System Planner

ACE1000 Remote Terminal Unit (RTU)

6802988C97-F

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Glossary

Mixed System – A SCADA RTU network comprised of any combination of MOSCAD, MOSCAD-L, MOSCAD-M, ACE 3600, and ACE1000 RTU equipment.

ACE1000-Only System - A SCADA RTU network comprised of ACE1000 and ACE 1100 equipment.

FEP – Front End Processor – A specialized Motorola RTU, responsible for terminating the MDLC sessions from one or more slave Motorola RTUs, and presenting a virtualized representation of the slave RTUs to a SCADA application, using standard ModBus or DNP3 protocol traffic.

RTU – Remote Terminal Unit – A hardened real-time processing unit capable of detecting, reporting, and acting upon a variety of inputs to control industrial processes and mitigate the impacts of system faults.

ACE 3600 – Motorola high-tier RTU platform.

ACE 4600 – Motorola high-tier Front End Processor platform.

ACE1000 – Motorola mid-tier RTU platform.

ACE 1100 – Motorola mid-tier Front End Processor platform.

ACE1000 System Overview

The primary objective of the ACE1000 system is to provide a product which is a low cost, low power, small, effective RTU that is easy to install and configure for existing customer process in Alerting, Oil/Gas and Water Management.

The RTU collects data from on-site sensors, adds data from off-site sources, and uses this data aggregate to make decisions regarding how the process is operating.

Also the ACE1100 FEP will provide the ability to mirror all information from the remote sites to the SCADA so no direct interrogation from the SCADA to remote sites will be required.

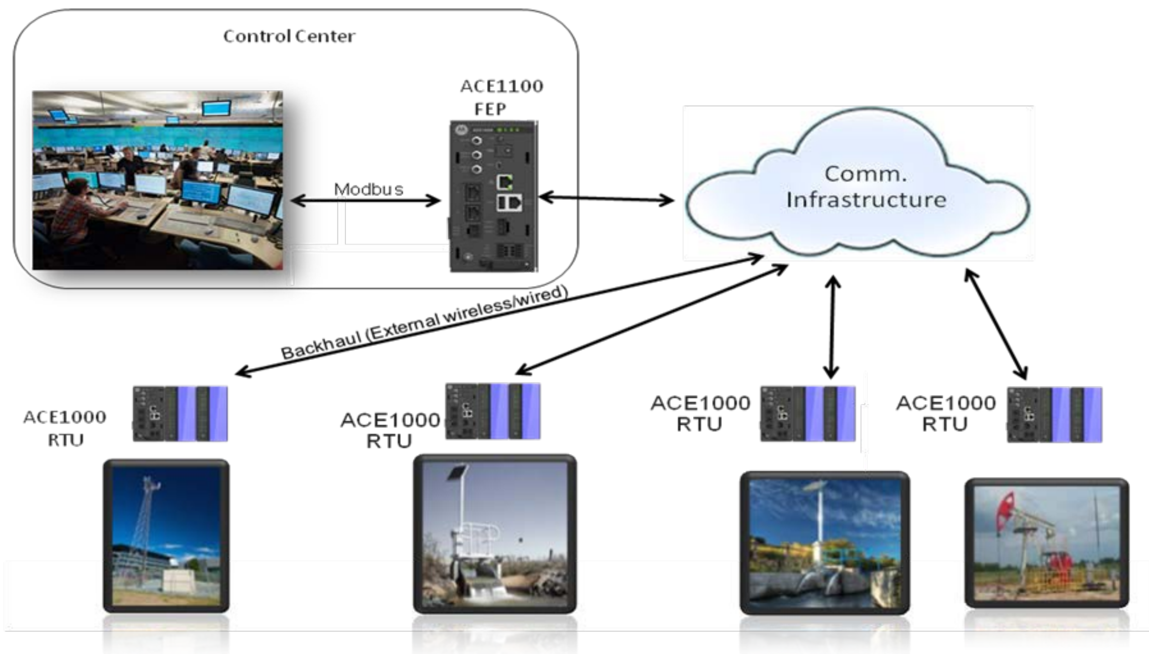


Figure 1-1 "ACE1000-Only" System

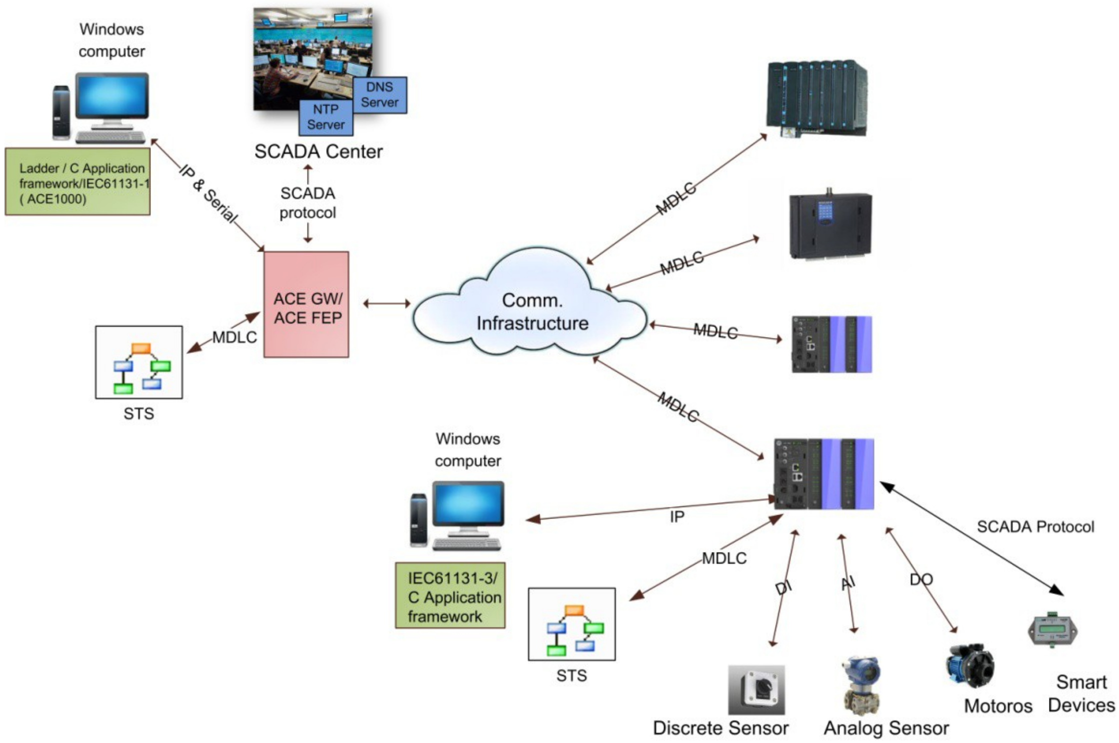


Figure 1-2 ACE3600, MOSCAD-M, and ACE1000 "Mixed System"

- System components
  - Remote Terminal Unit (RTU) – ACE1000:

The ACE1000 resides in the remote site. Its main goal is to collect data from on-site sensors, add data from off-site sources and use this data aggregate to make decisions regarding how some process is operating. The RTU may make changes to the local process; messages may be initiated that send data elsewhere to influence the operation of off-site equipment or to advise the SCADA Manager of some important change. The operator can program the ACE1000 Operator to create a customized unit that addresses his/her needs.

  - Front End Processor (FEP) – ACE1100:

The Front End Processor is used at the central site to provide a two-way path to the communication system and to remote RTUs from the SCADA Manager entity. The FEP contains the RTU units' run-time information and configuration. The FEP provides the ability to remotely (over MDLC) upgrade RTUs, and is designed to provide a central configuration management toolset. The FEP supports the standard SCADA protocol to communicate with the SCADA center and interface with the RTU via MDLC.

- Communication

The RTUs in the system may communicate with the FEP or among themselves (in a mixed ACE1000/legacy system) using a variety of communication choices: IP networks, cellular or data radio or any other communication network. The key advantage of the ACE1000 is its ability to communicate over wireless communication infrastructure such as TETRA, P25, Analog radio, etc.
MDLC, the main communication protocol employed by the ACE1000, is based on the seven-layer OSI recommendation, and is designed to be totally functional for a variety of communication media.

The ACE1000 system network consists of RTUs communicating with one or more computerized control centers. Each control center is connected to the communication network.

- SCADA Manager:

The SCADA Manager provides the operator with the display and report tools necessary to view and manage the associated process(es). The SCADA Manager obtains data from the FEP according to its needs and typically presents that data on custom-created display formats; control messages may also be initiated from these custom screens. Security is typically implemented via permission levels activated by the operator's sign-on password. Microsoft Windows is generally the operating system of choice because it easily supports the desired graphic symbols used on the custom screens. The report capability may be provided by the SCADA software or a data export to Microsoft Excel or equivalent may be utilized. The end result is an easy to use pictorially-described representation of the field status of key equipment items, plus the means to make changes in the operation of those pieces of equipment.

- Configuration and monitoring tools

This refers to the components:

In ACE1000-only systems, the ACE1100 (FEP) web interface (Easy Configuration tool) is used as the main tool for configuring, installing and monitoring of the entire system.
In ACE1000-only systems, the ACE1000 (RTU) web interface (Easy Configuration tool) is used for local monitoring and configuration.
Advanced customers can create an ACE1000 user application via the IEC61131-3 or C application development environments. These frameworks are run on a standalone computer or laptop.
In mixed systems (systems comprised of ACE1000 and legacy products (e.g. ACE3600), the main configuration tool is the ACE3600 System Tools Suite (STS). ACE1100 FEP is not supported in a mixed system. User should not use the Web interface to program ACE1000 RTUs in a mixed system.
The STS is a software program that allows the system engineer to set up and maintain an entire system in accordance with system-specific requirements.

The STS host (PC) may be connected to any RTU in the system and have connectivity established with any other site through the MDLC "Store-&-Forward" capability

- ACE 4600 IP Gateway (Relevant for Mixed Systems only)

The ACE 4600 IP Gateway is a real-time protocol converter that connects MDLC on its communication medium to TCP/IP. It does not contain a database. It is configured using the ACE3600 STS by simply assigning an MDLC address and an IP address for the respective systems. An API is provided to enable SCADA HMI vendors to develop a communication driver between the SCADA programs that require data from the IP Gateway and the IP Gateway itself (contact your Motorola Data Specialists to determine if a driver is already available for the host hardware/software being used).

A typical example of the ACE IP Gateway (IPGW) is shown in the figure below; a SCADA control center is connected via the ACE IP Gateway to RTUs on a radio link, to RTUs on an RS485 link and to RTUs over IP in the ACE3600 system.

The SCADA control center, which includes workstations and a SCADA computer, exchanges data with the ACE3600/MOSCAD/ACE1000 system via the ACE IP Gateway, which serves as a Gateway from the TCP/IP world to the MDLC world.

The ACE IP Gateway uses the TCP/IP LAN protocol for exchanging data application messages with the SCADA software. The ACE IP Gateway API (Application Programming Interface) allows SCADA driver developers to quickly and easily build the ACE IP Gateway Interface (driver), which serves as a communication interface with the MDLC world.

Data exchange between the SCADA (client) and the ACE IP Gateway (server) is carried out using TCP/IP "peer -to-peer" communication over LAN. The ACE IP Gateway can support multiple connections that are initiated from multiple SCADA computers.

The implementation of the ACE IP Gateway interface in the SCADA software allows the SCADA to perform the following operations:

- Poll an RTU in order to get data and COS (Change-of-State) events from the RTU tables.
- Send commands to the RTU and download parameters to its local process.
- Send commands via broadcasts to any required group of RTUs.
- Download parameters (set-points) to the RTU local process.
- Receive spontaneous reports (by contention) from RTUs (both burst and event transmission).
- Receive time-tagged events logged in the RTUs (1 msec resolution).
- Adjust the RTUs' clocks (1 sec resolution).
- Synchronize the RTUs' clocks.

- Support redundant ACE IP Gateway configuration by setting the Gateway mode to be Primary/Secondary).
- Retrieve Gateway status.
- Retrieve RTU links status.
- Update RTU links in the site table.
- Retrieve software diagnostics from ACE IP Gateway itself.

For a detailed description of the interface, refer to the ACE IP Gateway API manual and to the *ACE3600 System Planner*.

ACE1000 RTU Construction

Each ACE1000 module is enclosed in a compact protective plastic housing. The CPU front panel provides easy access to connectors, ports and the antenna. The I/O module front panel includes terminal block connectors for sensor/device wire connection.
The ACE1000 is mounted on a DIN rail, in a customer-supplied plastic or metal enclosure.

