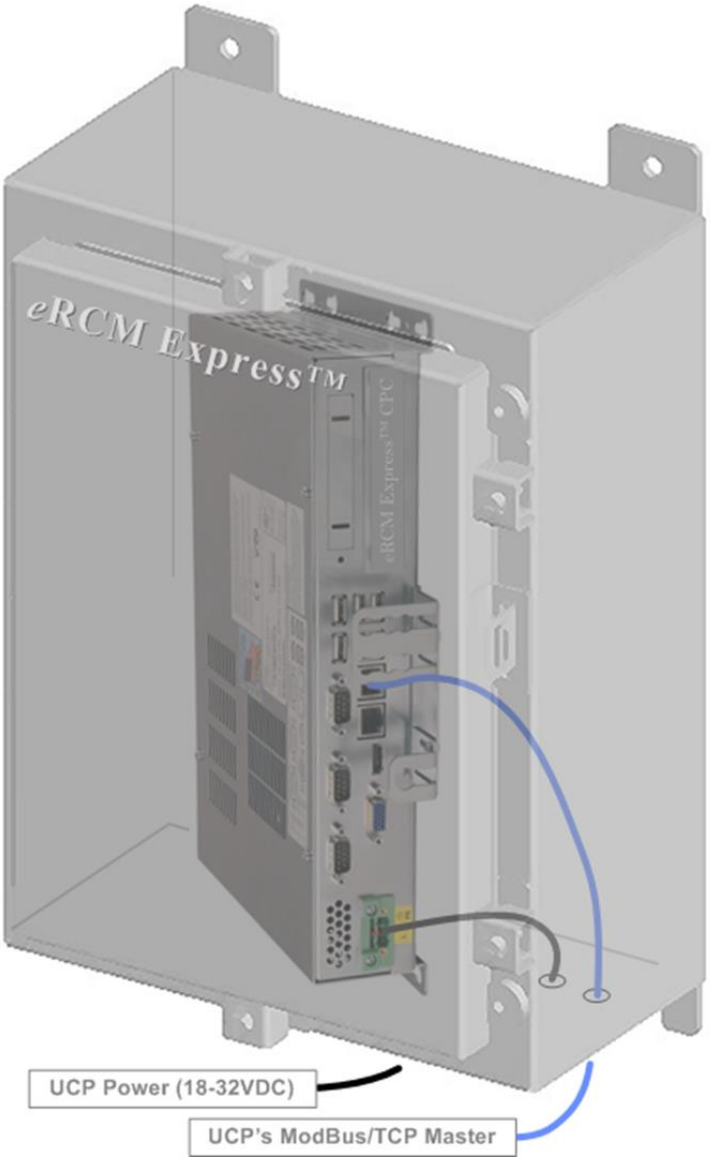
eRCM Express™

Manual



Ver 2017-May-19

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Topic Sections

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Unit

Specifics

When appropriate, additional pages of information generated by ACI software will follow this page. Inserted pages will detail Unit and Automation Information about the specific unit, Or units, included in the provided eRCM Express.

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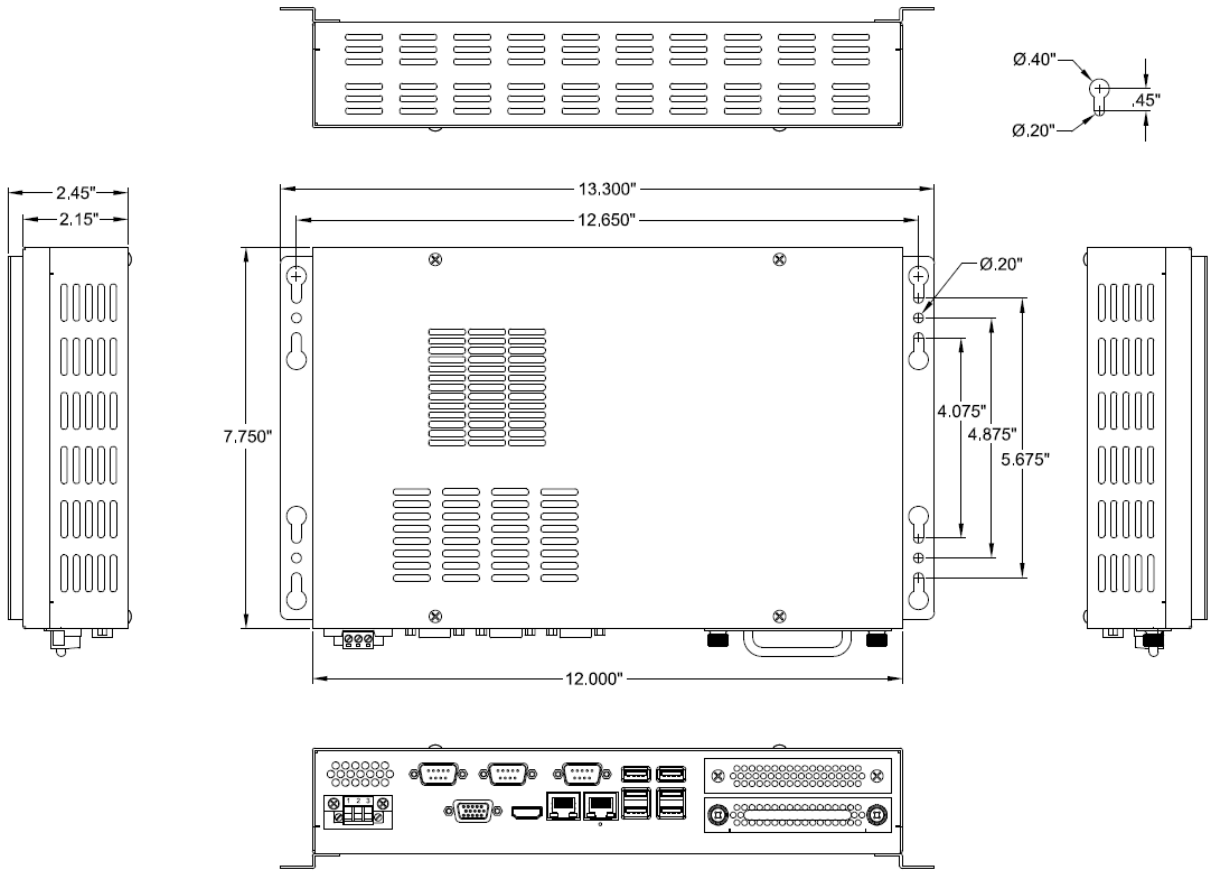
eRCM Express™

Technical

Specifications

Dimensions of the base-unit are:

- Size (W x H x D): 7.750″ x 12.00″ x 2.15″ (196.8mm x 304.8mm x 54.61mm)
- Weight: 6.5 lbs (2.9 kg)
- Overall with Mounting Brackets: 7.750” x 13.30” x 2.45” (196.8mm x 337.82mm x 62.23mm)



Operating Conditions Limits:

- Operating Temperature: 0°C to 55°C (32°F to 131°F)
- Humidity: 20% to 80% RH, noncondensing
- Shock: 15g peak acceleration, 11msec
- Vibration: 0.006″ peak to peak displacement, 1.0g max acceleration
- Altitude: Sea level to 10,000 feet

Electrical:

- Input Signal: 40W Typical
- DC Voltage Input: 18-36 VDC, 6.0 A Maximum
- The typical power consumption is 35 Watts, which would be 1.46A@24 VDC.
    - The power supply inside the unit has a fuse as well, which is 5A.
    - Sizing the power supply (and if desired an external fuse) at 2A.

Certifications/Compliance:

- FCC: 47 CFR, Part 15, Class A
- CE: CE, EN 55022: Class A, EN 61000-3-3, EN 61000-6-2, IEC 60950-1
- Safety Agency: UL 508 Listed, ANSI/ISA 12.12.01-2011, cUL Listed CSA 22.2, #142, cUL Listed CSA 22.2, #213
- UL and cUL Ordinary Locations Listed
- UL and cUL Hazardous Locations Listed
- Class I Division 2, Groups A, B, C, & D; Class II Division 2, Groups F & G; Class III when mounted in a NEMA enclosure
- FCC & European CE compliant

Agency Approvals:

- Class I Division 2, Groups A, B, C, D
- Class II, Division 2, Groups F & G
- Class III
- Temp. Code: T4A, when installed on a flat surface of a Type 1, 4, 4X, or 12 enclosure.

