GE Fanuc Automation

CP94x/RM94x Family

Ethernet Switches

HARDWARE REFERENCE MANUAL

Document Number: Rx-URMH 068 Rev B

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1 Introduction

The GE Fanuc Embedded Systems family of CP94X and RM94X semi-managed switches are designed to address three needs:

- State of the art Ethernet switch fabric

- Implementation in form factors appropriate for embedded and quasi-embedded applications (e.g., VMEbus, Compact PCI (CPCI) and custom)

- Economical solution for implementing Layer-2 Ethernet interconnections

GE Fanuc Embedded Systems achieves these goals by integrating advanced chip sets (for high performance switching functions) with numerous media front ends (e.g., BNC, fiber and copper). A benefit of this approach is that both hardware (e.g., media types, form factor) and software feature sets may be readily tailored to meet special needs within the context of the commercial off-the-shelf (COTS) model to which GE Fanuc Embedded Systems adheres.

1.1 Features

The CP940, CP941, RM942, RM940, RM940C, RM941, and RM942 provide high performance, configurable, 10/100Mbit Ethernet switch solutions in a VMEbus or CPCI form factor. All have identical switching and configuration capabilities. The differences are in I/O access (front/rear or fiber/copper) and environmental attributes (RM940 is conduction cooled and rated for wider temperature range). Features include:

- Eight 10/100Mbit Ethernet ports

- Each port auto-negotiating supports full-duplex or half-duplex operation (copper only)

    Note: The RM942 is 100BaseFX and runs at 100Mbits only

- Level-2 switching fabric connecting ports

- Full wire speed operation on all 8 ports

- No setup or operator interaction is required to enable basic switching capabilities

- Media Access Controller (MAC) address learning forwards incoming packets only to port with destination address

- Virtual local area network (VLAN) and Quality of Service (QoS) support options

- Support options configured via non-volatile serial read-only memory (SROM) for automatic power on setup

2 Theory of Operation

The switch architecture is illustrated in the block diagram below.
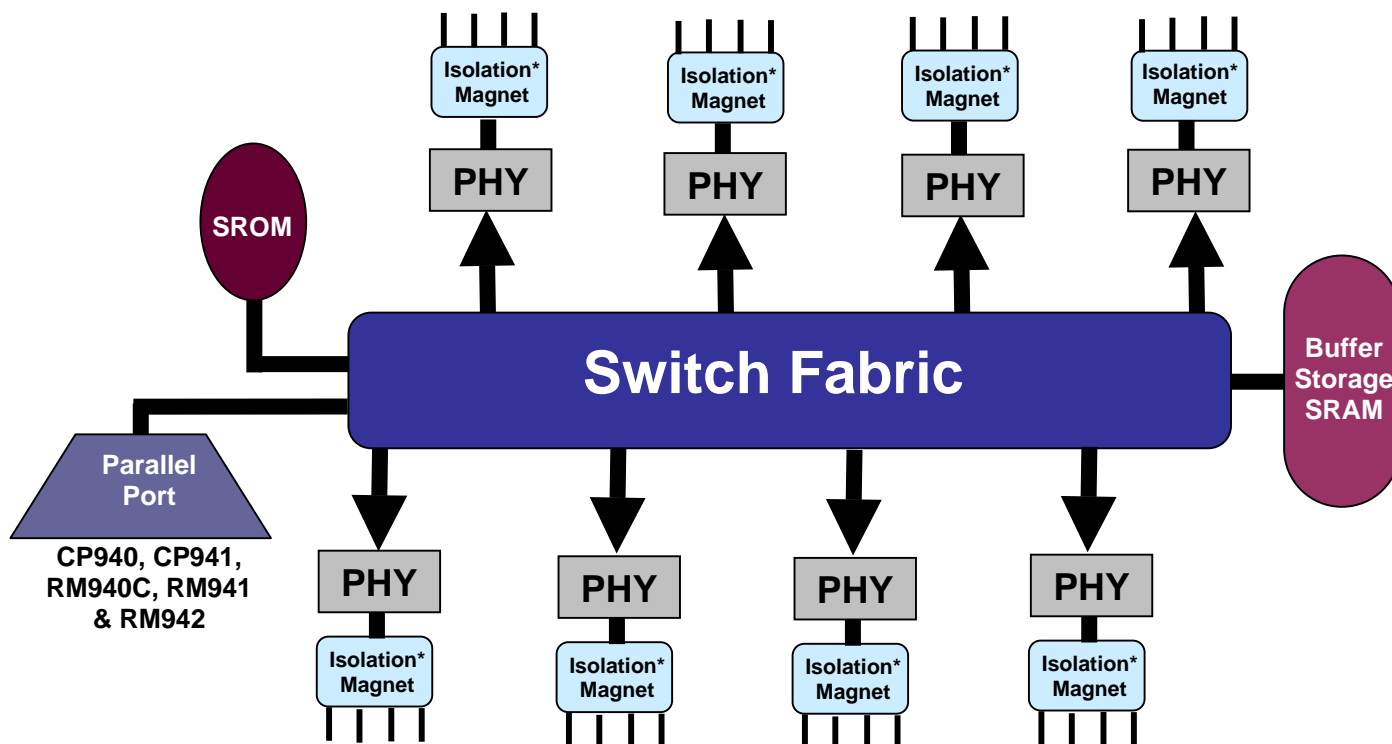
> **Note**: The RM942 has eight ports of Fiber. There are no magnetics on board.

