Hardware Installation Guidelines

KeyMaster Systems

Wiring RS-485 Networks

Revision A

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[RS-485 HIG Rev A ENG-US]

www.controlsoft.com

Building security solutions

Controlsoft

Wiring RS-485 Networks

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Introduction

Controlsoft provides a building security solution which requires 'intelligence' at access points. A door has to 'decide' whether to allow or deny access. Installation of intelligent devices at all access control points is a prohibitively expensive solution, especially in large sites.

The KeyMaster system features centralized decision-making equipment and remote identification equipment, linked by data communications networks.

Building security applications often require robust data networks in the order of thousands of feet long; hence, the KeyMaster system employs the RS-485 electrical standard to implement data communication networks. The RS-485 standard allows for very robust communications over distances of up to 3000 feet on networks wired with relatively inexpensive cable types.

RS-485 is used to implement KeyMaster networks, which link the access control system elements. KeyMaster systems consist of controller devices and reader devices connected in half-duplex, multidrop, RS-485 networks.

This document serves as a guide to wiring Controlsoft RS-485 networks. It forms part of a set covering the installation of KeyMaster Systems and should be read in conjunction with the master document, entitled 'KeyMaster System Hardware Installation Guidelines', which is distributed as *AC-6000 HIG Rev X ENG-US.pdf*.

A full list of supporting documentation can be found in Appendix 4.

The Underwriters Laboratories Inc. (UL) evaluation of KeyMaster Systems

This section documents the evaluation of KeyMaster System components by the Underwriters Laboratories Inc. The information in this section applies throughout the document. The UL Listed components have been tested to US and Canadian Safety Standards.

Adherence to the following electrical standards, utilized by Controlsoft in the implementation of KeyMaster System hardware, was evaluated by UL.

- RS-485

The following electrical standards or communications protocols, as utilized by Controlsoft in the implementation of KeyMaster Systems, were not evaluated by UL.

- RS-232
- Ethernet
- Public switched telephone network
- Internet

The following KeyMaster System products, mentioned in this document, are UL Listed (for outdoor and indoor use):

- AC-1100 Proximity Card Reader
- AC-1200 Wiegand interface Proximity Card Reader

The following KeyMaster System devices, mentioned in this document, are UL Listed (for indoor use only):

- AC-3151 Door Controller
- AC-3114 System Controller
- AC-4101 System Controller
- AC-4311 I/O Controller

The following KeyMaster System devices, mentioned in this document, were not evaluated by UL:

- KeyMaster software
- AC-4450 Isolating Repeater
- AC-1300 PIN Pad Proximity Reader

Installation notes

The onus rests with the installer of the KeyMaster System to ensure the following:

- All power supplies used in the installation of a KeyMaster system are UL Listed, power-limited power supplies suitable for access control.
- All power supplies have an "AC on" indicator light, which shall be clearly visible on the enclosures.
- No power supplies are connected to a receptacle controlled by a switch.
- UL Listed, access control, power-limited power supplies shall provide a minimum of four hours of standby power.
- The system is installed within a protected premise. The operating temperature range must be 0°C to 50°C.
- All equipment, except products evaluated for outdoor use, is installed indoors or in correctly rated, UL Listed, weather-proof enclosures.
- The system is installed in accordance with the National Electrical Code (NFPA 70), and the local authority having jurisdiction. If the system is to be installed in Canada, please refer to the Canadian Electrical Code.
- Suitable Recognized Wire or UL Listed cabling is used for all power supply and data communications purposes, in accordance with the National Electrical Code or Canadian Electrical Code.
- Tamper switches are installed on device enclosures.
- All external interconnecting power sources are UL Listed, access control, power-limited power supplies.
- Readers mounted back to back, or otherwise in close proximity, are separated by at least 2.5" or a metal plate.
- Equipment and cabling are separated, wherever possible, from sources of electromagnetic interference (EMI).
- Where the above is not possible, steps are taken to reduce the effect of EMI on the cabling or equipment.
- Common ground reference is maintained between all devices sharing copper-based RS-485 network connections.
- Input and output terminals are adequately protected from transient signals and are connected to power-limited circuitry.
- All grounding and power supply wiring is performed in accordance with the National Electrical Code or Canadian Electrical Code.

Wiring Controlsoft RS-485 networks

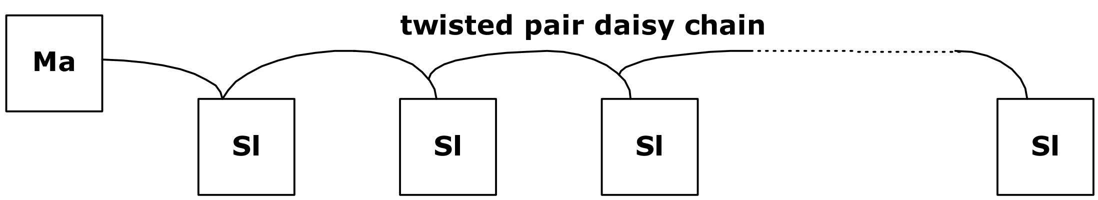
Operation

Controlsoft RS-485 access control networks use the convention '+' and '–' to represent the lines 'A' and 'B', defined by the RS-485 standard[1], respectively.

Two-wire RS-485 networks operate in half-duplex mode on one twisted pair. Data may only travel in one direction at a time. All devices on the network can be transmitters or receivers, but only one may transmit at any given time.

This means that the network must have a master device. The master device polls the network of slave devices and the slave then responds. Slave devices are normally receivers while the master normally transmits.

The following diagram shows the preferred topology of Controlsoft RS-485 networks.



A typical Controlsoft RS-485 network

All devices on the network receive any transmitted data. The device for which the data is intended responds if necessary.

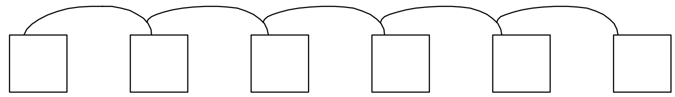
The card readers are normally in receive mode, 'listening' to the network for their address, while waiting for a card swipe.