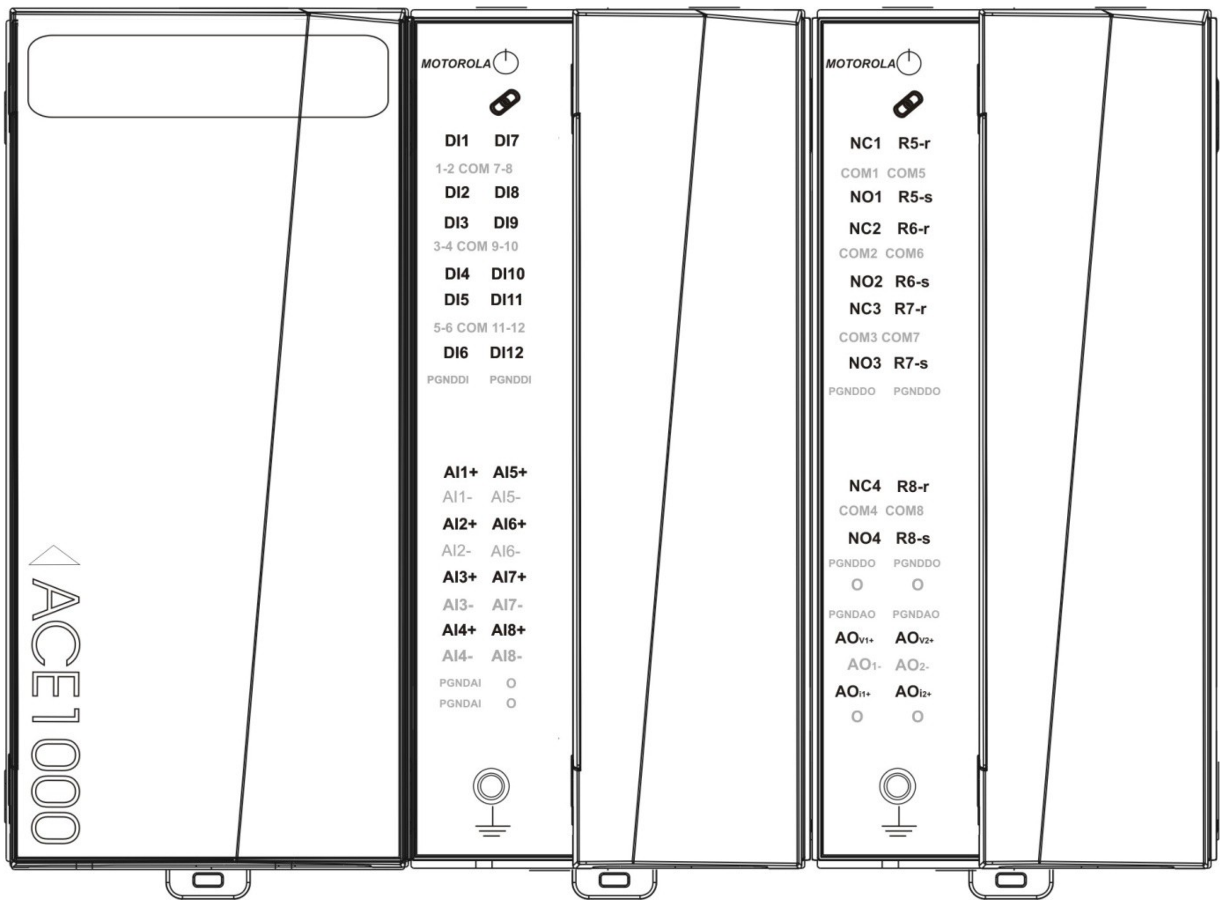


Figure 1-3 ACE1000 Unit with two I/O Expansion Modules with Covers

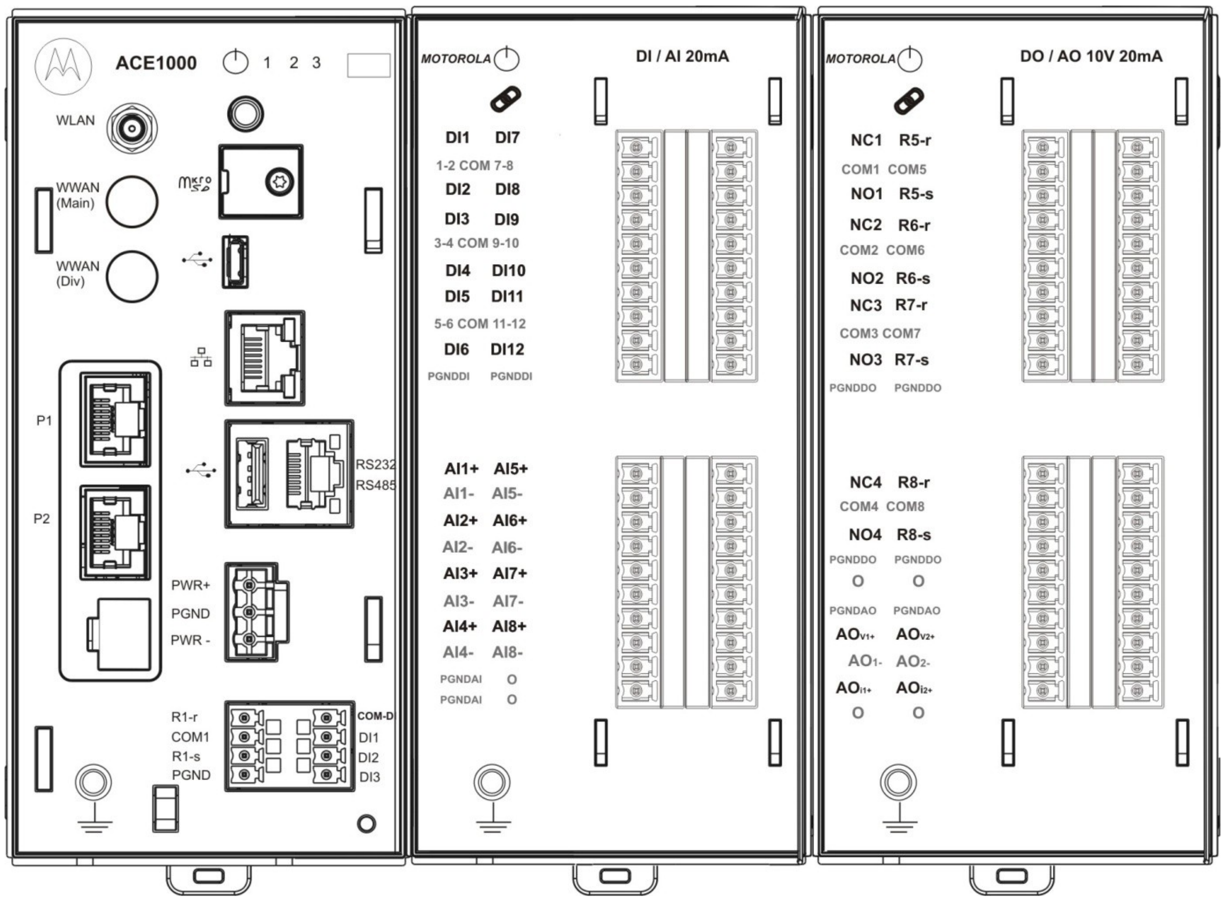


Figure 1-4 ACE1000 Unit with two I/O Expansion Modules without Covers

ACE1000 CPU I/Os

The ACE1000 CPU module includes three Digital Inputs (DI) and one Digital Output (DO). In addition, up to two Input/Output (I/O) expansion modules can be added to the ACE1000 CPU.

For details on the CPU and expansion module I/O specifications, see *ACE1000 General Specifications*.

For details on the I/O expansion modules, see *ACE1000 I/O Expansion Modules*.

ACE1000 Components

The table below lists the components which can be included in the ACE1000.

Table 1-1 ACE1000 Components

Component	Function
CPU	Communicates with the control center, RTUs and other devices via the communication ports.
Optional CPU plug-in board	Enables adding two optional RS232 or RS485 communication ports to the CPU.
Optional auxiliary power out connector (configurable)	Enables powering external devices.
115/230 VAC to 12VDC power supply or 115/230 VAC to 24VDC power supply	Converts the main AC power source to the voltages required by the unit/radio.
I/O expansion module (up to two modules per CPU)	Matches between the ACE1000 and signals of various types/levels. Interfaces between the ACE1000 and the process signals.
Terminal blocks (TB)	Connects the signals to the I/O modules.
RS232 cable + adaptor (FKN0022)	Connects devices to RS232 port
RS485 cable (FKN0030 #CB000207A01)	Connects devices to RS485 port
External DC power cable (FKN0033#CB000170A01)	Connects CPU to external power supply
MTM5200 data cable (FKN0027)	Connects MTM5200 radio to CPU.
APX 4000 data cable (FKN0025)	Connects APX 4000 radio to CPU.
APX 6500 data cable (FKN0035)	Connects APX 6500 radio to CPU.
XPR 5350 data cable – digital mode (FKN0026)	Connects XPR 5350 radio to CPU.

Component	Function
XPR 5350 data cable – Connect Plus (FKN0040A)	Connects XPR 5350 radio to CPU.
Ground cable (FKN0034A#30009286001)	Connects modules to ground.
Expansion module cable (FHN0065 #30013144001)	Connects CPU to I/O expansion module, and I/O expansion module to I/O expansion module.
Optional Microhard n920 Modem Interface Board	Connects the third party n920 modem to CPU.

ACE1000 CPU

The ACE1000 CPU controls all components attached to the unit. It can include an optional plug-in board with two RS232 ports and AUX power out connector. Figure 1-5 provides a general view of the ACE1000 CPU.

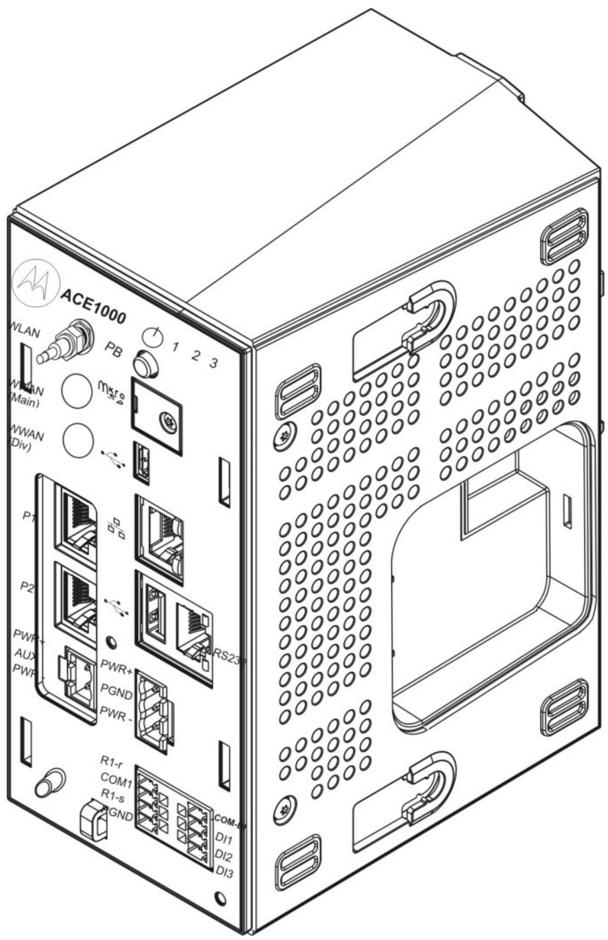


Figure 1-5 ACE1000 CPU– General View with and without Side Cover

The ACE1000 CPU panel includes status, user, power and communication port LEDs, a pushbutton, communication ports, antenna and ground connectors, and I/O connectors. Figure 1-6 shows the front view of the CPU.

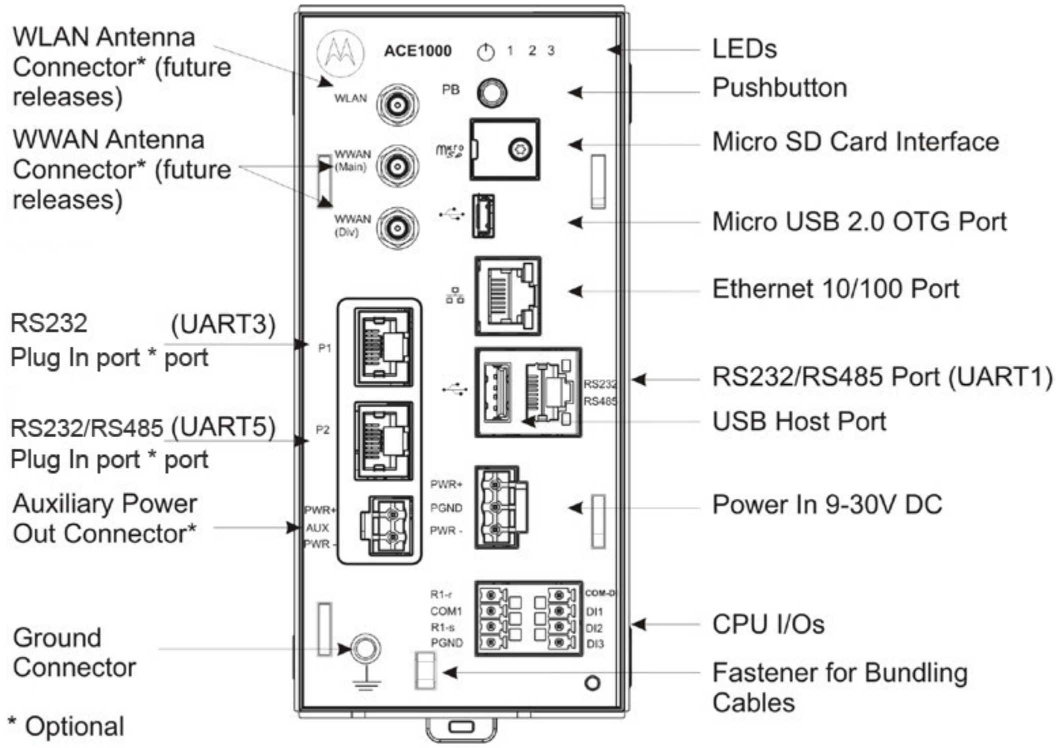


Figure 1-6 ACE1000 – Front View

ACE1000 CPU Pushbutton

The pushbutton on the ACE1000 CPU front panel has several functions:

- LED activation - Press the pushbutton for one second to activate the LEDs for a preconfigured period of time.
- Status indications - Press the pushbutton for three seconds to toggle between LED pages (see *ACE1000 CPU LEDs*).
- Microcontroller restart - Press the pushbutton for 20 seconds to restart the microcontroller.