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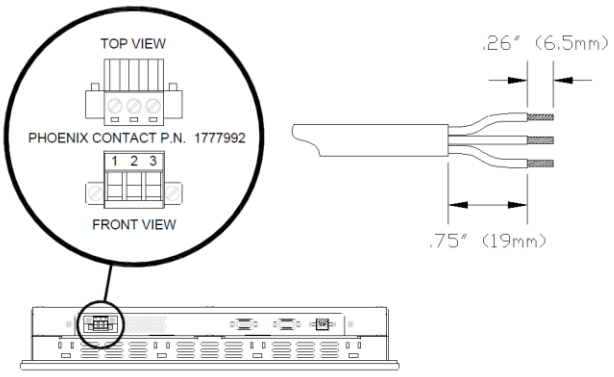
Connecting Power to an eRCM Express Unit

eRCM Express units are powered from 24 VDC (18-36 VDC).

- ***Damage will occur if 100-240 VAC power is connected to a unit equipped with the 24 VDC input power option.***

eRCM Express units are UL 1604 listed for Hazardous Location use (Class I division 2). As such, the units do not have a power switch for switching off supplied power. Consideration should be given to the installation of an appropriately rated external power switch if the application requires powering off the unit.

- Power is connected to the units through a removable Phoenix Contact plug (Phoenix Contact P.N. 1777992) that allows for screw termination of field wiring.
- This plug is included with each unit and is keyed to prevent installation in a unit with the wrong input voltage rating.
    - **When Field Wiring to these terminals the use of 18 AWG or greater (12 AWG maximum) copper wire with 60ºC or 60/75ºC wire insulation and the terminal tightening torque of 7.0 lb/in. (0.79 Nm) is required.**
    - The terminal screws are shown in "Top View" below.
    - Connect the field wiring according to the appropriate voltage in the table below.
    - Strip the wire insulation back on each conductor **6.5 mm (0.26 in)** and assure that the remaining wire is twisted together, not frayed, and clean.
    - If an outer jacket over each conductor is utilized then strip the outer jacket back an additional **19.0 mm (0.75 in)** as shown in figure below.
    - When installing the conductors, take care that there are not any stray strands of wire that can contact an adjoining connection.
    - Tinning of each lead can be utilized to prevent frays if desired.



	PIN NUMBER	18 VDC – 36 VDC INPUT
1 2 3 FRONT VIEW	1	+ DC Input
	2	- DC Return
	3	Protective Earth Ground

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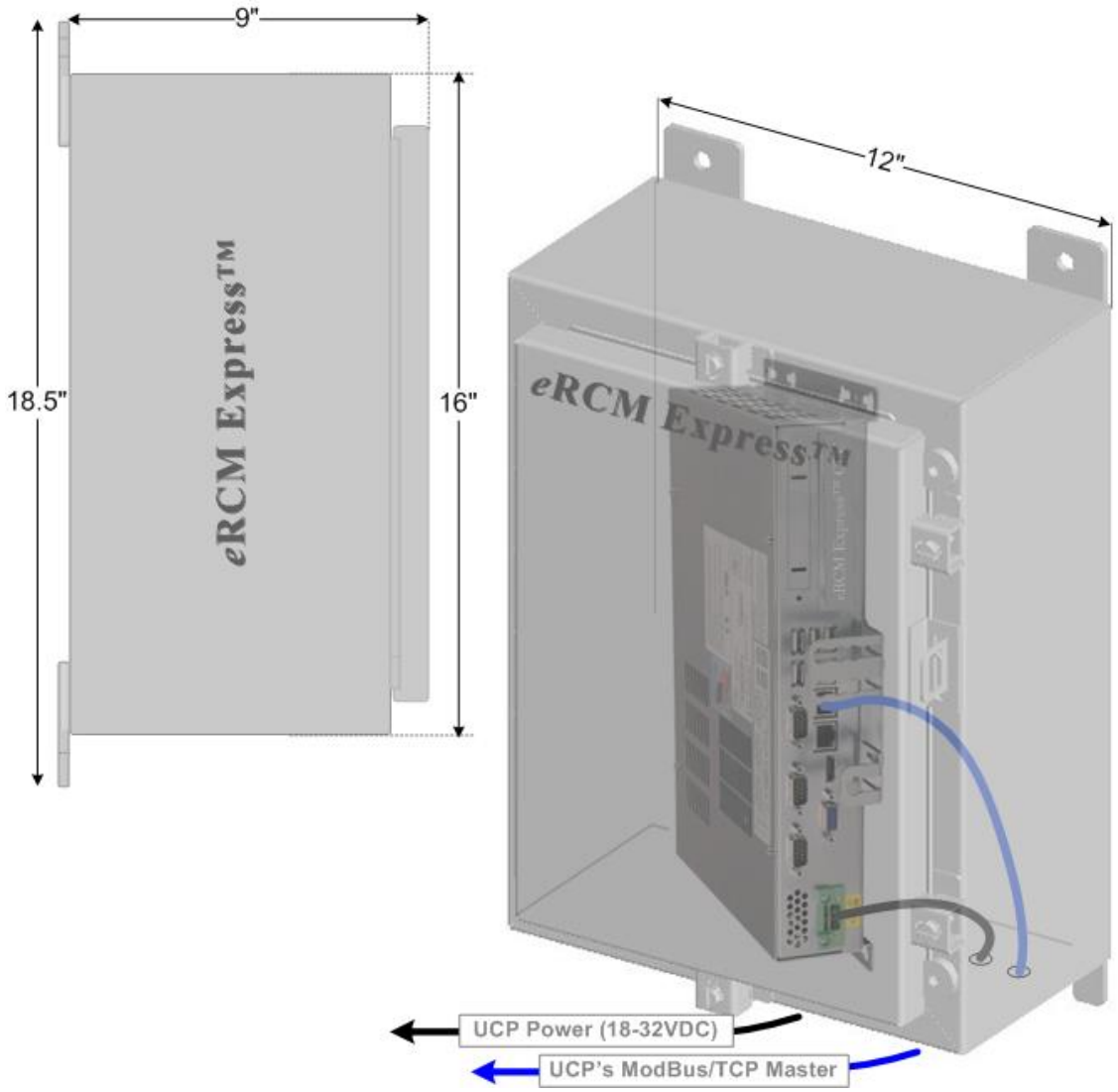
eRCM Express™

NEMA4 Enclosure

Drawings

This only applies to units ordered and shipped with the NEMA4 Enclosure.



ELECTRICAL

DC Input Voltage	18 – 36 VDC
DC Input Current	6.0 A Max @ 24VDC
Input Power	nPC300 – 60 W Typical* (40 W for N2800 Option)

Note (panel mount versions):

- Suitable for use in Class I, Division 2, Groups A, B, C and D; Class II, Division 2, Groups F and G; Class III hazardous locations, or nonhazardous locations only.
- For use on a flat surface of a Type 1, 4, 4x, or 12 enclosure with provisions for Class I Division 2 wiring methods.
- Temperature Code: T6 (T4A for N2800 option)

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eRCM Express™

Modbus

Registers

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*e*RCM™ Express Quick Start Guide

eRCM Express enclosure mounts on the side of a Unit Control Panel (UCP) or it can be mounted inside a UCP if the eRCM Express coprocessor is removed from its enclosure. A qualified I&E Technician should mount it, and route its cables as follows. *(Warning: Be sure the UCP power is off before proceeding).*

1. Route Power cable to a dedicated 24VDC power distribution terminals inside the UCP.
2. Route communications cable to the UCP master communications Port.

Once step 2. is complete, *and all hands are clear of power terminations*, restore UCP power. Following a short start-up cycle (approximately 5-30 seconds) eRCM Express is ready to communicate with the UCP.

The next step: A qualified UCP programmer (designated by owner/operator) should validate that the UCP is writing Operating Point Inputs to the data registers (see below), and is reading back appropriate eRCM Express outputs from other registers. Finally, the UCP programmer must properly integrate eRCM Express Outputs into the UCP process control and safety shut down (PC&SD) logic.

eRCM Express is a Modbus slave. The following are appropriate registry listings. Ethernet/IP protocol available Q414.

- Use Function 16 to write Operating Point Inputs to ModBus Registers 40001-40025 (see registry below).
- Use Function 03 to read back CPASA Outputs from ModBus Registers 40027-40077 (see registry below).