The reader collects data from the user's card or tag when it is swiped through the reader field. When the reader is next polled by the system controller (the device 'hears' its address), it responds by switching from receive mode to transmit mode. The reader becomes an RS-485 transmitter, waits for the system controller to switch to receive mode, and then transmits the card data on the multidrop network.

The system controller, when alerted by the reader that it should expect data, switches to receive mode and waits for the card data to appear on the network lines.

Connection

Controlsoft recommends using a multi-drop or daisy chain topology, as shown in the following diagram.

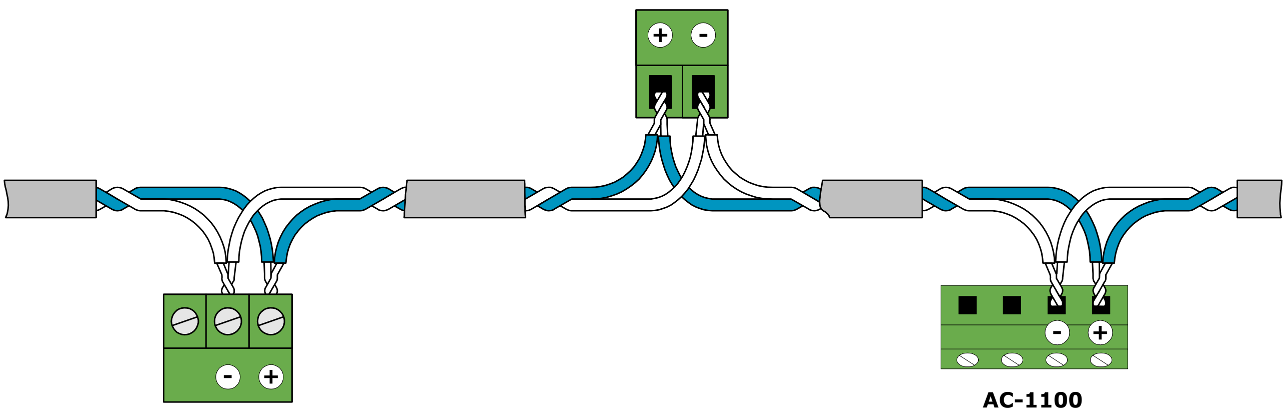


Daisy chain topology

In practice, the wiring of a daisy chain topology is most easily implemented by using the RS-485 connector on the device to link the network to the upstream and downstream nodes. This could lead to incorrect wiring, so care should be taken to avoid inadvertently connecting the network in a star configuration.

When the recommended conductors are used (see Appendix 1), the connector terminals are capable of accepting two conductors to facilitate this arrangement.

Connect the + wire from the upstream device into the local + connector and connect the + line for the downstream device into the same pin of the connector. Repeat this procedure for the – line.



Correct daisy chaining arrangement made at the connectors using 24 AWG twisted pair cable

The finished network should have all + connection points linked to the + line and all - connector pins linked to the - line. The network lines are distinguished by the conductor insulation coloring or marking. The diagram above shows the + line in blue and the – line in white, though the actual cable coloring will vary.

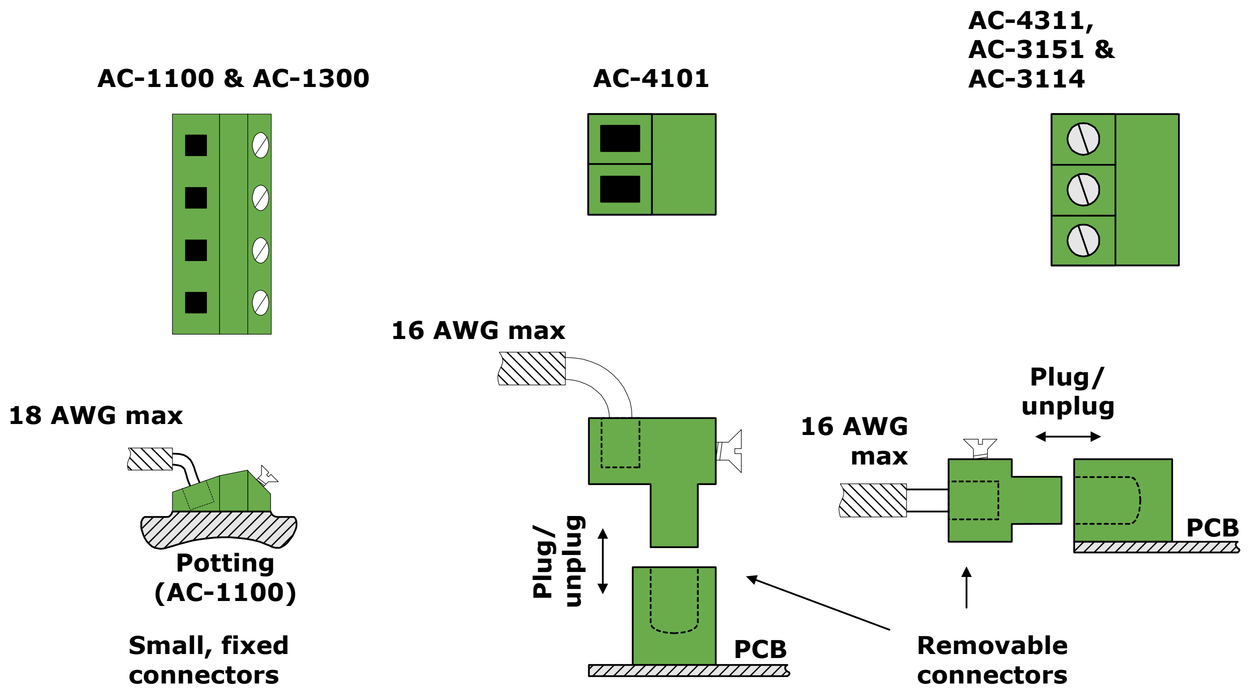
When integrating Controlsoft equipment with third party RS-485 networks, or third party equipment with Controlsoft networks, A is connected to + and B is connected to -.

