RIO General recommendations

RIO is fundamentally a single-master network, and the RIO processor (140CRP93x00) is the master node. The RIO processor is located at the PLC side, at the head-end of the RIO network. All other nodes on the network communicate with the RIO head via RIO adapters (140CRA93x00) located at the drops side. A Quantum RIO network can contain up to 31 drops. Each RIO Adapter on the network must be assigned a unique address number, which is set by rotary switches on the rear panel of the RIO adapter.

RIO legal topologies basis

RIO network topologies are precisely defined (single cable system, dual cable system, redundant cable system) and cannot be derogated from. Illegal topology may result into RIO Network dysfunction.

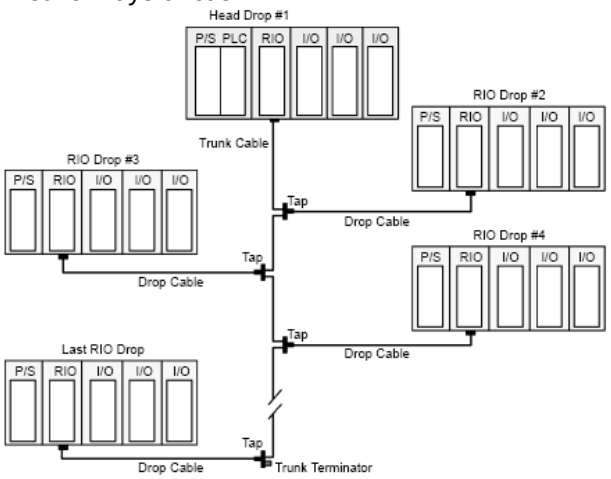
Trunk cable starts at the RIO processor and runs the entire length of the network as one or two (dual or redundant) *trunk* cable(s).
RG-11 cable (97-5951-000) is highly recommended for use as trunk cable.

Taps (MA-0185-100) are installed along the length of the trunk cable(s), and a drop cable is run from a tap to a drop adapter. The taps also isolate each drop adapter from all other drop adapters on the network so that they will not interfere with each other.

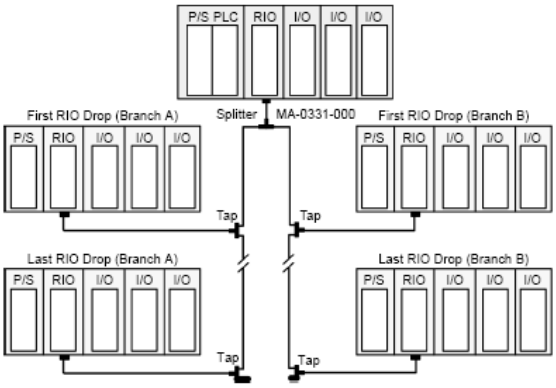
Note: When using previous version MA-0185-000 as a tap do not use a version earlier than Rev C.

Extending from a tap to an adapter is a drop cable. RG-6 cable (97-5750-000) is recommended for use as the drop cable.

Splitters (MA-0331-000) are used to create a branch in the network cable trunk. They provide isolation between the branches and allow the cable to be laid out in two directions.
Only one trunk splitter MA-0331-000 is allowed in a network.



View of a generic RIO network

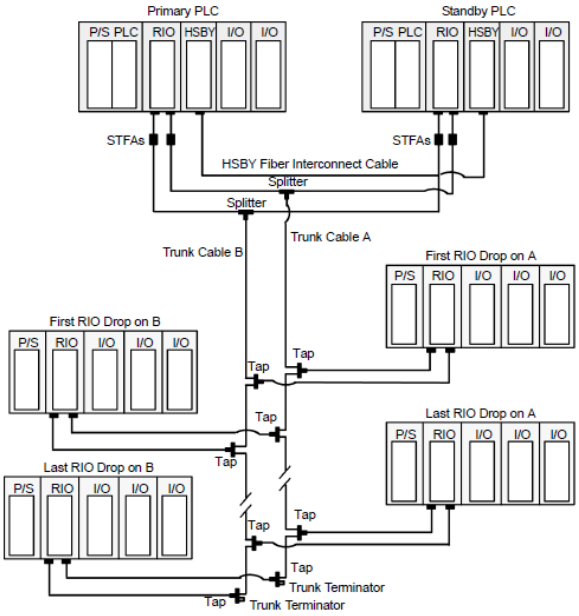


Splitter topology within single cable system

Focus on specific Hot Standby RIO topology

When using Hot Standby (HSBY), RIO network topologies are precisely defined (HSBY single cable system, HSBY redundant cable system) and cannot be derogated from. Illegal topology may result into RIO Network dysfunction.
HSBY system is based on two identically configured PLC's, therefore a specific splitter (MA-0186-100) connects the two RIO heads.
Only one trunk splitter MA-0186-100 is allowed in a network.