Function	Register	Operating Point inputs	Function	Register	Operating Point inputs
16	40001	TorqueLimit(%), Set by UCP Logic	03	40027	IsKernelBusy (Boolean)
16	40003	LoadStepSelectionMode(#), Always Zero	03	40029	FindOptimal (IdealLoadStep #)
16	40005	CurrentLoadStep (#), Set by UCP Logic	03	40031	NextLoadStepUp(#) | Raises BHP
16	40007	Ambient Temperature (°F), from UCP I/O	03	40033	NextLoadStepDown(#) | Lowers BHP
16	40009	Suction Pressure(psiG), from UCP I/O	03	40035	MinSpeed (RPM) @ Current LS
16	40011	Discharge pressure psiG), from UCP I/O	03	40037	MaxSpeed (RPM) @ Current LS
16	40013	Speed (RPM) - from UCP I/O	03	40039	MinSuction (psiG) @ Current LS
16	40015	Stage 1 Inlet Temperature (°F), from UCP I/O	03	40041	MaxSuction (psiG) @ Current LS
16	40017	Stage 2 Inlet Temperature (°F), if used	03	40043	AtmPress (psiA) | Static Design Pt.
16	40019	Stage 3 Inlet Temperature (°F), if used	03	40045	AuxLoad (BHP) | Current Operating Pt.
16	40021	Stage 4 Inlet Temperature (°F), if used	03	40047	CurrentTorq.(%) | Current Operating Pt.
16	40023	Stage 5 Inlet Temperature (°F), if used	03	40049	DriverMax (BHP) | Static Design Pt.
16	40025	Stage 6 Inlet Temperature (°F), if used	03	40051	Elevation (Ft.) | Static Design Pt.
			03	40053	IsentropEff (%) | Current Opns Pt.
			03	40055	MaxAllwdLd (BHP) | Current Opns Pt.

			03	40057	MaxDischTemp (°F) | Current Opns Pt.
			03	40059	MechanicalEff (%) | Current Opns Pt.
			03	40061	NumberOfCyldrs (#) | Static Design Pt.
			03	40063	NumberOfLdStps (#) | Static Design Pt.
			03	40065	NumberOfStags (#) | Static Design Pt.
			03	40067	NumberOfThrws (#) | Static Design Pt.
			03	40069	OEM_ID (#) | Static
			03	40071	NextLSUpPercentChange (%)
			03	40073	NextLSDownPercentChange (%)
			03	40075	eRCMExpressWatchdogPulse (#)
			03	40077	RelativeHumidity (%)| Static Design Pt.
			03	*40079-99*	*RESERVED – DO NOT USE*

***NOTE*: If NextLoadStepUp = -1 and NextLoadStepDown = -1 and FindOptimal = -1, then there are NO SAFE LOAD STEPS, and hence unit should Shut Down.**

***NOTE*: All registers (read & write) are Floating Point type.**

***NOTE*: To prevent shut downs during operations, if value sent as speed (Reg#40013) is less than minimum allowed then the minimum allowed speed is used instead and no errors are generated. Also, if value sent as speed (Reg#40013) is greater than maximum allowed then the maximum allowed speed is used instead and no again errors are generated.**

Modbus addressing starts at 40001, but this actually points to Registers 0 and 1, whilst address 40003 points to Registers 2 and 3. Since all modbus registers are 16-bit, for 32-floating numbers, two 16-bit registers are required.

The full list of all Modbus registers, and their complete descriptions, is available in a separate document.

Reading ModBus Registers:

1) For **ModBus over IP**, only read a Maximum of **100** Registers at a time.
2) For **ModBus over Serial**, only read a Maximum of **32** Registers at a time.

MODBUS Application Protocol Specification V1.1a Modbus-IDA
June 4, 2004 http://www.Modbus-IDA.org Page 15 of 51

6.3 03 (0x03) Read Holding Registers
This function code is used to read the contents of a contiguous block of holding registers in a remote device. The Request PDU specifies the starting register address and the number of registers. In the PDU Registers are addressed starting at zero. Therefore registers numbered 1-16 are addressed as 0-15.

The register data in the response message are packed as two bytes per register, with the binary contents right justified within each byte. For each register, the first byte contains the high order bits and the second contains the low order bits.

Request

Function code	1 Byte	**0x03**
Starting Address	2 Bytes	0x0000 to 0xFFFF
Quantity of Registers	2 Bytes	1 to 125 (0x7D)

Response

Function code	1 Byte	**0x03**
Byte count	1 Byte	2 x **N***
Register value	**N*** x 2 Bytes	

***N** = Quantity of Registers

Error

Error code	1 Byte	**0x83**
Exception code	1 Byte	01 or 02 or 03 or 04

Here is an example of a request to read registers 108 – 110:

Request		**Response**	
Field Name	*(Hex)*	*Field Name*	*(Hex)*
Function	**03**	Function	**03**
Starting Address Hi	**00**	Byte Count	**06**
Starting Address Lo	**6B**	Register value Hi (108)	**02**
No. of Registers Hi	**00**	Register value Lo (108)	**2B**
No. of Registers Lo	**03**	Register value Hi (109)	**00**
		Register value Lo (109)	**00**
		Register value Hi (110)	**00**
		Register value Lo (110)	**64**

The contents of register 108 are shown as the two byte values of 02 2B hex, or 555 decimal. The contents of registers 109–110 are 00 00 and 00 64 hex, or 0 and 100 decimal, respectively.

Reading more registers than the Maximum will usually cause the ModBus Protocol to stop responding. If that happens, close the communications link, set your code to read fewer registers, and then reopen the communications link.

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eRCM Express™

Directions for

Changing Unit

Modeling Files

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Steps to Install New eRCM Viewer™ File(s)

1) Obtain/create updated version of the appropriate eRCM Viewer™ file or files.
   a. Maximum number of eRCM Viewer files per eRCM Express is ten (10).

2) Copy the eRCM Viewer file(s) (*.rvf) to a USB Memory Stick on its **root directory**.

3)  Power OFF the eRCM Express™ system:
   a. Ensure proper shutdown by disconnecting power from source.

4) Open the eRCM Express's panel door:
   a. Insert the USB Memory Stick in the internal co-processor unit.
      i.  Insert USB memory stick into a **USB 2.0** port. (**WHITE** ports).
      ii.  **Do Not** insert memory stick into a USB 3.0 port. (BLUE ports).

5)  Power ON the eRCM Express system.

6)  Wait about one (1) minute while system reconfigures for new file(s).

7)  Remove the USB Memory Stick.

8) Close and seal panel door.

9)  Operation identified as successful if the eRCM Viewer file(s) on the USB memory stick have their filenames changed to include the appended text "_UPDATED".

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eRCM Express™

Directions for

Updating Unit

Software

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Steps to Install New eRCM Express Software (Firmware)

1) Obtain from ACI the latest version of the eRCM Express Software.
   a. This will be an EXE file such as **eRCM Express_##########.exe**.

2) Copy that file to a USB memory stick on its **root directory**.

3)  Power OFF the eRCM Express™ system:
   a. Ensure proper shutdown by disconnecting power from source.

4) Open the eRCM Express's panel door:
   a. Insert the USB Memory Stick in the internal co-processor unit.
      i.  Insert USB memory stick into a **USB 2.0** port. (**WHITE** ports).
      ii.  **Do Not** insert memory stick into a USB 3.0 port. (BLUE ports).

5)  Power ON the eRCM Express system.

6)  When eRCM Express reboots, the lights to the Ethernet port will turn OFF. Wait about 1-2 minutes while system reboots and reconfigures the system for the new software. eRCM Express with reboot to finish the software installing.

7) When then Ethernet port lights return to flashing and staying on, the system update is complete.

8)  Remove USB Memory Stick.

9) Close and seal panel door.

10)  Operation identified as successful if the EXE file on the USB memory stick had its filename changed to include the appended text "_UPDATED".

eRCM Express™

Setting Unit's

IP and Subnet Mask

Numbers

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Steps to Change Unit's IP (and if needed, Subnet Mask)

1) Create a text file using Notepad, with one of the two following sample formats:

`192.168.100.123`	Use the IPv4 format of xxx.xxx.xxx.xxx, where each xxx section represents a number from 0 to 255. If entered IP number is invalid, current IP number will not be changed.
`192.170.200.101` `255.255.127.0`	When desired, the subnet mask is always defined by the second line of input. If indicated IP number and/or subnet mask number are invalid, current IP number and/or subnet mask numbers will not be changed.

2) Save that text file to a USB Memory Stick on its **root directory**, with the filename ***eexpress_settings.txt*** (all lowercase). NOTE: Use an underscore '_', not a dash '-'.

3)  Power OFF the eRCM Express™ system:
   a. Ensure proper shutdown by disconnecting power from source.

4) Open the eRCM Express's panel door:
   a. Insert the USB Memory Stick in the internal co-processor unit.
      i.  Insert USB memory stick into a **USB 2.0** port. (**WHITE** ports).
      ii.  **Do Not** insert memory stick into a USB 3.0 port. (BLUE ports).

