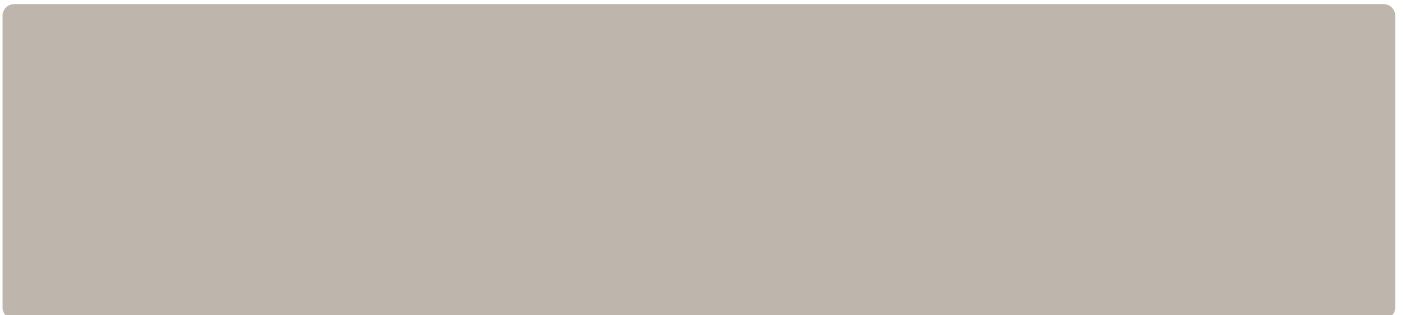


Best Practices for RFID Lift Truck System Design



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About This Document

This document provides guidelines (rather than rules) for RFID Lift Truck System Design. Design and deployment experience will lead to the development of a design methodology that works best for each particular individual and specific lift truck and lift truck RFID process.

This document includes tips and tricks for installing RFID hardware and cables. These methods will vary depending on how permanent the installation must be. Systems may need to be installed quickly for feasibility analyses or Proof of Concept (POC) work, but must be more permanently mounted for a full rollout of a lift truck system.



Note: Why use the term **Lift Truck** instead of **Fork Lift**? Not all lift trucks have fork attachments, but all of them lift something. There are many different types of lift truck attachments, but the fork attachment is most common.

Site Visits: Establishing Expectations

The better the understanding of your customer's expectations of RFID technology, the quicker the risks can be identified. If the customer is unwilling to change expectations, even if prior experiences with similar expectations were unsuccessful, you have two choices: respectfully tell the customer you will not participate in the POC or pilot and explain why — or prepare yourself for a science project!

To better understand the customer's expectations for an RFID system, you should perform a site visit. A site visit is a billable service under Intermec RFID Global Services and can include these activities:

- RFID Deploy Feasibility Analysis
- Proof Of Concept (POC)
- RFID Process Analysis
- RFID Site Analysis

The point is to make sure the customer understands the value of the service. When a deployment for a pilot or an installation occurs without a proper RFID Deploy Process Analysis, Site Analysis and Installation, the probability of success is greatly reduced.



The RFID Process and Site Analyses should occur prior to a pilot. A red flag should be raised if the customer believes these important studies are not required.

Site Visit Considerations

The customer may already have a vision of how RFID technology should be deployed in lift truck operations. This vision may already have been discussed in previous meetings or conversations. Work with your customer and document the project scope in writing to avoid scope creep, especially in a pilot or a rollout.

Among the items to note during the site visit:

- Document the customer's current process for lift truck operations.

- Determine whether the customer expects any mobile computers, sometimes called VMUs, to interact with the RFID readers. These VMUs may make use of scales and/or bar code.
- If the customer expects RFID to fit seamlessly into an existing terminal emulation (TE) application, or if the customer expects to use proximity sensors to trigger tag reading, hold a system software application discussion to set expectations for successful results.
- If the customer expects to use proximity sensors in the RFID system, explain that this is best worked out during a pilot. For more information, see **“GPIO for the IV7” on page 59**.
- If testing requires operating a lift truck so you can observe the process, ask the customer to provide a lift truck driver.



Note: Customers often insist that one of their drivers must operate the lift truck for testing. This is a liability and insurance issue, as many companies require their drivers to be certified on internal lift truck safety courses. Even though you may have passed an OSHA-certified lift truck safety class, the customer’s internal rules and regulations take precedence.

Conducting a Feasibility Analysis or Proof Of Concept (POC)

An RFIDDeploy Feasibility Analysis or Proof of Concept (POC) is a billable service. For POC work, most customers will want to see the forklift reader installed on the lift truck, and antennas positioned to read RFID tags. They will want to see if tags can be read simulating the system design required to meet their success criteria.

For a POC, ask the customer to document the success criteria, and then if the success criteria are met, identify the next steps. Get signatures if possible and acceptance. It is important to keep the scope of a RFID lift truck installation and the reason for it in proper perspective.

- Is this a POC that will last only a few days, or is this a pilot that will run for weeks or months?
- Is this a production rollout to be installed on a fleet of lift trucks?

The POC should adhere to the “keep it simple” approach. However, if the solution requires the readers and antennas to be mounted in a way that allows them to move with the load being tagged, it may make sense to order and install an Adaptable Load Back Rest (ALBR). This is the best way to show a professional looking installation.

For a Feasibility Analysis or POC, try to steer customers away from the expectation that the RFID reader and antenna will move up and down with the forks. But if the solution requires it, see **“Installing Multi-Conductor Cable” on page 36** to learn about studying the feasibility of using a multi-conductor cable from the lift truck cab to the load back rest.



Note: Although using Bluetooth communications between the IV7 and VMU is not officially supported, it is possible but not recommended. For more information, see **“Wireless Deployment for RFID” on page 63**.

Conducting a Pilot



The RFID Process and Site Analyses should occur prior to a pilot. A red flag should be raised if the customer believes these important studies are not required.

An RFID pilot will most likely require:

- application development.
- process change.
- cooperation from Operations.
- planning meetings.
- additional hardware.
- considerable time.

Most RFID pilots also require cooperation with the lift truck manufacturer or maintenance provider for costs associated with modifying existing lift trucks.

Planning for a Pilot

The issues to address are numerous and almost certainly require a project manager:

- 1** Project Plan
- 2** Process and hardware design in the form of a Process Analysis
- 3** Verification of the hardware design in the form of a Site Analysis
- 4** Hardware procurement.
- 5** RFID Tags (either rigid or smart labels)
 - a** Data format on tags
 - b** Tag commissioning.
 - c** Tag deployment.
- 6** Application design, development and testing. During the pilot, the application must be tested for sudden power loss and recovery.
- 7** Hardware installation on the lift truck.
- 8** Documentation of Milestones
- 9** Collection and analysis of data
- 10** Measurement of data against stated ROI
- 11** Measurement against success criteria



Note: For purposes of this document, only items 3 and 7 are being addressed.

Hardware Installation Considerations For a Pilot

In many cases, the IV7 and antenna will be located on the lift truck LBR. When determining the scope of the hardware installation, here are some issues to consider:

- RFID reading is often required in racking or items stacked in bulk storage.
- When reading a pallet tag on the pallet itself or a single tag on the pallet of product, most deployments for RFID in lift truck operations will try to identify what is being picked up before the operation actually occurs.
- The IV7 and RFID antenna will probably need to move with the lift truck attachment.

If applicable, recommend use of the Adjustable Load Back Rest (ALBR) that can be ordered from the Product Links section of the Price Guide. The IV7 has a specific configuration to support the ALBR, with the Antenna Cell as the preferred antenna.



Note: If the customer is willing to purchase ALBR units for all lift trucks being used for the pilot, make sure the lift truck hardware supports the ALBR. The ALBR is designed for use only with lift trucks that use a fork attachment. A clamp or other type of attachment requires a different solution.

If the standard LBR is used, the Bill of Materials (BOM) will be different than that for an ALBR. For more information, see [“Using the Adaptable Load Back Rest \(ALBR\)” on page 27.](#)

When a VMU Is Required

You may be required to install a VMU for a POC or pilot. The customer typically expects the vendor to do all the installation and not a mechanic. It is more important to do the installation correctly than to do it quickly. Make it look as professional as possible.

If multiple vendors are coming in for the POC or pilot, the customer will take great interest in how long it takes each vendor to install their equipment.

The installation of the VMU mounting bracket and VMU DC/DC power supply should be done by the lift truck maintenance provider. The VMU mounting location should be chosen with consideration given to the operator’s field of vision when operating the lift. The VMU DC/DC power supply mounting location must take into consideration the length of cables provided in the power supply kit.

Supplying Power

There are many options to consider when connecting and wiring power for the VMU and IV7. Consult the lift truck maintenance provider before installing the VMU DC/DC supply or wiring power to the IV7. Work with the provider to determine the best method and routes for power wiring based on the electrical schematics of the lift truck.

The preferred method for providing power and communications to the IV7 is to use a multi-conductor cable to connect the vehicle electrical system and the VMU to the reader. For more information, see [“Installing Multi-Conductor Cable” on page 36.](#)

Although the IV7 can work in a completely wireless solution, the reader was not designed for this type of installation. For more information, see [“Wireless Deployment for RFID” on page 63](#).

Power From the Lift Truck Battery

Gas powered lift trucks typically have a standard 12-volt car battery for starting the engine. Because the IV7 does not have an on/off switch, connecting the reader directly to the battery continuously drains the battery, possibly to the point where the truck cannot be started if it has been unused over a 12- to 24-hour period.

Intermec recommends that you provide a physical means of turning power to the VMU and the IV7 on and off, using a dedicated switch or possibly using the truck ignition switch.

Electric lift trucks will have much larger capacity batteries. To tap into the battery directly, you need to locate where the primary terminals from the battery inside the main control panel. Enlist the help of and get advice from the lift truck maintenance provider. Always disconnect the main lift truck connection prior to working on any wiring in the main control panel.

Using the DC/DC Power Supply Heater Output for IV7 Power

If you need to install a CV30 or CV60 to use as a VMU, you use the DC/DC power supply kit (P/N 203-779-001). This supply includes two outputs that power both the computer and the optional display heater for the CV60 (the CV30 heater does not require separate power).

If the lift truck will be operating in temperatures that do not require the CV60 heater, you can use the heater power output from the supply (12 VDC @ 4 A) to power the IV7. This option has been proven to work and provides several benefits:

- Powering the IV7 with the heater output voltage double-filters the power. Connecting the IV7 directly to the lift truck battery supplies the full lift truck battery voltage and battery amperage, which may produce heavy spikes at startup time even if filtered. The additional filtering provided by the VMU DC/DC supply protects the internal IV7 DC/DC supply from these spikes
- Only a single cable needs to be run to the lift truck power source for both the VMU and the IV7. Both units will share the same fuse and on/off switch (if used).
- The heater output voltage provides a good supply voltage for proximity detectors you may need to connect to the IV7 GPIO interface. The battery voltage on an electric lift could be too high for the sensors and is not conditioned, making a direct power connection to the battery undesirable. For more information on GPIO, see [“GPIO for the IV7” on page 59](#).



Note: To use the heater output to power the IV7, you need to splice the Port 2 pigtail of the Y-cable (P/N VE012-8019, included with the DC/DC supply kit) to the IV7 power cable. Cut off the connector and strip back the outer insulation. The red wire is 12 VDC+ and the white wire is ground.

RFID Applications and Abrupt Power Loss

An issue that should be addressed and resolved during a POC or pilot testing is the abrupt loss of power to the VMU while the RFID application is running. This can cause problems for Windows XP and Windows Mobile operating systems if it occurs frequently.

While a sudden loss of power does not affect the IV7 much, a VMU running Windows XP should be shut down like a desktop or notebook PC. Windows Mobile is much more forgiving, as it supports a suspend state.

A “shutdown” option in the application main menu is a good idea if the lift truck operator can be trained to shut the application down before turning off power. If the operator cannot be trusted to suspend or shut down the VMU before turning off lift truck power, then the best solution is likely a smart UPS back-up.

If a large fleet of electric lift trucks is used at a facility, the whole battery is replaced rather than using individual chargers for every lift. If a smart UPS backup is not in use, a shutdown process should be invoked before the main battery power cable is unplugged.

Propane-powered lift trucks will have the same issue, and powering the VMU DC/DC supply through the ignition switch will consistently cause an abrupt loss of power. The lift starter can pull the battery voltage so low that the VMU DC/DC supply resets.

Rolling Out a Lift Truck System

After solutions for issues and problems are worked out during a POC or pilot, the customer may wish to move ahead with a more permanent installation/rollout of the lift truck RFID system. This section covers some of the issues related to permanent, large-scale installations.

Hardware Installation Considerations for a Rollout

Many of the hardware installation techniques described so far are generally for temporary use, such as during a POC or pilot. For more permanent installations, Intermec recommends working directly with the lift truck fleet maintenance provider or in-house mechanic to determine the best design for the system. The fleet maintenance provided may be the best installation services provider for large-scale installations.

For more information, see [“Hardware Installation Considerations For a Pilot” on page 8.](#)



Note: Intermec Service should be contracted to install the electrical wiring on the lift truck to support power to the VMU or the IV7C. If this is not possible or practical, and the customer’s in-house mechanic or maintenance provider does the electrical work, Intermec cannot be held liable for problems related to these installations.

Considerations for VMU Mounting

For a rollout, let the lift truck mechanics determine the best method to mount the VMU. Instead of the clamp-and-pinch methods used for mounting the VMU during the pilot, they may want to drill holes for a permanent installation.

At this point, the customer needs to determine if drilling holes in the lift trucks is feasible or acceptable. For more information, see [“Installing the VMU and DC/DC Supply Kit” on page 26.](#)

Considerations for Power Supply Mounting

The battery connection for the VMU DC/DC supply and IV7 should be resolved as part of the pilot testing **before** a rollout. Some considerations for permanent installation are as follows:

- For a permanent installation, the maintenance provider should determine the mounting location of the DC/DC supply. If the supply will be hidden from view, the mechanic should make sure the supply is mounted against metal to use as a heat sink. The mechanic should adhere to the instructions provided with the power supply kit. There are no known issues with putting the DC/DC supply on the roll cage if the lift is not used outside.
- The customer should be aware of the fuse holder location and have a supply of extra fuses. If fuses are constantly blowing, it is a good indication that something is wrong.

For more information on power supply considerations, see [“Supplying Power” on page 8.](#)

Installing Hardware

This section outlines some techniques for quickly installing RFID hardware on customer lift trucks during feasibility analyses or POC work.

For all installations, you should consult the lift truck maintenance provider. This service may be provided by an in-house mechanic, or it may be provided by the original lift truck vendor. Either way, certain aspects of the installation require the specialized training and know-how that the maintenance provider should possess. The maintenance provider should be doing the bulk of the installation.

Suggested Tools

This list of tools is based on prior experience. Continued experience will refine what tools and supplies are preferred for an installation.

