Power Line Communications Metering Systems

Scan Transponder-5

Installation Manual

 www.quadlogic.com

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Thank you for purchasing a Scan Transponder-5 manufactured by Quadlogic Controls Corporation. Quadlogic has been designing, assembling and selling digital electric metering systems for over 25 years. We appreciate your business.

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Warning

This guide is for persons who have received training and are qualified to work with electricity and electrical metering equipment. All applicable national and local electrical codes and standards must be followed. Failure to follow proper procedures may result in serious bodily harm including death.

Disclaimer

The information in this guide has been compiled with care, but Quadlogic Controls Corporation makes no warranties as to the accuracy or completeness. Further, the product described herein may be changed or enhanced from time to time. This information does not constitute commitments or representations by Quadlogic Controls Corporation, and is subject to change without notice.

The Scan Transponder-5

The Scan Transponder (ST-5) is the central data collector and communications device for the Quadlogic metering system. The ST-5 uses two-way Power Line Communications ("PLC") to transmit and receive metered data over the power lines in a building. The ST-5 can be read remotely using a telephone modem, ethernet connection or via other communication systems. The device can also communicate via a direct connection using a computer and optical probe. The ST-5 is used to collect data blocks from each meter in the system on a daily basis. The ST-5 does not remove data, but instead retrieves a copy of the data that exists in the meter. This redundant data storage provides security and system flexibility. Up to 240 metering points can be routed to the ST-5, collecting and concentrating data blocks from each meter on the system. The data blocks contain all previously uncollected meter readings, interval readings and event logs. The data is then appended to the file and stored in non-volatile flash memory for an average of forty days.

Figure 1-1. The Scan Tranponder-5.

The ST-5 utilizes a non-volatile flash memory, enabling reliable data storage and integrity without battery reliance. In addition to metering data, it stores a comprehensive list of the relevant metering events. The recorded events include: power consumption, demand resets, power ups and power downs, time changes, and tampers.

Scan Transponder-5 Assembly

The Scan Transponder-5 includes the parts listed below (See Figure 1-2.) These parts can be purchased individually in the event that a component of the Scan Transponder-5 has been damaged.

A. Scan Tranponder Head
  A-1. Scan Transponder Module
  A-2. Communications Module
B. Back Box
C. Fuse Block

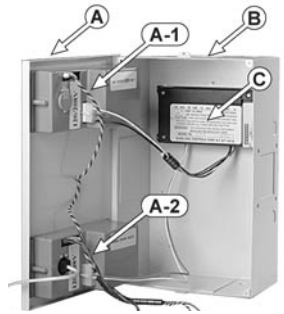

Figure 1-2. Scan Transponder-5 parts.

Specifications

Monitoring Specifications

- Voltage: 120/240V, 220/380V, 277/480V, 347/600V
- Communication Frequency Band: 10 – 90 kHz
- Number of Metering Points per Scan Transponder-5: Up to 240

Communications Options

Via Power Line Communications, the ST-5 collects metered data for up to approximately 240 metering points. Data retrieval from the ST-5 (for highrise applications) is typically achieved by remotely connecting through a standard 19.2k Modem/RS232 which is internal to the ST-5.

The data from the ST-5 can be taken directly through the use of the optical head which is a standard feature. An IEC Optical Communications Interface is needed to use with the optical head (optical probe is sold separately).

If more than one ST-5 is required due to volume of meter points or the electrical distribution, several ST-5's can be networked together using the following options:

- Network Data Link (4-wire RS-485) (SEE APPENDIX)
- Wireless Antenna

Liquid Crystal Display

- 32-digit liquid crystal display (16 digits x 2 rows)
- 6 whole digit consumption register
- Data digit height: 0.31"

Operating Range

- Voltage: 120/240V, 220/380V, 277/480V, 347/600V
- Frequency: 50-60Hz
- Rated Voltage: 85% to 110%

- Temperature: -20°C to +60°C

Memory

- 4 Megabyte non-volatile flash memory retains daily and interval data
- During power outage:
  - Flash memory retains daily and interval data for approximately 40 days rolling
  - Long-life lithium battery maintains time and retains data acquired within the incompleted interval at the time of the outage

Shipping Weight and Dimensions (1 Enclosure)

- Dimensions: 13.5”H x 8.5”W x 4.5”D
- Shipping weight: 11.5 lbs

Environment

- Usage: For indoor use only
- Enclosure: NEMA 1 rated
- Temperature: -20°C to +60°C
- Humidity: 0-90% relative humidity (non-condensing)
- Pollution Degree: 1
- Maximum Altitude: 2000 meters

Metering Industry Standards

- UL and CUL: recognized under E204142

Chapter 2 Installation

Installation Cautions and Warnings

- Do not install if the device is damaged. Inspect the box for obvious defects such as cracks in the housing.
- If the device is installed or used in a manner not specified by the accompanying documents, the safety of the device may be impaired.
- If the device functions abnormally, proceed with caution. The safety of the device may be impaired.
- Do not install around combustible gas or gas vapor.
- Do not install on an electrical service with current or voltage outside of the specified limit of the device.
- Do not operate this device with the cover removed.
- To avoid electric shock, disconnect mains before replacing fuses.
- Beware of working around this device when the voltage is live. There is a risk of electric shock.
- For protection against fire, replace only with fuses of the specified voltage and current rating.
- See instructions for connection diagrams.