ACE1000 CPU LEDs

The ACE1000 CPU front panel includes a power LED, status LEDs for on-board DIs/DO, and status LEDs on the communication ports. Some of the LEDs are single color (green) and some are bicolor LEDs (red or green). The LEDs are used to indicate various situations.

Figure 1-7 ACE1000 – CPU LEDs

By default, the CPU LEDs provide power, error, sleep mode, and DO status indications. Table 1-2 details the default display of the CPU LEDs (Page 0).

To see DI status indications, press the pushbutton for three seconds, to toggle to Page 1. Table 1-3 details the additional Page 1 CPU LEDs functionality. To toggle back to Page 0, press the pushbutton for again for three seconds.

Table 1-2 ACE1000 CPU LEDs – Page 0 (Default Display)

LED Name	Description	Status
⏻	Power/Error LED	Off - Unit is powered off. Steady Green - Unit is powered on. Steady Red - Unit is powered on with errors in the Error Logger. Fast Blinking Green (once per second) - Unit is in boot state. Medium Blinking Red or Green (once every 10 seconds) - Low input voltage fault state, when the processor is off. Slow Blinking Red or Green (once every 30-90 seconds) - Unit is in sleep mode.
1	DO Status	Reset state: The LED is off. Set state: The LED is on (green).
2	Not in Use	N/A
3	Not in Use	N/A

Table 1-3 ACE1000 CPU LEDs - Page 1 (DI Display)

LED Name	Description	Status
⏻	Power/Error LED	Fast Blinking Green (once in every 2 seconds) - Unit is powered on in Page 1. Fast Blinking Red (once in every 2 seconds) - Unit is powered on with errors in the Error Logger.
1	DI1 Status	Green - A powered-on DI is On (high from 6-30V). Off - DI is Off (low 0–3 V).
2	DI2 Status	Green - A powered-on DI is On (high from 6-30V). Off - DI is Off (low 0–3 V).
3	DI3 Status	Green - A powered-on DI is On (high from 6-30V). Off - DI is Off (low 0–3 V).

Table 1-4 ACE1000 CPU Port LEDs

Description	Status
Ethernet port LED	Green - Unit is connected to Ethernet. Green Blinking – Transmitting/receiving data
RS232/RS485 serial port (on-board) LED	Green - Transmitting data Yellow - Receiving data

ACE1000 CPU Memory

The ACE1000 unit includes the following memory:

- 256 MB FLASH memory/at least 32 MB available for user data
- 256 MB LPDDR DRAM/32 MB available for user data
- Micro SD Card slot, up to 32 GB (card not supplied)
- Optional user-supplied flash drive, up to 32 GB

ACE1000 CPU Real Time Clock (RTC)

The CPU includes a low drift RTC. The date and time are retained using an on-board rechargeable lithium battery.

The CPU date and time can be set using the Web browser-based Easy Configurator tool or the ACE3600 STS. The CPU can also be synchronized with other RTUs in the system, using the system clock, or via GPS, using a PPS signal connected to the DCD line of the RS232 port. For more information, see the *ACE1000 Easy Configurator User Guide* or the *ACE3600 STS User Guide*.

ACE1000 I/O Expansion Modules

The ACE1000 RTU can include up to two I/O expansion modules. Four I/O module types are available:

- Input module with mixed 12 DI and 8 AI 1- 5V
- Input module with mixed 12 DI and 8 AI 0- 20ma
- Output module with mixed 8 DO and 2 AO
- Mixed I/O module 7DI/6DO/4AI/1AO

The I/O modules are attached in a daisy-chain, with the first module attached to the CPU, and the next module attached to the first. A cable with two RJ50 connectors is used to connect the I/O module to the CPU or to another I/O module.

Each I/O module includes a power LED, a link LED (future use), individual I/O status LEDs, and an array of I/O connectors.Each I/O module includes a thermistor that measures the temperature of the I/O board.

An I/O module can only be added/removed to/from an ACE1000 unit when the power to the unit is off.
For detailed specifications of each I/O expansion module, see [*Appendix A: ACE1000 General Specifications*](#).

Figure 1-8 depicts the Input expansion module without a cover and with a cover. Figure 1-9 depicts the Output expansion module without a cover and with a cover.

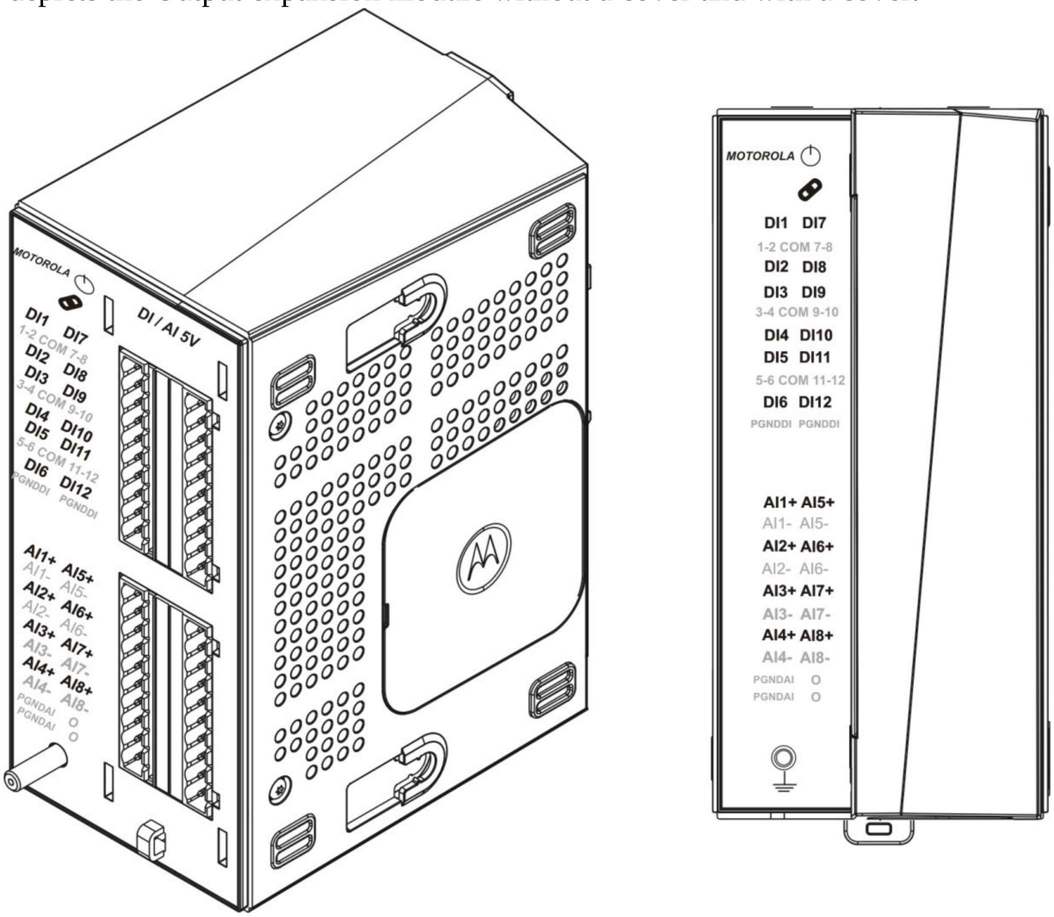


Figure 1-8 ACE1000 Input Expansion Module
General View **Front View with Cover**

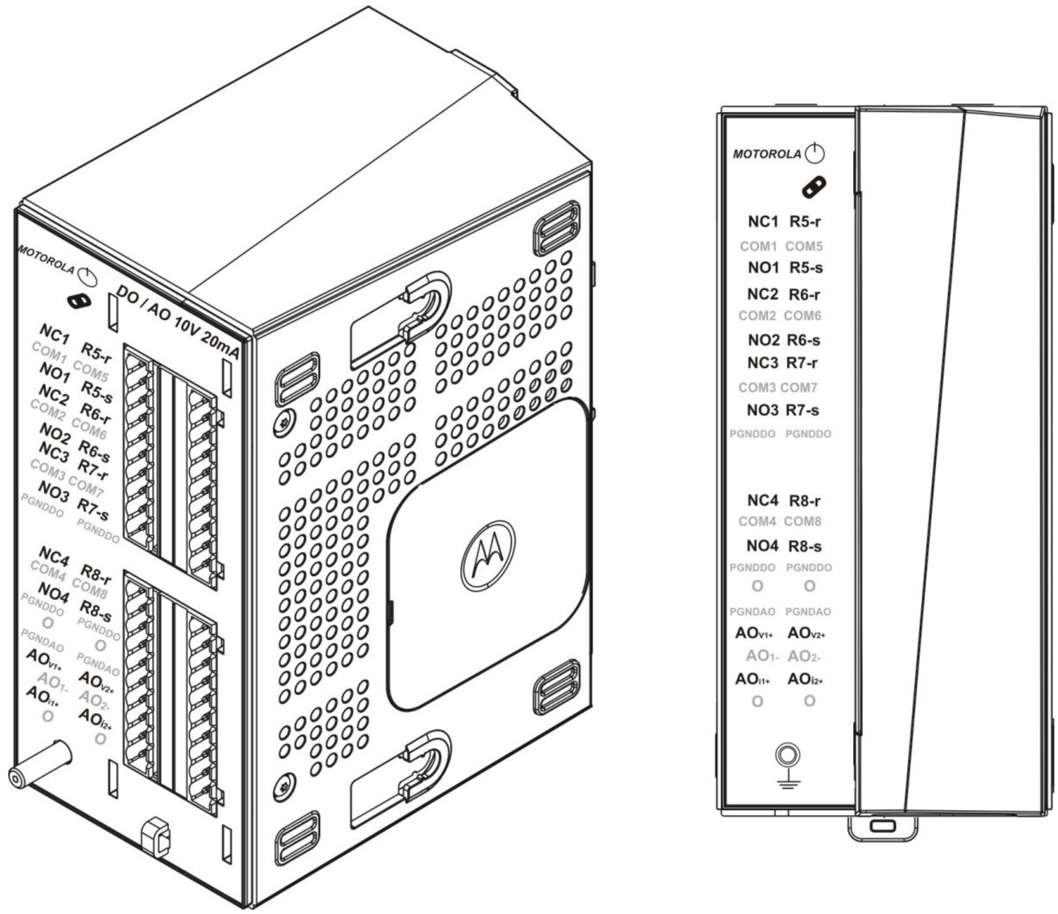


Figure 1-9 ACE1000 Output Expansion Module
General View **Front View with Cover**

ACE1000 I/O Module LEDs

The I/O module LEDs are used to indicate module and I/O status. LED indications are arranged according to the pins in the connectors.

The Input module has one LED indication for each I/O. The Output module has two LED indications for each DO and one LED indication for each AO. See *Table 1-5*, *Table 1-6*, and *Table 1*-7 for LED functionality of the modules.

Table 1-5 ACE1000 Input Module LEDs

LED Name	Description	Status
	Power LED	Off – I/O module is powered off. Steady Green – I/O module is powered on. Fast Blinking Green (once per second) – I/O module is in boot state.
	Link LED	Green – Proper Communication with Main CPU Red - No Communication with Main CPU.

LED Name	Description	Status
DI1-DI12	DI Status	Green - A powered-on DI is On (high from 6-30V). Off - DI is Off (low 0-3V).
AI1 - AI8	AI Status	Green - AI value is in range (0-20mA, 4-20mA, or 0-5V). Red - AI value is not in range.

Table 1-6 ACE1000 Output Module LEDs

LED Name	Description	Status
⏻	Power LED	Off – I/O module is powered off. Steady Green – I/O module is powered on. Fast Blinking Green (once per second) – I/O module is in boot state.
🔗	Link LED	Green – Proper Communication with Main CPU Red - No Communication with Main CPU.
NC1/NO1 - NC4/NO4	EE DO Relay Status	<u>Default (non-operated) state</u>: The NC# LED is on (green). The NO# LED is off. The NC# (normally closed) pin is connected to the COM# pin. <u>Operate state</u>: The NC# LED is off. The NO# LED is on. The NO# (normally open) pin is connected to the COM# pin.
R1-r/R1-s - R8-r/r8-s	ML DO Relay Status	<u>Reset state</u>: The R#_r LED is on (green). The R#_s LED is off. The R#_r pin is connected to the COM# pin. <u>Set state</u>: The R#_r LED is off. The R#_s LED is on (green). The R#_s pin is connected to the COM# pin. Note: The ML relay can be configured via software to preserve or reset the DO status at startup.
AOv1/2, AOi1/2	AO Status	Green - AO is active. Off - AO is not active.

Table 1-7 ACE000 Mixed IO Module LEDs

LED Name	Description	Status
⏻	Power LED	Off – I/O module is powered off. Steady Green – I/O module is powered on. Fast Blinking Green (once per second) – I/O module is in boot state.
🔗	Link LED	Green – Proper Communication with Main CPU

		Red - No Communication with Main CPU.
NC2/NO2 – NC3/NO3 NC5/NO5 NC6/NO6	EE DO Relay Status	Default (non-operated) state: The NC# LED is on (green). The NO# LED is off. The NC# (normally closed) pin is connected to the COM# pin. Operate state: The NC# LED is off. The NO# LED is on. The NO# (normally open) pin is connected to the COM# pin.
R1-r/R1-s- R4-r/r4-s	ML DO Relay Status	Reset state: The R#_r LED is on (green). The R#_s LED is off. The R#_r pin is connected to the COM# pin. Set state: The R#_r LED is off. The R#_s LED is on (green). The R#_s pin is connected to the COM# pin. Note: The ML relay can be configured via software to preserve or reset the DO status at startup.
DI1-DI17	DI Status	Green - A powered-on DI is On (high from 6-30V). Off - DI is Off (low 0-3V).
AI1 – AI4	AI Status	Green - AI value is in range (0-20mA, 4-20mA, or 0-5V). Red - AI value is not in range.