- Digital voltmeter (a **must-have**).
- Heat shrink gun.
- Wire strippers. You may want several with 10-gauge to 28-gauge ranges. One wire stripper must support crimping spade lugs, fuse ends, and crimp connectors.
- Allen wrench and socket set.
- Torx socket set.
- Metric 1/4-in drive set. You may need up to a 19-mm socket.
- Ratchet drive and extensions.
- Open end wrench set (English and metric).
- Needle nose pliers and line pliers.
- Various size drive bits for slotted, Torx, Phillips, square and Allen fittings.
- Removable bit drive ratchet screwdriver.
- Deep sockets suitable for u-bolts (with forklift installation kit).
- Cordless drill (for more permanent mounting).
- Telescoping magnet - handy if you drop a nut or bolt inside an electrical connection box.
- Telescoping mirror for when you mount the IV7 or the DC/DC supply in a place where you cannot see the LEDs (sometimes unavoidable).
- Crimp tool if you will be using the Intermec coaxial cable kits to prepare RFID antenna cables.

Useful Hardware for VMU and IV7 Wiring

Before starting the task of wiring VMU and IV7 power you should procure these useful items.

- If installing the IV7 and antennas on a standard load back rest (LBR), you need a forklift installation kit and hardware (P/N 203-769-001).
- Wire crimp connectors. Bring various sizes supporting 12- to 18-gauge wire. These connectors can also be found with heat shrink at each end.

- Extra heat shrink tubing.
- Black poly wire sheath. This can be used to provide additional protection to cables being pinched.
- Toggle switch rated to 15 amps. A metal switch is preferred over plastic.
- Plastic tie wraps in long, medium, and short lengths. Black tie wraps look better than white and have better UV exposure qualities.
- Extra wire is often required, such as two- or three-conductor cable with at least 18-gauge individual conductors, similar to the IV7 power cable.

Required Cables

For a Feasibility Analysis or POC, in addition to the RFID reader, antenna hardware, and tools, you need these cables:

- An IV7 I/O cable with a right-angle connector (P/N 236-089-001). This cable splits to both a 25-pin connector (for GPIO devices) and a 9-pin connector for RS-232 communication with a VMU.

The 5-ft pigtail on the 9-pin cable allows you to run it straight through the mast along with power. You can coil up the 25-pin line and hide it behind the IV7 with Velcro circle clamps.

- An IV7 power cable kit with a right-angle connector (P/N 203-713-002). You can run this cable through the center of the mast also.
- A standard modem cable (such as P/N 321-497-101, from the IF4 section of the Intermec Price Guide). Two of these 6-ft modem cables can be beneficial.

Required Applications

For ease of installation, try to conduct the feasibility analysis or POC with the JRFID application on your laptop. No interface with a customer host or VMU is required in this case, as you are just proving tag readability. However, if the customer requires the RFID installation to work with or connect to a VMU, more issues must be addressed and more time will be required.

Installation Examples

Often the equipment is installed on a standard lift truck load back rest (LBR). If possible, you should use the Adjustable Load Back Rest (ALBR). The installation will look more professional and can use the ALBR Antenna Cell. For more information on using the ALBR, see [“Using the Adaptable Load Back Rest \(ALBR\)” on page 27](#).

If lift trucks in the customer’s operations have no LBR installed (common in LTL lift truck operations), positioning the RFID reader and antennas can be challenging, assuming that the antenna and reader need to be on a movable part of the lift. If the hardware can be mounted on the stationary part of the lift, this is not a concern.

The next section includes photos of basic installation techniques you should use for quickly installing hardware during a Feasibility Analysis or POC.

Basic Hardware Installation

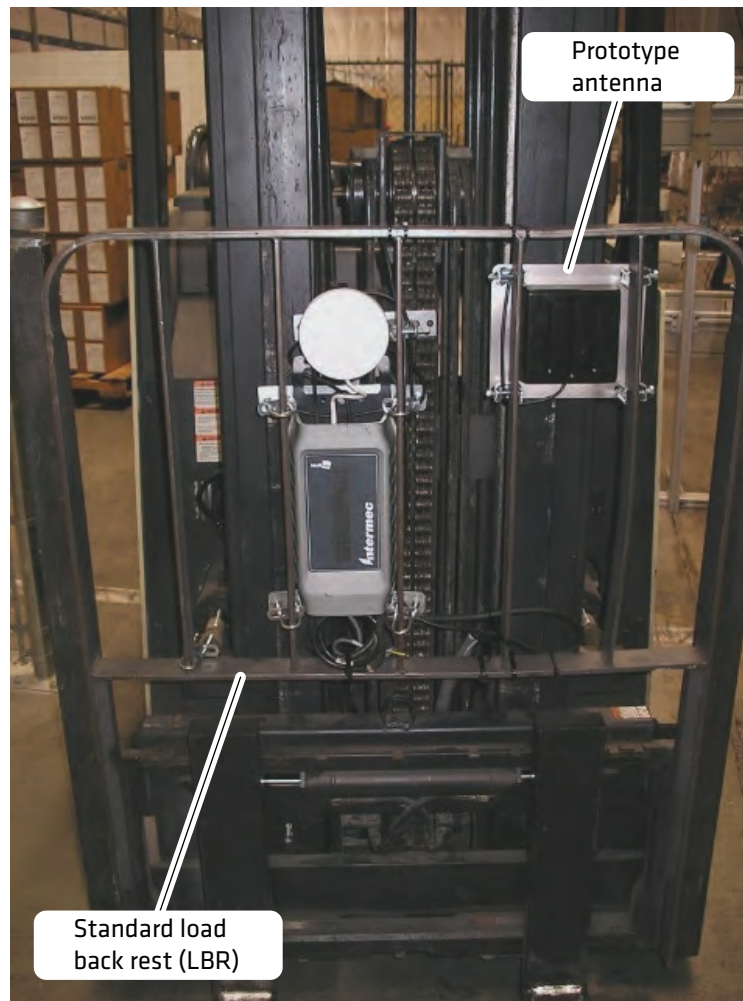


Figure 2 - Antenna Mounted on Standard Load Back Rest (LBR)

This photo shows a prototype antenna on the mounting plate with beam clamps. These can be moved anywhere on a standard LBR. The IV7 installation will take a longer with the straps and the u-bolts. Keep the hardware fasteners loose until all the u-bolts, back plates, straps and nuts are assembled - then tighten everything.



Note: Early applications on standard LBRs used prototype antennas. If you must install the hardware on a standard LBR, use the Antenna Cell (805-816-002) when possible.

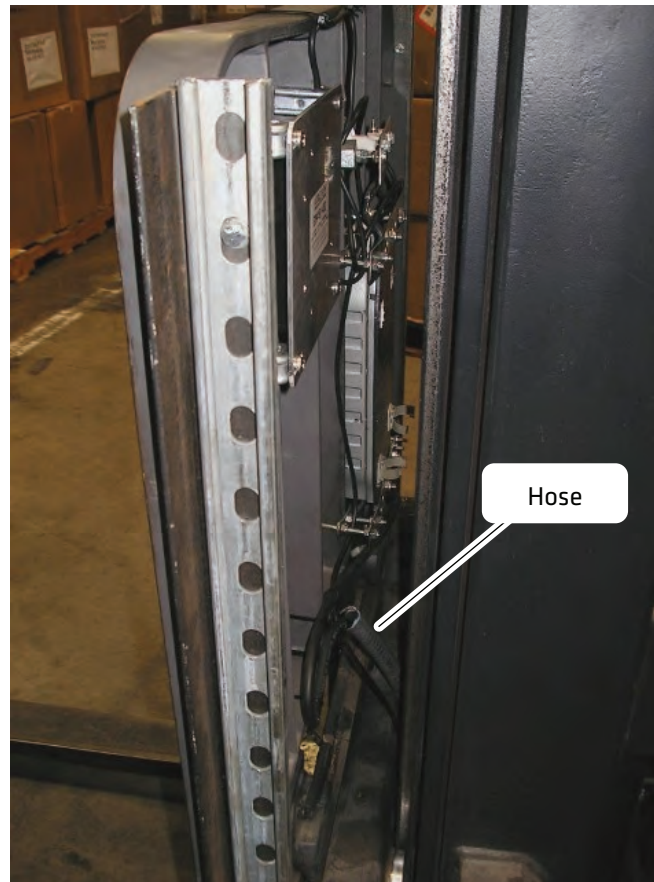
Using the LBR to Protect Hardware



Prototype Antenna Mounting: *Prototype installation before release of the Forklift Installation Kit (P/N 203-769-001)*

This illustration shows how the LBR protects the IV7 and antenna. The IV7 and antenna are mounted on the backside of the LBR to prevent damage from the load.

Protecting Cables



Cable Protection: The short piece of hose protects the multi-conductor cable during side shift operations, preventing damage and wear on the cable.

This photo shows the backside of an installation on a lift truck equipped with a side shift accessory. A short piece of hose helps prevent wear on and damage to the multi-conductor cable.

Running Power and RS-232 Connections to the IV7

The preferred solution is to run power and RS-232 to the ALBR from the cab and make connections in between with Molex connectors or some quick connect/disconnect connectors. Leave enough extra cable so the forks can be raised no higher than one or two feet off the ground.



Power and RS-232 Cabling

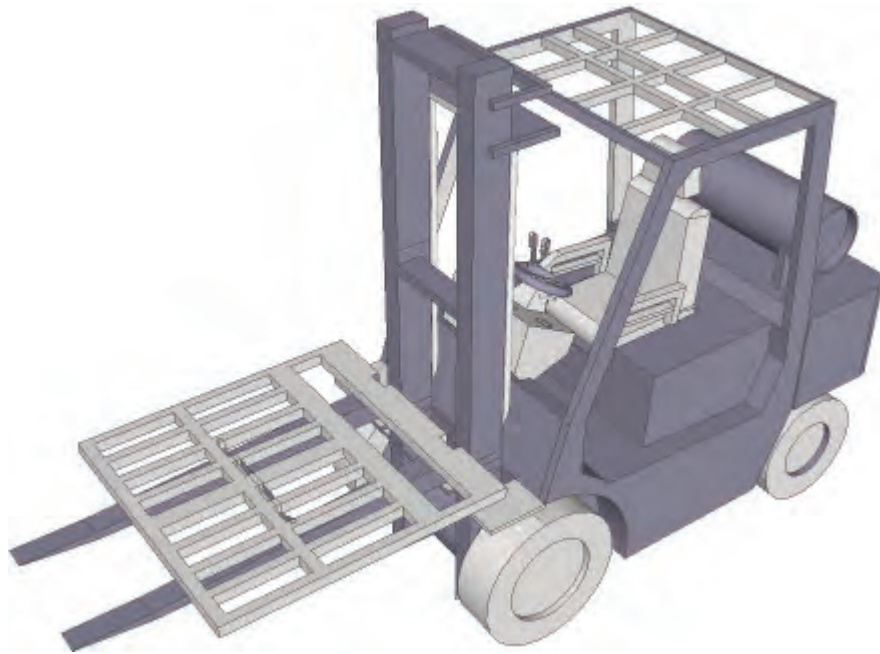
This illustration shows an example of cable routing between the mast and the front cowling of the lift truck. Power and RS-232 lines are covered with black poly and attached to the cowling with black Velcro squares. A standard modem cable is run to the inside of the cage and a Molex connector is used for power.

Power and RS-232 cables for the IV7 are run through the center of the mast and connected to those on the cowling. Power and RS-232 connectors for the IV7 are not shown, but they come from a larger black poly line going through the center of the mast.



Note: If the fork lift must be used for operations between testing periods, disconnect the lines and secure with tie wraps.

Pivoting the LBR for Easy Hardware Installation



LBR in Horizontal Position

Installing the IV7 is much easier if you can lower the LBR to a horizontal position as shown in this illustration. Raise the lift truck forks, loosen the lower bolts on each side of the LBR, and remove the top bolts on each side. Pivot the LBR forward and down onto the forks.

The LBRs on some lift trucks may have bolts that go in from the front and not the sides. You may find it easier to remove the LBR as sometimes the clearance between the LBR and mast can be very tight.

Installations For Lift Trucks Without an LBR



Lift Truck with Mounted Scale: Scale is attached to the lift carriage, with the forks placed on the scale attachment. Coiled cable provides power and RS-232 connections to the scale.

This photo shows a lift truck with no LBR and a very short mast. Note the scale which gets its power via the coiled cable. For a pilot or rollout, consider another coil cable to handle power and RS-232 to the RFID reader if you have to locate it on the scale. For a Feasibility Analysis or POC, a quick solution is required. Do not try to figure out a production solution as you would for a pilot or a rollout.

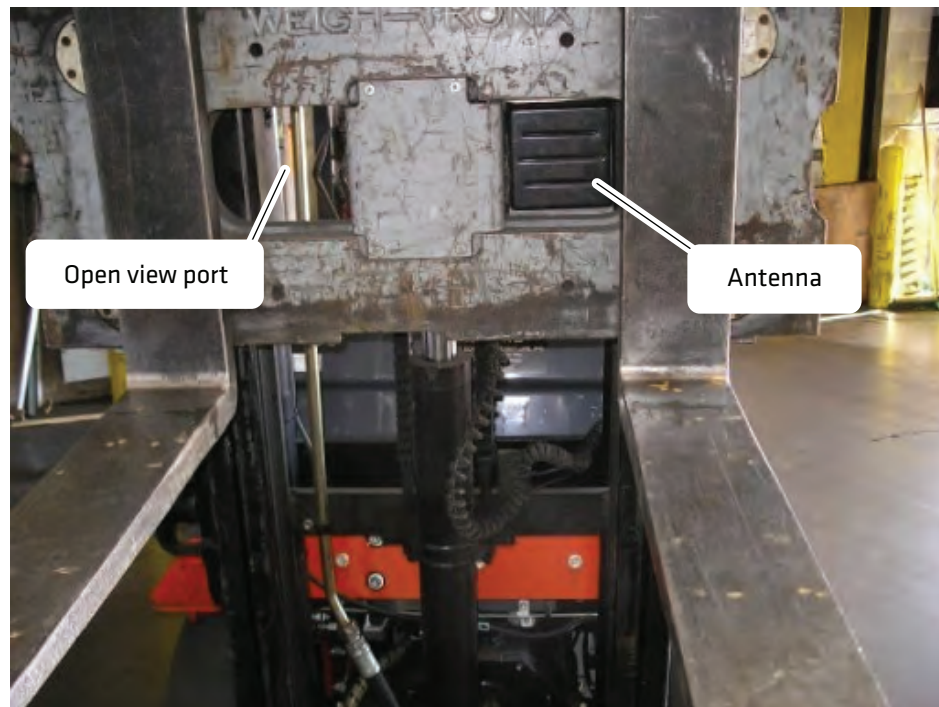
Installing Only the Antenna on the Load Back Rest



Antenna Testing: Antennas are mounted on the LBR. Temporary cable run goes to IV7 mounted on lift truck.