5)  Power ON the eRCM Express system.

6)  Wait about one (1) minute while the system reconfigures for new IP number.

7)  Remove the USB Memory Stick.

8) Close and seal panel door.

9)  Operation identified as successful if the text file on the USB memory stick had its filename changed to include the appended text "_UPDATED".

Pseudo Code

Examples

Pseudo Code Examples

Load in the correct eRCM Viewer model to use in the eRCM Express, then…

Sending Data to eRCM Express™:

```
ModBus.Data(1)  = 100   // Maximum Allowed Torque (%)
ModBus.Data(2)  = 0     // Always send 0 for item #2
ModBus.Data(3)  = 1     // Current Hardware Load Step
ModBus.Data(4)  = 71.4  // Current Ambient Temperature (degF)
ModBus.Data(5)  = 206.5 // Current Suction Pressure (psiG) into First Stage
ModBus.Data(6)  = 318.9 // Current Discharge Header Pressure (psiG) out of Last Stage
ModBus.Data(7)  = 1158  // Unit's Speed (RPM)
ModBus.Data(8)  = 74.5  // First Stage Suction Gas Temperature (degF)
ModBus.Data(9)  = 128.2 // Second  Stage Suction Gas Temperature (degF), when required
ModBus.Data(10) = 0     // Third Stage Suction Gas Temperature (degF), when required
ModBus.Data(11) = 0     // Forth  Stage Suction Gas Temperature (degF), when required
ModBus.Data(12) = 0     // Fifth  Stage Suction Gas Temperature (degF), when required
ModBus.Data(13) = 0     // Sixth  Stage Suction Gas Temperature (degF), when required


ModBus.NumberOfValues = 13  // 13 is the number of input values (1 Value = two 16-bit regs)
ModBus.Address = 40001      // 40001 is the starting address for the input values

ModBus.WriteData()          // Write new input values to the modBus registers.
                            // eRCM Express will detect a change in operating conditions
                            // and immediately perform performance and safety calculations
```

Reading Data from eRCM Express™:

```
DIM NextLoadStepUp as Integer
DIM LoadStepBHPs(4) As Double

ModBus.NumberOfDataValues = 1
ModBus.Address = 40027  // The address of the "IsBusy" register.
                        // Will return false (0) when eRCM Express has completed
                        // all of its performance and safety calculations.

ModBus.ReadData()               // Read data in the "IsBusy" register.
If ModBus.Data(1) = 0 Then      // If 0, then calculations are now complete.
       // Do the following to read specific items:
       ModBus.NumberOfDataValues = 34 (1 Value = two 16-bit registers)
       ModBus.Address = 40029      // Start of a block of data
       ModBus.ReadData()
       NextLoadStepUp = ModBus.Data(2)             //Data polled often and used often
       NextLoadStepDown = ModBus.Data(3)
       MinSpeedCurrentLS = ModBus.Data(4)
       MaxSpeedCurrentLS = ModBus.Data(5)
       MinSuctPressureCurrentLS = ModBus.Data(6)
       MaxSuctPressureCurrentLS = ModBus.Data(7)
         AtmPress = ModBus.Data(8)                   //Data usually only polled once.
         AuxLoad = ModBus.Data(9)
       CurrentTorque = ModBus.Data(10)
         DriverMaxBHP = ModBus.Data(11)
         Elevation = ModBus.Data(12)
       IsentropicEfficiency = ModBus.Data(13)
       MaxAllowedLoad = ModBus.Data(14)
         MaxDischargeTemperature = ModBus.Data(15)
         MechanicalEfficiency = ModBus.Data(16)
```

```
            NumberOfCylinders = ModBus.Data(17)
            NumerOfLoadSteps = ModBus.Data(18)
            NumberOfStages = ModBus.Data(19)
            NumberOfThrows = ModBus.Data(20)
            OEMID = ModBus.Data(21)
          NextLoadStepUpPercentChange = ModBus.Data(31)
          NextLoadStepDownPercentChange = ModBus.Data(32)
            MaxAllowedLoadChangePercent = ModBus.Data(33)
            MinAllowedLoadChangePercent = ModBus.Data(34)

          // Do the following to read an array of values at once:
          // Example: Get the load for load steps 1 through 23
          ModBus.NumberOfDataValues = 23
          ModBus.Address = 40201 // modBus address for start of LoadArray values (Load Step 1)
          ModBus.ReadData()
          LoadStepBHPs(1) = ModBus.Data(1)    // Load for Load Step 1  (Address 40201)
          LoadStepBHPs(2) = ModBus.Data(2)    // Load for Load Step 2  (Address 40203)
          LoadStepBHPs(3) = ModBus.Data(3)    // Load for Load Step 3  (Address 40205)
          LoadStepBHPs(4) = ModBus.Data(4)    // Load for Load Step 4  (Address 40207)
…
          LoadStepBHPs(23) = ModBus.Data(23)  // Load for Load Step 23 (Address 40245)
…
    END IF
```

Communications

Test

Whenever an important/critical auxiliary component, such as the eRCM Express, is connected to a control panel, there needs to be monitoring of the communications between the PLC and that auxiliary device.

eRCM Express uses the Modbus protocol. To be compliant with that protocol, please review the following sections of the "MODBUS MESSAGING ON TCP/IP IMPLEMENTATION GUIDE V1.0b" document.

- 4.2.2 Impact of Operating Modes on the TCP Connection
  - 4.2.2.1 Communication break between two operational end points
  - 4.2.2.2 Crash and Reboot of the Server end point
  - 4.2.2.3 Crash and Reboot of the Client

Additionally, eRCM Express supports a Watchdog register. The value of this register changes every time the eRCM Express unit updates internal calculations. Thus, if this value fails to change between calls to eRCM Express to change operating conditions, then communications has been compromised. If this happens for more than 1-2 seconds, then compressor Shut Down is prudent.

If your PLC does not support Modbus communications, then you will need to include a gateway device between your PLC and eRCM Express. Thus, the PLC will communicate with the gateway device, and the gateway device will communicate with the eRCM Express using Modbus.

- This adds another layer of communications. Thus, make sure the gateway device is programmed correctly to send and receive data to the PLC, and is programmed correctly to send and receive data from eRCM Express.
- To directly verify that the eRCM Express is sending and returning correct data, you can connect a PC to the eRCM Express and use ACI's eRCM Express Diagnostics & Communications Software.

Using Select

Features

1. **How do I make sure that the correct eRCM Viewer model is loaded into eRCM Express?**
    a. If there is only one (1) eRCM Viewer model used, then it is loaded by default and only a safety check needed.
    b. If there are multiple unit models loaded into eRCM Express (or you want to verify for security), then you need to run some code during start up to set and check:
        i. A default model will load in when eRCM Express starts. This may, or may not, be the desired model.
        ii. Check select items to determine if the loaded model is the desired model. The most common checks are: correct number of stages, correct number of load steps, ranges, and check if the clearances on a few specific Head Ends and/or Crank Ends are correct.
            1. If the check fails, then the wrong model is loaded.
                a. If there is only supposed to be one (1) model, and this is not it, then do NOT start the compressor!
                b. If there are additional models to check, then:
                    i. Set the **Next Viewer File Request** register [REG#42799] value to the value between 1 and 9, inclusive to identify the correct modeling file. When this register's value is returned to 0, then go back to 1.b.ii to check for correctness of file.
            2. If the check passes, then continue. The desired model is the current modeling being used in eRCM Express.

Example:

- If there are three (3) models in eRCM Express, a single-stage injection (Model-A), a two-stage injection (Model-B), and a single-stage withdrawal (Model-C), then:
    - Easily identify Model-B since it is the only one with two stages.
    - For Model-A and Model-C, check the suction and/or discharge pressure ranges. While both are single-stage, they serve different compression needs and hence likely have different defined operating ranges.
        - Alternatively, the two single-stage models cover different operating maps, and thus they likely have different number of load steps.

2. **How can I verify that eRCM Express is working, via code?**
    a. Check the value in the **eRCMExpressWatchdogPulse** register. If this value changes after your next call to **ChangeOpCondition** (done whenever you change values to any registers from **40009** to **40025**) then eRCM Express is

working as intended. The returned value will always be an integer from 0 to 6 million.

3. **How do I know if the eRCM Express is working and returning correct values in the unit's registers?**
    a. Install ACI's eRCM Express Diagnostics & Communications Software (available free from the ACI website). Install that software onto your Windows PC, set up an Ethernet connection from your PC to the eRCM Express unit and run the software. Reference that software's Help for more information about how to effectively use it.