ACE1000 Input Module I/O Arrangement

In the Input module, the upper 20 pins belong to the 12 Digital Inputs (DI). DIs are arranged in groups of three pins, e.g. DI1:COM1-2:DI2. Each group is isolated one from the other and has its own COM pin. PGNDDI pins must be connected to protected ground (ground screw).
The lower 20 pins of the Input module belong to the 8 Analog Inputs (AI). AIs are arranged in couples with positive and negative pins. Each AI channel is isolated from the

other and isolated from the logic circuit. PGNDAI pins must be connected to protected ground (ground screw). AIs are calibrated in the factory.

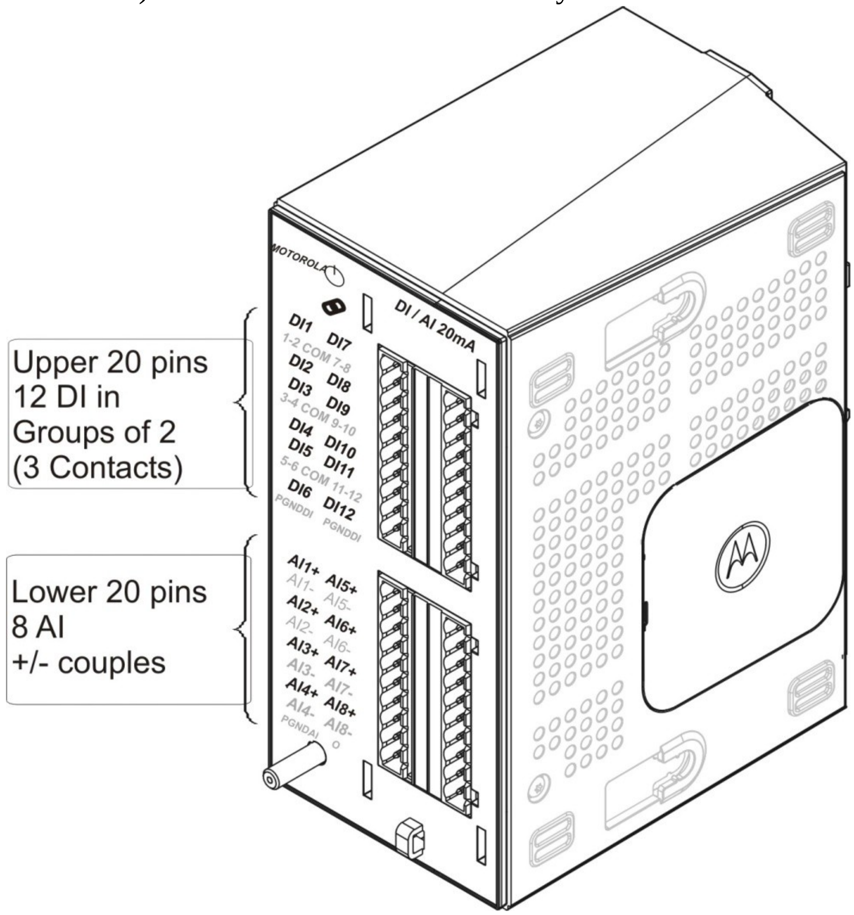


Figure 1-10 ACE1000 Input Module I/O Arrangement

For details on AI calibration, see the "ACE1000 Hardware Test" section of the *ACE1000 Easy Configurator User Guide*.

ACE1000 Output Module I/O Arrangement

In the Output module, the upper pins belong to the 8 Digital Outputs. The first four DOs are Electrically Energized (EE). The EE DOs are arranged in groups of three pins per relay, e.g. NC1:COM1:NO1. The second four DOs are Magnetically Latched (ML). The ML DOs are arranged in groups of three pins per relay, e.g. R5-r:COM5:R5-s. Each group is isolated from the other and has its own PGNDDO pin. PGNDDO pins must be connected to protected ground (ground screw).
The lower pins of the Output module belong to the 2 Analog Outputs (AO). The AOs are arranged in groups of three pins, e.g. AOv1+:AO1-:AOi1+.

- AOv1+:AO1- and AOv2+:AO2- are voltage output pins.
- AOi1+:AO1- and AOi2+:AO2- are current output pins.

The PGNDAO pins must be connected to protected ground (ground screw). The AOs are calibrated in the factory.

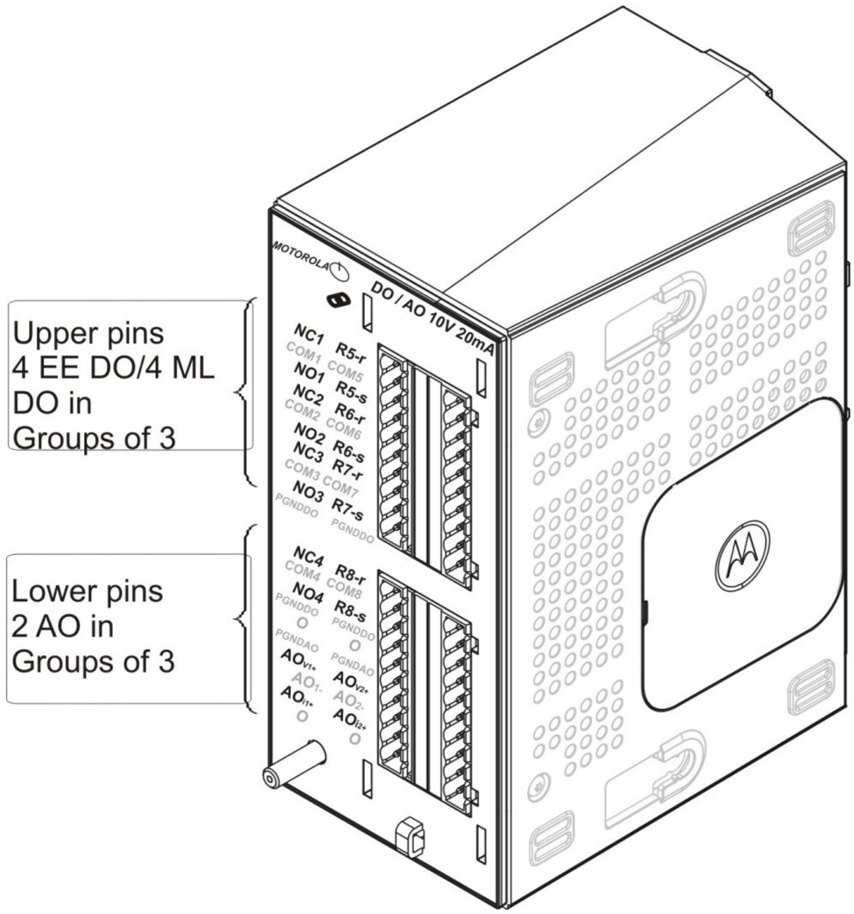


Figure 1-11 ACE1000 Output Module I/O Arrangement

For details on AO calibration, see the "ACE1000 Hardware Test" section of the *ACE1000 Easy Configurator User Guide*.
For pin table details and I/O module block diagrams, see *Appendix C: ACE1000 I/O References.*

ACE1000 Mixed I/O Module Arrangement

In the Mixed module the upper pins belong to the 6 Digital outputs.
DO's 1 & 4 are Magnetically Latched (ML). The ML DOs are arranged in groups of three pins per relay, e.g. R4-r:COM4:R4-s. Each group is isolated from the other and has its own PGNDDO pin. PGNDDO pins must be connected to protected ground (ground screw).
DO's2-3-5-6 are Electrically Energized (EE) .
The EE DOs are arranged in groups of two pins per relay, e.g. COM2:NO2

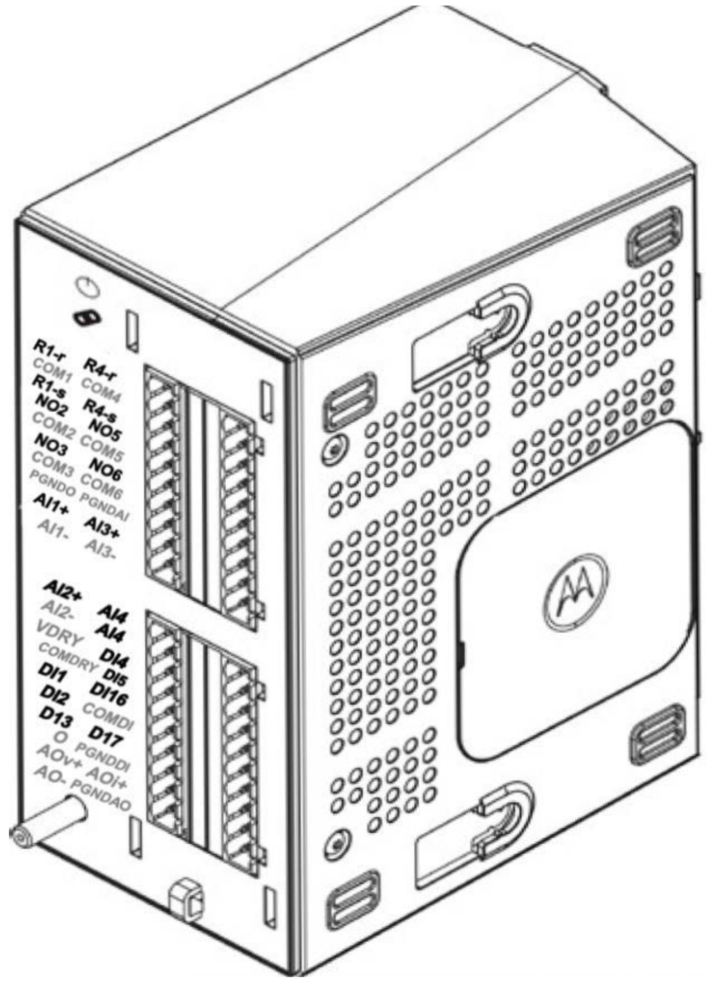


Figure 1-12 ACE1000 Mixed I/O Module Arrangement

ACE1000 I/O Module Terminal Block Connectors

Each I/O module is equipped with a set of two terminal block (TB) connectors (5 mm pitch), with 20 pins each. Each TB connector has a fixed female side on the module and two male plugs for the sensor/device wire connection. The TB male side (#FHN0061) is screw type for up to 2mm (12 AWG) wire. See the *ACE1000 Installation* chapter for details on connecting ACE1000 I/Os.
A TB extractor tool (FKN0024) is provided for easy removal of TBs. See the *ACE1000 Installation* chapter for details on extracting the TB connectors from the module.

ACE1000 Hardware Test

The ACE1000 unit can be tested using the ACE1000 Web browser-based Easy Configurator tool. The tests include retrieving general information, performing I/O operations, setting power management profiles, testing LEDs, and testing service mode. In addition, the user ‘C’ application can call system services to retrieve information from the main board and to set the main board DO.
For more information, see the "ACE1000 Hardware Test" section of the *ACE1000 Easy Configurator User Guide*.

Microhard n920 Modem Interface Board

The Microhard n920 Modem Interface Board (FCN0102A) is used as a plug-in board for connecting the Microhard n920 900 MHz spread spectrum wireless modem to the ACE1000 unit.

For detailed board specifications, see "Microhard n920 Modem Interface Board Specifications" in *Appendix A: General Specifications*.

ACE1000 External Power Supply or Battery

The ACE1000 can be ordered with an external AC/DC power supply. These are drop ship items that are provided with the ACE1000 unit. The following power supplies are available:

- Lambda Electronics DPP120-12-1 AC power supply 12VDC/10A, 120W, 90-264VAC (mounted on DIN rail) DC output
- Artesyn ADN5-24-1PM-C AC power supply 24VDC/5A, 120W, 85-264VAC (mounted on DIN rail) DC output, Limited temp. -25 - +70 ºC

Alternatively, a customer- supplied AC/DC power supply or DC power source (DC/DC converter or battery) can be used. See the ACE1000 input voltage and power consumption specifications in *Appendix A: ACE1000 Specifications*.)

ACE1000 External Devices

The following external devices has been tested and certified as ACE1000/ACE1100 compatible:

- Serial data modem (Data radio): MDS SD Series
- Cellular/ general PPP: Siarra wireless - AirLink FXT edge, Maxson – intelimax, Telit- Gate Tel GT-HE910-EUD
- Null modem (Leased Line): Westremo TD36
- ASTRO 25 (IV&D) radio: APX 4000, APX 6500
- Dimetra radio: MTM5200
- MOTOTRBO radio: XPR 5350e, XPR5380e, DM4400e, XiR M8620e, DGM5000e

- SanDisk Cruzer Blade (SDZ50-032G) and SanDisk Cruzer Blade (SDZ50-004G)

- GPS Receiver: NMEA-0183

  Note: Other similar devices can be used with ACE1000/ACE1100 and it is in the user’s responsibility to validate compatibility of any other devices.

CAUTION

Do not remove a storage device from the USB Host port while the ACE1000 unit is in sleep mode.

Software Licenses

3 software license options are available for the ACE1000. DNP3 Master, DNP3 Slave, and CODESYS support licenses are optional equipment that must be specified when the equipment is ordered from the factory. See the ACE1000 Ordering Guide on Motorola Online for pricing and option number information.

Ordering Information

Select a Model

The ACE1000 family is comprised of four models. The FEP (Front End Processor) model is F0043A. A FEP is a 'master' module and is required to communicate to one or more 'slave' RTU (Remote Terminal Unit) ACE1000 models. The three RTU models are the F0016A (Standard, non-ATEX compliant), F0043A (ATEX compliant), F0026A (ATEX compliant with Real Time Clock, reduced temperature spec). At this time, there is no support for direct ACE1000 RTU-to-RTU communications. All four models include the necessary screw terminal inserts for the connectors on the CPU.