Connector types

Controlsoft equipment uses two sizes of connectors. Smaller gauge connectors are used on the AC-1100 and AC-1300 readers than on the other devices. The small connectors accept wire sizes up to 16 AWG or 1.5 mm^2, while the large connectors accept cables up to 14 AWG or 2.5 mm^2.

To wire the connections, carefully strip about 1/4” of the conductor insulation, insert the bare conductor into the correct terminal orifice and then fasten the screw. Controlsoft recommends using a slot-head screwdriver with a blade 3/32” wide (suitable for size 0 or 1 screw). The screws should never be over-tightened as the conductors may thus be damaged.

The smaller connectors are fixed to the devices while the larger connectors are plug-type connectors which can be removed from the circuit board. The following diagram shows how the different connectors are wired.



Different types of RS-485 connectors found on Controlsoft equipment

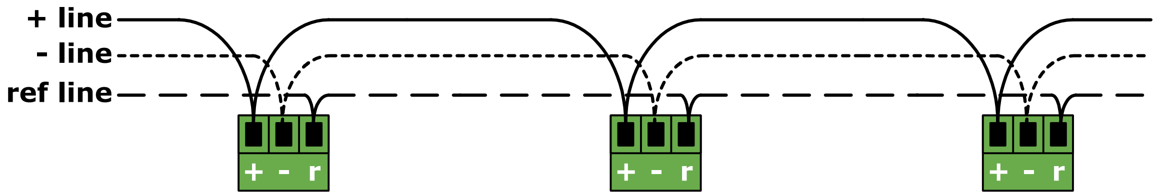
‘Three wire’ networks

RS-485 data is represented by a differential signal, which means that both network lines are used to carry signal data. **The – line is not a return path for the + line.**

The signal pair is interpreted by comparison with a ground or reference voltage. Variations in this reference level can cause misinterpretation of the signal (see Appendix 2).

This effect can be reduced by using a third conductor as a signal reference for all the network devices. The voltage on this third conductor will be approximately equal along its entire length, making it a more dependable reference for the interpretation of the signals on the other two conductors.

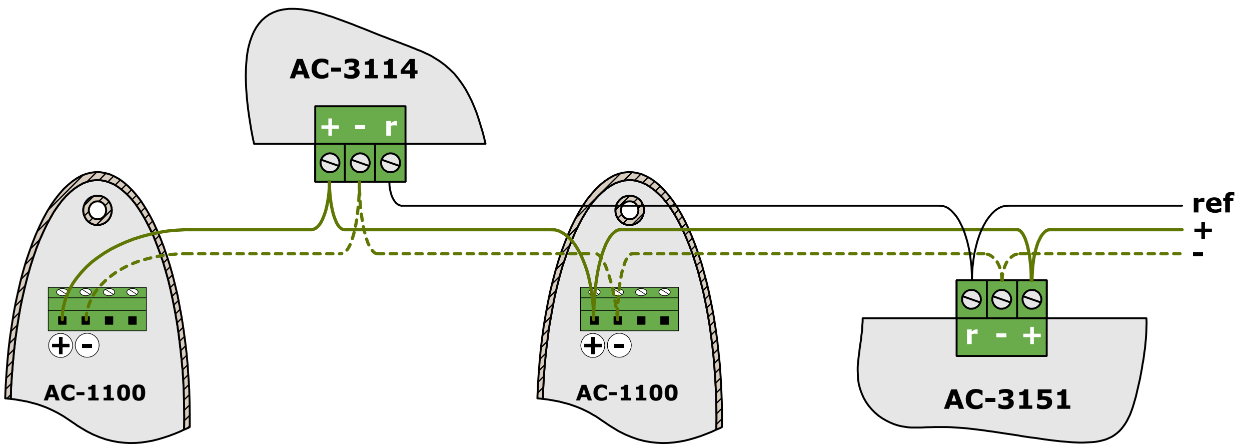
Some Controlsoft equipment is fitted with 3-way connectors which have +, - and ‘ref’ connection points. The ref connections, shown as ‘r’ in the following diagram, should be wired together in the same way as the + and – signal conductors.



Connecting the reference conductor

Sample configuration

The following diagram shows a sample RS-485 network. For a list of compatible equipment, please refer to Appendix 1.



RS-485 scanner network

The diagram above shows a standalone RS-485 network. The AC-3114 controller can host up to 16 slave devices.