4. **What do I change to make eRCM Express select load steps using larger (or smaller) increments?**
    a. Set the percent of desired change (for either load or flow) in the register **MinLoadFlowChangeAllowed**. Subsequent changes to conditions will lead to determination of **NextLoadStepUp** and **NextLoadStepDown** based on the new percent change value.

5. **How do I force eRCM Express to select load steps based on flow, or on power?**
    a. To base load step selection on Load, set **LSSelectionOnFlow** to 0. To base load step selection on Flow, set **LSSelectionOnFlow** to 1.
    b. In general, selection on Flow lends itself better to process control. However, some users prefer to control reciprocating compressor strictly on load.

6. **How do I determine which load step to set the unit to before closing the bypass valve?**
    a. To determine which load step to set the hardware configuration to, before closing the bypass valve, set the current operating conditions (pressure, speed, and temperatures), and then set **CheckSafeStartup** to 1. When this register's value returns to zero (0), retrieve the value in the **SafeLoadStepStartup** register – this register contains the load step to use.
        i. **NOTE**: For this option to be useful, you must send the discharge line pressure (***after the bypass valve***), and not a cylinder discharge pressure (before the bypass valve), when you set the current operating conditions.

7. **What does *MaxLoadChangeAllowed* do?**

a. The register value in **MaxLoadChangeAllowed** is used to prevent eRCM Express from selecting a load step that could result in undesirable consequences to the engine. A significant and sudden change in load (an increase or a decrease) can lead to problems with engines (over-speeding or under-speeding or surging). For many engines, the maximum load change limit is about a 15% change in load, whilst some may go as high as 25-30%. For electric motors, the limit may be higher since electric flows react faster than fuel flows.

8. What's the logic behind selecting Next Load Step Up (and Down)?

a. Based on the torque (or flow) of the Current Load Step, eRCM Express identifies which load steps are at least ***MinLoadFlowChangeAllowed*** percentage points higher (or lower for Next Load Step Down) but no more than ***MaxLoadChangeAllowed*** percentage points away. Then, the closest safe load steps to that limit are selected. If more than one load step is reasonable, then the load step with the best Load per Unit Flow ratio is selected (as it is the most efficient).

9. I'm not matching the correct bits set in the registers defined by ErrorArray().

a. The bits set in the ErrorArray register items can only be properly identified after that register's 32-bit floating point value is converted to a 32-bit long.
   i. All data retrieved from eRCM Express is defined as 32-bit floating numbers.
   ii. ErrorArray() requires some extra effort due to being stored in a non-integer format.
      1. Thus, first read the data from eRCM Express as a 32-bit float.
      2. Next, convert this to an integer. *This conversion needs to be done in the PLC, not in the gateway device if one is involved.*
      3. Then, look at the bits in that integer.
         a. Bits set/unset in the floating point are not relevant.
   iii. Example of process:
      1. Original has Discharge Temperature Exceeded bit set and Pin Reversal Exceeded, Bits #1 and #11
         a. `0000 0000 0000 0000 0000 1000 0000 0010`
         b. `Value = 2050`
      2. When converted to a 32-bit float, the bit pattern is changed to:
         a. `0000 0000 0000 1000 0000 0010 1111 1101`
         b. `Value = 2050 x 10-3`

   c. 2050 is the Significand and -3 is the exponent
      i. Here, 24 bits used for the significand and 8 bits used for the exponent.
3. Now, the two (2) 16-bit registers need to be taken from the eRCM Express, via a gateway if needed, to the PLC and recombined there to form a 32-bit float.
   a. NOTE: On some systems, the order of the 1st and 2nd Words (16-bit registers) needs to be swapped.
4. Finally, with a 32-bit float (REAL) value stored in the PLC, this needs to be **converted** to a 32-bit long (DINT).
   a. The value cannot be just copied from one data type to another.
      i. NOTE: For Allen/Bradley PLCs, the MOV command normally converts between data types if the destination register is not the same as the source register.
5. After the conversion, the new bit pattern in the DINT register should be:
   a. `0000 0000 0000 0000 0000 1000 0000 0010`
   b. `Value = 2050`
6. Thus, the original bit pattern is fully returned.
   a. Bit #1 is set, and hence there is a Discharge Temperature Exceeded error.
   b. Bit #11 is set, and hence there is a Pin Reversal Exceeded error.

General

eRCM Express

Process

1. When the PLC starts, if there is more than one potential eRCM Viewer model within the eRCM Express, then PLC needs to set the correct eRCM Viewer model and then identify it as being the current one loaded into eRCM Express.

2. Next, if you have access to the Discharge Header Pressure (the discharge pressure the compressor will compress to after the bypass valve is closed) then you should identify the load step to configure the unit to before closing the bypass valve (to prevent rod load and/or pin non-reversal issues during start up). This is done by using the ***CheckSafeStartup*** (REG#42725) and the ***SafeLoadStepStartup*** (REG#42727) registers.

3. If not set by the PLC, the eRCM Express will use the default values assigned to each of the following when the eRCM Viewer model was created. If you prefer different values, set them now.
   i. MinLoadFlowChangeAllowed (%): Usually 2%.
   ii. MaxLoadChangeAllowed (%): Usually in the 15-20% range. Set lower if engine cannot handle large step changes in load, set higher if engine can handle larger step changes in load and those changes are needed in areas of the operating map.
   iii. LSSelectionOnFlow: 0=Load, 1=Flow. In general, Flow is the better choice when trying to control a process.

4. If desired for an HMI screen, read the ranges and set in the PLC. These do not change until a new eRCM Model is loaded, so this set of registers does not need to be continually read. REG#s 42413 through 42455.

5. Read the following set of items, and store in PLC. These do not change until a new eRCM Model is loaded, so this set of registers does not need to be continually read.
   i. REG#40043, AtmPress (psi)
   ii. REG#40045, AuxLoad (HP)
   iii. REG#40049, BHPMax (HP)
   iv. REG#40051, Elevation (ft)
   v. REG#40057, MaxDischF (degF)
   vi. REG#40061, NumCyls (#)
   vii. REG#40063, NumLSs (#)
   viii. REG#40065, NumStgs (#)
   ix. REG#40067, NumThrws (#)

x. REG#40077, RelHumid (%)

6. When the unit is warmed up, and you are ready to close the Bypass valve, then set the unit to:
   i. The load step identified in Item #2, **or**
   ii. To the last (and ideally the least loaded) load step, Load Step #NumLSs

7. Close the Bypass Valve

8. When the Bypass Valve is fully closed, the unit is Online.

9. WHEN UNIT IS ONLINE:
   1. Set the Current Load Step in eRCM Express via REG#40005.
   2. Set the Maximum Torque Limit (%). Typically this is 100%.
   3. Read inlet pressure (Stage #1 Suction Pressure) and inlet temperature (Stage #1 Suction Temperature), the last stage's discharge pressure (Discharge Pressure), and the suction temperature to each stage after the 1st stage, and the current operating speed (RPM) from the sensors.
   4. Pass this information to eRCM Express via the registers (REGs#40009 through 40015, and if needed through 40025).
   5. Do not try to retrieve any performance data back from eRCM Express until the value in REG#40027 (IsKernelBusy) goes to zero (0). This item changes to one (1) when eRCM Express starts the compressor calculations and changes to zero (0) when those calculations are complete. This happens very fast (less than 1/1000th of a second for most calls).
   6. When IsKernelBusy is zero (0), then read the following items:
      i. FindOptimalLoadStep (REG#40029)
      ii. NextLoadStepUp (REG#40031)
      iii. NextLoadStepDown (REG#40033)
      iv. MinSpeedCurrentLS (REG#40035)
      v. MaxSpeedCurrentLS (REG#40037)
      vi. MinSuctPressureCurrentLS (REG#40039) (psiG)
      vii. MaxSuctPressureCurrentLS (REG#40041) (psiG)
      viii. MaxAllowedLoad (REG#40055)
      ix. NextLSUpPercentChange (REG#40071)
      x. NextLSDownPercentChange (REG#40073)
      xi. eRCMExpressWatchdogPulse (REG#40075)

xii. ACTIONS TO REVIEW AND TAKE IF NEEDED:

1. Communication Issues:
    a. If ModBus errors exist for more than 1 second, or if more than five (5) consecutive errors occur, then Shut Down.
    b. If WatchdogPulse does not change after setting items in 9(iv), then Shut Down.
2. No safe Load Steps:
    a. If NextLoadStepUp = -1 AND NextLoadStepDown = -1 AND FindOptimalLoadStep = -1 then Shut Down.
3. Set the PLC's Min Allowed Speed to MinSpeedCurrentLS
4. Set the PLC's Max Allowed Speed to MaxSpeedCurrentLS
5. Set the PLC's Min Allowed Suction Pressure to MinSuctPressureCurrentLS
6. Set the PLC's Max Allowed Suction Pressure to MaxSuctPressureCurrentLS
7. If there is an active call for More Load (or more Flow), PLC to change loading (sample given here, actual order determined by Automation and Control programmers):
    a. If not closed, start to Close Recycle, then
    b. If available, Unpinch Suction Throttle (up to MaxSuctPressureCurrentLS), then
    c. If not at Max Allowed Speed, Increase Speed, then
    d. If NextLoadStepUp ≠ -1, change load step to NextLoadStepUp.
8. If there is an active call for Less Load (or less Flow), PLC to change loading (sample given here, actual order determined by Automation and Control programmers):
    a. If not at Min Allowed Speed, Decrease Speed, then
    b. If NextLoadStepDown ≠ -1, change load step to NextLoadStepDown.
    c. If available, Pinch Suction Throttle (down to MinSuctPressureCurrentLS), then
    d. Start to Close Recycle Valve.

xiii. Read in ErrorArray (REGs#40101 to 40099+NumLSs*2)
xiv. Read in LoadArray (REGs#40201 to 40199+NumLSs*2)
xv. Read in FlowArray (REGs#40301 to 40299+NumLSs*2)

1. Display data from above three arrays on one HMI screen to show operators which load steps are valid, and the potential flow rates those load steps can deliver and their associated required loads. Ideal to highlight current Load Step, as well as the Next Load Steps Up and Down.

xvi. Read in StageArray (REGs#40401 to 40399+NumStgs*42)
   1. Display data on HMI

xvii. If/when you want key Throw Data displayed on HMI screen, then:
   1. Read in ThrowArray (REGs#40653 to 40651+NumThrws*52)
      a. Display data on HMI

xviii. If/when you want key Cylinder Data displayed on HMI screen, then:
   1. Read in HECylinderInfo (REGs#41173 to 41171 + NumCylinders*62)
      a. Display data on HMI
   2. Read in CECylinderInfo (REGs#41793 to 41791 + NumCylinders*62)
      a. Display data on HMI

xix. Go back to Item #9 WHEN UNIT IS ONLINE.

Change Default

File via PLC

Implementation of one of these methods is typically done when the compressor starts up, or when in idle mode and there is a need to change compression modes.

- If your eRCM Express only references one (1) mode of compression (i.e. there is only one eRCM Viewer model loaded into the eRCM Express), then this option is neither required nor useful.

Method – File Identification:

- eRCM Viewer files must be specially identified with a leading digit of "1" through "9" in their filenames for this method to work. Thus, if a file is named "Unit #4 1-Stage GMV6.rvf" this method will not work, but if the file is named "**1**Unit #4 1-Stage GMV6.rvf", then it will.
  - Thus, updating files to the eRCM Express must be handled so that the files have leading digits of "1" through "9" in their filenames.
  - Warning: Filenames with the same leading digit will lead to confusion. Thus, do not use filenames like "**1**_0 Unit#12.rvf" and "**1**_1 Unit#12b.rvf" as both have the same leading digit "**1**".
  - Samples:

Valid Filenames to Use	**Invalid Filenames**
1Unit7-Ariel 2-Stg.rvf	Unit7-Ariel 2-Stg.rvf
8Superior MH6 Single Stage.rvf	Superior MH6 Single Stage.rvf
2.rvf	Rev2.rvf
6 GE DS Service1-CNG.rvf	GE DS Service1-CNG.rvf

- To select file to use, simply set the register ***AdvToNextModel*** (Register Address 42799) to the special ID of that file, from "1" to "9".
  - When this register returns to its normal state of zero (0), then that desired file (if it exists) has been loaded.

- Sample Pseudo Code for Method:

```
' Load in file "4 CooperBessermer 2-Stg.rvf" into eRCM Express
Modbus.WriteRegister 42799, 4
PreventInfiniteLoop = 0
Do
  Pause 500 ms
  Modbus.ReadRegister 42799, Value
  PreventInfiniteLoop = PreventInfiniteLoop + 1
Loop Until Value = 0  OR  PreventInfiniteLoop > 10
IF PreventInfiniteLoop > 10 THEN
   ' Did not find desired file.
   MESSAGE "Desired modeling file not found."
   END
END IF
' Correct model now loaded in eRCM Express.
```

Miscellaneous

Notes

Relax eRCM Limits to Station Limits:

When implementing a compressor model in a Unit Control Panel environment, set certain limits within the model so that those limits do not trigger an invalid condition before the PLC would trigger an invalid condition.

- Example 1: If the PLC alarms at a discharge temperature of 300 °F and shut downs at a discharge temperature of 325 °F, then the maximum allowed discharge temperature in the eRCM Viewer model should be 325 °F, and not 300 °F.
- Example 2: If the unit is allowed to go to 40% torque, then make sure that the Min Allowed Torque setting in the eRCM Express is 40% or lower.

The goal is to not have the eRCM Express trigger unnecessary shut downs by indicating all load steps as unsafe, when in fact they may still be within the PLC's limits.

Using Compressor to Pack Discharge Line:

If the unit needs to pack a discharge pipe that has fallen below its normal minimum pressure, then ensure that the following limits are set in the eRCM Viewer model being used in the eRCM Express unit:

- Minimum Compression Ratio = 1.00
- Minimum Discharge Pressure = Minimum Suction Pressure

Running Unit at Low Torque:

If the unit needs to occasionally run in low torque conditions, then make sure that in the eRCM Viewer model being used in the eRCM Express unit:

- Minimum Torque = From 0% to 40%. *Typical Defaults: Motors = 25%, Engines = 60%.*

Running Unit when Discharge Pressure is Less Than Suction Pressure:

If the unit needs to occasionally run when the discharge header pressure is less than the suction header pressure, then:

1) Make sure that this is okayed by the OEM. Operations in blow-through can significantly degrade the life of compressor valves.
2) eRCM Express is not useful for determining unit safety under these conditions (blow-through). So, if that mode is ok with the OEM, then to keep eRCM Express from indicating operating issues, simply set the Discharge Pressure equal to the Suction Pressure. Thus, if Ps=390 psiG, and Pd=350 psiG, when sending data to eRCM Express, simply send 390 for Ps, and 390 for Pd.

Diagnostics

Testing

What to do if eRCM Express does not appear to be working:

Your eRCM Express hardware is designed for rugged industrial environments. If it does not appear to be working or appears to working incorrectly, please review the following checklist for potential issues/solutions.

Based on your knowledge of your system, you may need to just review one area of concern, some, or all. The four (4) areas of diagnostics are:

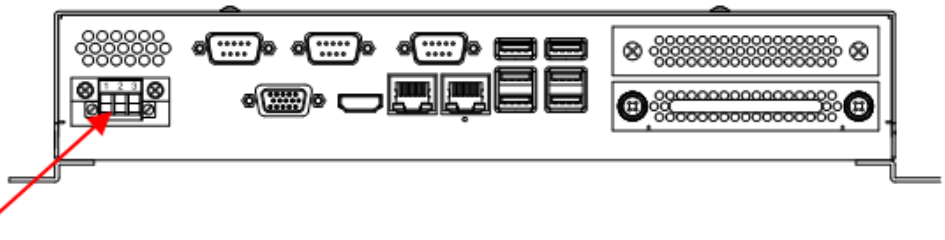
- Power Related Diagnostics,
- Port Related Diagnostics,
- Device Related Diagnostics, and
- Modbus Communication Diagnostics.

If device fails, please review suggestions in those areas. If it appears a unit has failed, then please contact ACI.

POWER RELATED DIAGNOSTICS

- **Power**: Review installation instructions and verify all items are set up correctly, that the power supply is within specifications, and a common ground is being referenced. See the "Connecting Power to an eRCM Express Unit" section of this manual for specific details.

- **Power Metering**: With a digital volt meter on the voltage DC setting verify that the source voltage to the unit is 24VDC +/- 2VDC. Ensure that all three wires are installed in the connector and they are not frayed or touching each other and that the power connector screws are installed to the computer power base connector.