A quick way to test an antenna on a LBR is to run the coaxial cable as shown in this illustration. The IV7 was mounted in the cab. You can disconnect the coaxial cable and secure it to the LBR if the lift truck has to be operated between testing periods.

Mounting Antennas in View Ports



View Port Mounting: Antenna is mounted in view port on right.

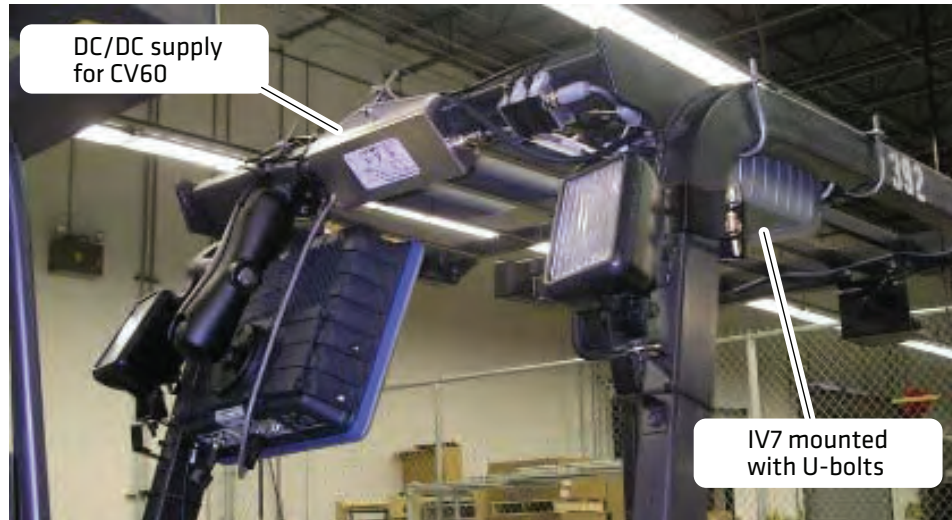
In this illustration, the antenna was located in one of two view ports and the coaxial cable was routed through the coiled power/RS-232 cable to the scale. The IV7 (connected to a CV30 acting as a VMU) was mounted on the roll cage. The forks could be raised and lowered and the antenna cable was run through the coiled cable. Coiled cables are sometimes usable when the height that the forks can be raised is limited, but are rarely usable for permanent installations. For more information, see [“Using Coiled Cables” on page 54](#).

VMU Installation Examples

This section includes examples of installing and connecting a VMU in a variety of situations. The methods shown primarily apply to POC and pilots. Some methods may be fine for installations, as access and ease of installation are critical in a large deployment.

- Ask several fork lift operators on site what they prefer. If the lift operators do not like the installation, it will be hard to gain operator and supervisor support for the project. Allow the operators to be part of the decision-making process.
- Avoid drilling holes if possible. Holes are permanent, the lift could be a rental or lease (thereby incurring potential damage and additional expense), and OSHA has regulations about drilling holes in the roll cage beyond what the manufacturer provides.
- Since the pilot may run for several weeks or even months, make sure everything is tightened down well. Liberal use of Loctite is not a bad idea.

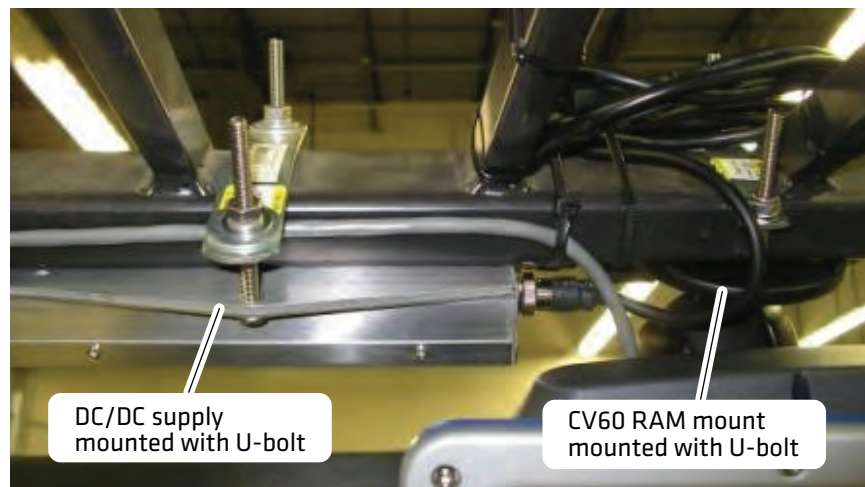
CV60 Power Supply Installation



Power Supply Installation: DC/DC supply and IV7 are secured to roll cage with U-bolts.

The next photo shows the IV7, CV60, and the dual output DC/DC supply for the CV60. Since the power indicator light on the supply helps with troubleshooting, mount the supply in a location where the light is easily seen. This installation uses the heater output voltage from the DC/DC supply to power the IV7 as described in [“Using the DC/DC Power Supply Heater Output for IV7 Power” on page 9.](#)

Using U-Bolts for Quick VMU Installation

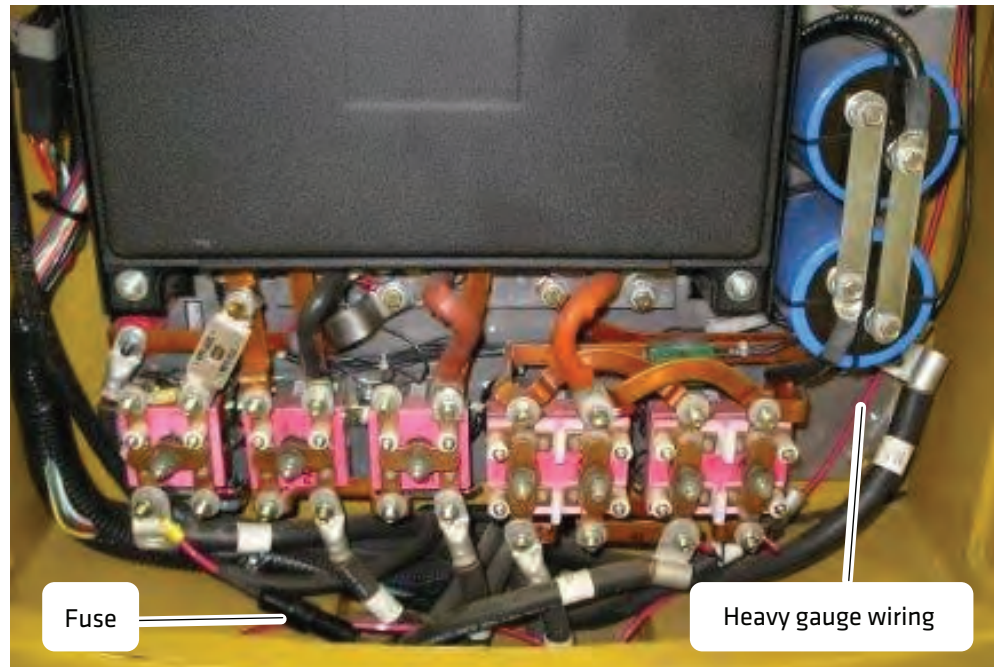


U-Bolt Installation: VMU mount and DC/DC supply are mounted with U-bolts.

This photo shows how to use U-bolts for mounting the DC/DC supply and the VMU mounting base. The CV60 “long mount arm” is best for this method.

U-bolts are good for installations on rounded roll cages or tubing. Use a U-bolt that matches the holes for both the DC/DC supply and the base plate of the mount. The back plate for the U-bolt can also be used with standard bolts instead of the U-bolt if it suits the installation.

About Power Connections on an Electric Lift Truck



Main Electrical Panel Connections: Note use of heavy gauge wiring. Fuse is located close to positive supply.

This photo shows how the main electrical panel connections might look for an electric lift. The location of the panel varies with the type of lift. The panel access door or plate may have a schematic showing where +Vbat and -Vbat come in. Always position the fuse close to the positive connection point.

Note the heavy-gauge black and red wiring. Heavier gauge cable can help suppress voltage spikes. You might prefer using this instead of the cable supplied with the DC/DC supply. To use this cable instead, cut the power cable from the converter input about six inches away from the connector and splice in the heavier gauge cable.

Cable Routing Considerations

As seen in the next illustration, the power cable exits the junction box and is routed along the roll cage to the DC/DC supply.

Prior to starting the wiring, plan the route that your wire must take. Some issues to consider:

- Protecting the wiring with some form of black poly sheath is highly recommended.
- To reduce the risk of damage, always run a cable on the inside of the roll cage.
- Before power is turned off, a CV60 should have a graceful shutdown and a CV30 should be suspended. Because of this, Intermec does not recommend powering equipment from a connection that becomes hot only when the key is turned on.

- When the DC/DC supply is located as shown, it can be disconnected at the input to the supply whenever testing is not underway, or when the lift may sit idle for awhile.
- A propane lift has a car battery for starting. Because the IV7 does not have a power switch and the DC/DC supply draws current even when the VMU is not turned on, the reader and power supply may drain this battery even when sitting idle. Intermec recommends a switch or other battery protection device for propane lifts to prevent draining the battery, which could keep the lift from starting.



Protecting the Cable: Power cable is secured to inside of cage with cable ties. Note the seat hinges nearby - keep wiring clear to minimize operator safety problems and cable damage issues.

Mounting a CV30

This example shows a CV30 mounted with a U-bolt from the side of the roll cage. The side mount allows the VMU to be adjusted lower, which keeps the operator's field of vision clear. The CV60 mounting bracket should be used with the CV30 and often the long mounting arm is best.



CV30 Horizontal Mounting: Driver's field of vision is clear with the CV30 mounted at this height.

Because this installation was done for a trade show, every effort was made to make a professional-looking installation. Instead of long, unsightly tie wraps around the roll cage, note the black square Velcro tie wrap attachments. All lines were covered in black poly sheathing.



CV30 Horizontal Mounting: A single U-bolt holds the VMU mount to the roll cage. Poly sheath and Velcro fasteners provide a finished, professional look.



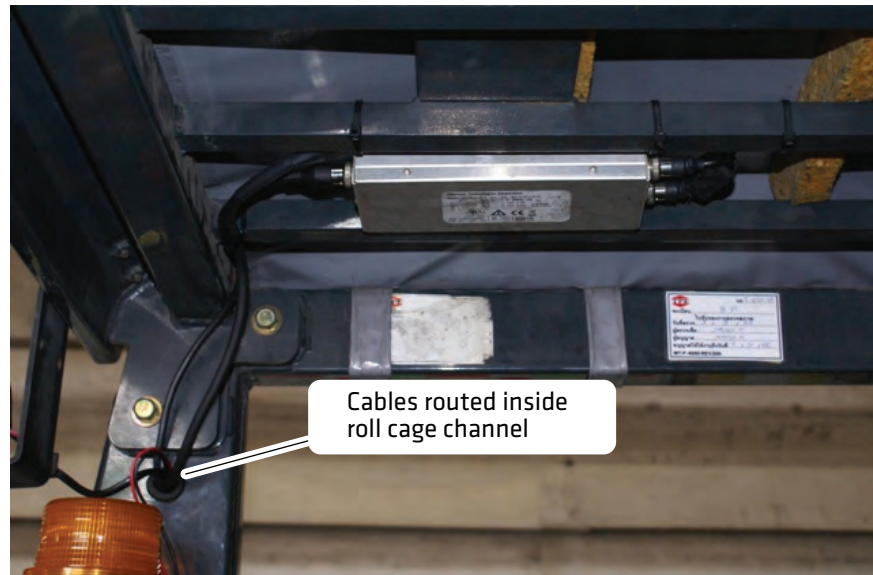
Mounting to Top of Roll Cage: VMU mount is secured with U-bolts.

Installing the VMU and DC/DC Supply Kit



VMU Mounting: Holes were drilled in the roll cage for VMU mounting. Note splices in cable.

If holes are drilled in the lift truck roll cage, make sure the mechanic or customer performs this task. There are potential liability issues at play and you want to stay out of that decision process. The lift truck could be leased and some lift truck vendors will claim that the roll cage integrity (protection rating) would be compromised if holes are drilled. Use U-bolts and brackets that match the bolt hole pattern of the VMU base to avoid drilling holes.

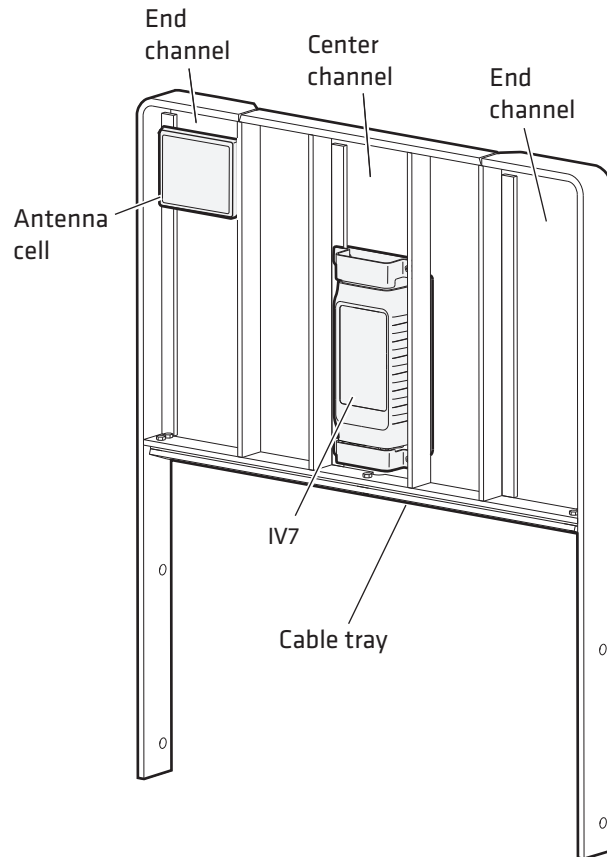


Cable Routing: Note use of grommet in drilled hole to prevent cable damage.

When selecting a mounting location for the VMU DC/DC supply, try to keep the LEDs on the supply easy to view for troubleshooting. The lift truck roll cage is one option to consider for installation. The roll cage also provides a quick and easy way to route the required cables with tie wraps or cable clips provided with the kit. Always route the cables on the inside of the roll cage to prevent damage.

Using the Adaptable Load Back Rest (ALBR)

If the POC or pilot shows that the best solution is to mount the reader and antennas on a load back rest, then using the adaptable load back rest (ALBR) is the best solution for a large rollout to a fleet of trucks.



Adaptable Load Back Rest: In this view, the IV7 is mounted in the center channel and the antenna cell in one of the end channels. All channels are the same width for maximum flexibility in hardware installation.

