC board. It is similar in size, construction and protective coating to other ScanData accessory boards.

The 4W2-A routes transmit (incoming) signals on the common 2- wire to the outgoing transmit 2-wire. Incoming signals on the receive 2-wire are routed out to the common 2-wire.

The 4W2-A sends the signals coming in on the common 2-wire to the transmit 2-wire over an active hybrid transformer. They appear across the hybrid on the receive 2-wire with a 20 db attenuation. Similarly, signals coming in on the receive 2-wire are sent out over the hybrid to the common 2-wire and appear across the hybrid on the transmit 2-wire with a 20 db attenuation.

Three pairs of screw connectors connect to the two 4-wire pairs and to the 2-wire pair. Another screw connector pair connects to the +12V power supply. Current consumption at 12V: 30 mA.

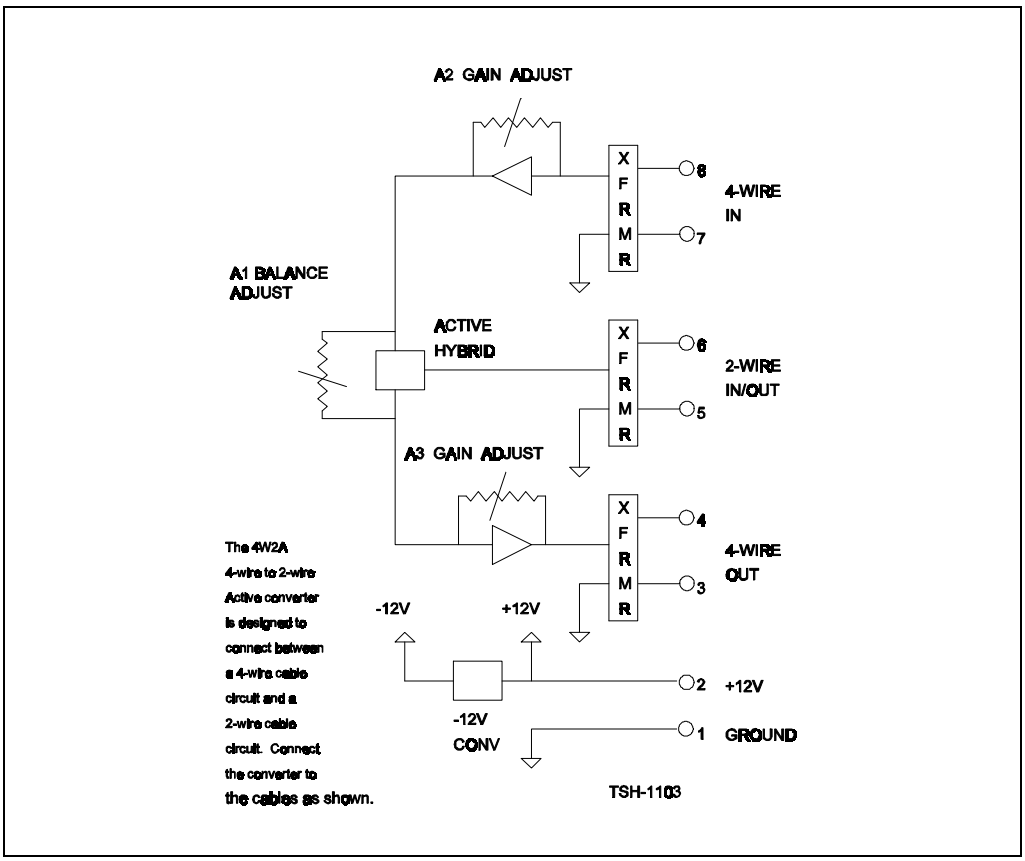
The 4W2-A contains a -12V power supply, a solid state hybrid transformer to separate the transmit and receive directions and a 600 ohm telephone grade transformer with surge protection in each of the three branches.

The gain in the transmit and receive directions is individually adjustable from -3db to +3db. The loss between the transmit and receive directions is better than 20 db (depending on the line impedance match).

ScanData Telemetry Test Set (TTS) will tell you if the cable pair is workable both ways.

Then you have to find out if your 2-wire is a true 600 ohm impedance line, with a good flat frequency response in the pass band 300 to 3,000 Hz. If it is, the 4W2-A active 2-wire to 4-wire converter will work well. It has 0 db loss in either direction and 20 db loss between transmit and receive directions provided there is a good 600 ohm impedance match.

Converting 2-wire to 4-wire circuits in this manner was often used by telephone companies. It used to be the only way to amplify long 2-wire circuits. Placing more than one pair of converters and one set of amplifiers on a circuit often caused instability and ringing, however. even on well maintained lines.



11.D NETWORKING WITH RADIO SYSTEMS:

Radio Telemetry and SCADA systems are inherently multi-drop. All the information transmitted out from the central station or from the master RTU is received by all the RTU receivers in the network and the information transmitted by any RTU is received by the central or master station and also by all the other

RTUs. In this, radio systems differ from cable systems where only the central receives the messages transmitted by the RTUs.