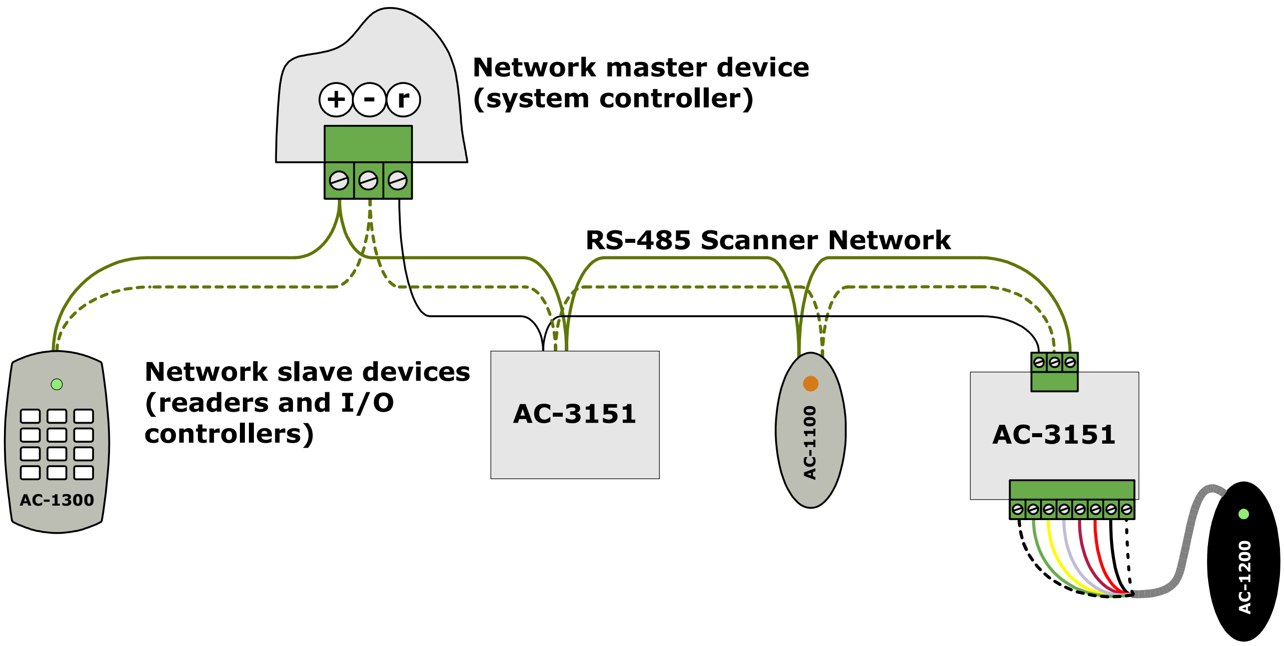
Preferred installation practices

What follows is a list of recommendations which will help you to install reliable networks. These are based on a mixture of theory and practical experience. Should you need more background on RS-485 networks, and why we recommend these practices, please read the appendices and follow up on some of the references provided at the end of this document.

1. **Plan ahead.** A little planning can save a lot of time. Check the building plans, work out cabling routes, equipment quantities and power requirements in advance. Design the network on paper before you install it. Check the site for potential sources of interference, adequate network route accessibility and the customer's aesthetic preferences **before installing.** Choose a 'color code' convention for running your cables and adhere to it.
2. **Network distance.** Where the network will exceed 3000 feet, use AC-4450 repeaters to refresh the signal. You can also use these repeaters to isolate network segments that run through electrically noisy areas or different buildings.
3. **Topology.** Maintain a daisy chain topology. This should be simple on first time installations, especially if you plan ahead. On revisiting a site, if you **have to** stub a network, use the AC-4450 to drive the stub.
4. **Grounding.** Running a third conductor as a reference is the preferred method of 'grounding' the network. Connect this third conductor to the negative rail of the controller's power supply. **Avoid connecting the reference conductor to more than one earth ground point.** See Appendix 2 for a discussion of network grounding.
5. **Termination.** Use the termination jumpers on the equipment (refer to the appropriate technical reference manual) to install resistive termination at the physical ends of network segments. Remove the termination jumpers on any devices not at the end of a segment. Where termination is required but not available on the end device, install a 120 Ω resistor between the + and – network connectors.
6. **Biasing.** Ensure that the network is biased by installing biasing jumpers on the equipment at the physical ends of the network segments. Remove all other biasing jumpers in the segment to reduce the load on the network drivers and thus enhance network performance. For a discussion of biasing, please refer to Appendix 2.
7. **Protection.** Protect the master power supply with an adequately rated fuse. Use a battery backed-up power supply. Use an AC-4450 to isolate any equipment you suspect is faulty, or any network segment which is performing poorly.
8. **Working conditions.** KeyMaster System devices are extremely sensitive to electrostatic discharge (ESD) and are shipped in anti-static bags. Please try to work free from ESD when installing the network. Use an anti-static mat if possible, and wear an anti-static wristband.

Appendix 1: Controlsoft RS-485

The scanner network consists of up to 16 card reader (scanner) devices controlled by a system controller. This network operates in half-duplex mode at 9600 bps, with a system controller as the master and card scanners as slaves.



A typical scanner network

The following table lists the devices which may be used on the scanner network.

RS-485 scanner network devices	
Part Number	**Description**
AC-3114	System controller. Eight inputs and eight outputs. Controls sixteen devices. Used in standalone applications.
AC-4101	System controller. Controls sixteen devices. Used in a wide variety of KeyMaster systems, including CS-NET based systems.
AC-1100	RS-485 proximity scanner. Standard proximity scanner used throughout KeyMaster installations.
AC-1200	Wiegand proximity scanner. Proximity reader which outputs Wiegand format card data.
AC-1300	PIN Pad proximity scanner. Slave device used for card reading and PIN entry. Capable of various output formats, including Wiegand.

RS-485 scanner network devices	
Part Number	**Description**
AC-3151	Door Controller. Slave device which provides auxiliary inputs and outputs for use by the KeyMaster system. Hosts one or two AC-1200 scanners (or AC-1300 scanners, or third party Wiegand scanners) on the RS-485 scanner network.

Addressing

For correct network operation it is important that each device has a unique address. This address does not correspond to physical location. The master device may be at either end of the network or anywhere in the middle, provided that the daisy chain topology is followed.

The scanner network may have 16 devices with addresses in the range from 0 to 15. The system controller is not addressed.

The following table lists the network elements and their address ranges. The 'Switch type' column indicates how the address is set on the device. Consult the appropriate technical reference manual for more detail on the individual products.

Network addressing			
Part Number	**Network type**	**Address range**	**Switch type**
AC-1100	RS-485 scanner	0-15 (0-F)	Rotary (0-F)
AC-1200	Not addressed		
AC-1300	RS-485	0-15	DIP Switch SW1 pos 1-4
AC-3114	System controller - not addressed		
AC-3151	RS-485	0-15	DIP Switch SW1 pos 1-4
AC-4101	System controller - not addressed		

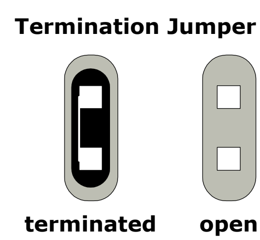
Network devices have switches which are used to physically set their network address. This is either a rotary switch, in the case of AC-1100 proximity card readers, or four positions of a DIP switch for AC-3151 I/O controllers or AC-1300 PIN Pad proximity readers.

The decimal addresses 0 to 15 are represented by four binary digits, which are the equivalent of a single hexadecimal digit. The following table shows the sixteen decimal addresses and their corresponding binary, hexadecimal and DIP switch values.