Description	**Nomenclature**
ACE1000 CPU 1010 MODULE	F0016A
ACE 1100 - FEP MODULE	F0043A
ACE1000 CPU 1011 MODULE ATEX	F5209A
ACE1000 CPU 1012 MODULE ATEX W/ RTC BATTERY	F0026A

Select Options

CPU Plug-in Board – There is a slot on the ACE1000 units for an optional plug-in board. For the FEP model F0043A, the 2XRS232 PORT AUX PLUG-IN BOARD is automatically included, so option VA00006AA should never be ordered with F0043A. The 2XRS232 PORT AUX PLUG-IN BOARD includes two RS232 ports and an Aux power output. The ATEX version of the plug in board (VA00046AA) does not provide an Aux power output. If no plug-in board is ordered with F0016A, F5209A, or F0026A, a blank cover is installed on the CPU. The VA00006AA option includes the screw terminal connector for the Aux power port.

Description	**Nomenclature**
ADD: 2XRS-232 PORT / AUX PLUG-IN BOARD	VA00006AA
ADD: 2XRS-232 PORT PLUG-IN BOARD ATEX	VA00046AA

DIN Rail Installation Kit, Module Covers – When the WALL MOUNT INSTALLATION KIT is ordered, a number of DIN rails are generated according to the other options selected. For example, if no I/O modules are ordered, a shorter length of DIN rail is provided. If I/O modules are ordered, a longer DIN rail is provided. If radio options are ordered, another length of DIN rail is provided to mount the radio and the radio power supply. Module covers are automatically included with ATEX models F5209A and F0026A, so VA00147AA should not be ordered with these models. For the F0016A and F0043A models, the VA00147AA option will provide the correct number and type of covers, based on the I/O options ordered.

Description	Nomenclature
ADD: WALL MOUNT INSTALLATION KIT	VA00148AA
ADD: FRONT CABLE COVERS	VA00147AA

I/O Modules – I/O module options are available for all models except the FEP (F0043A). Up to two total models may be ordered (two of a kind, or one of each). When ordering the DI/AI module, a second option must be ordered to specify the voltage/current spec of the module. For example, to order one DI/AI 0-5V module and one DI/AI 0-20mA module, Qty 2 VA00150AA, Qty 1 VA00151AA, and Qty 1 VA00152AA would be ordered. To order two DI/AI 0-20mA modules, Qty 2 VA00150AA and Qty 2 VA00152AA would be ordered. The total quantity of options VA00151AA and VA00152AA must always equal the quantity of VA00150AA.

Description	Nomenclature
ADD: 12DI/8AI HW ONLY NO LIC	VA00150AA
ADD: 8DO/2AO HW ONLY NO LIC	VA00149AA
ADD:MIXED IO 7DI/6DO/1AO/4AI 0-20mA HW ONLY NO LIC	VA00599AA

Description	Nomenclature
ADD: 0 - 5V DI/AI	VA00151AA
ADD: 0 - 20MA DI/AI	VA00152AA

Power Supply Cable – A DC Power Cable should be ordered to connect to a 12V/24V DC supply and ACE1000/1100 CPU unit. The cable is fused. AC/DC power supplies are not orderable as options at this time. There are two commercially available DIN rail mount AC/DC power supplies that have been certified to work with ACE1000:

1. Manufacturer: TDK LAMBDA, PN DPP120-12-1. It is available at www.newark.com, PN 66M7752.

2. Manufacturer: ARTESYN EMBEDDED TECHNOLOGIES , PN ADN5-24-1PM-C. It is available at www.digikey.com, PN 454-1368-ND.

Description	Nomenclature
ADD:DC POWER CABLE	VA00155AA

Radios– To order a radio, two items must be ordered – the system type (MOTOTRBO, ASTRO 25), and the frequency band. The installation kit is included with the radio. The radio power supply is NOT included, and must be ordered separately.

Radio System Options

Description	Nomenclature
ADD: MOTOTRBO DIGITAL CONVENTIONAL	VA00159AA
ADD: MOTOTRBO CONNECT PLUS TRUNKING	VA00195AA

ADD: ASTRO 25 DIGITAL TRUNKING	VA00196AA
ADD: ASTRO 25 DIGITAL CONVENTIONAL	VA00197AA

Radio Equipment Options

Description	Nomenclature
ADD: VHF MOBILE RADIO	VA00160AA
ADD: UHF R1 MOBILE RADIO	VA00161AA
ADD: UHF R2 MOBILE RADIO	VA00162AA
ADD: 700/800MHZ MOBILE RADIO (APX only)	VA00201AA
ADD: 800/900MHZ MOBILE RADIO (XPR only)	VA00202AA

Accessories - There is one accessory available with the model – an extractor tool for easy and safe removal of the screw terminal connectors from the CPU and I/O modules.

Description	Nomenclature
ADD: I/O MODULE EXTRACTOR TOOL	VA00153AA

Installation Guide

General

The ACE1000 is shipped from the factory ready for mounting on a wall or in a customer's enclosure.

WARNING

Installation of the ACE1000 should be done only by authorized and qualified service personnel in accordance with the US National Electrical Code. Only UL Listed parts and components will be used for installation. Use UL Listed devices having an environmental rating equal to or better than the enclosure rating to close all unfilled openings.

If the installation involves high-voltage connections, technicians must be specifically qualified to handle high voltage.

INSTALLATION CODES

This device must be installed according to the latest version of the country's national electrical codes. For North America, equipment must be installed in accordance to the applicable requirements in the US National Electrical Code and the Canadian Electrical Code.

INTERCONNECTION OF UNITS

Cables for connecting RS232 and Ethernet Interfaces to the unit must be UL-certified type DP-1 or DP-2. (Note- when residing in a non LPS circuit.)

Do not separate or disconnect units, modules or cables when energized.

OVERCURRENT PROTECTION

A readily accessible Listed branch circuit overcurrent protective device rated 20 A must be incorporated in the building wiring.

CAUTION

If the ACE1000 is subject to high levels of shock or vibration, you must take suitable measures to reduce the acceleration or amplitude. We recommend that you install the ACE1000 on vibration-damping materials (for example, rubber-metal anti-vibration mountings).

Ethernet LAN, RS485 and I/O cables can be a maximum length of 100m.

Mounting the ACE1000 on a DIN Rail

The ACE1000 is mounted on a customer-supplied 35 cm DIN rail, which can be installed either on a wall or in a plastic or metal enclosure.

Figure 2-1 shows the dimensions of the unit. Allow an additional 5 cm (2") (in W, H) and 10 cm (4") (in D) around the unit. When mounted in an enclosure, allow an additional 6 cm (2.4") (in W, H) and 7 cm (2.75") (in D) around the enclosure.

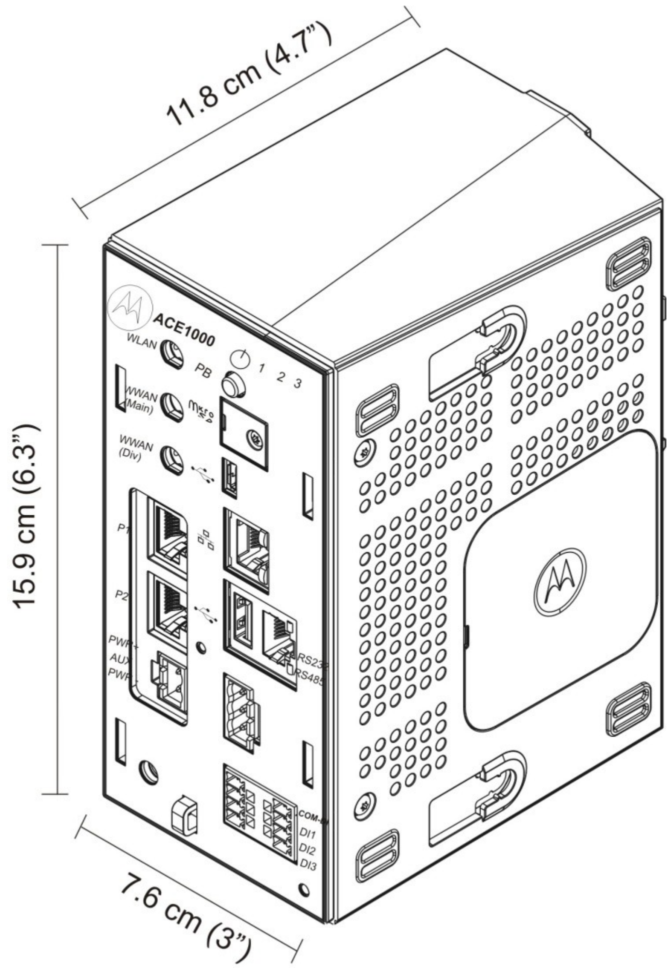


Figure 2-1 Installation Dimensions with and without Front Cover

Prerequisite: Before performing this procedure, secure the DIN rail using at least three M5 screws and three M5 washers.

Prerequisite: Connect the ACE1000 CPU to any I/O expansion modules before mounting on the DIN rail. See Procedure 2-2.

Procedure 2-1 Mounting the ACE1000 on a DIN Rail

1) Slide the supplied plastic tab at the back of the unit all the way down to the bottom of the unit. See Figure 2-2. If the ACE1000 unit includes one or more I/O expansion modules, repeat this step for all I/O expansion modules.

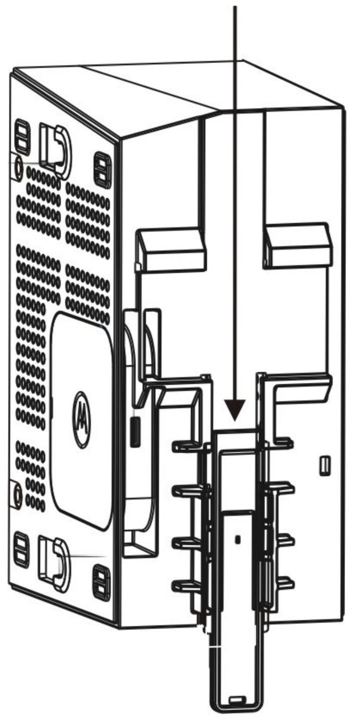


Figure 2-2 Plastic Tab in the ACE1000 Unit

2) Lift the ACE1000 unit and hang onto the DIN rail, using the hooks in the back of the unit. See Figure 2-3.

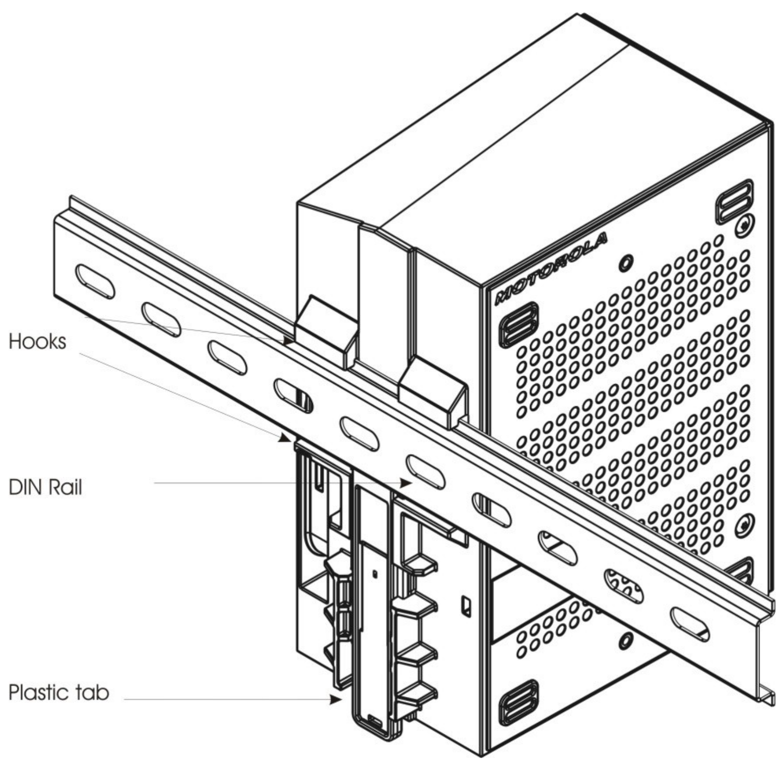


Figure 2-3 Hooking the ACE1000 Unit onto the DIN Rail

3) Slide the plastic tab upwards, until it locks against the DIN rail. See Figure 2-3. If the ACE1000 unit includes one or more I/O expansion modules, repeat this step for all I/O expansion modules. See Figure 2-4.