Note: When using previous version MA-0186-000 as a splitter do not use a version earlier than Rev B.



Dual-cable Hot Standby system topology

CAUTION

UNEXPECTED BEHAVIOR OF APPLICATION
Don't use more than one splitter as a branching device on the RIO networks.
This restriction applies to both MA-0331-000 and MA-0186-100.

Failure to follow these instructions can result in equipment damage.

Cabling recommendations to avoid communication signal disturbances

Lengths recommendations:

- The minimum length for a RG6 drop cable is 2.5m (8.53 ft) – shorter drop cable generates unacceptable signal reflections from the tap.
- The maximum length RG6 drop cable is 50m (164 ft). Keeping the drop cable lengths within this limit helps to reduce attenuation on the drop and noise issues on the system.
- The maximum length of the trunk cable is determined by the maximum system attenuation.
- Install taps at least 2.5m (8 ft 2 in.) away from one another. Indeed if taps are placed too close to each other (or too close to a splitter in a Hot Standby system), a cumulative reflection will result.

CAUTION

UNEXPECTED BEHAVIOR OF APPLICATION
Do not connect or disconnect a drop cable from a tap on an ACTIVE network. Either of these two actions can cause excessive communications errors on the network.

Failure to follow these instructions can result in equipment damage.

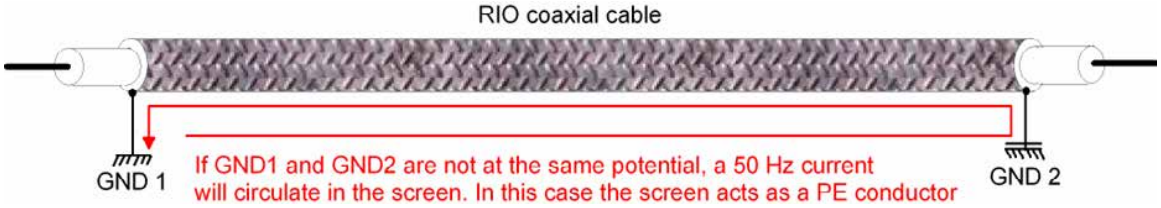
Network impedance:
All RIO cable & components have a characteristic impedance of 75 Ohms. A proper impedance match is required across the entire network with 75 Ohms terminators. Both RIO processor & RIO adapter have internal terminators.

Install the dedicated 75 Ω terminator to each unused port:

- add a 52-0422-000 terminator at the last tap of the network on the unused trunk port (trunk impedance termination).
- in any open drop cable ports on taps that have been installed for future system expansion, put 52-0402-000 terminators.
- in-line on cables running from the primary and standby controllers to the splitter in a Hot Standby system, put 52-0411-000 Self-terminating F Adapter or STFA, on RG6 cable; this allows you to disconnect one of the two Hot Standby controllers while the other one maintains primary control.

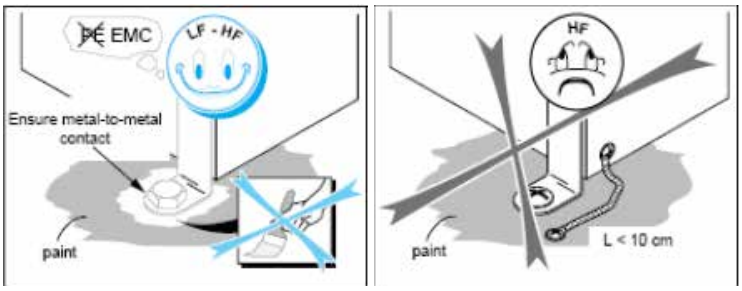
RIO network grounding

- The cable system should be grounded at only one point within 6m (20 ft.) of the RIO processor at the head-end of the network. A 60-0545-000 Ground Block, a single MA-0185-100 Tap, a MA-0186-100 Splitter, or a MA-0331-000 Splitter may be used; assuring that the cable system will be permanently grounded even when disconnected from the RIO processor.



This will assure safety for maintenance personnel and RIO users. Choose a low impedance earth ground for your cable system, preferably factory ground.

- A poor earthing and bonding condition affects electronics equipment (e.g. PLC's, I/O modules, communication interfaces, etc.) and by the way the quality of communication links (RIO, Modbus, Ethernet, etc.).
- For earthing, avoid long wires, loose contacts, contacts done on painted surfaces, that don't insure a good electrical contact.