RS-485 addressing						
Address			**DIP switch positions (Switch SW1 pos 1 - 4)**			
Dec	**Hex**	**Bin**	**Pos 1 (LSB)**	**Pos 2**	**Pos 3**	**Pos 4 (MSB)**
0	0	0000	OFF	OFF	OFF	OFF
1	1	0001	ON	OFF	OFF	OFF
2	2	0010	OFF	ON	OFF	OFF
3	3	0011	ON	ON	OFF	OFF
4	4	0100	OFF	OFF	ON	OFF
5	5	0101	ON	OFF	ON	OFF
6	6	0110	OFF	ON	ON	OFF
7	7	0111	ON	ON	ON	OFF
8	8	1000	OFF	OFF	OFF	ON
9	9	1001	ON	OFF	OFF	ON
10	A	1010	OFF	ON	OFF	ON
11	B	1011	ON	ON	OFF	ON
12	C	1100	OFF	OFF	ON	ON
13	D	1101	ON	OFF	ON	ON
14	E	1110	OFF	ON	ON	ON
15	F	1111	ON	ON	ON	ON

Termination

Devices at the physical ends of RS-485 networks should be resistively terminated in order to prevent signal reflections. Most Controlsoft equipment is fitted with built-in resistors to meet this requirement. Termination resistance is switched in by installing jumpers as shown in the following diagram.



Installing termination jumpers

The following table lists the network devices and the corresponding termination jumpers. This information is also available in the technical reference manuals for each product.

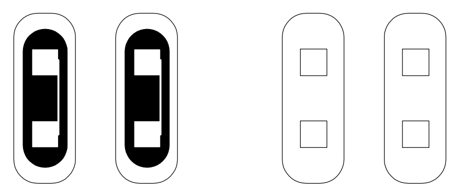
Equipment-specific jumper numbers		
Part Number	**RS-485 termination**	**RS-485 biasing**
AC-3114	J24	J22 & J25
AC-3151	J14	J13 & J16
AC-4101	J4 & J8	J5 & J6

Biasing

Controlsoft RS-485 networks are biased into a defined state when not transmitting. When idle, the + line should be at least 200 mV ‘above’ the - line. ‘Above’ means that the potential difference (or differential signal) from A/+ to B/- should be at least 200 mV.

The bias is applied to the network lines using ‘pull-up’ or ‘pull-down’ resistors which maintain the correct differential voltage. Most Controlsoft network elements have built-in biasing circuitry which can be switched in using jumpers.

A pair of biasing jumpers



Network biasing is applied with biasing jumpers

It is not necessary to bias the network lines at all the network elements. Doing so actually creates excessive loading for the line drivers. It is only necessary to apply enough bias to ensure that a differential voltage of more than 200 mV_{dc} is maintained when the network is idle. The required biasing resistance will vary depending on network length and number of elements, so it is best to evaluate each situation individually.

As a general suggestion, insert the biasing jumpers of the devices at the physical ends of the network only. If the devices towards the middle of the network operate erratically, more biasing may be required. Following this suggestion will minimize the loading on the transmitters and probably result in better signal integrity.

Biasing jumpers are always paired. To ensure proper biasing, make sure that jumpers are installed together or removed together. The previous table lists the common network elements and the corresponding biasing jumpers.

Data transmission

The data carried on Controlsoft RS-485 networks will be a 24 bit or 32 bit number, depending on the type of tag that is being used in the system.

This number is broken into eight bit sequences (eight bits = one ASCII character) which are transmitted as part of the poll response from the reader. Each eight bit sequence has a start bit and stop bit.

Alternatively, the original binary sequence is converted to a decimal or hexadecimal number and the resulting ASCII numerals are transmitted.

Cabling requirements

The minimum cable required to connect a Controlsoft RS-485 network is a shielded, twisted-pair cable with a single pair of stranded cores no smaller than 24 AWG. Examples of this type of cable include the Belden 9501 or 3105A and the Alpha Wire Company 5471C.

This type of cable meets the data transmission requirements of a daisy chain RS-485 network.

Controlsoft recommends using a cable with more conductor pairs because the extra pairs can be used to carry power to the devices. A shielded category 4 or category 5 type of cable may be used, provided that the cores are stranded.

Some vendors provide application-specific cables, such as the Belden 'Industrial RS-485' cables.

Cable selection depends on many criteria, like network length, transmission speed, future expansion, physical environment and so on. Care should be taken when selecting a cable type to ensure that unnecessary cabling work and expense are avoided.

All Controlsoft networks should be cabled using 'UL Listed' or 'Recognized Wire' cable types to ensure compliance with the National Electrical Code, ANSI/NFPA 70.

Cabling specifications	
Parameter	**Value**
Cable type	Twisted-pair conductors within a cable shield and jacket
Conductor type	Stranded cores within insulation
Conductor gauge	24 AWG (0.23 mm^2)
Characteristic impedance (Z_0)	100-120 Ω
Certification	UL Listed or c-UL Listed (Canada) or Recognized Wire. Cable type UL AWM 2464. AWM: Appliance Wiring Material