By definition, a Network Switch differs from a hub in that each packet received into the switch is transmitted to the minimum number of ports. This greatly improves aggregate data rate (i.e., multiple pairs of ports can be involved in data transfer at a single point in time). As each packet arrives at the switch, both the source and destination address of the packet are examined. The source is retained and associated with the arrival port as the location of that device. If the packet is unicast (i.e., destined for a single receiver) and the destination is known, the packet will only be transmitted to the port associated with the destination address. Since the learning is automatic, no operator intervention is needed. As attached workstations (or other network capable devices) communicate, their locations are learned and traffic can be localized to the port.

In default configuration, the CP94X and RM94X family of switches delivers a fully auto-configuring interconnect. Each port will negotiate speed and form full duplex with the connected interface. Once a link has been established, incoming packets are examined and the MAC address added to the table associated with that port. When the destination address has been associated with a port (from an earlier transmission) the packet is forwarded only to that port. This process is independent for each port, so that the aggregate throughput of the switch fabric is much higher than that of a single channel.

Where the destination has not yet been acquired, the packet is sent to all ports (see the VLAN section for behavior when this option has been configured).

Because the negotiation and learning process is automatic, there is no operator or start-up interaction required. The static random access memory (SRAM) buffer provides local storage to allow for dealing with multiple incoming packets with a single destination port. Packets will be sequenced and buffered to avoid data loss. The QoS (optional) offers a mechanism to prioritize traffic.

2.1   Operational Options

The switch fabric has a number of performance operations usually found only in managed switch products. These options include:

- Port based VLAN

- QoS

- Port speed/duplex forced configuration

All of these parameters are set via the SROM. This can either be programmed prior to manufacturing or configured in the field from the front panel parallel port (The RM940 must be configured at the factory).

2.1.1   Port Based VLAN

The switch fabric provides the designer with the ability to define a single port-based VLAN for each of the eight ports. This VLAN is individually defined for each port, assigning a VLAN ID (value between 0–7) for each port.

When packets arrive at an input of the switch, the search engine will determine the VLAN ID for that port and will then determine which of the other ports are also members of that VLAN by matching their assigned VLAN ID values. The packet will then be transmitted to each port with the same VLAN ID as the source port.

2.1.2   QoS

QoS provides a new level of capability to unmanaged switch applications with two transmit queues per output port.

The fabric manages the output transmission queues for all ports of the fabric. Once the destination address search is complete, the packet is inserted into the appropriate output queue. Either VLAN tag information or the Type Of Service (TOS) field in the IP header controls packet entry into high or low priority queue. Each of these priority fields can used to select the transmission queue priority as well as a packet drop probability. The mapping of the tag and TOS fields to either the high or low priority queue is configured on power-up from the SROM.