If the ALBR is not being used for installation/rollout, the installation will be more time-consuming. Make sure all cables are protected from damage and suggest applying Loctite to all bolt threads.

Ordering the ALBR

The ALBR is made by Cascade Corporation. To order an ALBR, see the Product Links section of the Intermec Price Guide and look for the Cascade contact information. Cascade requires that you provide specific measurements for the lift truck in question. If a Cascade side shift attachment is already installed on the lift truck, you need to provide the model number. Contact Cascade directly for more information.

Installing the IV7 and Antenna Cell on the ALBR

This section includes examples of RFID hardware installations on the ALBR.

Basic instructions for installing the IV7 and antenna cells on the ALBR are included in the [IV7 Vehicle-Mount Reader Instructions](#) (for forklift back rest mounting plate).

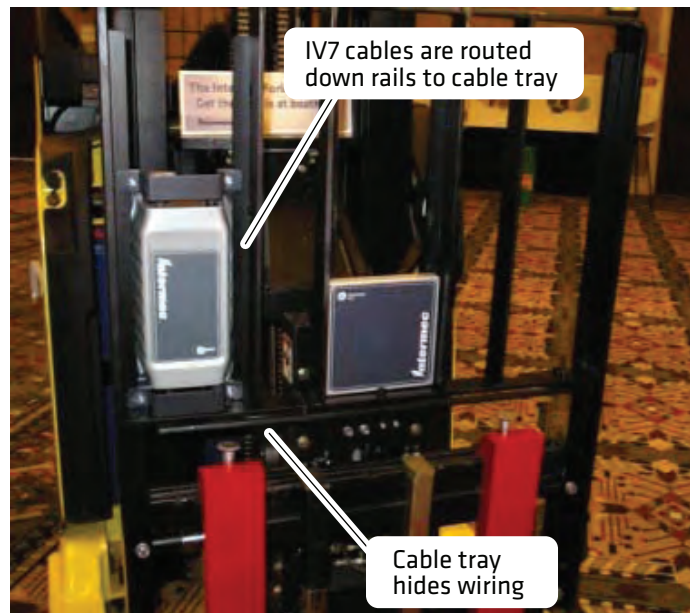


Note: Since the pilot or POC should have determined the best locations to mount the IV7C and antennas, they can and should be installed on the ALBR before installing the ALBR on the lift truck.

It is easiest to lay the ALBR on the forks and raise it to a convenient height for installing equipment and routing cable.



Ease of Installation: ALBR is laid horizontally on the forks while RFID hardware is installed.



IV7 and Antenna Cell on ALBR: Cables are routed down rails on backside of ALBR to cable tray.

Keep the coaxial cable wires loose to allow making adjustments during testing. Wait to secure all the wiring until after testing is done and the desired reading performance is achieved. The antenna cell can be slide up or down to make adjustments.

Keep the power and I/O connectors on top of the IV7 and route those cables down the sides of the IV7 to the cable tray. This is the best way to protect those cables from damage.



Close-up of Cable Routing: Note cables run down along rails to cable tray below.



IV7 and Multiple Antennas: 4-antenna installation with IV7 in center channel of ALBR and antennas in end channels.



Backside of ALBR: Note cable tiedowns along ALBR rails. All cables are run to cable tray for added protection.



Installing Cables in ALBR Cable Tray

As seen in the photo, the cable tray provides plenty of room for cables. Excess cable can be folded inside the cable tray and secured with tie wraps.

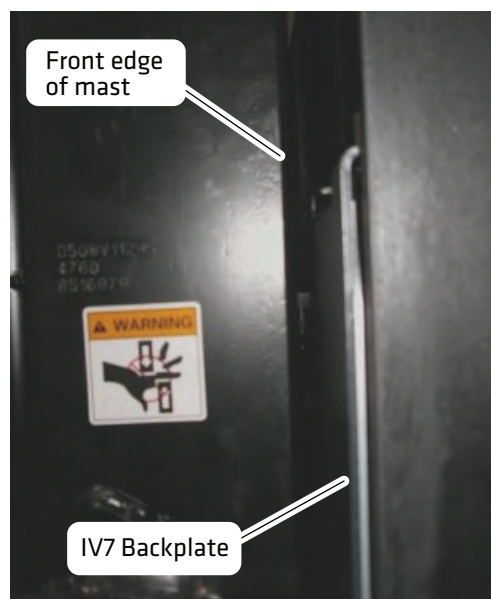
Note the use of adhesive tie points in the cable tray. The squares also come in black and can be found at hardware stores.

The next illustration shows the ALBR with IV7 and antenna cell on a Hyster lift.



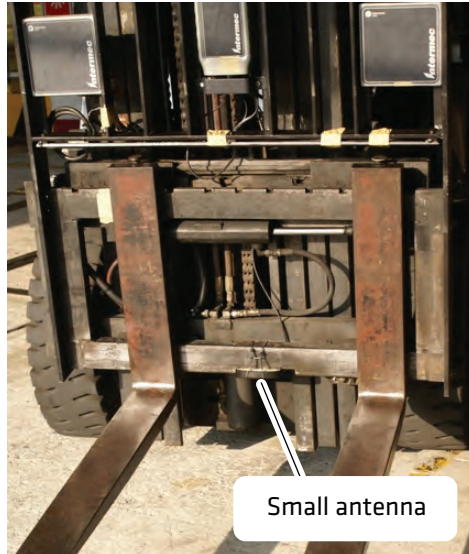
IV7 and Antenna Mounted on ALBR: IV7 is placed in end channel, with antenna in center for best tag reading in this installation.

The clearance between the mast and the ALBR or LBR may be narrow on some lifts. Insert large washers on the ALBR bolts for Yale or Hyster lifts to add clearance between the mast and the IV7 on the ALBR or LBR.



ALBR Spacing: When there is little clearance between the ALBR and the mast, insert washers to provide more clearance.

The next photo shows an ALBR installation that includes another antenna mounted below the fork attachment.



Additional Antenna: This small antenna for reading location tags in bulk storage was mounted below the fork attachment.

Coaxial Cables for the IV7

This section explains how to prepare coaxial cables to be used when connecting the IV7 reader to RFID antennas.

Intermec supplies two short coaxial cables suitable for use when the IV7 and antennas are mounted together on the LBR or ALBR.

Preassembled Coaxial Cables

Intermec P/N	Length	Use for This Version	Connectors
203-850-001	4.5 ft	FCC	RP-SMA-P to RP-N-P
203-851-001	1.4 m	ETSI	SMA-P to N-P



Note: Use these preassembled cables whenever possible instead of using a cable kit.

If you need longer cables, Intermec also supplies the following coaxial cable kits which can be cut to length as needed. For current pricing, see the IV7 Cables section in the Intermec price guide.

Coaxial Cable Kits

Intermec P/N	Length	Use for This Version	Connectors
203-719-001	3.6 m	ETSI	SMA-P to N-P
203-719-002	6 m	ETSI	SMA-P to N-P
203-720-001	12 ft	FCC	RP-SMA-P to RP-N-P
203-720-002	20 ft	FCC	RP-SMA-P to RP-N-P



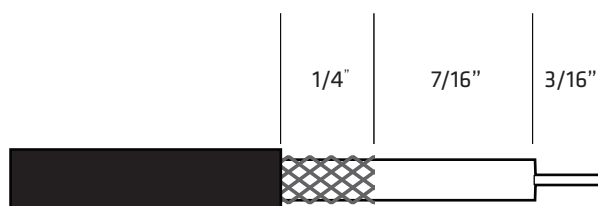
Note: You must have the crimp tool (P/N 592154) to attach the appropriate connector to the unterminated end of the cable. The kit does not come with instructions for cable preparation. For help, see the next section.

Making Custom Coaxial Cables

If you are using a coaxial cable kit to create a custom length of cable, follow the next procedure to install the appropriate SMA connector on the unterminated end of the cable. You need the crimp tool (P/N 592154) to install the connector. Intermec recommends you also have a pair of wire strippers that includes 10- and 18-gauge settings.

To prepare IV7 coaxial cables

- 1 Cut the RG 58 coaxial cable to the desired length. Remember it is better to have some extra cable than to have the finished cable be too short.
- 2 Slide the metal sheath over the cable.
- 3 Use a wire stripper with a 10-gauge strip setting to strip off 1" of the black insulation. Do not cut or nick the metal braid.
- 4 Peel back the metal braid and trim it to 1/4" past the end of the black insulation.
- 5 Measure 7/16" from the end of the braid along the center insulator, and use the wire stripper 18-gauge setting to strip the center insulator (about 5/16") from the cable.
- 6 Trim 1/8" from the end of the center conductor. There should be about 3/16" left of the center conductor. The cable should look like the next illustration.



Coaxial Cable Preparation: Strip the end of the coaxial cable to the dimensions shown. Do not nick the braid or center conductor.

- 7** Use the .10 slot in the crimp tool to install the pin on the center conductor:
- a** Seat the pin in the .10 slot as seen in the next photo.
 - b** Squeeze the crimp tool just enough to hold the pin in place.
 - c** Twist the center conductor slightly to ensure there are no loose strands.
 - d** Insert the center conductor into the pin and squeeze the crimp tool tightly.
 - e** Release the crimp tool and pull on the pin to ensure it is crimped well.



- 8** Slide the N connector shell over the pin and against the end of the black insulation.
- 9** Fold the wire shield up around the base of the shell.
- 10** Slide the metal sheath over the top and snug against the N connector shell.
- 11** Use the .213 slot in the crimp tool to crimp the metal sheath onto the cable.

Installing Multi-Conductor Cable

If the best solution includes mounting an IV7 reader on the lift carriage, you will need to use a multi-conductor cable to supply power and RS-232 communications to the IV7.

This section discusses how to install a multi-conductor cable on a lift truck and includes guidelines for proper cable installation.

Basic Lift Truck Design

All lift trucks support two basic, hydraulically-controlled features: **lift** and **tilt**. There are many types of accessories that attach to the lift carriage. Although not all lift trucks have forks attached to the carriage, most lift trucks support the addition of two accessories and a method to run hydraulic hoses to those accessories.

The most common accessories are:

- a side shift installed on the lift carriage.
- a fork positioning option which allows the operator to adjust the width of the forks while operating the lift.

Any hydraulic cylinder attached to the lift truck carriage requires two hydraulic hoses to the cylinder. The higher the lift carriage goes, the more nesting “tiers” the mast will have, and the more complex the pulley system inside the mast becomes to support additional hydraulic hoses or a multi-conductor cable.

The complexity and features of newer fork truck models versus older models is significant. Ergonomic, easy-to-use controls allow the operator to control all hydraulic features from their fingertips resting on a hand rest, or, in the case of a stand-up lift, from the same joystick the steering is done from. Computer-aided diagnostics now allow maintenance and adjustments on brakes and other systems without touching any hardware.

Reach lift trucks have hydraulic controls to move the lift carriage horizontally in and out of high bay racking with narrow aisles. These lifts may already have multi-conductor cables on pulley systems in the mast, and connected to sensors which are used to automatically raise the lift carriage to pre-set heights. With a newer lift truck model, it may be possible to tap unused conductors in an existing multi-conductor cable or replace it with another multi-conductor cable that provides more conductors.

Investigating the Feasibility of Using Multi-Conductor Cable

Lift truck vendors learned long ago that the best method to run hydraulic hoses to the lift carriage is inside the lift truck mast on pulley systems where they are protected from damage. When the IV7 reader and antennas must be mounted on the lift carriage, the pulley system is also the preferred method for running a single multi-conductor cable to the reader.

It is not a difficult process to investigate the feasibility of adding a multi-conductor cable. Lift trucks often only have one accessory, usually a side shift, and in these cases, adding a multi-conductor cable should be supported.

However, if reading tags can be accomplished when the load is at ground level, the reader and antennas can be installed on the lift truck chassis, eliminating the need for the multi-conductor cable.

To determine the feasibility of a multi-conductor cable installation, you need to enlist the help and expertise of the lift truck maintenance provider. Often, this is the same company that provided the lifts to the customer either bought or leased. Some customers may have in-house maintenance personnel that service the lifts, but generally this is not the case. The maintenance provider should have the lift truck service documentation, expertise, and training to determine if the lift truck can support a pulley system for the cable inside the mast.

If there are questions about the technical capability of the on-site maintenance person, seek another source of technical advice, such as from a technician at the lift truck vendor.

If a VMU is required for the installation, the maintenance provider should also be responsible for installing the VMU and its DC/DC power supply on the lift truck.

Getting Help From the Maintenance Provider

Set up a meeting with the maintenance personnel on site and have the lift truck model present. Take pictures of the lift truck for reference. Ask the provider to bring the lift truck maintenance manuals. Before asking questions, you need to inform/educate the maintenance personnel about what you want to achieve:

- You want to install an RFID reader and antennas on the attachment to the lift carriage. This is typically a standard fork lift with a load back rest (or, preferably, an Adaptable Load Back Rest (ALBR)).
- You need to support both power and RS-232 communications to the RFID reader, which requires a minimum of 5 conductors, and you would like to run a single multi-conductor cable to the reader. The multi-conductor cable needs to survive constant flexing and have a service life similar to hydraulic hoses.
- The cable will need cable grips and springs installed to maintain tension at both ends of the cable run (coming out of the mast to the lift truck body and out of the mast to the load back rest), which prevents the cable from jumping off the pulley when the lift is raised and lowered. A good mechanic will know that tension on a multi-conductor cable will be required. Hydraulic hoses do not require cable grips, as they are usually run to metal fixtures on the lift carriage and the base of the lift mast.
- If the VMU is not already installed, you will want to discuss VMU mounting location and installation of the VMU DC/DC supply.

Ask for the following information:

- Make and model number of the lift truck.
- Number and type of lift carriage attachments installed in the lift truck (forks, fork positioning, clamp, slip sheet).
- Number of tiers in the mast.

When Additional Cables Are Not Supported

If the lift truck model cannot support more hydraulic accessories and a multi-conductor cable cannot be installed within the mast on pulleys, a cable reel is the next best solution. Using a cable reel does provide some protection for the cables, but the reels are expensive to purchase and install. For more information, see [“Installing a Cable Reel” on page 52](#).

As a last resort, you can use coiled cables to provide power and RS-232 connectivity to the IV7. However, the main disadvantage of this method is the lack of protection for the cables, which makes this method inappropriate for a long duration pilot or permanent installation. A coiled cable will not survive the rigors of day-to-day use and abuse. The greatest advantage of using coiled cables is that no extra hardware is required to install them, so preparation for the pilot can be done quickly. For more information, see [“Using Coiled Cables” on page 54](#).

Procuring the Required Parts

Once it has been determined that the lift truck model can support a multi-conductor cable, the parts for the pulley system, multi-conductor cable, cable tension and protection need to be procured.