Protective Conductor Terminal 

Securely fasten one end of the grounding wire (#12 AWG recommended) so that the grounding screw cuts the paint on the back box. Securely fasten other end of the wire to true ground connection. When grounding to the electrical conduit, use continuous metallic pipes, bending when necessary instead of using couplers.

Installation Guidelines for Scan Transponders

QLC’s Scan Transponder-5 (ST-5) is the data collector and communications device for the metering system. The placement of ST-5s is dependent on the number of services to the building, the number of metering points and the data storage requirements.

1. In order to determine the number of ST-5s, first determine the number of utility “services.” “Services” are defined as 120/208V, 277/480V, 480V, 347/600V and 600V utility transformer secondaries where the primary voltage is typically higher than 4kV. There should only be one step down transformer (i.e. from 480V to 120V) between the utility “service” and the QLC meters.

2. Determine the metering requirements or number of tenant spaces fed from each "service" and determine which "service" feeds each meter point. This information is vital to proper system operation because with the QLC system, "service" to tenant space determines the ST-5 to QLC meter relationship and is therefore critical for communications.

3. Determine the desired number of meter points you will require the ST-5 to store metered data.

4. In cases of parallel utility transformer secondaries or unusual service entry designs, please consult factory for design assistance in ST-5 placement.

SUMMARY:
An ST-5 is required:

a. For each "service" as defined above
b. For approximately every 240 QLC metering points
c. To meet certain data storage limitations

Installation Instructions for Scan Transponders

NOTE The use of the following procedure is mandatory both for safety and Scan Transponder-5 certification purposes. Certification requires a visual inspection of the voltage taps on the incoming feeder phase wires and communication checks between the Scan Transponder-5 and the Quadlogic meters.

1) The ST-5 requires a 3-phase 4-wire voltage connection to the "service" for Power Line Communications.

2) The best location for ST-5 installation is the closest point to the QLC meters before the main feeder for the "service" branches out into sub-feeders. This is the last point in the "service" before the first riser switch that feeds any QLC meters (see Figure 2-1).

To find this point, follow the feeders from the secondary of the distribution transformer (or service entrance if the transformer is off the property) and place the Scan Transponder at the last point before the feeder breaks into multiple feeders. **Typically, this will be in the main switchboard for the "service".**