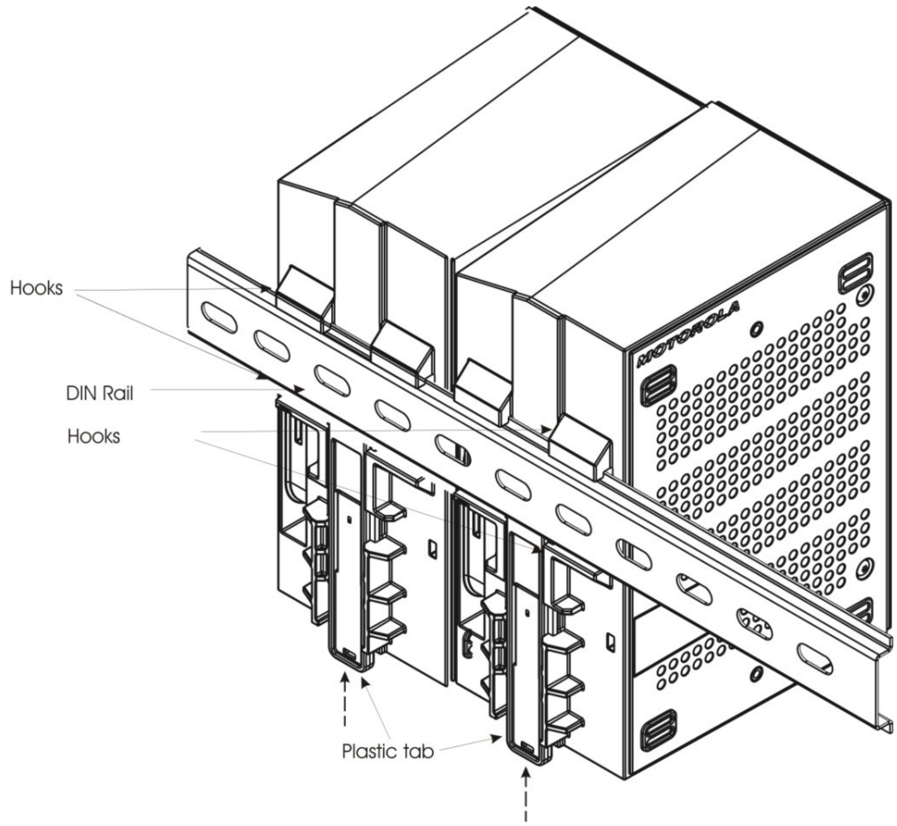


Figure 2-4 Hooking the ACE1000 Unit with I/O Expansion Module onto the DIN Rail

4) (Optional) Clip two stoppers onto the DIN rail, one to the left and one to the right of the unit to keep the unit in place. Tighten the built in screws.

5) Connect the data cables to the unit. See *Connecting ACE1000 Data Cables.*

6) Connect the I/O sensors. See *Connecting ACE1000 I/Os*.

7) Bundle the cables and attach them to the fastener on the module. See *Bundling ACE1000 Cables*.

8) Insert the four legs of the front cover into the matching grooves on the front of each module and slide the cover down.

Mounting the Optional Power Supply

When both a power supply option and the wall mount installation kit are ordered, the proper number and length of din rails and stoppers are included. Mount the power supply to the left of the ACE1000 CPU for ease of maintenance and cabling. A 25 mm (one inch) space should be open to the left and right sides of the power supply for proper airflow.

Mounting the Optional Radio

Mount the radio above the ACE1000 in the cabinet to avoid transferring heat from the radio to the ACE1000. Metal shielding for heat and RF isolation between the radio and the ACE1000 is recommended, but not required. The following diagram is an example of an ACE1000 installation with the APX 6500 mobile radio installed and connected.

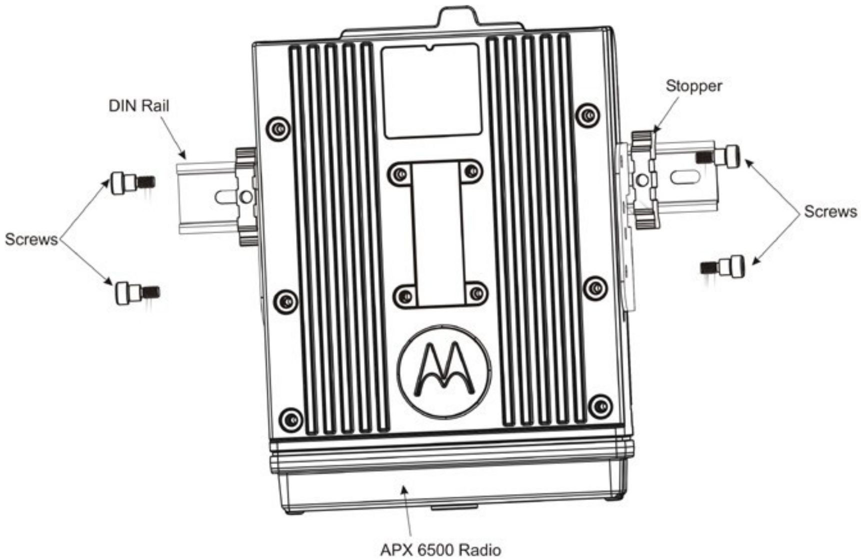


Figure 2-5 ACE1000 CPU Side Cover

Connecting an I/O Expansion Module to the ACE1000 CPU

The I/O expansion modules must be connected to the ACE1000 CPU before mounting the unit on the DIN rail. Follow the procedure below to connect an I/O expansion module to the ACE1000 CPU.

Procedure 2-2 Connecting an I/O Expansion Module to the ACE1000 CPU

1) Insert a narrow tool (e.g. flat screwdriver) into the groove of the side cover on the right side of the ACE1000 CPU and remove the cover.

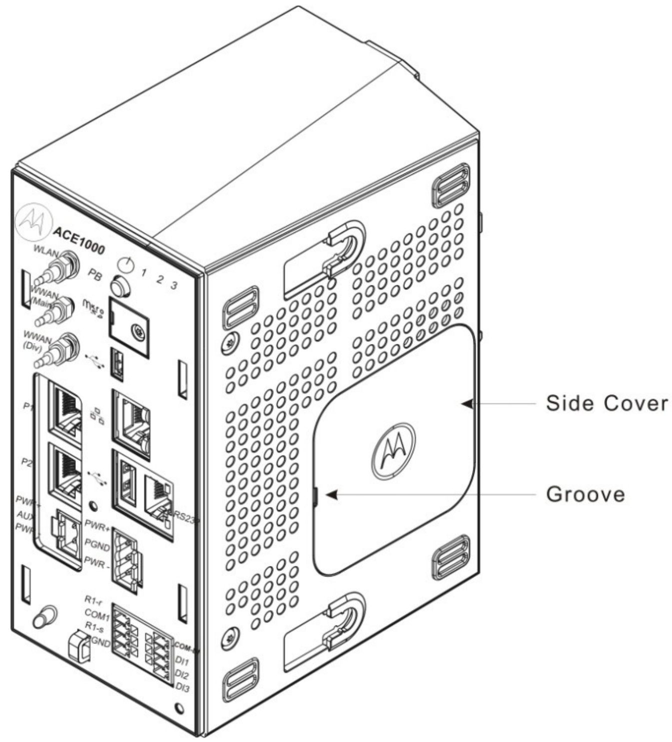


Figure 2-6 ACE1000 CPU Side Cover

2) Click the 90º bent end of the 10-pin I/O connector cable (#30013144001) into the RJ50 connector on the right side of the CPU. See Figure 2-6.

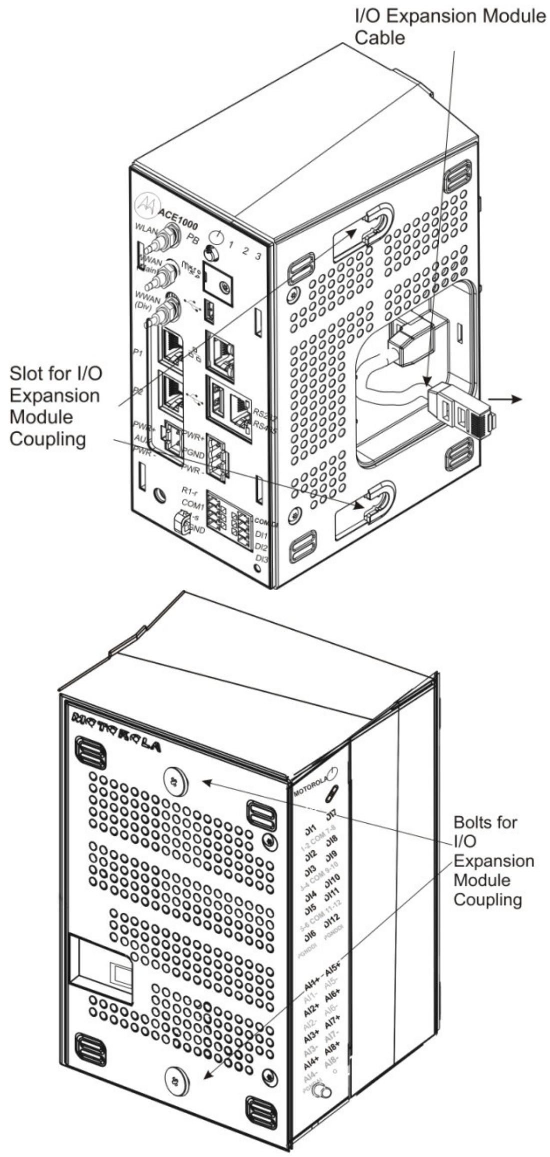


Figure 2-7 ACE1000 CPU Connection to I/O Expansion Module

3) Click the other end of the I/O 10-pin connector cable into the RJ50 connector on the left side of the I/O expansion module. See Figure 2-6.

4) With the front of the modules facing you, press the CPU and I/O expansion modules together while sliding the bolts on the I/O expansion module into the slots on the CPU. Be careful not to pinch the cable between the modules.

5) Press the I/O expansion module slightly back and the CPU module slightly forward until they click.

Connecting an I/O Expansion Module to another I/O Expansion Module

Follow the procedure below to connect more than one I/O expansion module to the ACE1000 unit.

Procedure 2-3 Connecting an I/O Expansion Module to another I/O Expansion Module

1) Remove the cover from the right side of the ACE1000 I/O expansion module.

2) Click the 90º bent end of the 10-pin I/O connector cable into the RJ50 connector on the right side of the leftmost I/O expansion module. See Figure 2-7.

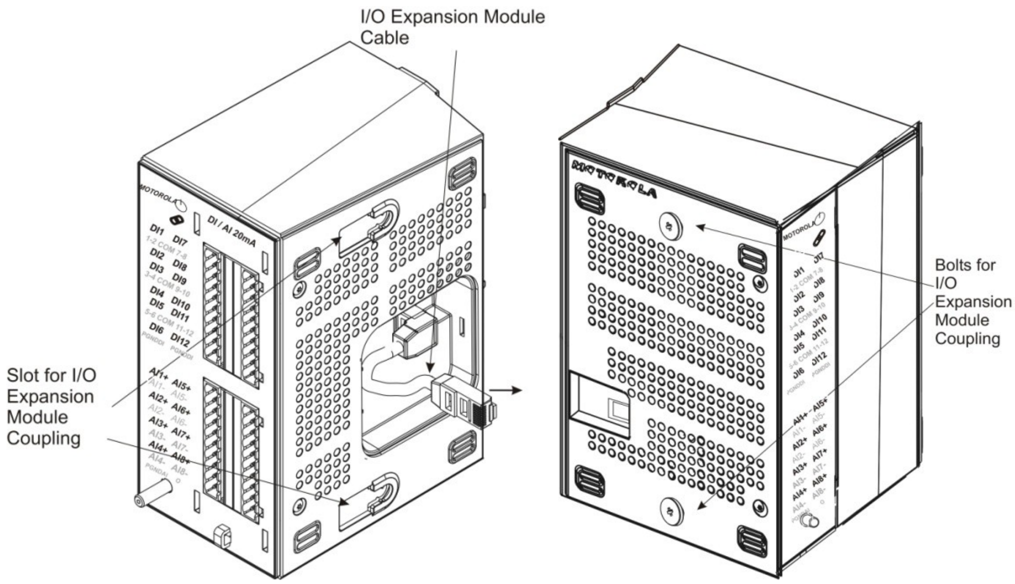


Figure 2-8 ACE1000 I/O Expansion Module Connection to I/O Expansion Module

3) Click the other end of the I/O 10-pin connector cable into the RJ50 connector on the left side of the next I/O expansion module. See Figure 2-7.

4) Press the two I/O expansion modules together while sliding the bolts on the rightmost module into the slots on right side of leftmost module. Be careful not to pinch the cable between the modules.

5) Press the rightmost module slightly back and the leftmost module slightly forward until they click.

ACE1000 Power and Ground Connections

All internal electrical connections are performed in the factory and supplied with the RTU.

The procedures for the main power, ground and battery connections are provided below.

CAUTION

The power and ground connections should be performed only by qualified and authorized service personnel. All power and ground connections must be in accordance with local standards and laws.

NOTE

Make sure that the ground cable is long enough to reach the grounding point, but as short as possible. The wire gauge of the ground wire in the cable must be 6 AWG.

Only a single wire can be connected to a contact in the Terminal Block connector. Wire size for the CPU Power connector must be AWG 12.

Connecting the ACE1000 to Power and Ground

Follow the procedure below to connect the ACE1000 unit to power and ground. See Figure 2-9 and Figure 2-10.

Procedure 2-4 Connecting the ACE1000 to Power and Ground

1) Once the ACE1000 unit (including any I/O expansion modules) is installed on the DIN rail, mount the power supply (not supplied) nearby.

2) Connect one end of the DC power cable (FKN0033) to the 9-30 VDC power supply (red to + and black to -).
Note: The DC power cable includes a 5A fuse.

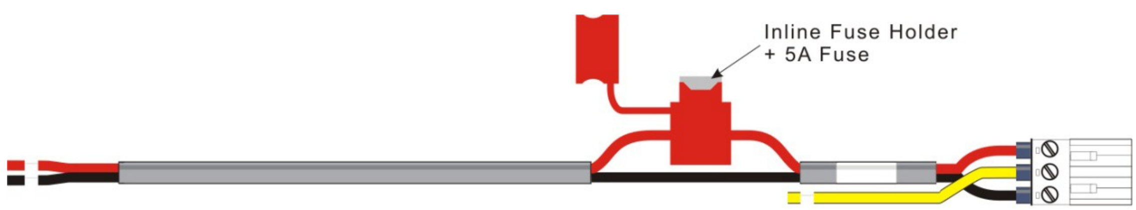


Figure 2-9 ACE1000 DC Power Cable with Fuse

3) Connect the other end of the power cable to the DC power connector on the front panel of the ACE1000 unit.