Pulley System For the Cable

The maintenance provider will know the correct parts to order after reviewing detailed manuals for the lift truck model. Leave this task to the experts as they have the knowledge, training and access to detailed service manuals. Avoid getting involved in ordering the proper parts and installing them. The maintenance provider should already have a billing structure for parts and labor with the customer.

Ordering the Multi-Conductor Cable

Lift truck vendors have been using multi-conductor cables in various types of lift trucks and order pickers for a long time. The lift truck industry commonly uses what is called an 18/8 (18 gauge/ 8 conductors) multi-conductor cable in these applications. This would be the preferred type of multi-conductor cable to install.

The maintenance provider should be able to procure the proper cable that is designed to survive the environment and the lift truck vendor is likely to have part numbers for the type of cable required. Remember these important points:

- Make sure that excess cable is available at both ends of the cable for splicing in the cables for power and RS-232.
- The cable must have a minimum of five (5) 18-gauge conductors. Intermec recommends using cables with eight (8) 18-gauge conductors, as the 8-conductor cable allows you to “double up” and use two conductors for each power connection.
- The conductors must have a stranded copper core and be twisted around the core.
- The core of the cable is often cardboard.
- Do not short yourself when ordering the length of cable.

In the event that the maintenance provider can not provide a source for this cable, you should help locate a vendor. A Google search of “multi-conductor flexible control cable” will show many sources for this type of cable. The key requirement is that the cable must be designed to survive continuous flexing from the pulley system. Make sure anyone looking for a vendor understands exactly where and how this cable will be used.

For an example of the required multi-conductor cable, see:

http://www.leviton.com/OA_HTML/ibeCCtpSctDspRte.jsp?section=23587&subsection=23631&minisite=10073

From the list on the right side of the web page, choose American SDN “Flexible Control Cable | 18-12 AWG” to view a datasheet.

Cable Grips and Springs for Tension

To prevent the multi-conductor cable from jumping off the pulleys, the cable run requires tension:

- where the cable comes from the lift truck chassis into the pulley system.
- where the cable comes from the pulley system to the load back rest.

Two single-eye cable grips and springs should be used when installing the cable. Standard cable grips (such as Genuine Kellems Cable Grips, made by Hubbell) are readily available from many different sources. Cable grips support all different kinds of size cables, so make sure to get the proper size to match the cable diameter. The maintenance provider may actually stock or know how to procure the proper cable grip for the multi-conductor cable.

Installing the Cable and Pulley System



Note: This task is for the experts trained on lift trucks. The maintenance provider gets the call when a lift requires service and bills the customer for service labor. You do not want to get the phone call if problems occur with the installation of this hardware.

Installing the pulley system, multi-conductor cable, cable grips and protection for the cable must be done by the maintenance provider or in-house mechanics.

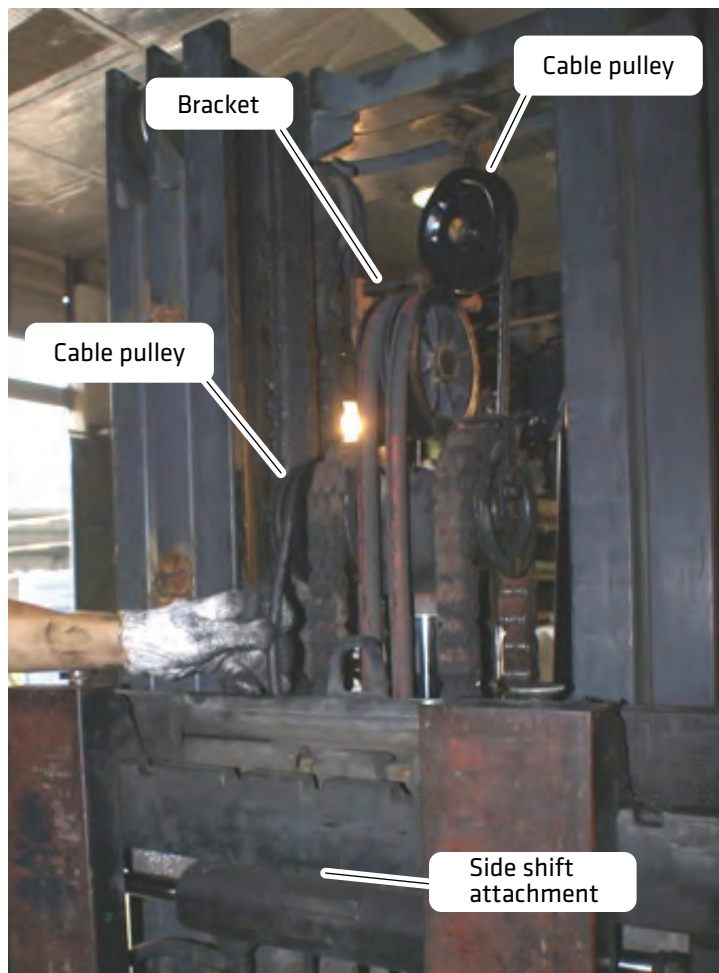
Watching the installation can be very informative. A lot can be learned from a good lift truck mechanic. That knowledge can be useful in a situation where you suspect the capabilities of a different lift truck maintenance provider you work with in future installations.

Installing the Multi-Conductor Cable and Pulleys

If you are able to watch the cable installation being done, request that floor plates and side plates be removed so cabling can be routed properly. The multi-conductor cable path should follow the existing hydraulic hose path out from the mast into the chassis.



Cable Routing Under Floor Plates: With the floor plates raised, cables for the VMU RS-232 connection and IV7 power were run to the splice point (lower right-hand corner) and spliced to the multi-conductor cable.



Pulley Installation: Two pulleys were installed to manage the multi-conductor cable. Protective brackets (as on pulley for hydraulic hose) should be installed on all cable pulleys.

Installing Cable Grips, Springs and Cable Protection

The cable grips and radiator hose used at sharp bends or potential wear spots must be put on the multi-conductor cable in the right order. Dry fit the cable first to determine where hose protection is needed and the proper orientation of the cable grip at each end of the cable run through the pulley system.



Cable Grip Installation: Make sure the grip is sized correctly for the cable.

The spring used should not be too stiff and fairly long. The springs must have hooks at each end. Radiator hose to protect the cable can be procured at any automotive or hardware store.

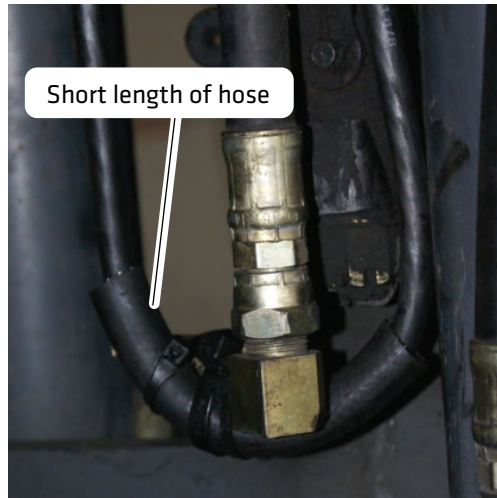


Spring Installation

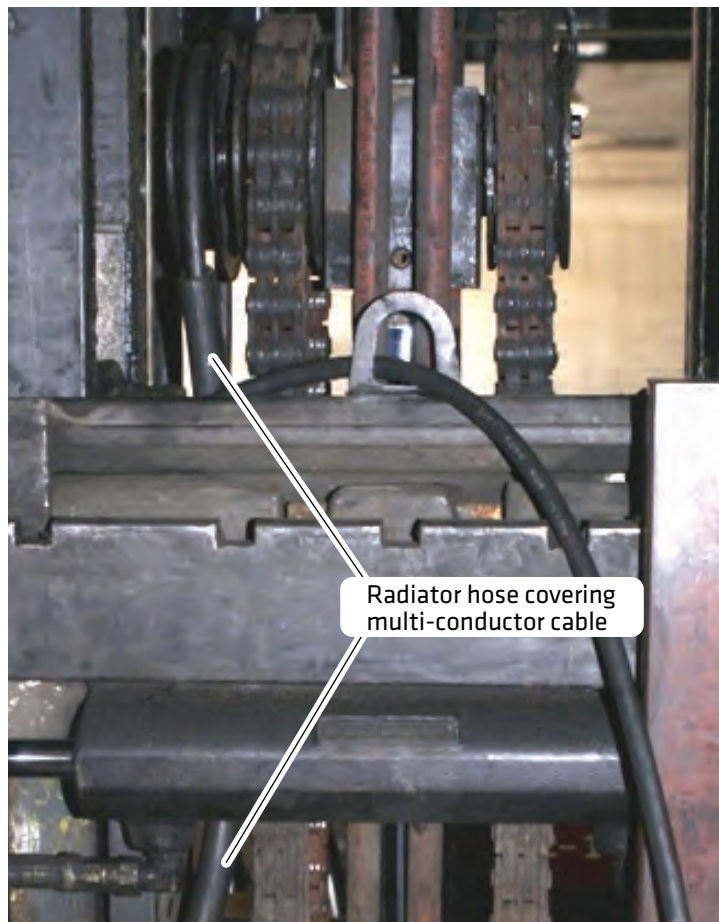


Cable Grip and Spring Installation: This cable grip and spring provided tension on the cable section coming out of the mast to the lift truck chassis.

Avoid bending the cable around a very tight radius and protect the cable where it exits the pulley system to the load back rest. This is where a side shift attachment can wear or pinch the cable against metal, chain or other hardware in the mast. The best solution is automotive radiator hose of slightly larger diameter than your cable. Four feet of hose should be plenty.



Cable Protection: Short length of radiator hose protects the multi-conductor cable where a sharp bend was required.



More Cable Protection: Another piece of radiator hose was slipped over the multi-conductor cable to protect it from rubbing and chafing against the metal chain. This is where the multi-conductor cable exits the pulley system inside the mast and is run to the lift carriage.

Splicing Connections for IV7 Power and RS-232

You will need to strip and splice conductors at each end of the multi-conductor cable to make power and RS-232 connections to the IV7. These splices will occur at the lift truck chassis and at the attachment on the lift carriage where the IV7 is installed.

As you plan the route for the multi-conductor cable in the lift track chassis, take time to determine where splicing will occur. Both a power cable and an RS-232 cable from the VMU will have to run to this location.

There are several issues to consider about the VMU and IV7 power source and how the cabling for power is done. For a discussion of these issues, see **“Supplying Power” on page 8**.



Note: Intermec recommends using 8/18 multi-conductor cable for these installations. Although you need a cable with only 5 conductors, the 8-conductor cable allows you to “double up” and use two conductors for each power connection.

About the IV7 Power Cable Kit

The IV7 power cable kit includes all the components you need to connect the multi-conductor cable to the IV7 power port and vehicle power supply. The power cable kit comes in two versions:

- P/N 203-713-002 includes a cable with a right-angle connector for the IV7 power port.
- P/N 203-713-003 includes a cable with a straight connector for the IV7 power port.

Both kits also include crimp connectors, shrink tubing, terminal lugs, and a fuse assembly. For more information on installing the kit, see the **IV7 DC Power Cable Kit Instructions**.

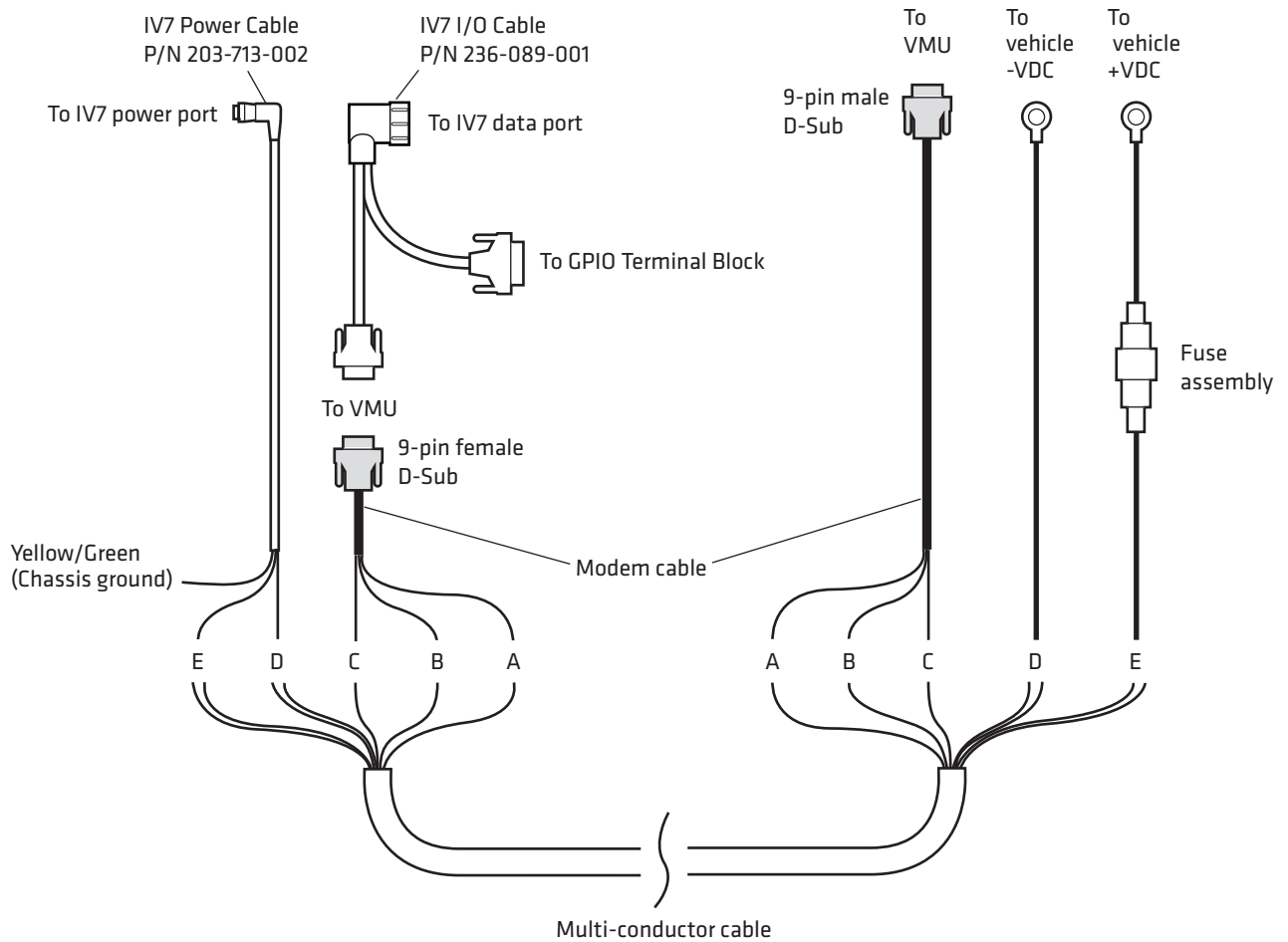
The next illustration shows how the power cable could be installed in a typical installation.