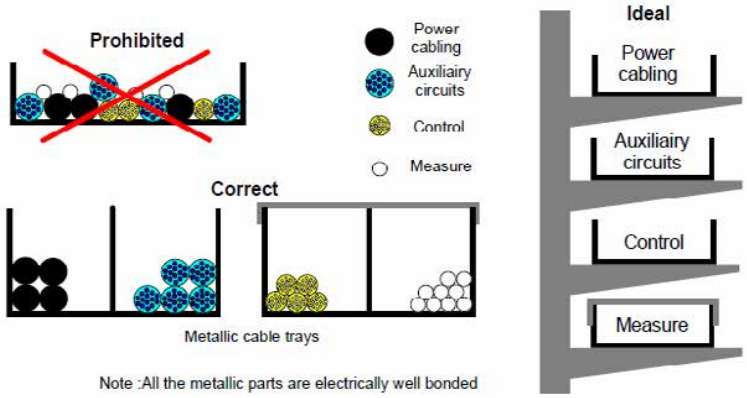


Guideline for avoiding Electromagnetic interferences

- The cable system must be dedicated to RIO – no other signals or power can be applied or transmitted on this network.
- Do not route trunk cable into equipment cabinets or panels. Trunk cable and taps should be mounted away from cabinets or panels in a separate enclosure.
- Install cable in steel conduit in high noise environments.

- Avoid installation of RIO cables in trays or conduits that contain AC or DC power cable or power services; Separate RIO cable from power cable or power sources; trunk cable runs should avoid panels, trays, and other enclosures that contain power wires. Make sure that any RIO cable shall cross power cable at right angles only.

Note: We recommend that a spacing of 0.3 to 0.35m/kV (12 to 14 in./kV) of power cablings shall be maintained between the RIO cable installation and power cables.



Mechanical considerations

- Minimum bending radii specified for the trunk and drop cables shall not be exceeded.
- The physical cable installation must be well supported, and cable pull strength must be considered; some manufacturers suggest that RG-6 and RG-11 cable be supported at least every 50 ft. Contact the manufacturer to ensure that you do not exceed the cable strain limit.

Note: If the cable is bent more than the allowable bending radius or if the installation is not adequately supported, you can easily damage the central conductor, the dielectric, and the cable shield. This damage can cause signal waveform reflections back into the cable system and distortions due to cable impedance alterations away from 75 Ω. The end result will be a series of transmission errors or a non-functioning link system.

Environmental conditions

In harsh electromagnetic environment (e.g. with a lot of power converters, powerful speed drives, long and very disturbing power cables running, motors, welding machines, power contactors, etc.) it is recommended, for communication networks, to use optical fibre media between different rooms, islands or buildings. The optical fibre provides electrical isolation between the different islands and avoid electromagnetic coupling regarding disturbing zones.

Surge suppressors are recommended when a cable system is installed outdoors or in any environment where lightning protection is required. The surge suppressor must be grounded to work properly.

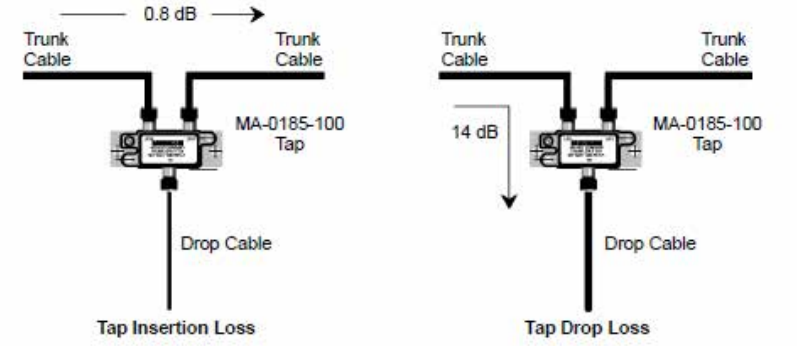
On the same equipotential room, coaxial cables could be used.

Designing a Coaxial Cable System to an Attenuation Limit

Attenuation on RIO network appears a signal passes through taps, splitters, splices, cables, connections and feed-through terminators. The attenuation between the head processor (or the last optical fiber repeater, if an optical link is used) and any drop adapter must not exceed 35 dB at 1.544 MHz. If the cable design exceeds the maximum attenuation limit, transmission error may occur on the network.