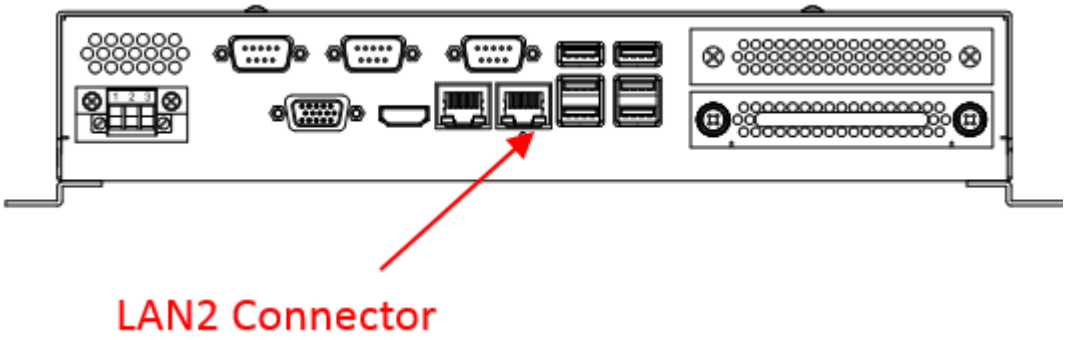


24VDC Source Voltage Connector

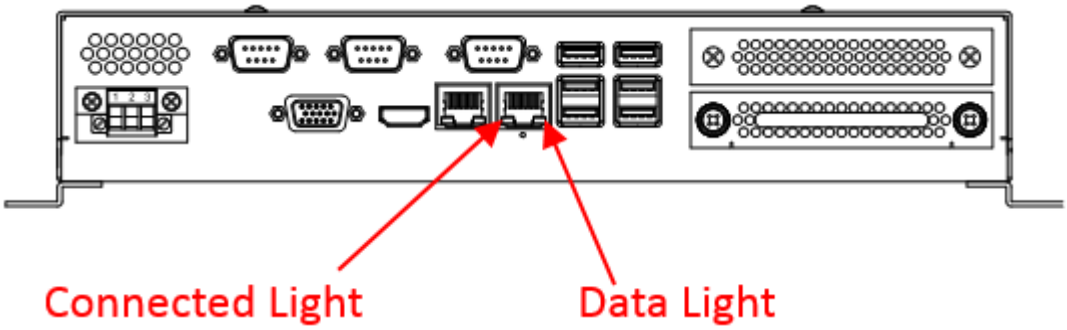
- **Static Buildup**: Disconnect power and Ethernet cables, and let unit sit for a few minutes. Reconnect power and Ethernet cables. Restart.

PORT RELATED DIAGNOSTICS

- **NIC Ports**: When the unit is powered up, check to make sure that the green LED light is visible through outer case vents on the top of the unit. This light is attached to the motherboard and illuminates once the unit is powered on. If this LED is not visible then the unit must be replaced as the motherboard has been damaged.



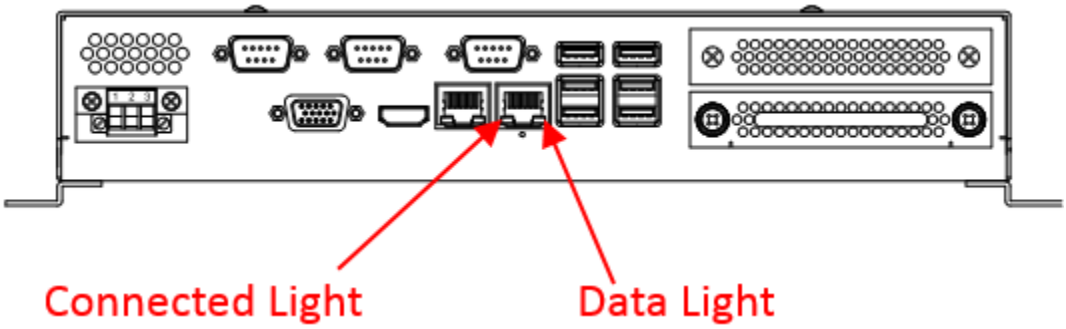
A green LED (Connected Light) should light up on the Ethernet port once the unit is started and properly connected to another Ethernet port. This can take up to 1 minute.



If the green Connected Light is not visible then do the following:

- Verify that the Modbus master unit Ethernet port has a green connected indicator light
- Swap the Ethernet cable. If the unit is connected to hub then the cable will be a standard patch cable. If the unit is directly connected to the Modbus master (recommended) then the cable will be a crossover cable.
- If the green Connected Light is still not illuminated then plug the Ethernet cable in to LAN1. If the green Connected Light is illuminated then LAN2 is damaged and the unit will need to be replaced.

When data is sent and received through the Ethernet port the green or amber Data Light on the Ethernet port should be visibly blinking.

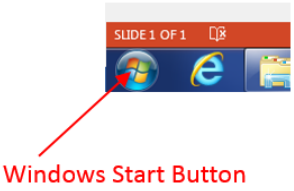


If this is not the case then either data is not being sent or the port is not receiving data. Do the following:

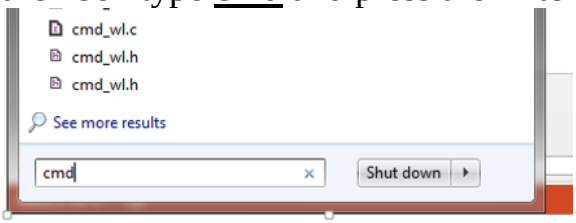
- Check the green or amber Data Light on the Modbus master. If it is not blinking then the Modbus master is not sending data.
- Move the Ethernet cable to LAN1. If the green or amber Data Light is blinking then LAN2 is damaged and the unit will need to be replaced.

- Check for any other connections (USB or Ethernet) to the unit. There should only be one Ethernet connection to the LAN2 port and this connection should be directly connected to the Modbus master host using a crossover cable.
  - IT IS NOT RECOMMENDED TO CONNECT THIS UNIT TO A SWITCH, HUB OR ANY OTHER NETWORK. THIS UNIT IS DESIGNED TO COMMUNICATE DIRECTLY WITH THE MODBUS MASTER.

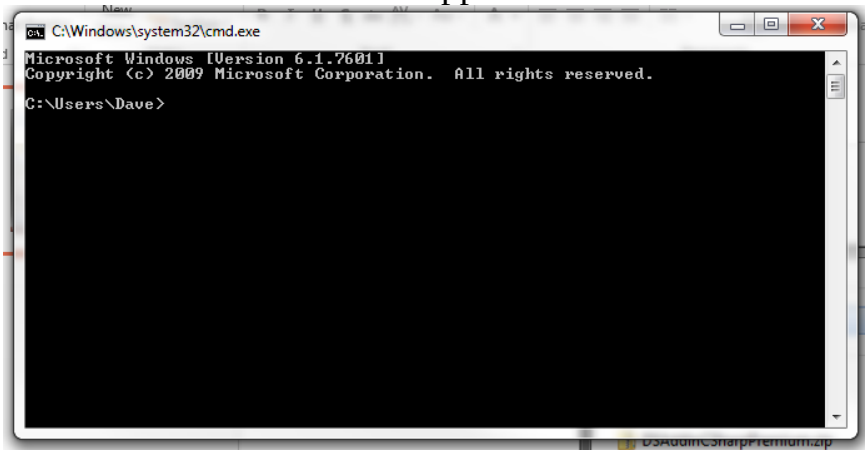
- **Pinging Ethernet Ports**: Click on the Windows® Start Button located in the bottom left corner of the Windows screen.



In the search box type **cmd** and press the Enter key.



A black console screen will appear.