Using a Modem Cable for RS-232 Connections

For simplicity, use a standard modem cable (such as Intermec P/N 321-497-101) to connect the multi-conductor cable to the IV7 I/O cable (P/N 236-089-001) and to the VMU.

The cable must have one female and one male 9-pin D-Sub connector. Cut the cable in two and splice the end with the male D-Sub connector to the multi-conductor cable at the IV7 end. Splice the end with the female D-Sub connector to the multi-conductor cable at the VMU end.

The next illustration shows how the modem cable could be installed in a typical installation.



Splicing Connections: This illustration shows where to splice power and RS-232 connections to the multi-conductor cable. Note use of two conductors at D and at E for the power connections.

RS-232 Modem Cable Connections for Multi-Conductor Cable

Signal	Modem Cable Wire Color (when using P/N 321-497-101)	Connects to Multi-Conductor Cable At
XMIT	Red	A
RCV	Brown	B
GND	Yellow	C

IV7 Power Cable Connections for Multi-Conductor Cable

Power	IV7 Power Cable Wire Color	Connects to Multi-Conductor Cable At
- VDC	Blue	D
+ VDC	Brown	E



Note: Intermec recommends using **two** wires in the multi-conductor cable for each power connection.

To use a modem cable for splices to the multi-conductor cable

- 1 From the male D-Sub connector end of the modem cable, measure one foot of cable and cut the cable at that point.
- 2 Strip four inches of the outer insulation off the cut ends of each length of cable.
- 3 Splice the modem cable with the male D-Sub connector to the end of the multi-conductor cable closest to the IV7. Three of the color-coded wires are required for this connection.

If you use the Intermec modem cable (P/N 321-497-101), use these wires:

- Brown (Pin 2 - RS-232 receive)
- Red (Pin 3 - RS-232 transmit)
- Yellow (Pin 5 - RS-232 ground)

If you use a different modem cable, use the DVM to identify the color of these wires for pins 2, 3, and 5. For all modem cables, unused wires can later be cut where the outer insulation starts.

- 4 Connect the male D-Sub connector to the female D-Sub connector on the IV7 I/O cable.
- 5 Splice the modem cable with the female D-Sub connector to the end of the multi-conductor cable closest to the VMU. Be sure to use the same wire colors when connecting these cables.

The length of this piece determines the location where the splice occurs on the lift truck chassis. The VMU is most often mounted on the right side of the operator in a lift where the operator is sitting. The longer piece of the cut modem cable is then run down the front support of the lift truck roll cage.

Keeping Track of Connections

Document the color of the wires used in the multi-conductor cable for the power and RS-232 connections. The following is a sample table to document the splice connections:

Sample Connection Table

Signal	Multi-Conductor Cable	IV7 Power Cable	Modem Cable
Power (+Vbat)	Red and Red/Black stripe	Brown	N/A
Power (-Vbat)	White and White/Black stripe	Blue	N/A
RS-232 Tx	Green	N/A	Brown
RS-232 Rx	Orange	N/A	Red
RS-232 Gnd	Blue	N/A	Yellow

Checking the RS-232 Connection

Be sure to test the RS-232 connection end to end before you crimp any connectors or secure any cables. Use wire nuts for quick connections, or twist the conductors together and wrap in electrical tape.

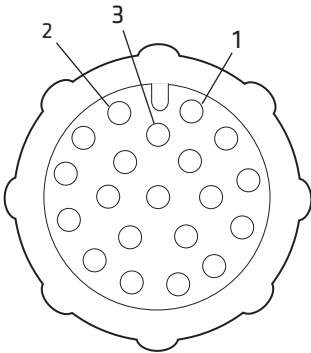
To quickly test the connection, you need:

- a laptop PC running HyperTerminal (115200, 8, N, 1, No flow control).
- a complete power connection to the IV7. Before you begin the test, turn off power to the IV7.

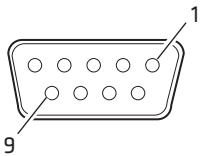
To test the RS-232 connection to the IV7

- 1 Connect the laptop PC to the VMU end of the multi-conductor cable.
- 2 Apply power to the IV7. If the connection is working, you should see the IV7 “power up” message.

An alternative method is to ohm out the complete path for the RS-232 signals end to end, but this does not verify RS-232 communication actually works. The next table and illustrations below show the pins to use for an ohm test.



IV7 I/O Cable Pins



Female D-Sub Connector Pins

Pinout Connections

Female D-Sub Connector	Connects to IV7 I/O Cable
Pin 2 (Rx/D PC)	Pin 1 (Tx/D IV7)
Pin 3 (Tx/D PC)	Pin 2 (Rx/D IV)
Pin 5 (GND)	Pin 3 (GND)

One can test this very quickly using only the IV7 data cable (236-089-001). Now test it with the complete multi-conductor cable in between. Your connectors should be exactly the same at each end as the standard IV7 data cable.

Using the Unterminated IV7 I/O Cable

Instead of using the standard IV7 I/O cable (P/N 203-089-001), you can use the alternate I/O cable kit (P/N 203-776-001) for connections spliced to the multi-conductor cable at the lift attachment.

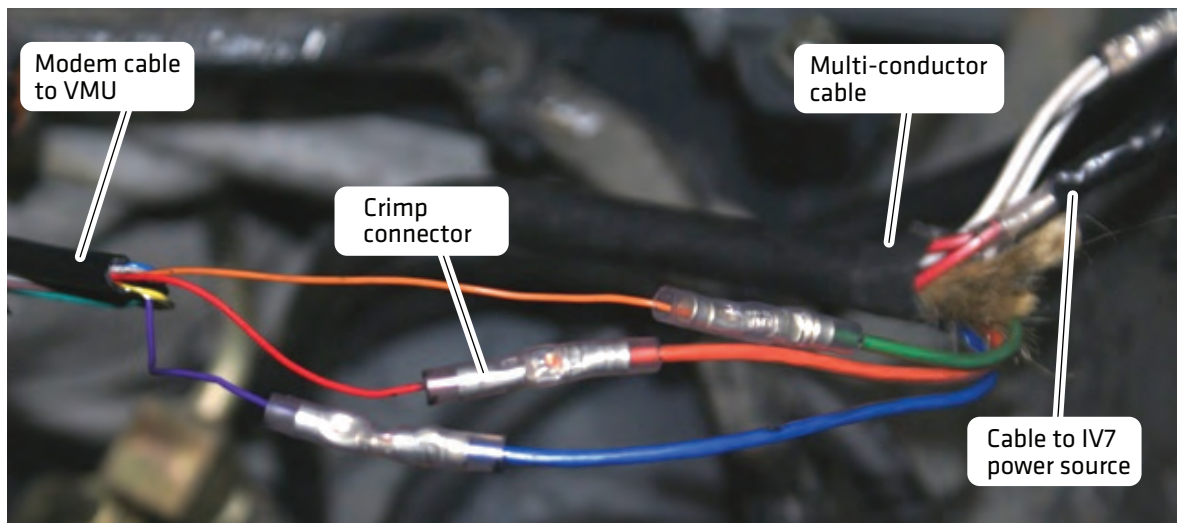
This kit includes a 12-ft data cable terminated on one end with an IV7 data port connector; the other end is unterminated. The kit comes with crimp connectors, shrink tubing, and resistors for use in a GPIO system if needed. For more information, see the [IV7 Vehicle-Mount Reader Data Cable Kit Instructions](#).

A diagram in the instructions provides information about the individual signals brought out on this cable. The critical signals are RS-232 TxD (black wire), RxD (white wire), and ground (red wire). Other signal lines are for GPIO.

For ease of installation and adjustment, Intermec recommends using some sort of quick disconnect connector for the RS-232 signals and IV7 power. For more information, see [“Using Quick Disconnect Cabling” on page 49](#).

Using Crimp Connectors

The next photo shows where crimp connectors are used to splice the power and RS-232 connections from the IV7 and VMU to the multi-conductor cable. Note that two conductors from the multi-conductor cable are used for both +Vbat and -Vbat.



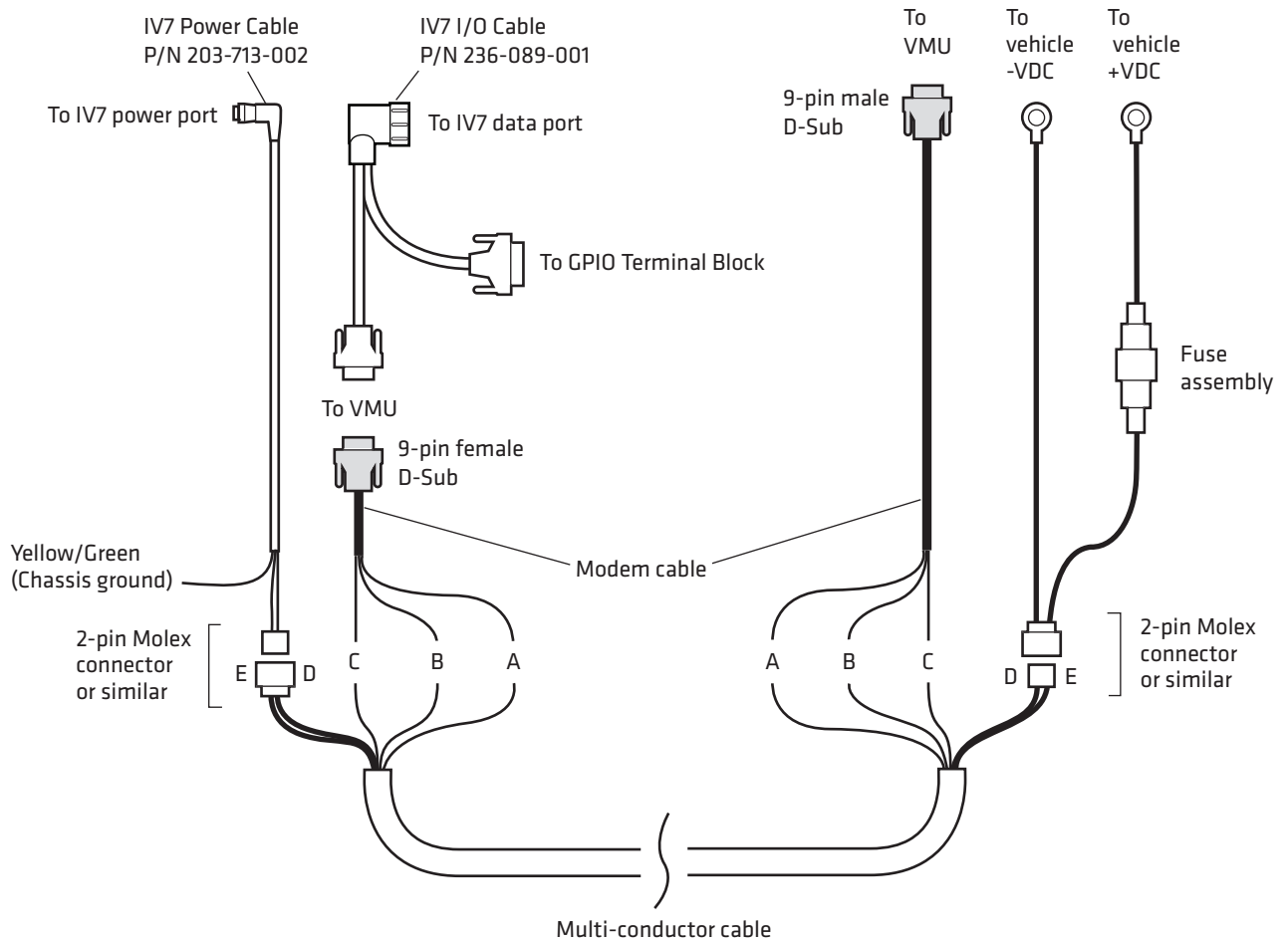
Crimp Connectors: Close-up view of spliced connections using crimp connectors to multi-conductor cable.

Tips for using crimp connectors:

- Because a crimp connector for 18 gauge is too big for the higher gauge conductors used in the modem cable, strip the wires and fold them over before you crimp connectors onto them.
- To avoid a large bulge in the cable after covering the splice with heatshrink, stagger the crimp connectors as shown in the photo.
- Always test the connections for a solid crimp when finished.

Using Quick Disconnect Cabling

For ease of removal of the LBR or ALBR, install quick disconnect connectors for the power cabling as seen in the next illustration. These connectors can be found at automotive or electronic stores.



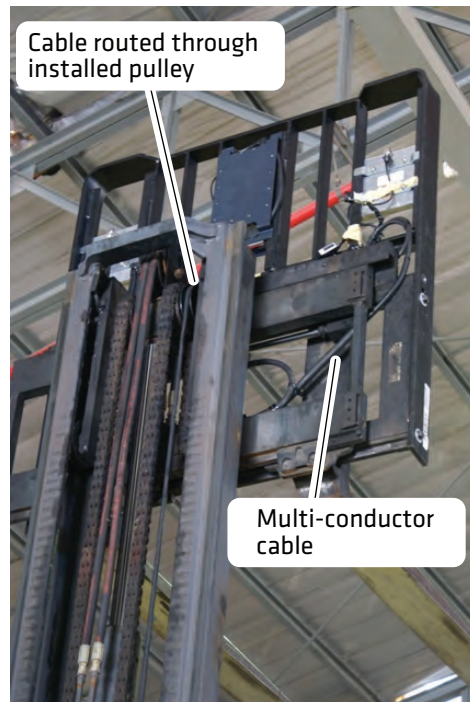
Using Molex Connectors for Quick Disconnect: This example shows where to install 2-pin Molex connectors on the power connection. See the table on [page 45](#) for pinouts.



Quick Disconnect: This installation uses a Molex connector for quick disconnect of the power cables, along with a modem cable for the RS-232 connection.

About Side Shift Accessories

This section shows some examples of the precautions you should take when you install multi-conductor cable on a lift truck with a side shift attachment.



Side Shift Accessories and Multi-Conductor Cabling: Leave slack in the cable to accommodate the range of motion required to use the side shift.



Testing the Installation: Have someone stand on the forks watching for potential trouble spots while an operator moves the side shift back and forth.



Multi-Conductor Cable Installation Example: This Crown RC3000 lift truck includes a side shift accessory. Thicker pulleys were added and the multi-conductor cable is inside the mast. Labor and parts was roughly \$550 (USD).



Note: For an example of a lift truck that does not support pulleys for a multi-conductor cable, see [“Cable Reel Example” on page 53](#).