The fabric utilizes Weighted Round Robin (WRR), Random Early Drop/Random In/Out (RED/RIO) bit, and a timestamp method of scheduling packets for transmission. WRR uses an efficient method to ensure that each of the transmission queues gets at least a minimum service level. With two output transmission queues, the fabric will transmit "X" packets from the high priority queue before transmitting "Y" packets from the low priority queue. The "X" and "Y" weights are user definable. The high priority weight can be set to a value between 0-16. The low priority weight is fixed at the value 1. If the high priority weight is set to the value 4, then the fabric will transmit four high priority packets before transmitting each low priority packet.

The timestamp method of scheduling packets for transmission allows the fabric to offer latency guarantees to high priority packets. This is ideal for voice and video packets that have strict latency requirements. Packets are given a timestamp when they arrive at the input port. Once they are scheduled into a transmission queue, the fabric will keep track of the packets delay time through the chip. Under heavy congestion the timestamp may be utilized to change the order of packet transmission to ensure timely delivery of packets and orderly service of congested queues. The following are the transmission scheduling exceptions:

1. Packets with high priority and low priority drop will be transmitted before any in the low priority queue.

2. If the high priority delay is => 2ms, then transmit from the high priority queue.

3. If the high priority delay is < 1ms and the low priority queue is congested, then transmit from the low priority queue.

4. If the high priority delay is < 2ms and the low priority queue is full, then transmit from the low priority queue.

The QoS capabilities of the fabric are enabled by loading the appropriate values into the configuration registers and either enabling or disabling the flow control. Performing the following five steps enables QoS for packet transmission:

1. Select the TOS or VLAN Tag field as the control for packet transmission. The selection is made using bit 6 of the FCB Buffer Low Threshold (**FCBST[6]**) register.

2. Select the TOS or VLAN Tag field as the control for IP packet transmission. The selection is made using bit 7 of the Flooding Control (**FCR[7]**) register.

3. Set the transmission queue weight for the high priority queue in the Transmission Scheduling Control (**AXSC[3:0]**) register.

4. For half-duplex operation, the transmission queuing must be enabled using bit 7 in the Trans-Mission Scheduling Control (**AXSC[7]**) register.

5. Set the priority mappings from the TOS or VLAN Tag field to the high or low priority output queue.

When Flow Control and QoS are enabled, the fabric will utilize WRR to schedule packet transmission, and will use either backpressure or 802.3x flow control to handle situations of buffer memory congestion. When Flow Control is disabled and QoS is enabled, the fabric will use RED/RIO to drop random packets in order to handle situations of buffer memory congestion. In this method only certain packet flows are slowed down, while the remaining see no impact from the network traffic congestion. RED/RIO is a method of handling traffic congestion in the absence of Flow Control mechanisms. When Flow Control is enabled, all devices that are connected to a switch node that is exercising flow control are effectively unable to transmit, even nodes that are not directly responsible for the congestion problem. RED/RIO allows traffic to continue flowing into ports on a switch and randomly drops packets with different probabilities based upon each packet's priority markings. As the switch congestion increases, the probability of dropping an input packet increases. As congestion decreases, the probability of dropping an input packet decreases. In this manner, only traffic flows that have had packets dropped will be affected by the congestion. Other traffic flows will see no effect.

2.1.3 Port Configuration

By setting parameters in the SROM, each port can be individually configured in speed (i.e., 10MB or 100MB) and duplex (i.e., full or half). The RM942 must run at 100Mbit, the user can define full or half duplex operation only.

3   Handling And Installation

3.1 Handling Precautions

Electronic assemblies use devices that are sensitive to static discharge. Observe anti-static procedures when handling these boards. All products should be in an anti-static plastic bag or conductive foam for storage or shipment. Work at an approved anti-static workstation when unpacking boards.