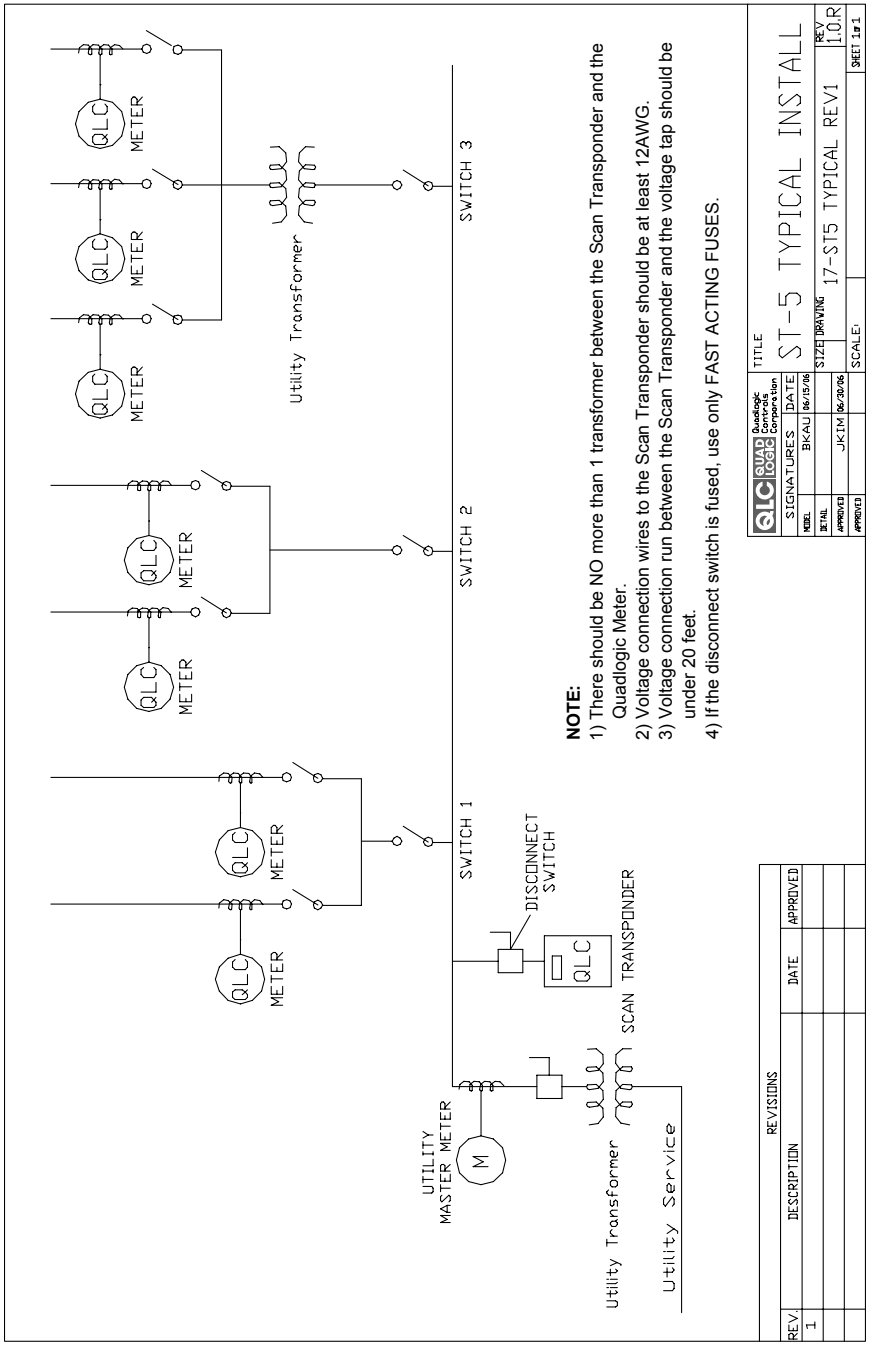

Figure 2-1. Typical Scan Transponder Installation

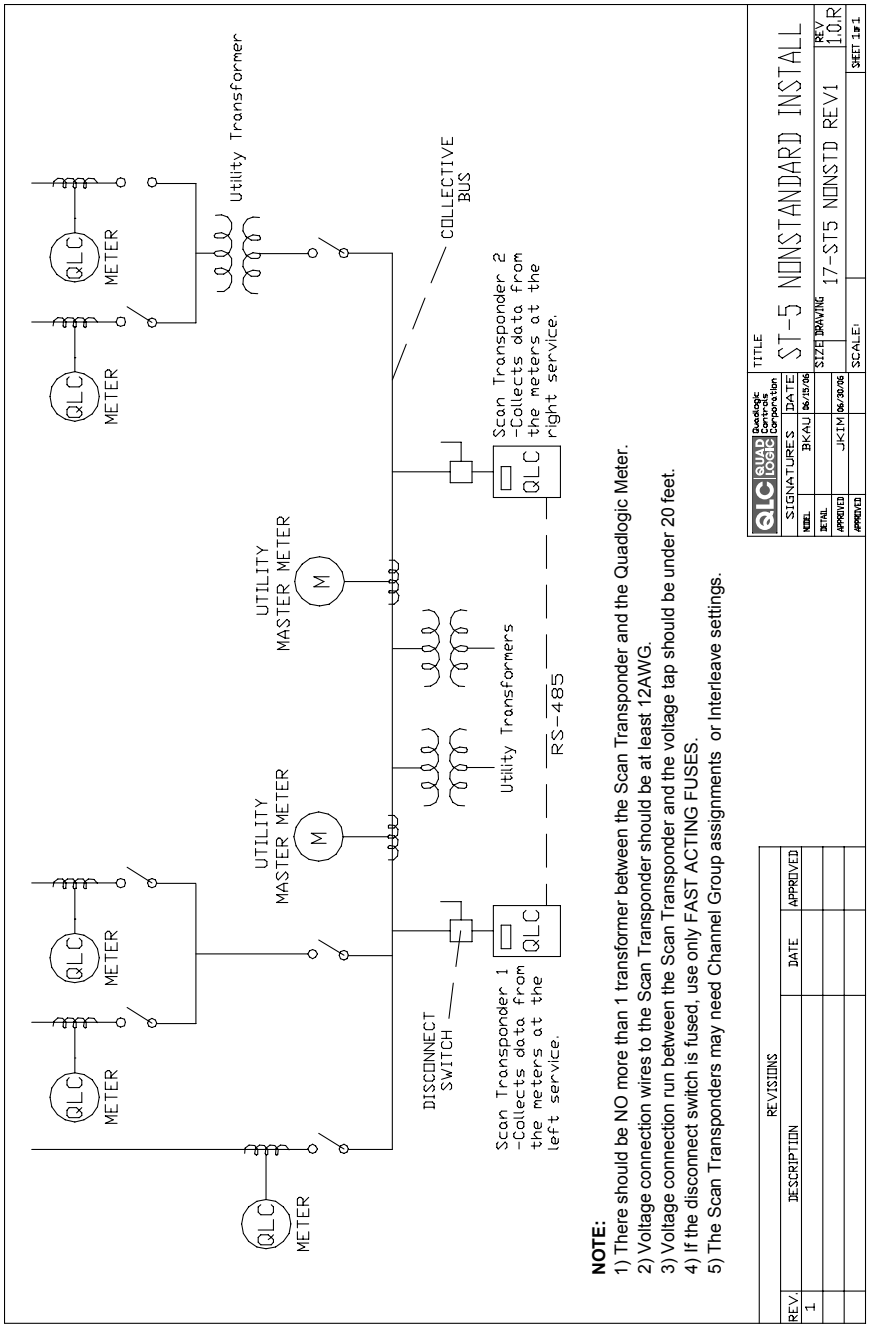

Figure 2-2. Non standard “collective bus” Scan Transponder Installation

The voltage connection should be connected by #12 AWG wire and a service disconnect switch is recommended (local codes apply). If the switch is fused, fast acting (not slow blow) fuses must be utilized.