Appendix 2: RS-485 background

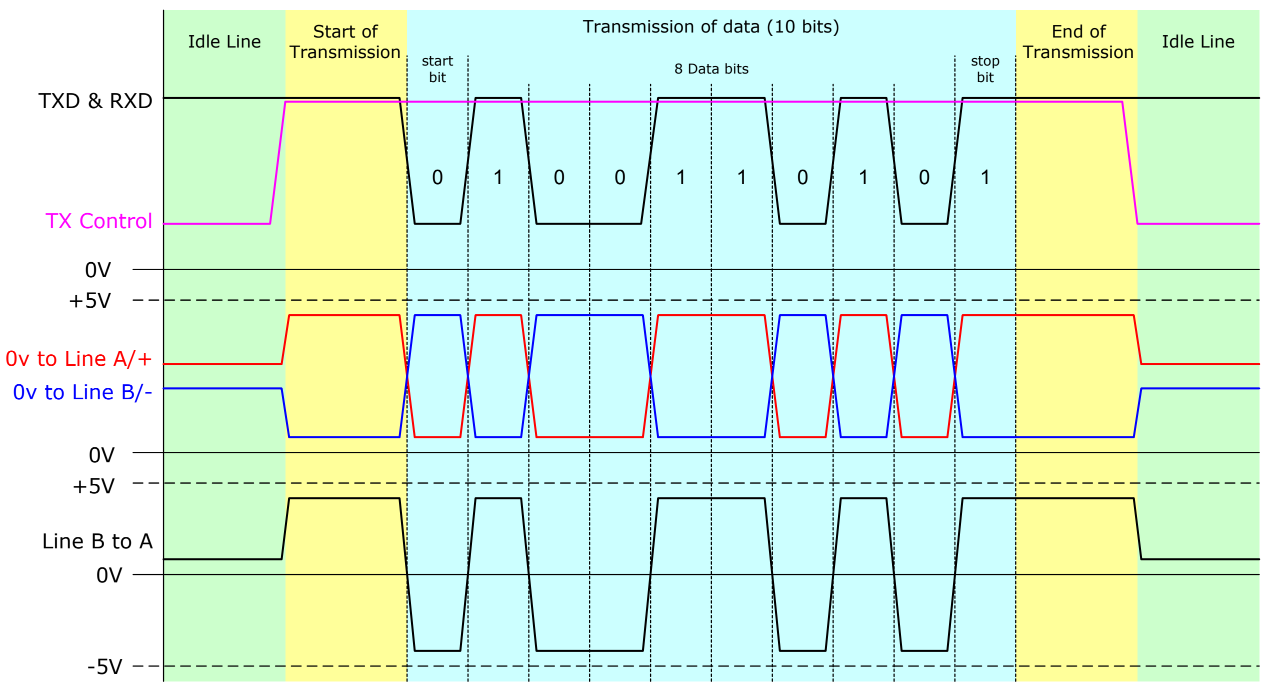
RS-485 signals

RS-485 is a balanced line communications standard, which means that a pair of opposing signals is used to represent a single data stream. **Two data lines are necessary for each signal.**

The RS-485 standard can be used to implement 'two-wire' or 'four-wire' networks, which distinguish half or full duplex communications. Two-wire networks use the same pair of conductors for the go and return signals, implying that only one device on the network may transmit at any given time. Four-wire networks are capable of 'full-duplex' RS-485 communications because data can travel along both twisted pairs simultaneously.

The standard calls the balanced lines 'line A' and 'line B'. Line A and line B would ideally carry equal and opposite signals, hence the term balanced.

This is illustrated in the diagram and discussed in the following paragraphs:



Ten bits of data (one ASCII character) on the RS-485 differential bus

The graph represented in the diagram above illustrates the signals associated with Controlsoft two-wire RS-485 over the period of time required to complete a transmission sequence of 10 bits.

The green areas to the left and right show the lines in an idle (not transmitting) state, before and after the transmission sequence. This idle state is defined so that the receivers on the network 'know' the lines are idle. This defined state is achieved by **biasing** the network lines.

The first yellow area shows the lines being switched into a state where they are ready for transmission. The transmission control signal is switched on by the device's microcontroller, which causes the network data lines, A/+ (red line) and B/- (blue line), to be switched into a binary 1 state (A high and B low). Other devices on the network, thus made aware that data will soon be available on the bus, switch into receive mode.

The blue area in the centre of the diagram shows the 10 bit transmission sequence, comprising a start bit, 8 data bits and a stop bit.

The start bit is a logical 0 (A low and B high) because the switch from the logical 1 'ready-to-transmit' state lets the receivers know that the first data bit will follow.

The eight (data) bits following the start bit are 10011010.

The differential signal, defined as the difference in potential between line A and line B, is read from the data lines by the network receivers. Logical 1 has a differential signal of approximately 5 V and logical 0 has a differential signal of approximately – 5 V. **The signals on line A and line B are relative to the 0 V level at the transmitting device.**

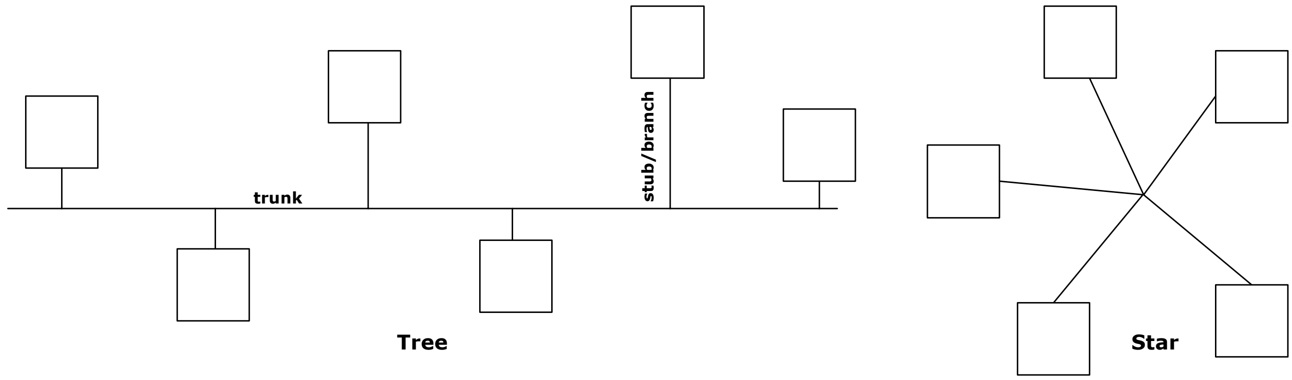
The stop bit completes the transmission.

The second yellow area represents a period of time after the transmitted sequence during which the transmitting device still has control of the network bus. The reason the device holds the bus for this period is to prevent any other devices from transmitting, thereby causing data collisions, while the sequence may still be 'travelling' at the far reaches of the network. After a sufficient period, the transmit enable (pink) signal goes off, allowing the lines to return to idle mode (second green area).

Topology

One network bus is much easier to manage than several, particularly where long bus distances are involved. RS-485 network drivers are designed to drive one twisted pair.

Network topologies such as the star or tree are not recommended by the standard.