3.2 Unpacking And Verification

GE Fanuc Embedded Systems products are shipped in individual, reusable shipping boxes. When receiving the shipping container, inspect it for any evidence of physical damage. If the container is damaged, request that the carrier's agent be present during the unpacking of individual boxes and the inspection of each unit.

Remove the RM94X card from the shipping box and anti-static packaging. Verify that it is not damaged and that all items are present by referring to the packing list. Each RM940, RM94C and RM941 is shipped with a 6U assembly.

3.3 CP940, CP941, RM940C, RM941 and RM942 Installation

The CP940, CP941, RM942, RM940C and RM941 consume a single slot in the chassis.

> _Notes_: 1.   **VMEbus (RM940C) Only**:   Because the Input/Output (I/O) (network) connections are via the reserved pins on the P2 connector, it is critical that there is no other already present load on these pins. Check that the slot to be used does not have a transition module (for a different card) or other attachment on the backplane prior to restoring power.
>
> 2.   There are no on-board user-configured jumpers for this product.
>
> 3.   The CP940 routes its rear I/O signals to the J5 connector.

- Locate the slot in the chassis into which the CP940, CP941, RM940, RM941 or RM942 Ethernet Switch will be installed.
- Remove power from the chassis.
- Observing proper anti-static procedures insert the switch assembly into the chassis. Use the ejector handles to ensure the card is fully seated into the backplane
- The chassis may now be powered-up.

3.4 RM940 Installation

Installation is done generically as with the commercial versions of the card. Follow any specific procedures recommended by the manufacturer of the ATR chassis used.
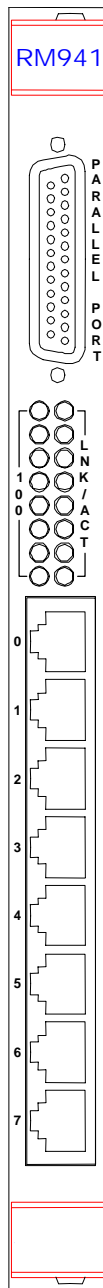
3.5 Front Panel Connections And Indicators

The front panel of the RM940C and RM941 are illustrated in the diagrams below (no front panel on the RM940).
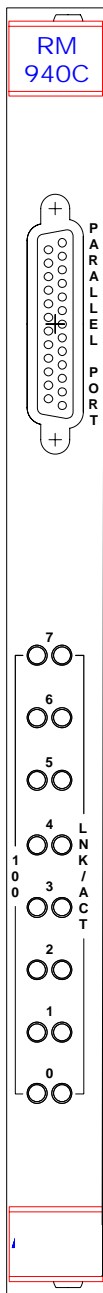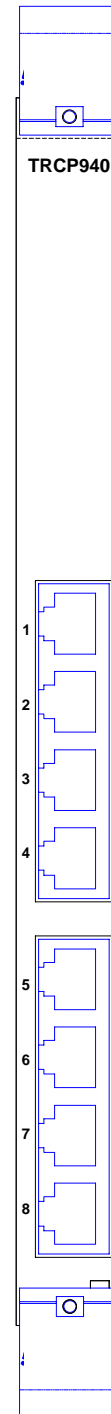
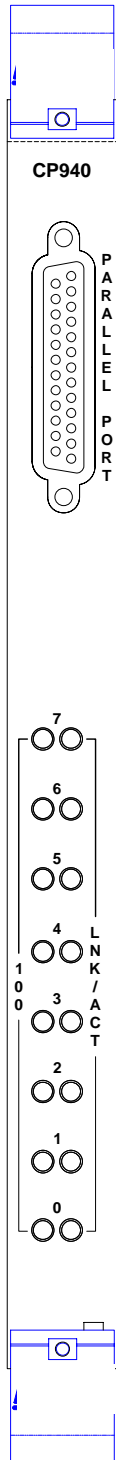**RM940C**   **RM941**   **TRCP940 Transition Card**
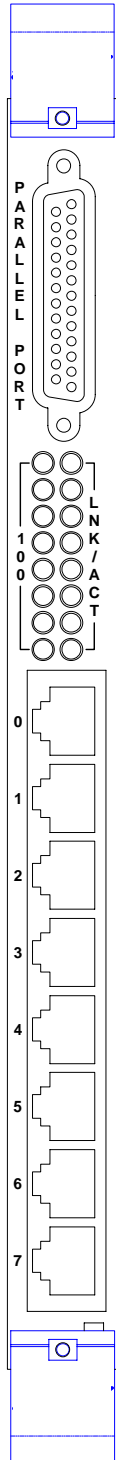
The front panel of the CP940, CP941 and RM942 are illustrated in the diagrams below.