11.D.1 BRANCHING IN RADIO SYSTEMS:

Branching in radio systems can only be done with radio repeaters. There are two types of radio system repeaters:

- **The single frequency store and re-transmit radio repeater.**
- **The dual frequency radio repeater which uses an additional secondary frequency.**

Each type has its advantages and its drawbacks. The single frequency store and re-transmit repeater's advantage is that you don't need another radio frequency license. The drawbacks are that there will be a re-transmit delay (which affects all RTUs) and that you can not use more than one of these type of repeaters in a system, unless they are very widely separated. Spacing them too close would make the transmitter of one repeater mask the other, as they both turn on at the same time.

The dual frequency radio repeater's advantages are that there is no delay and that you can use as many repeaters as you like in your system, provided each has its own secondary frequency. The drawback is that you have to have a secondary frequency license for each of your repeaters. As with the store and re-transmit repeater, you cannot place two repeaters with the same secondary frequency near each other.

Lock-up in dual frequency radio repeaters can occur when each receiver locks on the other frequency's transmitter. This is avoided by using the ScanData RDC Repeater Direction Controller. The RDC detects the Bell-202 carrier from either receiver. The first receiver with a carrier sets a flip flop in the RDC which turns on the corresponding secondary transmitter. It remains on as long as there is a carrier, during which time the second receiver remains disabled. When the carrier disappears the flip flop is released. No lockup can occur.

11.D.2 BRANCHING INTO A CLUSTER OF RTUS:

The repeater radio can of course talk to a single RTU. This is often the only way to reach an RTU situated behind a hill.

The repeater radio can also talk to a data concentrator. The central station addresses the data concentrator exactly as it addresses any other RTU. The data concentrator in turn talks to a cluster of RTUs, gathering data from all of them. In this type of operation, the data concentrator appears as a large RTU to the central station.

Note that the data concentrator can talk to its cluster of RTUs over radio (a secondary frequency will be needed) or equally well over a star or a multi-drop cable network as described above.

Using the FSD-202A is a neat way of connecting two or more RTUs to a single radio transmitter and receiver. You can wire all the RTU **'TRANSMIT ON'** outputs together (they are all open collector) and into the radio.

11.E NETWORKING WITH DATA CONCENTRATORS:

Using data concentrators in Telemetry and SCADA networks can offer number of advantages:

Cable system costs can be significantly reduced by arranging RTUs in clusters with a data concentrator at the center of each cluster. The data concentrator simply appears as a (large) RTU to the polling software.

Radio systems can be considerably simplified by clustering RTUs by cable or by radio in a similar manner wherever it is geographically desirable. This cuts down on both radio link and cable costs.

The data concentrator can be equipped with optional PCS (Protocol Converter) software to also act as a protocol converter. In this manner, older systems can be expanded by using clusters of newer, more capable and more cost effective RTUs.

THE PRC DATA CONCENTRATOR AND PROTOCOL CONVERTER

The ScanData PRC Data Concentrator and Protocol Converter is mounted on a 4" x 6" PC board. It is similar in size, construction and protective coating to other ScanData accessory boards.

The PRC has one line serial port, one RTU serial port and an auxiliary printer port. The line serial port connects over an MDM-202A type modem to the radio or cable network. The PRC will answer polling requests and execute commands over this port as if it were an RTU.

The RTU serial port connects over another MDM-202A type modem to an RTU or to several RTUs in a radio or cable cluster. This port continuously polls all the RTUs in the cluster and transmits all commands to the RTUs arriving through the line port from the central station.

The PRC is therefore transparent to the central polling station. It appears as single large RTU, containing all the I/Os of all the cluster RTUs combined.

The PRC can be equipped with optional Protocol Translation Software (PTS). This software makes it possible for new high capacity and low cost, modern protocol RTUs to be incorporated into existing systems without having to change the old protocol.

11.F USING DATA CONCENTRATORS WITH SMART TRANSMITTERS:

The Data Concentrator and Protocol Converter is also often used to talk to one or more Smart Transmitters (analog transmitter with an RS-232 port).

The obvious advantage with this approach is that one or more Smart Transmitters will appear as a single RTU to the Central Station.

Placing Scan-Data RTUs on the WEB.

The UDS Device Servers allows connecting serial devices such as Scan-Data RTUs, PLCs and SCADA master station PCs to IP based Ethernet networks, quickly and easily. Using a method called serial tunneling, the UDS encapsulates serial data into packets and transports it over Ethernet. Using two UDS units, connected by a network, virtual serial connections can be extended across a facility or around the world.

There is no need to develop special software to take advantage of Ethernet networking. With virtual COM ports, mapped to remote Device Servers o the network, you can replace direct serial connections.

In modem emulation mode, the UDS is used dto replace dial-up modems. The unit accepts modem AT commands on the serial port, then establishes a network conection to the end RTU or PLC, leveraging network infrastructure and bandwith to eliminate dedicated modems and phone lines.

The UDS Device Server includes a built-in WEB server, which can be used for configuration or to display operating and troubleshooting information on the attached device. When attached to the Internet, it provides links to online support.

Flash memory provides for maintenance-free non-volatile storage of WEB pages, and allows future system software upgrades.

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.

fwa-1020.pdf 4-wire to 2-wire cable converter.

sdc-1321.pdf Data concentrators reduce cable runs and radio circuits

app-1127.pdf How to test radio communication circuits.

spc-1001.pdf Protocol converter upgrades 'orphan' SCADA systems.

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

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.