Testing the Installation

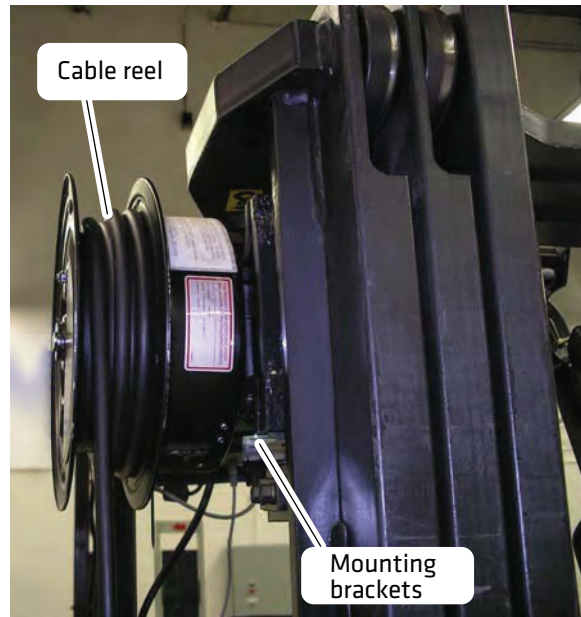
After installing the cable, have the operator raise and lower the lift carriage multiple times at full speed, and observe how the cable runs on the installed pulley system. You may need to increase the tension on the cable by moving the cable grips. You may also need to adjust the pulley mounting brackets to ensure that the cable feeds into the pulleys in a straight line.

Installing a Cable Reel

If it is not possible to install a multi-conductor cable in the mast, the next best method is to install an external cable reel at the top of the mast. Installation must be done by a qualified lift truck mechanic and usually requires welding and drilling holes.

The cable reel shown in these examples is manufactured by Cascade Corporation and supports up to six hydraulic and electrical connections. For a datasheet, see:

[http://www.cascorp.com/downloads/links/6024475/\\$FILE/6N1.pdf](http://www.cascorp.com/downloads/links/6024475/$FILE/6N1.pdf)



Cable Reel Installation: The reel shown here is manufactured by Cascade.

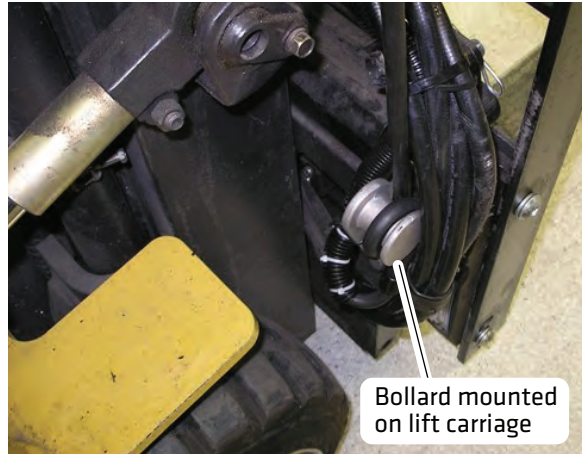
Cable Reel Considerations

The cable reel handles electrical and hydraulic supplies well, but is not an optimal connection for high-speed RS-232 communications. Reducing your serial communications speed may be required.

Cable reels are expensive in hardware and labor to install.

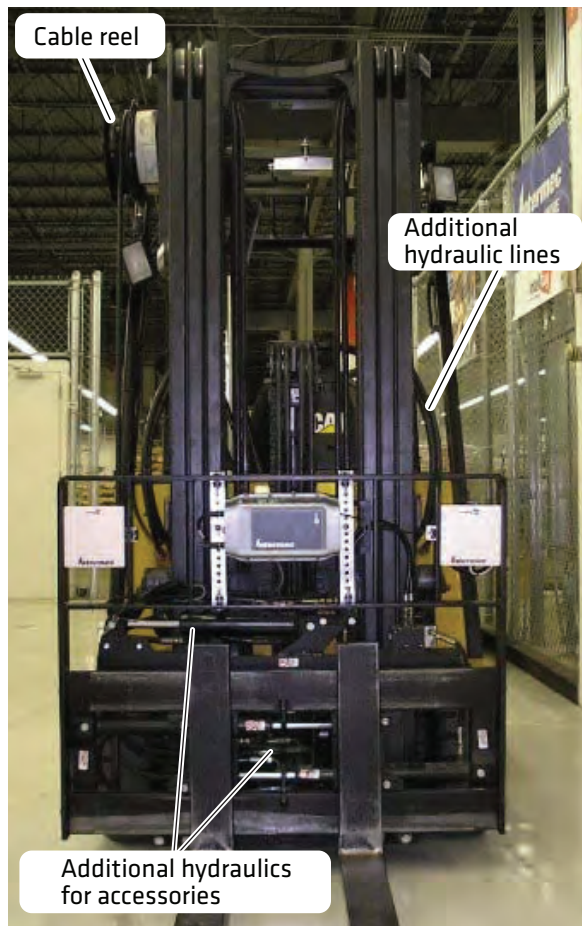
The reel may eventually get damaged, or the cable may catch on something and break.

A bollard (provided with the cable reel) is attached to the lift carriage. The cable rolls around the bollard when the lift carriage travels above the cable reel. The direction the reel turns reverses when the bollard rises above or below the cable reel.



Cable Reel Example

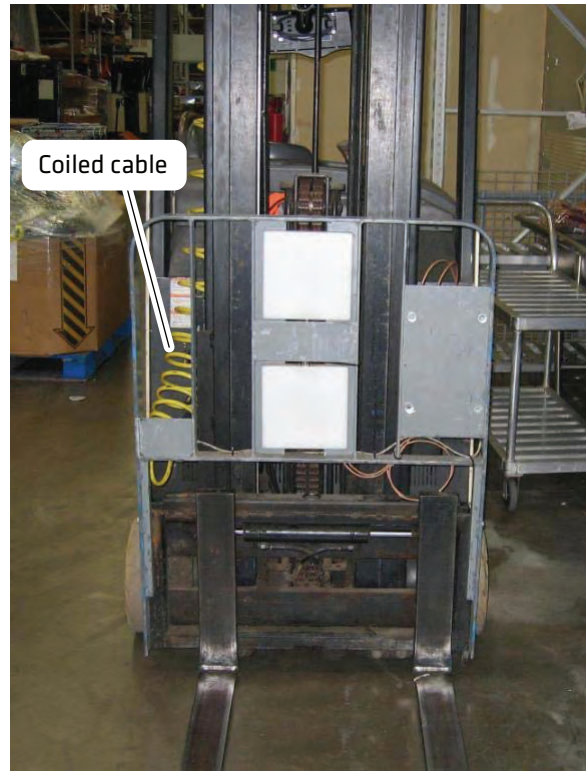
The cost of installing the cable reel was roughly \$1500 (USD) for the lift shown in the next photo. Because this lift had many accessory options, running a cable inside the mast was not an option. The maintenance provider insisted on performing the work at its facility, resulting in additional pick-up and delivery costs.



Cable Reel Installation: This illustration shows some of the items that create added cost. Because of the number of accessories, the truck could not support a pulley system.

Using Coiled Cables

For a POC requiring a quick solution, you can run a coiled cable between the LBR and truck cab as shown in the next photo. Since the coiled cable hangs free unprotected from damage, this method is not a permanent solution. This could be considered for a POC, if successful POC testing can be done with the forks close to the floor. This could be an alternative to wireless deployment for a quick POC if you must read tags with the forks raised.



Coiled Cable Installation: For POC work, use of a coiled cable can substitute for a multi-conductor cable or cable reel installation.

Preventive Maintenance

All lift trucks require periodic preventative maintenance (PM). Checking an installed multi-conductor cable should be done during PM checks after it is installed. The tension should be checked and the cable inspected for damage or wear.

You want to make sure a close watch is kept on the cable for the first several days after installation. It usually difficult to make sure an operator will monitor this but you should make a point of this precautionary step.

Try to do as much thorough testing of the installed cable as time permits. Raise and lower the lift carriage at full speed multiple times

All bolts and fittings should be checked for loose lock nuts. Lift trucks are submitted to a lot of vibration.

Miscellaneous Tips and Tricks

- Have extra crimp connectors available for different gauge wires.
- When you are crimping together multiple lines, set up the connectors so they are staggered. This avoids one big bulge in your wiring and looks more professional. For an example, see [“Using Crimp Connectors” on page 48](#).
- Have electrical tape on hand - yes, it still has its uses.
- Black poly sheath to protect cable runs can be found in various sizes at any automotive store.
- Use tie wraps (preferably black) liberally. Have a variety of lengths on hand.
- When you want everything to look nice, such as for a trade show, use small black Velcro squares to slip tie wraps through. These match the typical black roll cages found on lift trucks.
- Make sure you squeeze the crimp tool hard when installing the fuse holders in Intermec DC/DC kits, or you may be out a fuse holder. Or, use automotive style fuse holders with wire on each end. If you ruin a crimp you can just trim some wire and crimp again.
- You can find rolls of insulated multi-conductor wire at automotive or hardware stores. Cables included in the DC/DC power supply kits may not be long enough for some installations.
- Use U-bolts and base plates that match the large base holes of the 2 ¼” RAM mount and the mounting holes on the DC/DC supply. Have long, medium and short bolts with lockwashers and nuts to use with the DC/DC supply and 2 ¼” RAM mount.
- Use Loctite for all bolt threads.

Recommended BOMs for RFID POC or Pilots

This section includes recommended bills of materials (BOMs) for an RFID POC or pilot using these Intermec products:

- CV30 Fixed Mount Computer (if a VMU is needed)
- IV7 Vehicle-Mount Reader

CV30 BOM and Information

If you need to use a CV30 computer as a VMU, the items in this list should be considered the minimum requirements. See the CV30 section in the Intermec Price Guide for additional options, current part numbers, accessories, and pricing. Note that the power cord is the US version.

BOM for CV30 Fixed Mount Computer Installation

Intermec P/N	Description	Qty.	Notes
CV30A0E1000804	CV30 Fixed Mount Computer, WME, N/SD, 804	1	For POC, TE application is unnecessary.
VE011-2022	Keyboard, compact, CV30	1	Optional.
VE011-2003	Mounting kit, keyboard, compact, CV30	1	For optional keyboard.
VE011-2004	Kit, tethered stylus, CV30	1	
VE011-2017	Cable assy., dual, USB, CV30	1	
VE011-2018	Cable assy., Developers, ActiveSync	1	For application developer use only.
203-779-001	Kit, DC/DC converter, 6-60V, dual output, RoHS	1	
805-814-001	2 1/4" RAM ball mount kit, 8 1/4" overall	1	
805-813-001	1 1/2" RAM ball mount kit, 11.5"	1	Alternate RAM mount kit.
805-815-001	Desktop kit for CV30	1	For desktop development only.
851-082-004	Desktop universal AC power supply, CV30	1	For desktop testing only.
1-974028-025	U.S. power cord, RoHS	1	For desktop testing only.

- Use a USB thumb drive to move files and applications to the CV30. You can also move files via a Wi-Fi ad hoc connection to your notebook PC using Microsoft ActiveSync.
- If there is a need to edit an XML file often on the CV30, you might consider a second-party editor.
- Second-party software or shareware is available that displays the CV30 screen on a remote PC. This can be useful when done over a Wi-Fi ad hoc link.
- During testing, the CV30 screen can not be seen because you will not be allowed to drive the fork lift in many facilities.
- Standing behind or close to a lift all day to see the screen is dangerous.

For a comprehensive list of all CV30 manuals, see:

http://home.intermec.com/eprise/main/GSS/Service/Content/Manuals/Show_ManualSearchResults?Product=CMPTRCV30&Language=English

IV7 BOM and Information

Only FCC version part numbers for the IV7 are in this BOM. See the IV7 section current Intermec price guide for specific configurations, current part numbers, antennas and coaxial cables for other regions, and pricing.

BOM for IV7 Vehicle-Mount Reader Installation

Intermec P/N	Description	Qty.	Notes
IV7D102014	IV7C, FCC, ALBR	1	Use this IV7 model for adjustable load back rest (ALBR) installation.
IV7D202014	IV7C, FCC	1	Use this IV7 model for non-ALBR installations.
805-816-002	Antenna cell, FCC	1 to 4	MobileMark antennas are also in Product Links.
203-713-003	Kit, IV7 power cable, straight	1	Includes standard connector.
203-713-002	Kit, IV7 power cable, right angle	1	(Preferred) Includes 90-degree right angle connector.
236-089-001	Cable, IV7B/C, 90-degree, 9-pin DSUB, 25-pin DSUB, 5 ft	1	Best for desktop or POC use.
203-776-001	Kit, IV7C I/O cable, with 12 ft GPIO pigtail	1	Best for GPIO and splicing to cable in mast.
592154	Crimp tool, RG-58 N connector.	1	One-time buy. Use with FCC and ETSI coaxial cable kits.
203-720-001	Kit, Cable assy., Rev. SMA, Rev N, 12 ft	1 to 4	FCC coaxial cable kit.
851-075-001	Universal power supply	1	For desktop testing only. Requires splice to IV7C power cable.
1-974-28-025	Power cord, US, RoHS	1	For desktop testing only.
203-850-001	RG-58, 4.5 ft, RP-SMA/RP-N	1 to 4	Use instead of FCC coaxial cable kit. Does not require crimp tool.
321-497-101	Serial modem cable, 6 ft, RoHS	2	Connects VMU to IV7. Required for PoC.

For a comprehensive list of IV7 instructions and related manuals for associated kits and other accessories, go to:

<http://www.intermec.com/support/manuals/search.aspx?productnodeid=RFIDIV7C>

Related Documents

This section includes links to Intermec customer documentation for RFID hardware and software discussed in this article.

IV7 Vehicle-Mount Reader Instructions

For IV7C with optional lift truck mounting plate (intended for ALBR installations). Includes information on Antenna Cell installation:

- http://epsfiles.intermec.com/eps_files/eps_man/943-100.pdf

For IV7C with standard mounting plate:

- http://epsfiles.intermec.com/eps_files/eps-man/075280.pdf

IV7 Vehicle-Mount Reader Drilling Template

(Not for ALBR installations) Use if you need to drill holes for mounting the IV7C with the standard mounting plate:

- http://epsfiles.intermec.com/eps_files/eps_man/931-000-001.pdf

IV7 Vehicle-Mount Reader Data Cable Kit Instructions

Describes how to assemble the IV7 data cable kit (P/N 203-776-001):

- http://epsfiles.intermec.com/eps_files/eps_man/943-067.pdf

IV7 Vehicle-Mount Reader DC Power Cable Kit Instructions

Describes how to assemble the IV7 DC power cable kits (P/N 203-713-002 with a right-angle cable, or P/N 203-713-003 with a straight cable):

- http://epsfiles.intermec.com/eps_files/eps_man/943-068.pdf

Intermec Forklift Advanced RFID Extensions (ARX) User's Guide

Describes Intermec's Forklift Advanced RFID Extensions (ARX) software, which can differentiate between tags on a pallet being moved by the lift truck and stationary tags in the surrounding environment:

- http://epsfiles.intermec.com/eps_files/eps_man/934-047.pdf

Basic Reader Interface (BRI) Programmer's Reference Manual

Describes all BRI commands supported by Intermec RFID readers:

- http://epsfiles.intermec.com/eps_files/eps_man/937-000.pdf

Appendix

This Appendix includes discussions of the use of proximity sensors with the IV7 GPIO (general purpose input/output) capability, and of the inherent problems of implementing the IV7 in a wireless solution.