Cable attenuation: 97-5750-000 RG6 cable has 1.18dB/100m (0.36dB/100ft) attenuation at 1.544MHz.
97-5951-000 RG11 cable has 0.56dB/100m (0.17dB/100ft) attenuation at 1.544MHz.

Tap attenuation: All RIO taps have a 14dB drop loss and a 0.8dB insertion loss.



Maximum system attenuation at 1.544 MHz can be calculated as follows:

dB *loss* = TCA + DCA + TDA + (Number of splitters x 6) + (Number of taps x 0.8)

Where:

- TCA = the trunk cable attenuation from the head to the end of the trunk.
- DCA = the drop cable attenuation, generally at the last drop.
- TDA = 14 dB, the tap drop attenuation.

Note: On a network using dual or redundant trunk cables, calculate attenuation on each section separately. Each trunk on a dual or redundant RIO network can handle attenuation up to 35 dB.
Note: Use (Number of Splitters x 3.5) if MA-0331-000 is to be installed.

Specific use of Optical fiber repeaters (490NRP95400)

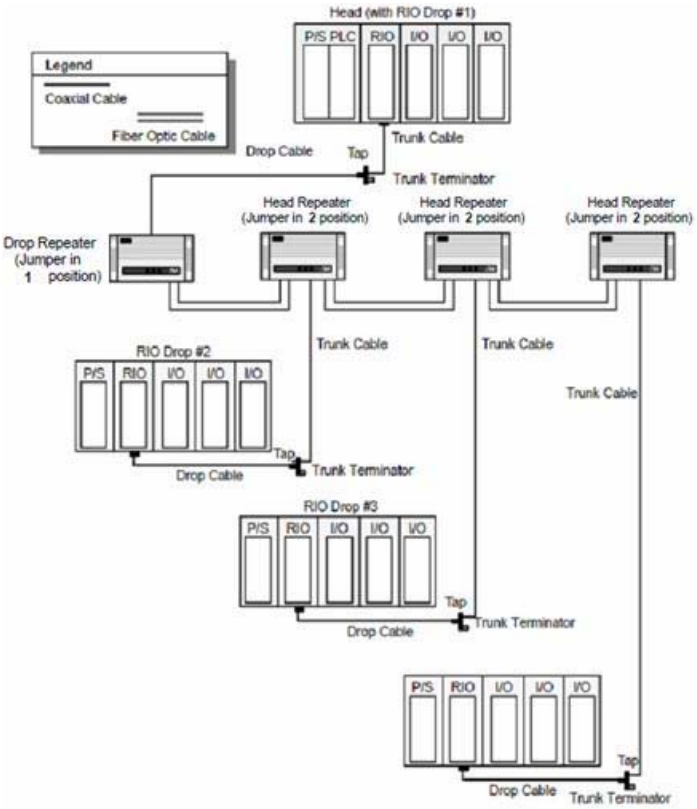
490NRP954 Optical Fiber Repeaters can be introduced in an RIO cable topology to allow you the transition from coaxial to fiber cable then back again to coax at one or more of the remote drops on any RIO network.

RIO Optical fiber Topologies

RIO network topologies, when using optical fiber repeater, are precisely defined (point-to-point, bus, tree or self-healing ring) and cannot be derogated from. Illegal topology may result into RIO Network dysfunction.
A maximum of five NRP repeaters can be used in a bus or ring topology.
The maximum distance between two repeaters is limited by the attenuation and the jitter of the optical fiber cable. This must be calculated separately from coaxial cable attenuation. The maximum length of optical fiber in a self-healing ring is 10km (32809 ft).

Note: On CRP side, the coaxial cable coming out of a tap from the trunk cable, running into a NRP optical fiber repeater is a drop cable. On CRA side, the coaxial cable coming out of a NRP, running into a tap to service CRA drops is a trunk cable.

Note: For more information, see RIO *Cable System planning & installation guide* (890USE10100) or *Optical Fiber Repeaters User's Guide* (GM-FIBR-OPT).



Earthing recommendations
When using optical fiber repeater 490NRP95400, either to extend total RIO network length, or to improve RIO immunity to EMC disturbances, NRP chassis must be connected to Ground, through dedicated screw. RIO cable shield must be set to specify the NRP relationship to chassis ground. Jumper switch is shipped in neutral position, it must be placed either in position 1, when NRP acts as a drop on CRP side (cable shield is isolated from chassis ground by a capacitor), or in position 2, when NRP acts as a head on CRA side (cable shield is connected directly to chassis ground).

Note: The NRP repeater RIO port has the same electrical specifications & restriction as the CRP Head processor.