3) The voltage wiring should be the shortest distance possible between the “service” tap and the ST-5 as this is the signal injection path. **If possible, use direct busway taps and keep runs under 20 feet.**

4) The voltage connection must be 3 phase 4 wire and all voltage and neutral connections must be from the same “utility” service.

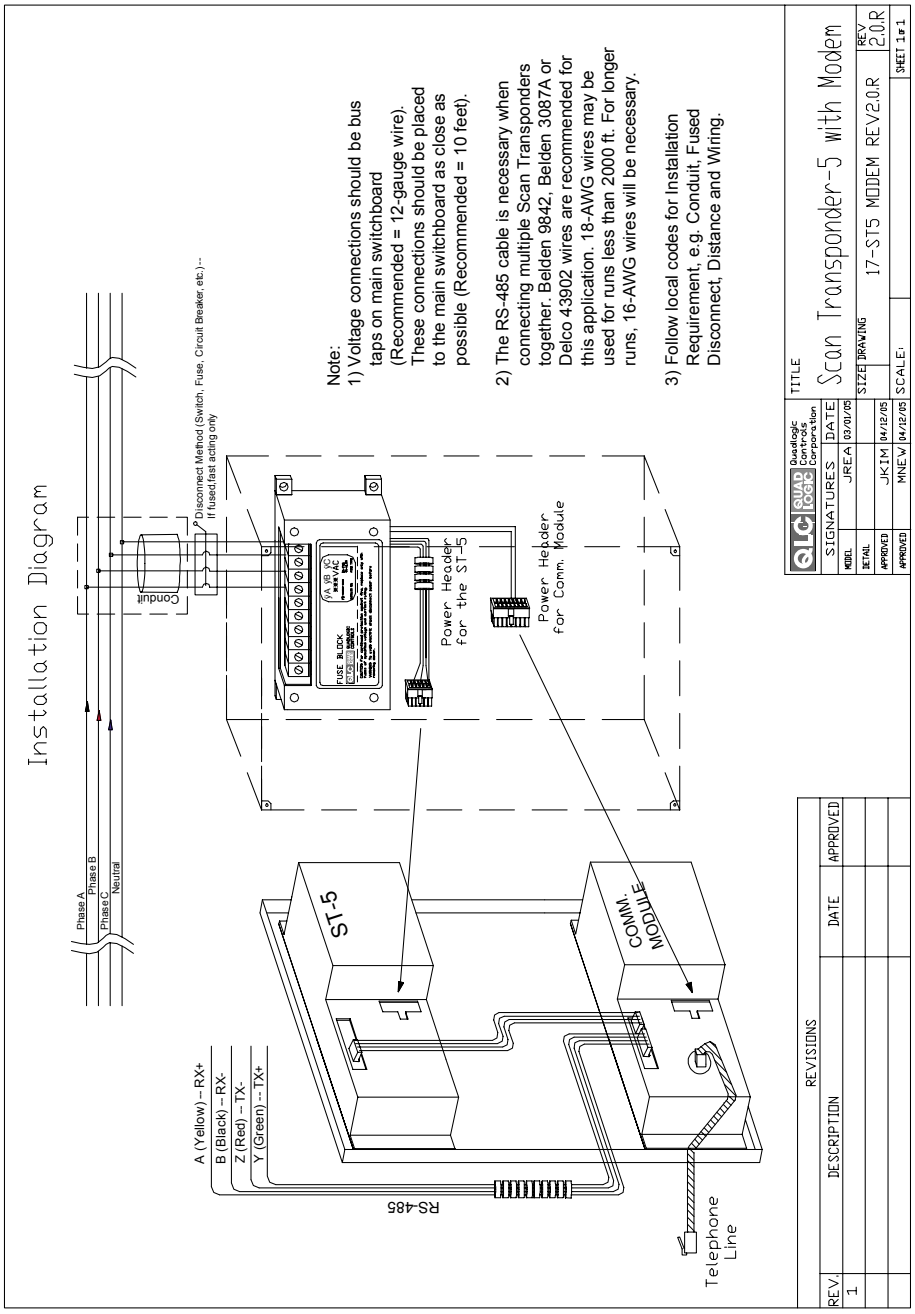

Figure 2-3. Scan Transponder-5 with Modem Installation Diagram.