4) Connect the yellow wire from the power cable to the grounding screw on the front panel of the ACE1000 unit.

5) Connect the protective ground cable (not supplied) (FKN0034) between the grounding screw on the unit (CPU or I/O expansion module) (ground screw nuts torque 4 LB-IN) to the grounding point outside of the enclosure. In an ACE1000 unit with I/O expansion, all grounding strips should be connected to a common grounding point.

6) Bundle the cables as described in *Bundling ACE1000 Cables*.

7) Connect the power supply power cable (AC power cable is not supplied).

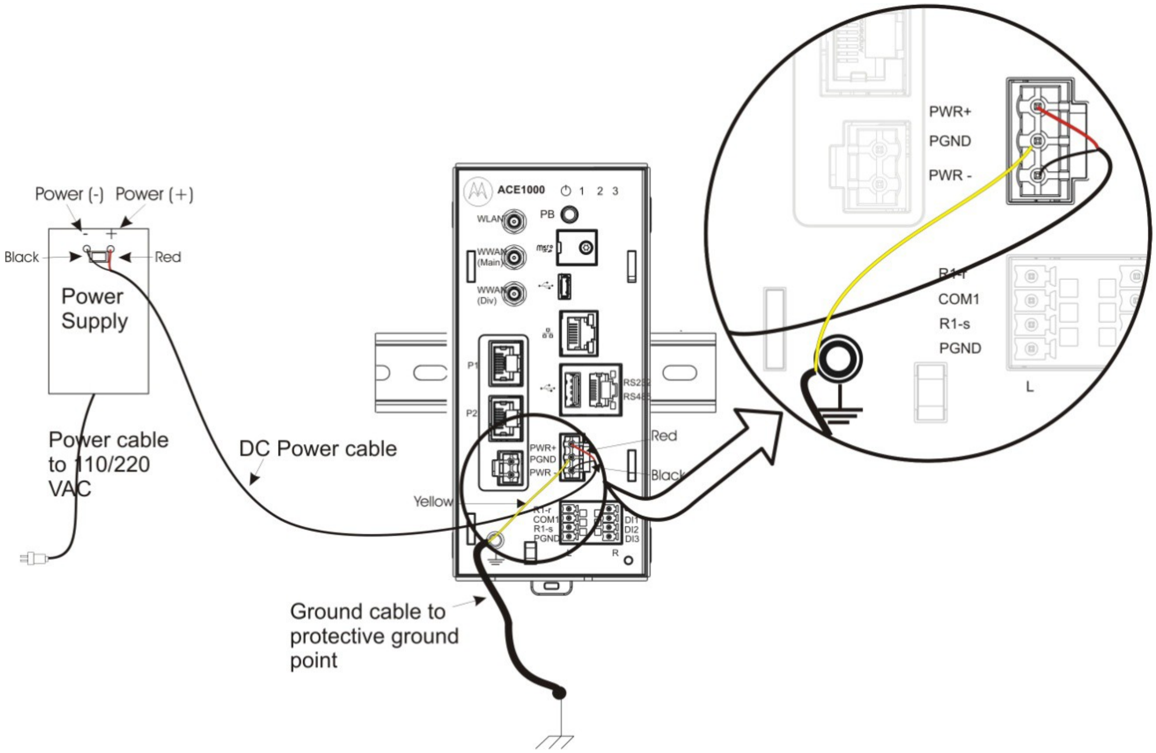


Figure 2-10 ACE1000 Power and Ground Connections

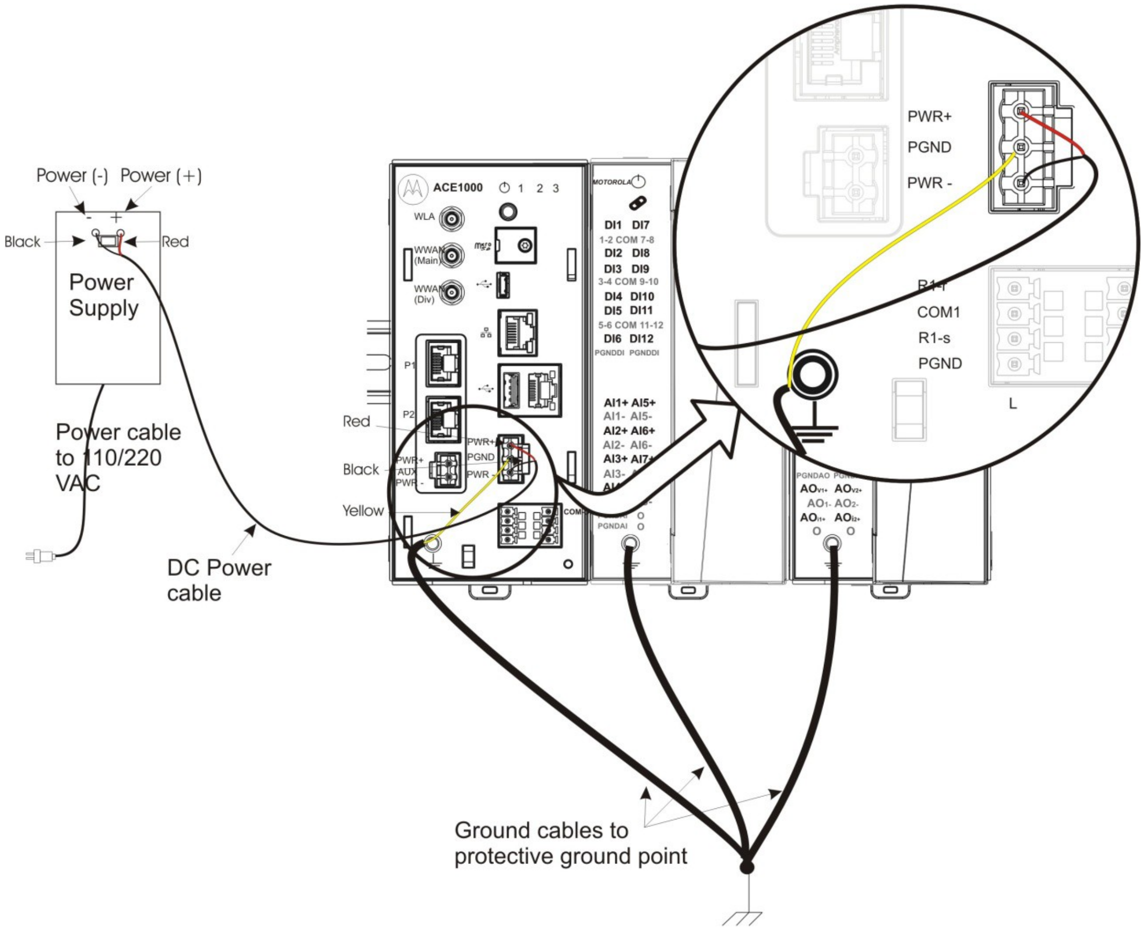


Figure 2-61 ACE1000 with I/O Expansion Power and Ground Connections

Connecting ACE1000 Data Cables

Follow the procedure below to connect the data cables to the ACE1000 RTU ports.

Procedure 2-5 Connecting the ACE1000 Data Cables

1) Connect the data cable(s) (RS232, RS485, LAN) from the ACE1000 CPU to the appropriate device(s). For details, see *Appendix B: Cables and Adaptors*.

2) Bundle and attach the cable(s) to the fastener on the CPU module, as described in *Bundling ACE1000 Cables*.

Connecting ACE1000 I/Os

Follow the procedure below to connect a user-supplied I/O sensors/device to the ACE1000 RTU I/O modules.

NOTE

Only a single wire can be connected to a contact in the TB connector. Wire size for the CPU I/O connectors can be AWG 16,18,20,22,24,30. Wire size for the I/O expansion module connectors can be AWG 12,14,16,18,20,22,24,26. Wire size for the PGND in must be AWG 12.

Procedure 2-6 Connecting the ACE1000 I/Os

1) Using a small flat screwdriver, loosen the screws on the TB connector (#FHN0061). Insert the exposed wire tips from the I/O sensors/devices. Tighten the screws (torque 2 LB-IN).

2) Line the TB connector up to the corresponding connector on the I/O module and press it forward into the module, as shown in Figure 2-11. Then press downwards to lock.

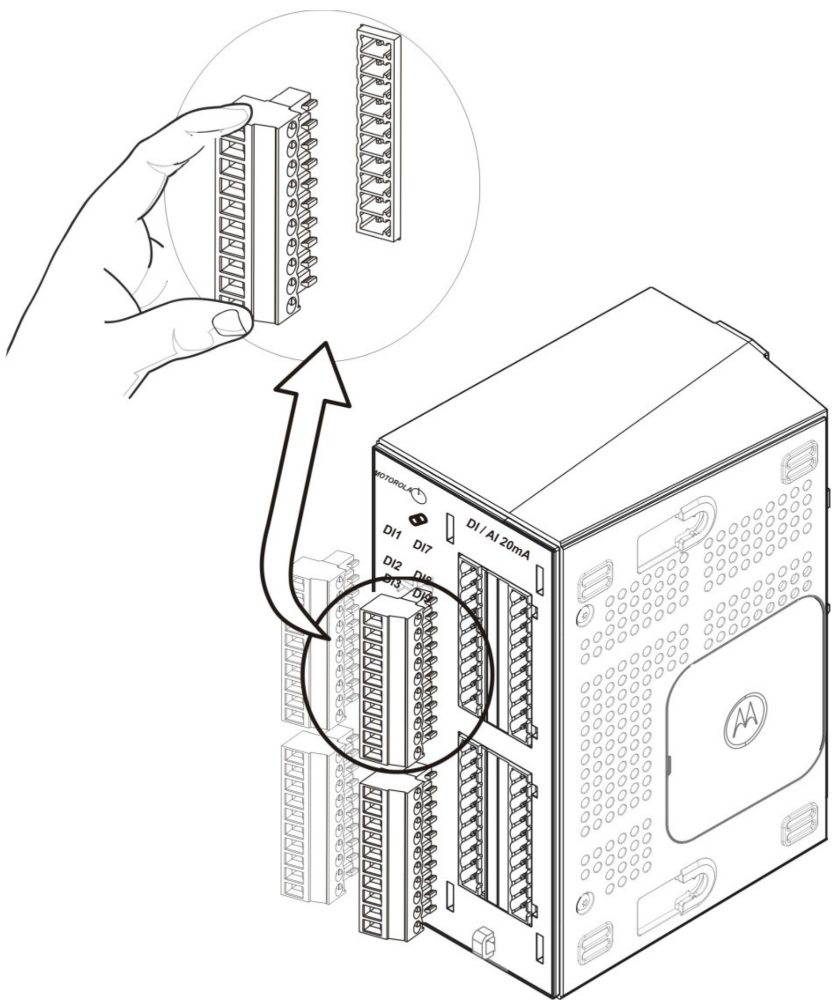


Figure 2-72 ACE1000 I/O Module with TB Connector

3) Bundle and attach the I/O cables to the fastener on the I/O module, as described in *Bundling ACE1000 Cables*.

Bundling ACE1000 Cables

To allow air flow and cable clearance in an enclosure, keep appropriate distance from the front face of the ACE1000 modules and the adjacent surface of the enclosure.

To allow the ACE1000 cable covers to be attached to the front of the ACE1000, cables must not exceed a 35 mm (1 $^3⁄_8$ inches) distance from the front surface of the ACE1000 modules.

All ACE1000 cables must be bundled in a tear-off cable tie for strain relief at the bottom of the module's front panel. Follow the procedure below to bundle the ACE1000 cables.

Procedure 2-7 Bundling the ACE1000 Cables

1) Once all cables are connected to the module, collect all cables in one or more tear-off cable tie(s) (not supplied). See Figure 2-13.

2) Thread the cable tie through the plastic fastener at the bottom of the front panel. See Figure 2-13.

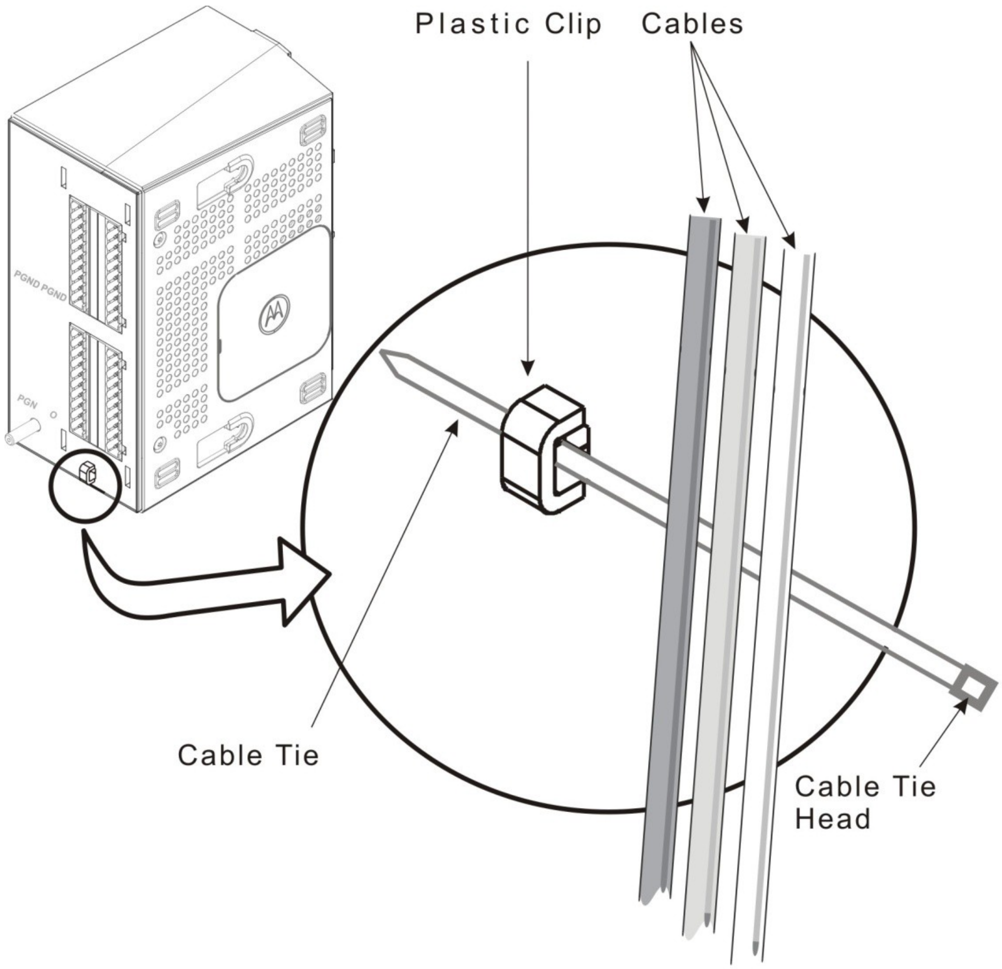


Figure 2-83 ACE1000 Cables in Plastic Fastener

3) Slide the pointed tip of the cable tie through the head and pull tightly.