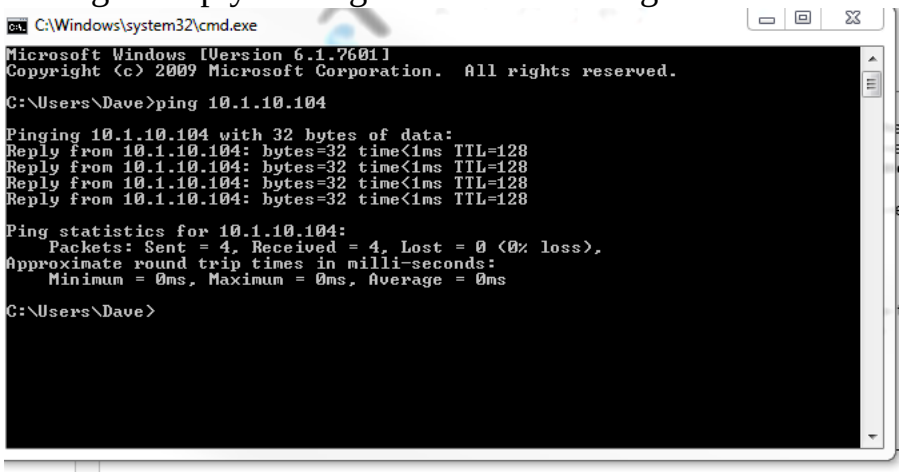
Type the following in the black console screen:

Ping xxx.xxx.xxx.xxx

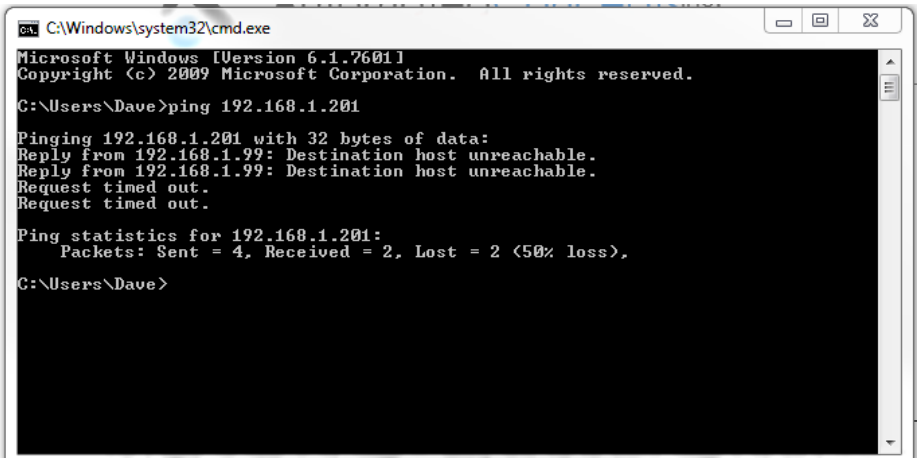
Where xxx.xxx.xxx.xxx is the IP address of the eRCM Express LAN2 port.

Example: ping 192.168.1.201

You should get a reply message like the following:



If you get a response like the following:

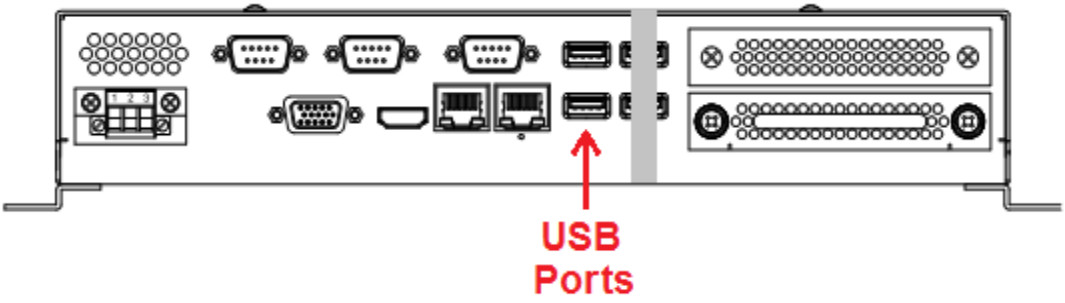


Then the eRCM Ethernet port is not responding.

Verify the IP address settings. If these are set properly then the port or the software is not responding.

- Power cycle the unit
- If there is still no response then replace the unit.

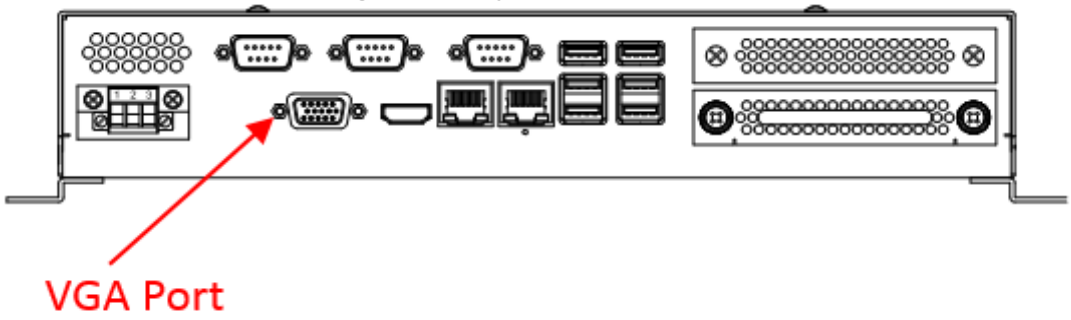
- **<u>USB Ports</u>**: (If possible, update to latest firmware before this test.) Insert a blank USB drive into one of the USB2 ports (USB ports closer to the LAN ports) and wait a few seconds. Then remove the drive and check it via your PC. If the port is working, then the current eRCM Viewer models within that eRCM Express will be copied to the USB, as well as a log file.



  - If no log file created, then either that USB drive is not compatible with the eRCM Express, or the USB port is not working. Try the other driver, and/or try a different type of USB drive.
    - *If that fails, then return the unit to ACI.*
  - If a log file is created, then the USB port and drive are both good.

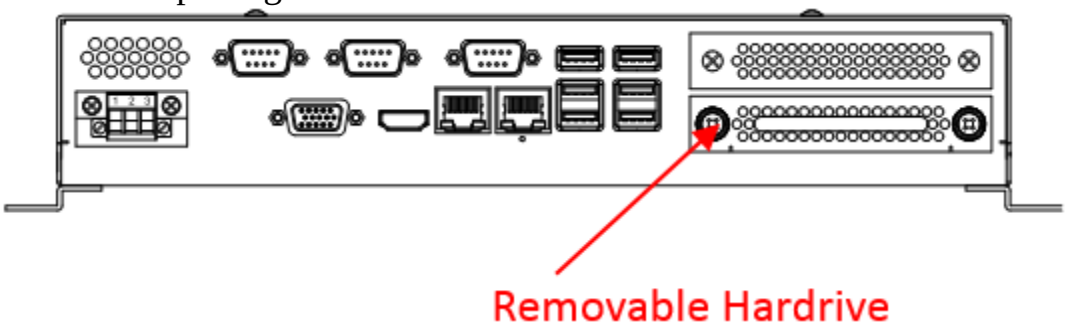
DEVICE RELATED DIAGNOSTICS

- **Functioning Device**: If unit is working, then when a monitor is plugged into the VGA port or into the HDMI port, a Windows® Login Screen should appear. If not, then the unit is not starting correctly.



If unit did not start correctly then do the following:

- With the monitor connected, power OFF/ON the unit. If nothing appears on the screen then the motherboard or power supply has failed and the unit will need to be replaced.
- If the unit boots up and displays general booting messages, but does not complete the Windows startup to the login screen, then either the hard drive has been corrupted, there is a driver issue, or a motherboard component has failed.
    - If there is a spare/replacement hard drive available, then do the following:
        - Remove power from the unit
        - Remove the hard drive from the unit by unscrewing the thumb screws and pulling the handle



        - Insert the spare hard drive, and screw in the thumb screws
        - Apply power to the unit
        - Repeat this test
        - If the unit does not startup and display the Windows Login Screen then a hardware failure has occurred. Replace the original hard drive. Unit needs to be replaced.

- If unit does start up, then contact ACI as your replacement hard drive will need to be licensed for this device to run properly.
    - Issue with original hard drive, not with device itself. However, device will not fully operate and be useable in service until new hard drive is licensed to that device.

MODBUS COMMUNICATION DIAGNOSTICS

Issues can be between the PLC and the Gateway, between the Gateway and eRCM Express, or between the PLC and the eRCM Express (when using a direct connect).

- **Gateway Boxes**: If using gateway devices to add Modbus support to the PLC, please make sure that those devices are setup, programmed, and communicating correctly. Consult each manufacturer (e.g. ProSoft and RedLion) for their specific power and communication specifications.

- **eRCM Express**: To identify if the eRCM Express is itself communicating correctly:
  - Disconnect the local Ethernet cable into the data port, and then connect an Ethernet crossover cable between your laptop and the eRCM Express.
  - Set the IP address of the computer to an address that is on the same subnet as the eRCM Ethernet address. Refer to your IT group for instructions.
  - Run the eRCM Express Diagnostic Software on the laptop and follow prompts.
    - If the ACI eRCM Express Diagnostic Software cannot communicate with the eRCM Express, then make sure that the correct IP/sub net mask are set in the diagnostic software, and laptop/PC are setup correctly to communicate with that IP number.
      - If still cannot communicate, then
        - Update your eRCM Express to latest firmware and re-test.
          - *If still cannot communicate, then return unit to ACI.*
          - If communications work, then the issue is at the Gateway, PLC, or cabling.