Catalog Numbers

UNITED STATES ORDERING INFORMATION

- **Models beginning in "ST5-" include:** Transponder head, fuse block, back box, RS- 485 connection
- **Models beginning in "ST5M-" include:** Transponder head, fuse block, back box, Modem, RS-485 connection, RS-232 connection

Enclosure Size: 13.5"H X 8.5"W X 4.5"D

Catalog #	Volts	Scan-Transponder with RS-485 Only	Scan-Transponder with Modem, RS-485 and RS232
ST5-120V	120V	√	
ST5-277V	277V	√	
ST5M-120V	120V		√
ST5M-277V	277V		√

CANADIAN ORDERING INFORMATION

A complete Scan Transponder is comprised of two catalog numbers when purchased for Canadian installations, the Scan Transponder Head and the Back Box Assembly.

Scan Transponder-5: Head (T5H)

Includes: Models beginning in "T5H": Transponder head and RS-485 connection
Models beginning in "ST5HM": Transponder head, Modem, RS-485 connection and RS-232 connection

Also requires: Scan Transponder Back Box Assembly (ST5 BBA)

Catalog #	Volts	Scan-Transponder with RS-485 Only	Scan-Transponder with Modem, RS-485 and RS-232
T5H-120VX	120/208V	√	
T5H-240VYX	240/416V	√	
T5H-347VX	347/600V	√	
T5HM-120VX	120/208V		√
T5HM-240VYX	240/416V		√
T5HM-347VX	347/600V		√

Scan Transponder-5: Back Box Assembly

Includes: Back box and fuse block
Enclosure Size: 13.5"H X 8.5"W X 4.5"D
Also requires: T5H Transponder head

Catalog #	Volts
ST5 BBA 120V	120/208V
ST5 BBA 240/416VY	240/416V
ST5 BBA 347V	347/600V

Release Dates

	MANUAL	QLC PART NO.	REVISION NO.	RELEASE DATE
(1)	ST-5 Installation Manual	ST-5 MANR1.0.R	1.0.R	05.25.07

Preventive Maintenance

Preventative maintenance is not required.

Use a soft dry cloth to clean the device.

A Toshiba CR2032 coin battery is used in each device ONLY for the clock when power is lost, and is intended to be good for decades before replacement. The device does not rely on the battery, and the device data is stored in non-volatile FLASH memory.

Product Limited Warranty

Quadlogic Controls Corporation warrants its equipment for 3 years from the ship date against defects in material or workmanship when installed in accordance with manufacturer's instructions by qualified personnel.

This warranty does not cover installation, removal, reinstallation or labor costs and excludes normal wear and tear. The warranty does not cover product which has been altered from its original manufactured condition due to faulty installation, tampering, accident, neglect, abuse, force majeure or abnormal conditions of operation.

Obligation under this warranty is limited to repair and/or replacement, at Quadlogic's option, of the manufactured product and in no event shall Quadlogic be liable for consequential or incidental damages.

RS-485 Overview

Quadlogic devices may sometimes use a RS-485 interface to construct a multi-point communications network. The RS-485 interface is connected in a 4-wire full-duplex mode and is capable of handling 32 devices. In a four-wire network it is necessary that one node be a master node and all others be slaves. The network is connected so that the master node communicates to all slave nodes and all slave nodes communicate only with the master node.

Guidelines for Proper Wiring of a RS-485 Network

Recommended wires include Delco 43902, Belden 3087A, and Belden 9842.

Cable Selection[1]

Selecting data cable for a RS-485 system is important because intermittent communication problems are often caused by marginal cable and can be difficult to troubleshoot. The most important parameters that dictate the type of cable that will be used are Characteristic Impedance, Shunt Capacitance, and Cable Length (or Transmission Run.)