GPIO for the IV7

Imagine a distribution center with RFID tags on locations, pallets, and individual cases, and where lift trucks with RFID readers are always actively reading tags. The RFID system application has to continuously sort and filter all the tag read data, wasting a lot of processing power and increasing overall network traffic. There are also issues of interference with other RFID readers to consider.

Instead of this scenario, GPIO devices such as proximity sensors can be used to initiate the RFID read process in certain situations. For example, a sensor can initiate the read process when a lift truck driver is approaching a pallet to be lifted. Using GPIO devices in this manner can reduce the amount of time spent reading tags, thus reducing network throughput and interference between RFID readers.

However, using GPIO devices is not simple. The distance at which reads should be triggered is critical; too far a distance will cause unwanted reads. If the antenna beam pattern is too broad, unwanted tags (items not being picked up) may be read. The challenge of reading and reporting only desired tags is not trivial.

Two possible solutions are:

- to have the operator initiate RFID reading
- to implement RFID reading in a manner where the operator does not even have to think about automated data collection.

The best solution is a balance between the two. If the customer's goal is to completely eliminate lift truck operators interfacing with RFID data collection, the criteria for success have been set very high. Error recovery or exception handling without operator intervention is a difficult requirement to meet.

Practical Considerations for Using GPIO

For example, consider a clamp truck application which requires reading only those items to be clamped. The clamp is capable of picking up the same item in configurations of one, two and three wide - and one, two or three high. A working solution must address the need to read tags for any of these configuration sizes.

If you assume the reader and antenna move up and down with the lift attachment, the proximity detector must also move up and down. The IV7 and IF4 do not have an internal power source for GPIO devices.

GPIO devices may not be able to handle standard battery voltages from electric lifts. Proximity sensors will work off a range of DC voltage such as 10 VDC to 30 VDC, which is why using the heater output of the Intermec dual output DC/DC VMU supply has been suggested. If the heater is needed for the VMU, an additional dual output supply should be considered. The lift truck mechanic could be very useful in helping to identify alternative sources to power GPIO from existing sources on the lift. Rather than try to find such a source on your own, ask the lift truck maintenance provider for help.

Try to avoid using GPIO for a POC. For a pilot, a requirement for GPIO will need to be addressed.

Although the IV7 and IF4 have different GPIO connectors, the electrical interface is the same. Both of these readers have weak internal pull-up resistors on the GPIO input lines to +5 VDC. If no GPIO is connected and the BRI command READGPIO is executed, the response will be “15” which indicates that all inputs are on. The IV7 GPIO voltages for input and output should not exceed 6.5 VDC.

Wiring Proximity Sensors

A proximity sensor is a simple switch that remains open until the sensor is triggered, closing the switch. When triggered, sensor output can be high (PNP) or low (NPN). The open switch state of a PNP sensor output line is ground (V bat -) and the closed state is the same positive voltage (V bat+) that is powering the sensor.

To avoid confusion, wire the sensor to match the logic stated in the BRI programmer’s manual which is PNP. It is misleading that all GPIO inputs are pulled high (on) when no input is attached. When a PNP sensor is wired and is not triggered, the GPIO input connected to the sensor should be off (pulled to ground). When you look at sensor specifications, note that some sensors have only three outputs, which means they are designed as either PNP or NPN, and some sensors give you five outputs which allow you to wire either PNP or NPN. An additional line lets you choose if the visible LED on the sensor is on or off when triggered.

A typical PNP sensor schematic shows an output line going to a load and then to ground (V bat-). Inside the sensor this output line is a switch to V bat+. In this case, the load is the IV7 GPIO internal circuitry, in addition to any external voltage conditioning circuits required. If the sensor input is +12 VDC, then replace the load (as shown in the schematic) with two 2K, 1-W resistors in series. Connect the IV7 GPIO input line from the IV7 **between** the two resistors, and it should read +6 VDC when the sensor is triggered. The IV7 GPIO return is connected to ground (V bat-). The sensor schematic should indicate separate lines for V bat+ and V bat- if the sensor is wired as an emitter only.

The wires on the IV7 I/O cables are very thin (28 gauge). To make sure you get a good crimp on these thin wires, strip them long and double them over before inserting into a crimp connector. Before making something permanent you might use some wire nuts to make your connections, or simply twist the wires together and test prior to crimping.

The internal GPIO circuit should be protected from over current and resistors are required if the GPIO box is not used. The IV7 data cable kit (P/N 203-776-001) includes four 2K, 1-W resistors, shrink tubing, crimp connectors, and wiring diagrams. The kit supports wiring GPIO input devices only. You should try to limit input and output voltages to +5 VDC and never exceed +6.5 VDC. Using higher voltages may require external circuitry such as voltage dividers or active regulators. The resistors provided with the kit assume the sensor input voltage is 12 volts. Higher voltages to the sensor would require different resistor values for the divider circuit.

For more information on the IV7 data cable kit, see the *[IV7 Vehicle-Mount Reader Data Cable Kit Instructions](#)*.

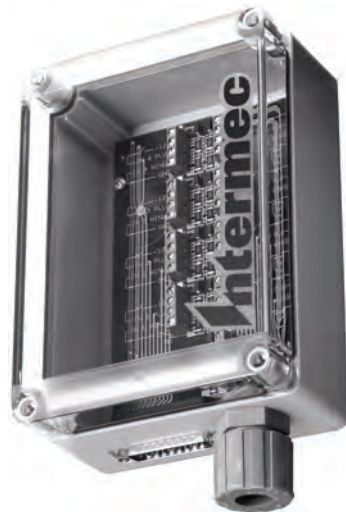
For more about the IV7 GPIO interface, see the *[IV7 Vehicle-Mount Reader Instructions](#)*.

For more about the IF4 GPIO interface, see the *[IF4 915 MHz Reader Quick Start Guide](#)* (GPIO information applies to all IF4 models).

External triggers need to be thought through from an application standpoint. The BRI triggers for GPIO can be either level or edge triggered. For more information on implementing GPIO in your RFID application, see the documentation for the Intermec Developer Library (IDL) RFID Resource Kit. For more information on Resource Kits, visit www.intermec.com/idl.

Using the GPIO Terminal Block

The IV7 I/O cable (P/N 236-089-001, with a right-angle IV7 connector) is designed to work with the GPIO terminal block (P/N 203-726-002, listed in the IF61 section of the Intermec Price Guide). The 25-pin D-Sub connector on the IV7 I/O cable connects directly to the terminal block.



Intermec GPIO Terminal Block

Consider that the GPIO terminal block supports four input and four output devices and often only a single proximity detector is necessary. If you choose to use the GPIO terminal block on a lift truck for a pilot, you need to address how and where to mount it.

If you need to access the GPIO lines without using the terminal block, use the following table to determine the appropriate line connections.

GPIO Cable Wiring

Description	Color	Pin on 25-pin D-SUB Connector
GP input 0	Black	1
GP input 1	Red	2
GP input 2	Orange	3
GP input 3	Green	4
GPIO-RTN	Blue	5
GPIO-RTN	White	6
GP output 0	Black/white	7
GPIO-RTN	Red/white	8
GP output 1	Green/white	9
GPIO-RTN	Blue/white	10
GP output 2	White/black	11
GPIO-RTN	Red/black	12
GP output 3	Orange/black	13

Intermec documentation on GPIO can be confusing. The IF61 manual refers to GPIO input and output as lines 1 through 4. When you look at IF4 and IV7 documentation the inputs are referred to as lines 0 through 3. The BRI manual refers to the GPIO lines as 1 through 4. GPIO-RTN lines are all the same.

Testing Proximity Sensors

If the customer expects to use proximity sensors to trigger tag reading, you need to test for the best sensor trip point and adjust that position based on the customer's preferred setup. Avoid having to implement a sensor for a Feasibility Analysis or POC. Sensors and an application to support them are best addressed during a pilot.

Procuring Sensor Hardware

Banner Engineering is a leading provider of sensors, stack lights and industrial automation equipment. For more information, visit www.bannerengineering.com.

You can purchase product at their web site. The Banner QS30D is a good sensor for lift truck applications. Four Banner QS30D proximity sensors can be purchased online for about the same cost as the GPIO terminal block.

Research thoroughly before you buy, or call Banner for help. You can buy the wrong type of sensor if you are not careful in your research.

Look at the various mounting bracket options available for proximity sensors. You may want to tilt the beam in a particular application and the right kind of bracket will make the installation easier.

Wireless Deployment for RFID

Because the IV7 reader was not designed to be a self-contained system, it does not include wireless connectivity or an internal power source. So a “wireless” RFID installation on a lift truck still requires a way to power the IV7 and to communicate with it.

If a customer insists on a wireless RFID system, try to differentiate the Intermec solution and investigate the **preferred method**: installation of a multi-conductor cable inside the mast to supply power and RS-232 connections to the IV7 reader.

- Stress the advantage of the ALBR for simplicity, cable protection, and reduced labor to support large rollouts.
- Stress the ruggedness of the IV7 and the ability to support four RFID antennas.

The customer may be unaware of some of the additional issues to consider when deploying a wireless RFID system. Although competitors may have a single-package, wireless solution with an internal battery, antenna, sensor, and 802.11b/g or Bluetooth connectivity, these solutions have their disadvantages:

- From an Operations standpoint, a wireless RFID solution requires the lift truck operator to remove, replace, and charge batteries. Can the operators be relied upon to perform these tasks? Get a manager from Operations involved and aware of what a wireless solution entails. Enquire what the labor turnover rate is for fork truck operators, as new operators will need to be trained to manage the RFID system batteries.
- For a given wireless solution, how much does an internal battery and charger cost? How many charge cycles before replacement? Will a special charging area be required? What about an electrician to bring in a dedicated power circuit to support the amperage required for the chargers?

Making the IV7 Work in a Wireless Solution

The IV7 was never intended to be deployed as a wireless RFID reader. A wireless installation with the IV7 will not look elegant, and requires a sealed lead acid battery (and spare) along with a charger. The installer has to design a way to install the battery on the ALBR or LBR and allow for easy replacement. The design must include protection from physical abuse, such as vibration. There is no worse environment for abuse and vibration than a lift truck.

Although the IV7 can work in a “wireless” solution, such a solution should only be used for a quick POC in which:

- you must show that tags can be read with the lift truck forks raised.
- the customer is not willing to install a cable reel or a cable run inside the mast with the hydraulic lines.

Instead of a wireless solution, consider using a coiled cable for such a POC. For a description, see **“Using Coiled Cables” on page 54**.

Handling Communications and Power

Although the only officially supported method for data communication to the IV7 is through a hard-wired RS-232 connection, Bluetooth adapters from Socket have been used for POC testing with a CV30 serving as the VMU. A Bluetooth adapter was required for the CV30 since RFID communications can occur only on COM3.

Power for the adapters was drawn from the IV7 RS-232/GPIO connector and from one of the CV30 RS-232 ports:

- +5 VDC is available on pin 9 of the 9-pin adapter for IV7 cable P/N 203-089-001.
- +5 VDC is available on pin 9 of either one of the CV30 RS-232 ports.

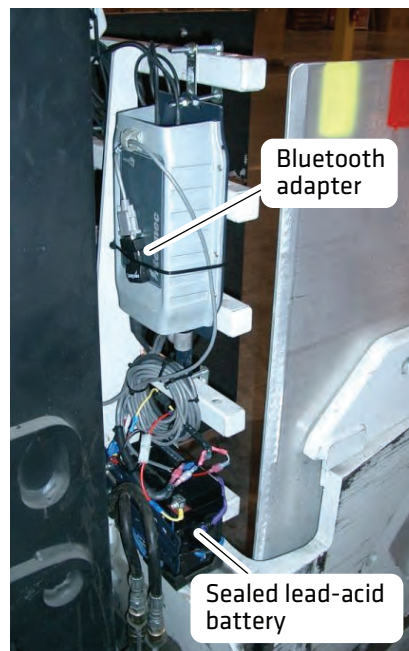
There are high- and low-power versions of these adapters. For more information, see the datasheet for these products at:

<http://www.socketserial.com/support/CSA/CSA%20Datasheet.pdf>

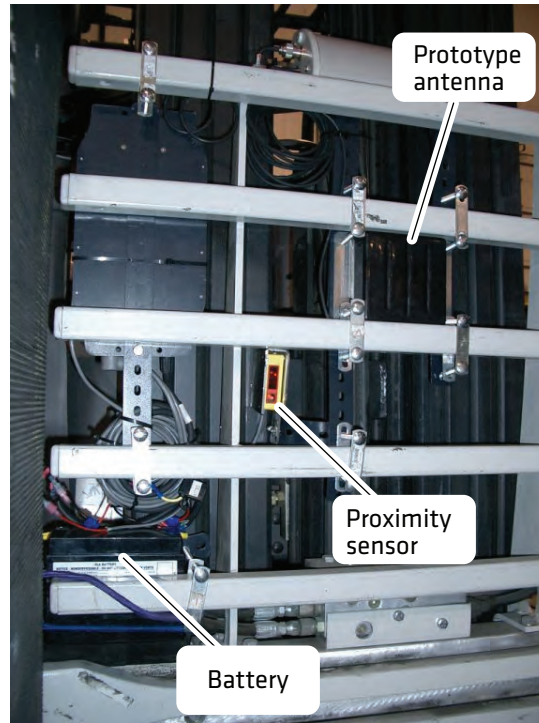
The test adapters required hardware CTS/RTS handshake or xon/xoff, neither of which is supported by the IV7C. By connecting CTS to RTS on both the CV30 cable and the IV7 cable, the adapter can be made to work.

The battery solution should use a sealed, lead-acid battery providing 12 VDC and a minimum of 5 Ah. A charger and spare battery are recommended. You are responsible for sourcing and securing the batteries, battery charger, accessories, and so on. A battery length dimension closely matching the distance between vertical bars in the LBR or ALBR allows for better mounting.

The following pictures show the IV7 deployed on a clamp truck, using a large battery with much more capacity than required. A CV30 VMU was mounted in the cab and a proximity sensor was placed in the LBR. Total installation time was about 3 hours for two experienced people. For this two-day POC, the customer did not want to install a cable reel or multi-conductor cable.



Wireless RFID System: Bluetooth adapter and battery are required for wireless installations.



Backside of Wireless RFID System: *Prototype antenna and proximity sensor are shown here.*

Because of the additional problems that are introduced when using an IV7 in a wireless installation, Intermec recommends that you avoid this type of installation whenever possible.



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