Design precautions for optical fiber repeaters
- The NRP operates either from a 110/220VAC or from a 24VDC line power. When using the 24VDC power port, a dedicated 24VDC power source should be used with EMI low emission, to avoid injecting interferences on RIO network. Do not use this source to power any other equipment of the cabinet.
- Minimum bending radii specified for fiber cables must not be exceeded, for example when routing fiber cables into plastic trunking/tube. Plan for extra fiber length on main cable to prevent damages for mechanical constraints; use patch cords to connect the NRP fiber ports to the main fiber cable.
- Unused NRP fiber ports or fiber cables should be protected from dust – use dedicated caps.
- The RIO network must be powered off before installing or replacing an optical fiber repeater.
- Do not look at the ends of optical fiber cable under magnification while a transmit signal is present on the cable – severe eye damage may result. Use white light only.

⚠ CAUTION

EYE DAMAGE
Do not look at the ends of optical fiber cable under magnification while a transmit signal is present on the cable.
Use white light only.

Failure to follow these instructions can result in injury or equipment damage.

Attenuation & jitter considerations in a optical path
As with coaxial cable, on an optical fiber link, splices, cables and connections determine the attenuation. The allowable attenuation or Power Loss budget for the NRP repeaters to work correctly is 11.0dB for a 62.5/125µm multimode, graded index fiber, rated at 3.5dB/km attenuation at 820nm. This budget already includes the loss of the two ST-type connectors which connect at the two repeaters and also a system margin of 3dB.

dB *loss* = FCA x Length + (Number of additional connectors x CA) + (Number of splices x SA)

Where:
- FCA = the optical fiber cable attenuation per kilometer
- CA = connector attenuation
- SA = fiber splice attenuation

The maximum number of repeater in a network is five, but this number may be reduced by the RIO system total pulse-width distortion or jitter. The total allowable jitter equals 130ns for a RIO fiber network. The Jitter effects from fiber links separated by a coaxial cable segment are cumulative

For a 62.5/125µm multimode, graded index fiber, jitter contribution is 5.0ns/km. For each NRP repeater, the optic-to-optic jitter contribution is 10ns and the electrical-to-optic jitter contribution is 40ns (transmit and receive).

$$\textbf{Maximum number of repeaters} = \frac{\textbf{200ns} - (\textbf{fiber cable length} \times \textbf{jitter/km}) - \textbf{40ns}}{\textbf{10ns}}$$

Note: For other types of fiber and to know how to select optical fiber cable, see RIO *Cable System planning & installation guide* (890USE10100) or *Optical Fiber Repeaters User's Guide* (GM-FIBR-OPT).

RIO network commissioning

Commissioning the RIO network after initial installation, or any later modification, it is mandatory to perform the following:

- Time-Domain Reflectometer (TDR) measurement allows ensuring proper installation of the RIO copper network, but also quality of each component (trunk cable, drop cable, tap, splitter, termination, connectors), by measuring attenuations & return loss (total should not exceed 35dB budget) and checking network adaptation (no reflection should appear).
    - *Available from Tempo®: TV90 or TV220 Cable Scout™ - Cable TV TDR*

- Optical power loss kit allows ensuring proper installation of the RIO fiber network, but also quality of each component (patch cords, main multi-fiber cable, splices, connectors), by measuring attenuations (total should not exceed 11dB budget).
    - *Available from Fluke Networks™: SimpliFiber™ Optical Loss Test Kit*

RIO network grounding must also be verified during commissioning:

- Checking that Trunk cable is actually grounded at only one point within 6m (20 ft.) of the RIO processor
- Remove this single ground connection and check with an ohmmeter that the whole RIO cable is now isolated from Ground. When using optical fiber repeater, perform the same verification on all copper sub-networks.

CAUTION

ELECTRIC SHOCK

Do not disconnect RIO network from ground.

Hazardous voltage can appear on RIO cable in case of electrical fault on the network. This check should be done with installation being powered-down.

Failure to follow these instructions can result in equipment damage.

How to go further

- To know about RIO cable suppliers, cable preparation and installation procedure,
- To know about fundamental RIO network tests to ensure reliability,
- To know about RIO troubleshooting and common problems,
    - See RIO *Cable System planning & installation guide* (890USE10100).
    - See *Grounding and Electromagnetic Compatibility of PLC Systems - Basic Principles and Measures User Manual*

- To know about RIO optical fiber troubleshooting and broken cable detection
    - See *Optical Fiber Repeaters User's Guide* (GM-FIBR-OPT).

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Printed in 11 /2009