Characteristic Impedance (Ohms)

"Characteristic Impedance is a value based on the inherent conductance, resistance, capacitance and inductance of a cable that represents the impedance of an infinitely long cable. When the cable is cut to any length and terminated with this Characteristic Impedance, measurements of the cable will be identical to values obtained from the infinite length cable. That is to say that the termination of the cable with this impedance gives the cable the appearance of being infinite [in] length, allowing no reflections of the transmitted signal. If termination is required in a system, the termination impedance value should match the Characteristic Impedance of the cable."[1]

Shunt Capacitance (pF-ft)

"The amount of equivalent capacitive load of the cable, typically listed in a per foot basis. One of the factors limiting total cable length is the capacitive load. Systems with long lengths benefit from using low capacitance cable."[1]

[1] http://www.arcelect.com/485info.htm

Cable Length (Transmission Run)

Typical RS-485 systems have a maximum transmission run of 4000 feet. The total cable length (transmission run) will start from the first unit up to the last unit in the data link network.

The type of cable used for RS-485 is typically a twisted-pair wire which is simply a pair of wires with equal lengths that is twisted together. A twisted-pair wire helps prevent radiated EMI and it also reduces the effects of received EMI. Because the two wires are close together and twisted, the noise received on one wire will tend to be the same as that received on the second wire. This type of noise is referred to as "common-mode noise." As RS-485 receivers are designed to look for signals that are the opposite of each other, they can easily reject noise that is common to both.

Termination Resistors[2]

"A terminating resistor is simply a resistor that is placed at the extreme end or ends of a cable. The value of the terminating resistor is ideally the same value as the characteristic impedance of the cable."[2]

The value of the terminating resistor MUST match the characteristic impedance of the wire or else reflections will occur when the signal travels down the cable. There are instances where reflections are bound to happen because of cable and resistor tolerances; however, large enough mismatches may cause reflections big enough to bring about errors in the transmitted data.

With this in mind, it is important to match the terminating resistance and the characteristic impedance as closely as possible. The position of the terminating resistors is also very important. Termination resistors should always be placed at the far ends of the cable.

Datalink Network

Quadlogic meters and Scan Transponders can be set-up to be a data link communication network when an RS-485 module is available (see Figure A-1). The data link communication network can have up to thirty-two (32) meters which are daisy chained together. The beginning and end of each 32-meter segment within the network MUST have two (2) terminating resistors for each

[2] http://www.maxim-ic.com/appnotes.cfm/appnote_number/763

pair of wires.

The data link communication network most of the time will have a Quadlogic device with a Modem/RS-485 module where a dedicated telephone line will be plugged in. It is highly recommended to put the Quadlogic device with the Modem/RS-485 module at the beginning of the network. Furthermore, the total wire run of the network MUST not exceed the wire limit of 4,000 feet.

Occasionally, however, it becomes necessary for a particular meter to be further away from the main RS-485 Data Link trunk than the distance allowed by the data link assembly. In such an event, a longer, extended cable CANNOT be used to connect that meter to the RS-485 Data Link in an elongated "T" junction configuration. Rather, the RS-485 must be routed directly into that individual meter and then drawn back out from that meter to the next meter in the system in one continuous line.

While it would seem reasonable for a branch or "T" connection to run from RS-485 Data Link and permit the proper functioning of the data gathering, this is not a solution. It is absolutely imperative that a Quadlogic metering system with RS-485 Data Link never have branches running from the main line. The twisted, shielded pair wires must "enter" and "exit" each meter in the system with the exception of the first and last "terminator" meters.

RS-485 Data Link Installation Guidelines

If more than one ST-5 is required due to volume of meter points or the electrical distribution, several ST-5s can be networked together using interconnecting RS-485 line.

1. If there is more than one ST-5, install the other ST-5s and the interconnecting RS-485 line, if required, which links all of the ST-5s. See Figure A-1.
2. An RS-485 line is two pairs of wires, AWG #20 or larger in diameter, which begin at one ST-5 where a terminator is placed.
3. The RS-485 line runs from ST-5 to ST-5 ending at the final ST-5, where another terminator is placed.
4. It is critically important that there should never be three RS-485 pairs entering or leaving one ST-5 box.
5. For the two ST-5s which gave terminators, only one RS-485 pair leaves each box.
6. For the other ST-5s, if there are more than two, exactly two RS-485 lines should leave the box: each line goes to another transponder in the daisy-chain.

CAUTION:
Only one modem should be installed in a data link system. If there are two or more modems in a data link system, the ST-5s will not communicate with each other.

7. There may be no more than 32 ST-5s on a daisy-chain.
8. If possible, run the RS-485 lines in a conduit to protect them from damage. It is critically important to observe the polarity of the wires. The RS-485 data link uses a black and yellow color code. Match black to black and yellow to yellow; otherwise the data link will not work.
9. Avoid having loose conductors by using wire nuts to connect wires together. Use wire nuts suitable for the wires' gauge.
10. The data link should run no more than 4000 feet.
11. To test the data link, measure the DC voltage across the yellow to black wires and across the red to green wires. This should measure between 0.1V and 0.3V. If it is negative or outside of that range, re-check all of the ST-5 boxes according to the above specifications.