Star and tree topologies

Addressing

In a two-wire RS-485 network, both wires are necessary for transmission in one direction because of the balanced nature of the RS-485 standard.

If this network had many 'peers', which could all have transmission control of the bus at any time, data corruption would soon result from collisions as devices attempted simultaneous transmission.

For this reason, a two-wire RS-485 network can only operate in half-duplex mode. One device transmits while the others all receive. When a device needs to transmit, the previous transmitter must first switch to receive, to ensure data only travels in one direction.

To make this type of operation possible, the network must have a master device which normally acts as the transmitter. Other devices on the network only transmit when they need to, and do so when they are asked to by the master.

The master device continuously addresses (polls) the slave devices. A slave device that has data becomes a transmitter upon hearing its address on the bus.

Slave devices are distinguished from each other by their network addresses, each of which must be unique. If two or more devices share the same address, they could transmit at the same time and cause data collisions.

Termination

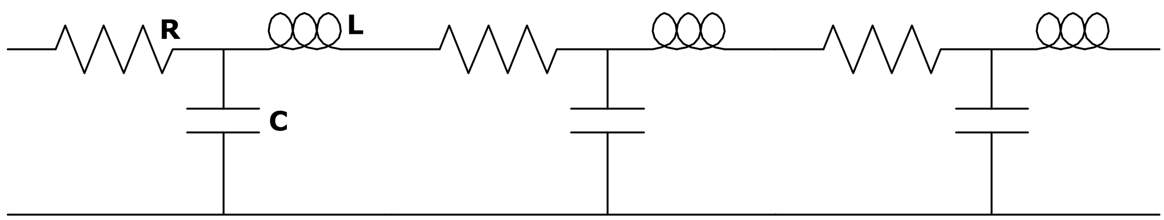
RS-485 is often implemented using twisted pair conductors because they are cost-effective and have good noise immunity. The uniform nature of twisted pair cables makes transmission line effects predictable. These effects are quantified by the cable's characteristic impedance.

Signal integrity on RS-485 networks can be compromised by reflections, especially in long networks. Terminating network lines with the cable's characteristic impedance reduces reflections.

Characteristic impedance

Long RS-485 networks are subject to transmission line effects. A transmission line is considered to be long when the distance a signal travels is much greater than the wavelength of the signal.

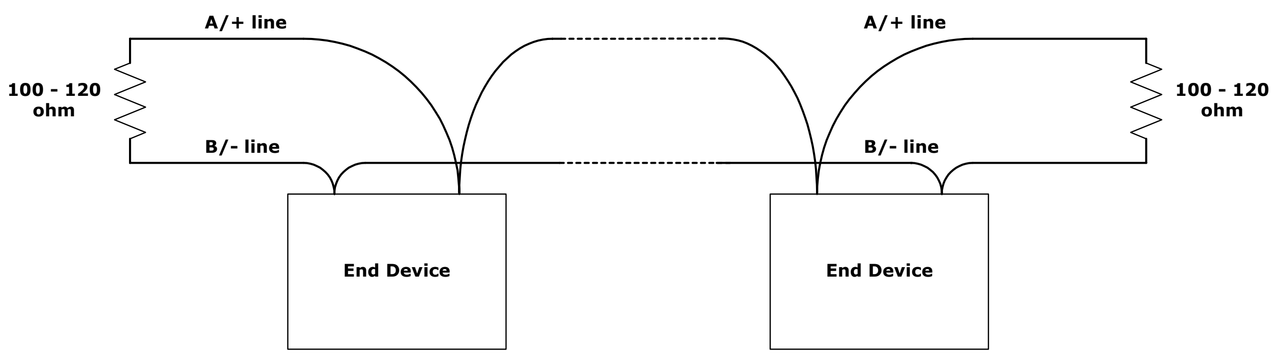
On uniform transmission lines, such as twisted-pair cables, signal reflections and standing waves can appear on the line. These transmission line effects result from the distributed electrical characteristics of the transmission medium, such as the resistance, inductance and shunt capacitance per unit length.



The electrical characteristics of a transmission line are distributed uniformly along its length

These properties are quantified by the **characteristic impedance** of the line. This quantity is one by which cable types, such as CAT 5, are rated.

Characteristic impedance for typical twisted pair conductor is between 100 Ω and 120 Ω. It is possible to reduce transmission line effects by matching this characteristic impedance where the cable is terminated. This is called parallel termination, illustrated in the following diagram.



Parallel or bi-directional termination of long network

Do not terminate devices which are not at the physical ends of the network. Unnecessary shunt resistance in the network makes more work for the line drivers and can cause data corruption.

Grounding

Grounding is a very important consideration when wiring RS-485 networks. A common misconception is that the two network lines form a loop – that one of the conductors is a return path for the other. This is not true, despite what may be inferred from circuit board markings + and -.

Each conductor carries a **signal** voltage which is measured relative to ground.

The voltage levels of the signals are used by receiving devices to interpret the data carried on the pair of wires. These are determined by comparison of the signal with a reference level called ground.

Two signals representing each bit of data are generated by the transmitting device. Both of these signals have a level which is determined by comparison with ground. This means that an RS-485 'two wire' network actually has three voltage levels.

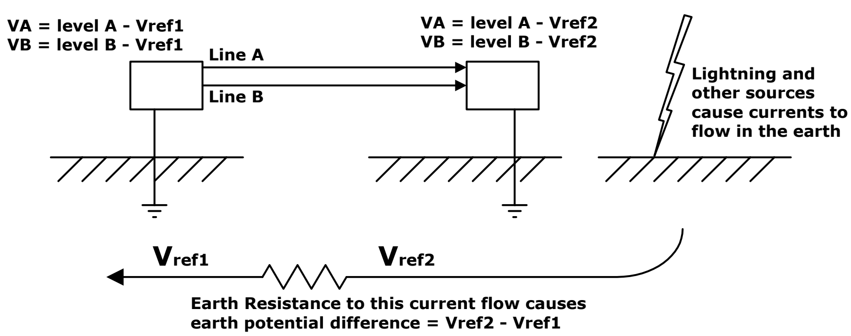
The two signals, set by the standard as A and B, are referenced to a third level called ground. There are several ways to implement this 'ground' or reference level, each of which has merits and drawbacks.