CP940   **CP941**   **RM942**
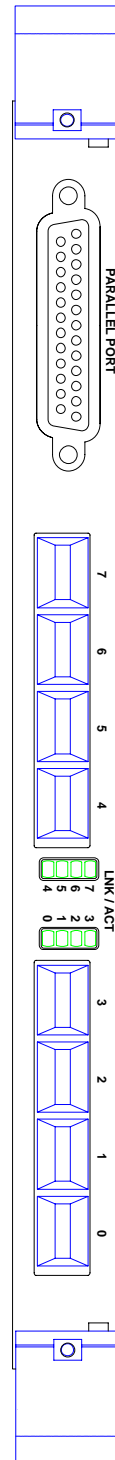
3.6 Network Connections (CP941, CP940*, RM941 Only)

The eight RJ45 connectors have 10/100BaseT network connections. They are wired per industry specification. Any standard network cable may be used to connect them with a Network Interface Card (NIC).

> **_Notes_**: 1. *CP940 has a rear transition module with RJ45.
>
> 2. Connecting to another Ethernet HUB or SWITCH: In this case a "crossover" cable must be used, or the connection must be to the "uplink" port of the hub or switch.

3.7 LED Indicators

3.7.1 100Mbit Speed Indicators

Each port has an associated 100Mbit LED that will illuminate when a link is operating in 100Mbit mode.

3.7.2 Link/Activity Indicators

Each port has an associated Link/Activity indicator (LED). This indicator will be illuminated when a valid link is detected. When packets are received/transmitted (data traffic) on a port, the illuminated link LED will blink. If the LED is solid on illumination, it indicates a link is present, but no data traffic is present on the port. If a valid link is not present, the LED will not illuminate and activity cannot take place on a port.

4 Setting Optional Characteristics

As described in section **2 Theory of Operation**, the switch fabric can be configured to support QoS, VLAN and port profile information. This data is captured in an on-card SROM that is loaded into the fabric control engine during power on. The contents of the SROM can be altered (on the RM940C and RM941) using a standard parallel port and PC.

Contact GE Fanuc Embedded Systems to receive a copy of the programming tool (for Windows 95/98 and NT). There is no charge for this program.

SROM contents may also be set at the factory, consult your GE Fanuc Embedded Systems sales representative for information on this service.

5 I/O Pin Assignments

The RM940 and RM940C use the "user assigned" pins of the A and C rows of the VMEbus P2 connector for the 10/100BaseTx signals. Each of the eight ports has six signals, of which only four are essential. The remaining two are common mode outputs from the isolation transformer. These are not used in standard cabling. To connect to a standard UTP cable (RJ45), only the Tx and Rx signal pairs should be used.

Port	Tx +	Tx -	Rx +	Rx -	Shield	CT0	CT1
0	A29	C29	C31	A31	A32	A30	C30
1	C27	A27	A25	C25	A28	A26	C26
2	A21	C21	C23	A23	A24	A22	C22
3	C19	A19	A17	C17	A20	A18	C18
4	A13	C13	C15	A15	A16	A14	C14
5	C11	A11	A9	C9	A12	A10	C10
6	A5	C5	C7	A7	A8	A6	C6
7	C3	A3	A1	C1	A4	A2	C2

6 Functional Specifications

6.1 CP940

Below are the functional specifications for the CP940 8-port CompactPCI Embedded Layer 2 Switch, Rear I/O:

Power	**4 Total Watts**
@ 3.3 V	**1.2 Amps**
Form Factor	
cPCI	**6U Single Slot**
MTBF	
MIL 217-F Nav Shel 25 Deg. C	**283000 Hours**
Temperature	
Operating	**0 to +60° C**
Storage	**-40 to +85° C**
Humidity	
Operating	**5% to 95% Non-Condensing**
Storage	**5% to 95% Non-Condensing**
Conformal Coating	**Yes, additional charge**

PCI Standards	
Hot Swap	**Yes**
Switches	
Ports	
10/100 Base-TX	**8**
Port Routing	
Rear	**(8) ports 10/100BaseTX**
Switching	
Management	**Unmanaged**

Transition Module available	**TRCP940**

6.2   CP941

Below are the functional specifications for the CP941 8-port CompactPCI Embedded Layer 2 Switch, Front I/O:

Power	4 Total Watts
@ 3.3 V	1.2 Amps
Form Factor	
cPCI	6U Single Slot
MTBF	
MIL 217-F Nav Shel 25 Deg. C	283000 Hours
Temperature	
Operating	0 to +60° C
Storage	-40 to +85° C
Humidity	
Operating	5% to 95% Non-Condensing
Storage	5% to 95% Non-Condensing
Conformal Coating	Yes, additional charge

PCI Standards	
Hot Swap	Yes
Switches	
Ports	
10/100 Base-TX	8
Port Routing	
Front	(8) RJ45 10/100BaseTX
Switching	
Management	Unmanaged
Layer	2

6.3   RM940

Below are the functional specifications for the RM940 8-port 10/100BaseTX Ethernet Switch, Rear I/O, Conduction Cooled:

Power	4 Total Watts
@ 5 V	0.8 Amp
Form Factor	
VMEbus	6U Single Slot
MTBF	
MIL 217-F Nav Shel 25 Deg. C	283000 Hours
Temperature	
Operating	- 40 to +85 ° C
Storage	- 50 to +95 ° C
Humidity	
Operating	5% to 95% Non-Condensing
Storage	5% to 95% Non-Condensing
Conformal Coating	Yes, additional charge

Switches	
Ports	
10/100 Base-TX	8
Port Routing	
Rear	(8) ports 10/100BaseTX
Switching	
Management	Unmanaged
Layer	2 & 3

6.4 RM940C

Below are the functional specifications for the RM940C 8-port 10/100BaseTX Ethernet Switch:

Power	**4 Total Watts**
@ 5 V	**0.8 Amp**
Form Factor	
VMEbus	**6U Single Slot**
MTBF	
MIL 217-F Nav Shel 25 Deg. C	**283000 Hours**
Temperature	
Operating	**0 to +60 ° C**
Storage	**-40 to +85 ° C**
Humidity	
Operating	**5% to 95% Non-Condensing**
Storage	**5% to 95% Non-Condensing**
Conformal Coating	**Yes, additional charge**

Switches	
Ports	
10/100 Base-TX	**8**
Port Routing	
Rear	**(8) ports 10/100BaseTX**
Switching	
Management	**Unmanaged**
Layer	**2 & 3**

6.5   RM941

Below are the functional specifications for the RM941 8-port 10/100BaseTX, VME Unmanaged Switch:

Power	**4 Total Watts**
@ 5 V	**0.8 Amp**
Form Factor	
VMEbus	**6U Single Slot**
MTBF	
MIL 217-F Nav Shel 25 Deg. C	**283000 Hours**
Temperature	
Operating	**0 to +60 ° C**
Storage	**-40 to +85 ° C**
Humidity	
Operating	**5% to 95% Non-Condensing**
Storage	**5% to 95% Non-Condensing**
Conformal Coating	**Yes, additional charge**

Switches	
Ports	
10/100 Base-TX	**8**
Port Routing	
Front	**(8) RJ45 10/100BaseTX**
Switching	
Management	**Unmanaged**
Layer	**2 & 3**

6.6   RM942

The functional specifications for the RM942 8-port 100BaseFX, VME Embedded Unmanaged Switch will be published at a later date. Periodically check GE Fanuc Embedded Systems Internet Site to keep abreast of the latest changes.