RS-485 Data Link Troubleshooting

RS-485 network problems are often caused by cabling issues which may be difficult to troubleshoot. Complications include:

- Inability to login into a Quadlogic device.
- Intermittent or no communication to a Quadlogic device.
- Garbled characters appear on the terminal screen when logged into a Quadlogic device.

Listed below are guides that can help troubleshoot a faulty RS-485 network.

- Make sure the meter is energized.
- Make sure that there is voltage coming into the fuseblock of the Quadlogic device. It may also be necessary to check if the fuses in the fuseblock are not blown.
- Make sure the voltage plug is connected properly to the meterhead and communications module.
- Make sure the 4-wire communications cable is connected to the communications module and the Quadlogic meter or Scan Transponder

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head.

- Make sure there is black tape covering the optical port window on meter.
- Make sure that recommended wires were used.
  - Must use 2 Pair (Dual Twisted ONLY) wire with 24 AWG or thicker. Shield is not necessary but if there is a shield, ground shield to metal housing at only of the ends of the network. Do not connect at the other end or at midpoints.
  - Recommended wires are Belden 9842, Belden 3087A or Delco 43902.
- Make sure the RS-485 wires are spliced together correctly.
  - Like colors from pigtails connect to the same circuit.
  - Make sure enough insulation is stripped off wire to make solid contact with the circuit.
  - Use wire nuts that are rated for the number of wires and gauge.
  - Avoid excess bare wire outside of the wire nut.
  - Make sure that the wires are not shorted together or to the box.
- Make sure there are no "T" branches in the RS-485 network.
  - Pigtails make a short wire connection to straight network.
- Make sure there are no bare wires touching any metal conductors.
- Make sure data link is not more than 4000 feet with the meter at the end of the link.
- Make sure terminating resistors are in place.

If the problems persists after verification contact a Quadlogic technical support representative for further assistance.