Earth ground is a commonly used reference voltage. Examples of earth ground are the green/yellow wire on AC mains and the chassis/case ground on computers.

The earth, being made of less than perfectly conductive materials, has a finite resistance between two points.

When the network is run through an electrically active environment, there may be currents running through the earth which, as a result of earth resistance, cause a difference in the level of the earth potential from point to point. This is particularly true in areas of high lightning density and where heavy current machinery or switchgear is installed.

In a situation where the transmitting and receiving devices are referenced to earth ground, as shown in the diagram, the reference voltages used by the devices may differ from each other as a result of currents in the earth.



The RS-485 standard accommodates an earth potential difference of up to 7 volts. Therefore, if the difference in the earth potential between two points of signal interpretation is greater than 7 volts, the data may not be correctly interpreted from the signal levels. Furthermore, the earth potential difference may damage the network drivers.

In the event of high voltage earth faults, lightning strikes or 'leaky' heavy current machinery, the earth potential difference between two points can be much greater than the 7 volt threshold.

For these reasons, the earth is an unreliable ground reference for RS-485 signals. Using widely distributed earth points as reference voltages could even lead to equipment failure.

A better way to ensure that signals are correctly interpreted is to dedicate a third conductor, such as the cable shield or an extra twisted pair within the cable, to reference. This solution is sometimes referred to as 'three wire' RS-485.

The reference conductor should be grounded at one point in the network, preferably at the power supply.

The ground of the transmitting device should thus be at the same level as the ground of the receiving device, ensuring that both levels are correctly seen by the receiver. This concept is referred to in Controlsoft documentation as 'common ground reference'.

When installing RS-485 networks, especially within electrically active areas, ensure common ground reference between network points.

Biasing

Interpretation of the data bit is based on the difference between the signals on line A and line B. A differential signal in the range -200 mV_{dc} to +200 mV_{dc} is too small to be recognized correctly and renders the line state indeterminate. Signals must be measured in the middle of the bit to avoid misinterpretation during the signal transition.

If network lines are left floating, that is, they are not forced into any state when they are not carrying data, noise of sufficient magnitude induced on the network lines may be incorrectly interpreted as data.

It is best to make sure that, when the lines are not transmitting any data, all devices are aware that the lines are idle. This is achieved by biasing the lines into a known state when they are inactive. The minimum differential voltage which can be interpreted as a state by the receivers is +/- 200 mV.

RS-485 lines are biased into a known state using pull-up and pull down resistors. This ensures that extraneous signals are not interpreted as data. When receivers see a distinct transition from the biased state, they can assume that it is data and not noise or an induced signal.

RS-485 transceiver devices often have a third state in addition to transmit and receive. This state, called 'tristate' or 'disable', presents a high shunt impedance to the network lines. The device or network must first enable the transceiver before transmission begins.

Appendix 3: References

1. TIA/EIA-485-A: Electrical Characteristics of Generators and Receivers for Use in Balanced Digital Multipoint Systems; Technology Industries Alliance, March 1998.
2. RS422 and RS485 Application Note; B & B Electronics
3. National Semiconductor Application Note 847; John Goldie, 1992
4. Example Applications: RS-485 Two-wire; Robust Data Comm
5. http://www.lvr.com/serport.htm; Jan Axelson

Appendix 4: Documentation resources

Document naming convention	
Convention	
AC-#### DOC Rev Y LLL-CC.pdf e.g. AC-3114 QSG Rev C ENG-US.pdf	
Hardware part codes (AC-####)	
AC-####	Controlsoft part number
Hardware documentation codes (DOC)	
QSG	Quick Start Guide
TRM	Technical Reference Manual
HIG	Hardware Installation Guidelines
IUM	Installer's User Manual
Document revision	
Rev Y	The current revision, ascending from A to Z
Language codes (LLL)	
ENG	English
Country codes (CC)	
US	United States of America

KeyMaster System reference documentation			
System	**Description**	**Documents available**	**Revision date***
AC-6000	KeyMaster System	Hardware Installation Guidelines (this document) AC-6000 HIG Rev A ENG-US	Dec 2002
AC-6000	DC Power Supply	Powering KeyMaster Systems Power HIG Rev A ENG-US	Dec 2002
AC-6000	RS-485 Wiring	Wiring RS-485 Networks RS-485 HIG Rev A ENG-US	Dec 2002
AC-6000	KeyMaster Lite Software	Installer's User Manual AC-6000 IUM Rev A ENG-US	Aug 2002
AC-6000	KeyMaster Lite Software	Quick Start Guide AC-6000 QSG Rev A ENG-US	Aug 2002
* Documents tabulated are current at the date of this document.			

KeyMaster System device documentation			
Device	**Description**	**Documents available**	**Revision date***
AC-4101	System controller	AC-4101 TRM Rev A ENG-US AC-4101 QSG Rev B ENG-US	Dec 2002 Sep 2002
AC-3114	System controller	AC-3114 TRM Rev B ENG-US AC-3114 QSG Rev B ENG-US	Dec 2002 Sep 2002
AC-4311	I/O controller	AC-4311 TRM Rev B ENG-US AC-4311 QSG Rev B ENG-US	Dec 2002 Dec 2002
AC-3151	Door controller	AC-3151 TRM Rev A ENG-US AC-3151 QSG Rev B ENG-US	Dec 2002 Sep 2002
AC-1300	PIN pad reader	AC-1300 TRM Rev B ENG-US AC-1300 QSG Rev C ENG-US	Dec 2002 Nov 2002
AC-1200	Wiegand reader	AC-1200 TRM Rev B ENG-US AC-1200 QSG Rev B ENG-US	Dec 2002 Sep 2002
AC-1100	Proximity reader	AC-1100 TRM Rev B ENG-US AC-1100 QSG Rev B ENG-US	Dec 2002 Sep 2002
* Documents tabulated are current at the date of this document.			