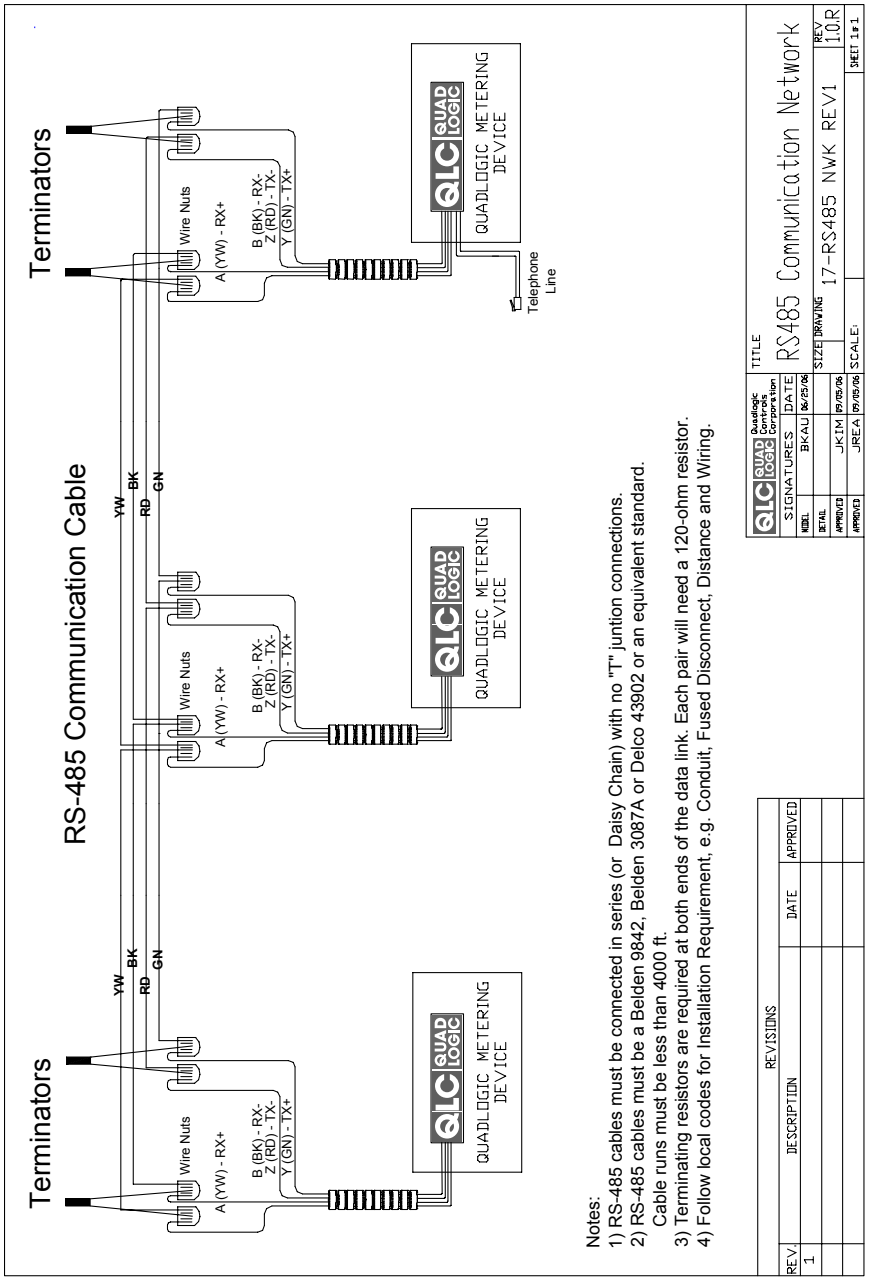

Figure A-1. Scan Transponder-5 Communication Network

Interleaving

Sometimes it will be necessary to utilize more than one ST-5 in the building. In cases where two or more ST-5s are connected on the same electrical service, "interleaving" will be necessary to prevent communication issues between the ST-5s. With interleaving, each ST-5 is given a time slot to perform its tasks i.e., a separate time slot is assigned to each ST-5 on the service. Once the interleave cycles have been set, during a specific time slot, only the ST-5 assigned to that time slot is active. Any other ST-5s installed on the same service are in inactive mode while the first ST-5 is communicating. When that ST-5 reaches the end of its time slot, it goes into inactive mode and the next ST-5 becomes active. The interleave cycles are set up for specific periods of time. For example, on a system with two ST-5s, a typical interleave cycle would be to divide the 24 hour day in two. The first ST-5 interleave cycle would be 12 hours and the second ST-5 would be assigned the second 12 hour section of the day. Each ST-5 would then have 12 hours to complete its tasks. Additional ST-5s on the same service would require more interleave cycles to accommodate all the ST-5s. The entire set of meters on the service is allocated to each ST-5 in time succession. Interleaving is the solution when more than one ST-5 is bolted onto the same bus. In some cases ST-5s are installed on separate services which may be too close together. This issue requires a different solution known as channel groups.

Channel Groups and Poll Address Overview

Channel Groups set the ST-5 to communicate with each dependent meter on different frequency ranges. This allows multiple ST-5s to be used together within one building site. For Channel Groups to work effectively and not require interleaving (time slot scheduling), there must be some electrical impedance difference between the ST-5s (transformer, distance, etc.). This document is not meant to explain the full topic of configuring multiple ST-5s but only provide an overview of setting channel groups.

During the initial communications between the ST-5 and the meter, the ST-5 addresses each meter by its unique 8-digit serial number. Once communication is established, the ST-5 sets a Poll Address by which the meter is addressed in all future communications. Poll addresses MUST NOT be repeated within a system or potential meter addressing and data errors may occur.

A Channel Group and starting Poll Address must be set for each ST-5.

Setting Channel Groups and Poll Addresses

There are 15 Channel Groups and 15 staring Poll Addresses available for assignment for each ST-5 as shown in Table B-1. For each ST-5, assign a Channel Group and assign the corresponding Poll Address.

Channel Group (CG)	Poll Address
-4	252
4	502
-2	752
2	1002
-6	1252
6	1502
-8	1752
-3	2002
3	2252
-1	2502
1	2752
-5	3002
5	3252
-7	3502
7	3752

Table B-1. Channel Groups and their corresponding Poll Addresses available for assignment.

Table B-2 shows the association of the number of ST-5s to the available Channel Groups. As an example, consider a building that has 2 ST-5s. One ST-5 will be assigned to have channel -4 and the other ST-5 to have channel 4. The ST-5 will be assigned Poll Addresses of 252 and 502 respectively. For additional ST-5s, other channels and Poll Addresses will be assigned as shown in the table below. For a single ST-5 (CG = 0), any available poll address may be assigned.

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- Appendix B -

No. of ST(N)	Channel Group Association (ST_1, ST_2, ST_3,.....ST_N,)
1	0
2	-4, 4
3	-4, 4, -2
4	-4, 4, -2, 2
5	-4, 4, -2, 2, -6
6	-4, 4, -2, 2, -6, 6
7	-4, 4, -2, 2, -6, 6, -8
8	-4, 4, -2, 2, -6, 6, -8, -3
9	-4, 4, -2, 2, -6, 6, -8, -3, 3
10	-4, 4, -2, 2, -6, 6, -8, -3, 3, -1
11	-4, 4, -2, 2, -6, 6, -8, -3, 3, -1, 1
12	-4, 4, -2, 2, -6, 6, -8, -3, 3, -1, 1, -5
13	-4, 4, -2, 2, -6, 6, -8, -3, 3, -1, 1, -5, 5
14	-4, 4, -2, 2, -6, 6, -8, -3, 3, -1, 1, -5, 5, -7
15	-4, 4, -2, 2, -6, 6, -8, -3, 3, -1, 1, -5, 5, -7, 7

Table B-2. ST-5-to-Channel Group Association.

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