4) Snip off the extra plastic at the end of the tie.

Extracting Terminal Block Connectors from the I/O Module

Follow the procedure below to extract the TB connector from an ACE1000 I/O module.

Procedure 2-8 Extracting the TB Connector from the I/O Module

1) Lift and remove the cover of the I/O module to expose the TB connectors. (See I/O module with and without cover in Figure 1-3.)

2) Position the TB extractor to the right of the preferred TB connector, and fit the curved tip behind the TB. (See Figure 2-14.)

3) Press down on the TB extractor and rotate counter clockwise, and then rotate clockwise to extract the TB connector from the I/O module.

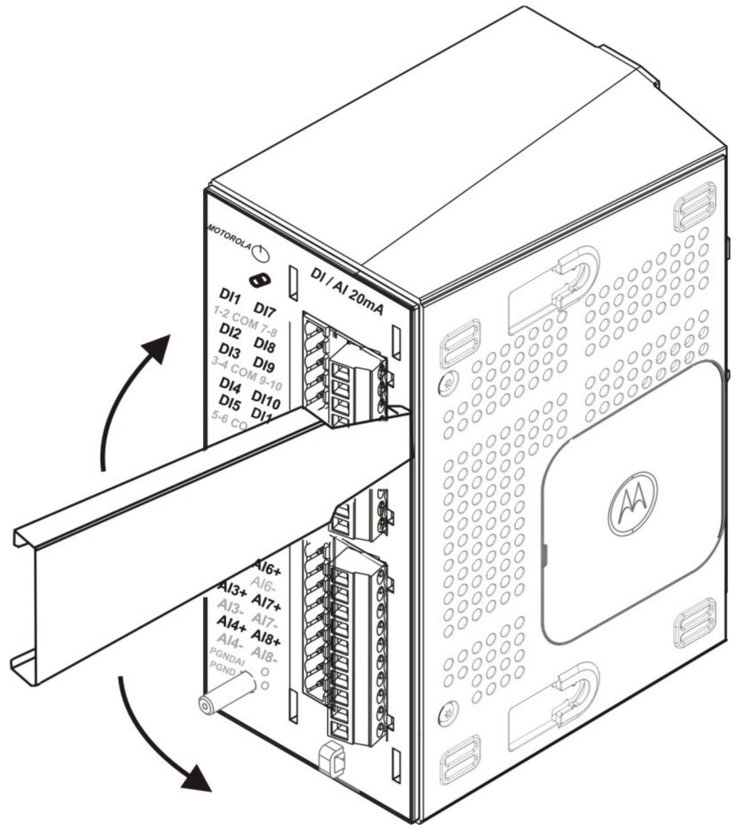


Figure 2-94 TB Extractor on TB

Adding an Optional SD Card

Follow the procedure below to add an optional SD card (not supplied) to an ACE1000 CPU.

Procedure 2-9 Adding an Optional SD Card

1) Using a Phillips screwdriver, loosen the screw on the SD cover (torque 2 LB-IN). See Figure 2-15.

2) Gentle pull the screw outwards, on its axis, to remove the SD cover.

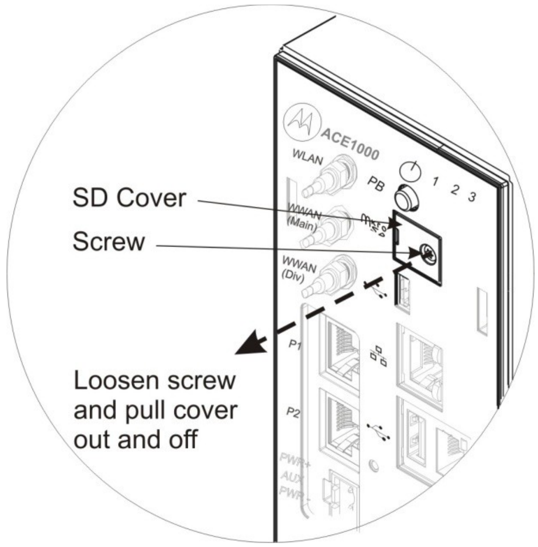


Figure 2-105 ACE1000 CPU SD Cover

Replacing the ACE1000 DC Power Cable Fuse

Follow the procedure below to replace the fuse on the ACE1000 DC power cable (FKN0033).

Procedure 2-10 Replacing the ACE1000 DC Power Cable Fuse

1) Remove the faulty 5A fuse from the fuse holder. See Figure 2-8.

2) Plug the new 5A fuse (# 6580283E03) into the fuse holder.

Sleep Mode

The ACE1000 offers deep sleep mode for remote installations that rely solely on renewable energy sources for power (solar and wind energy). Any activity detected by the three inputs of the CPU module wake up the ACE1000, which can subsequently activate power to the mobile or portable Motorola radio. The actions taken upon wake-up and the conditions that trigger the sleep mode are customizable. Applications can be written with C Toolkit to implement the triggers for sleep mode and the actions upon wake-up or recovery.

When entering sleep mode, the CPU saves the operating system status and I/O states to non-volatile memory. The 12VDC power source to the radio (if equipped) is removed. The I/O modules power is switched Off Upon wake-up/recovery, the CPU does not reboot the operating system – the tasks running prior to sleep mode are restored to their operational status, and power is restored to the I/O modules and to the connected radio (if equipped).

If the 12VDC power source falls below 9V during sleep mode, the unit shuts down. When 12VDC power is restored, the system performs a cold start.

Communications

The ACE1000 (as well as MOSCAD family RTUs) facilitates the establishment of a highly sophisticated hybrid data communication network for SCADA that utilizes a variety of radio and/or line communication links. Radio links may include conventional, analog trunked, digital trunked, and both analog and digital microwave radio technologies. Line links may include point-to-point, multi-drop, cellular packet data modems, and Local Area Networks (LAN).

Multiple data bit rates are available to accommodate the particular need of these links. Lower data speeds are used when the bandwidth of the link is reduced either by their design or by laws in the user's country, or when data speed is sacrificed to achieve greater communication range. The higher data speeds typically usable, combined with the optimized-for-radio MDLC data protocol, ensure high network throughput even if the network is spread over a large geographical area.

The ACE1000 system network consists of RTUs communicating with one or more computerized control centers and/or with other RTUs. Each control center is connected to the communication network.

The system can be relatively simple, comprising several RTUs and one control center. It can be modularly expanded to a more hierarchical system, where several sub-systems (comprising intelligent RTUs and/or sub-centrals controlling their peripheral RTUs) communicate with a central computer.

The communication network is flexible, enabling each RTU to communicate with hierarchies above it (RTU-to-FEP), parallel to it (RTU-to-RTU)*, under it (another RTU), and also relaying messages through it (when the RTU serves as a communication node).
**Note: RTU-to-RTU is available only in mixed system topology*

While the communication protocol allows for a complex hierarchical system structure, it does not make it complicated. This is because most of the communication interactions are transparent to the user, except in those cases where the communication is to be defined by the user program ladder application. In such cases, you should perform simple programming operations to configure the required application.

Each RTU may be configured to serve as a far-end terminal or as a regional center. The RTU may function as a regional center either by definition or only after loss of communication with the central. It also can act as a communication node (an interconnection point between two or more different links) while performing its other tasks.

The RTU network uses the MDLC protocol, which incorporates all seven layers of the OSI model adapted for SCADA. It supports multiple logical channels per physical port, enabling simultaneous central-to-RTU and RTU-to-RTU sessions. It also enables each RTU to simultaneously run several kinds of communication applications, such as reporting alarms by contention, on-line monitoring, performing diagnostics checks, etc. The MDLC protocol is discussed below.

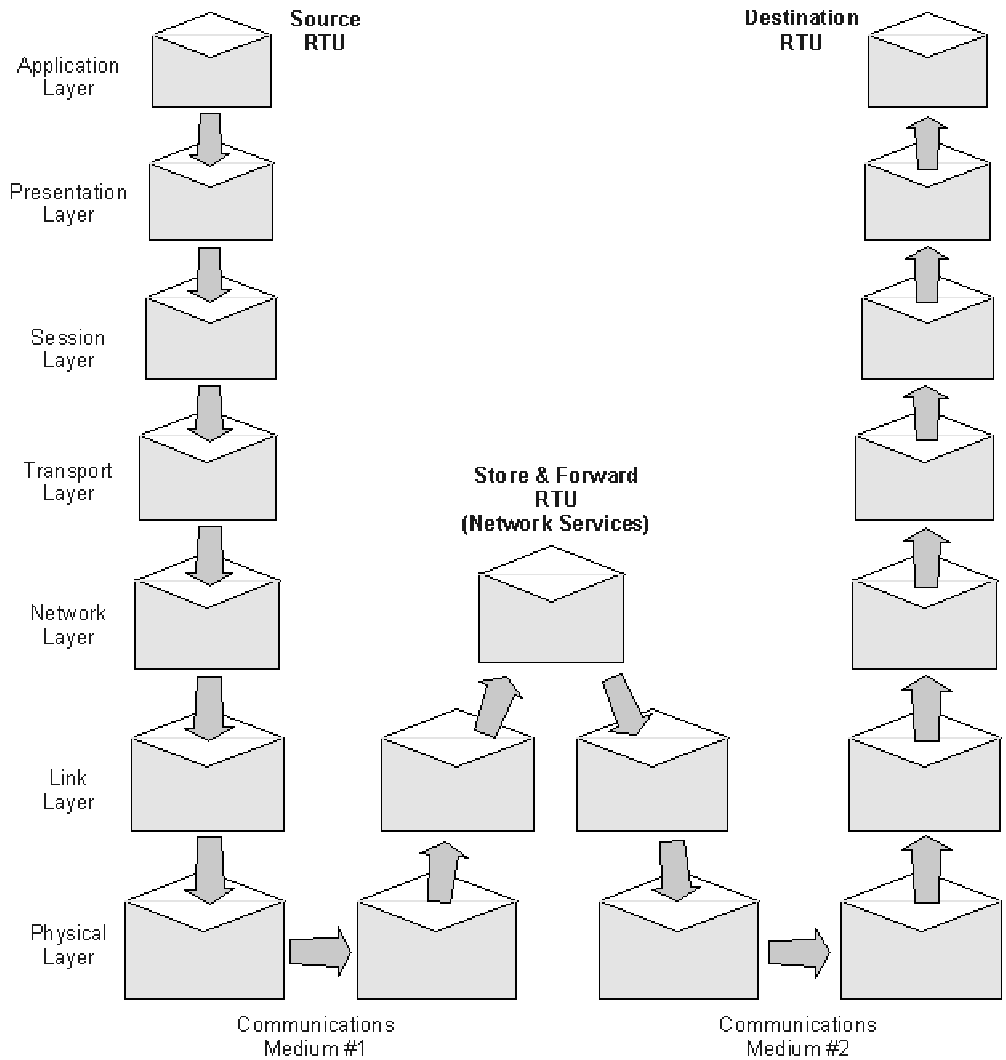
MDLC Protocol

The MDLC protocol is a Motorola SCADA protocol that is based on the Open System Interconnection (OSI) model recommended by the International Organization for Standardization. MDLC utilizes all seven layers of the OSI model. This protocol is designed for optimum operation in SCADA systems which operate with diverse communication media such as two-way radio, line, LAN, etc. Each RTU, FEP has all seven layers of the MDLC protocol available to them. The functions of the seven layers are summarized below.

Layer	Function
Layer 1: Physical	This layer caters to communications over conventional radio, trunked radio, data radio, serial data channels, modems, Ethernet or telephone lines. The layer is also responsible for channel access and collision control on shared media.
Layer 2: Link	This layer ensures proper communications over a physical link. The layer arranges the data in variable-length frames and attaches addresses, frame sequence numbers, and Cyclic Redundancy Code (CRC) to the frames.
Layer 3. Network	This layer is responsible for the establishment of end-to-end communication paths in a network. This is necessary since communications may take place on more than one link and a message may travel through several nodes before reaching the final destination.
Layer 4. Transport	This layer ensures end-to-end integrity of the information flow between two nodes in the network. This is achieved by remote-end acknowledgement that data has been received completely and passed in the correct order to the next layer.
Layer 5. Session	This layer allows the definition of any number of entities capable of conducting simultaneous sessions with an equivalent entity in some remote unit. This enables transparent communications among multiprocessing machines without interference in their applications.
Layer 6. Presentation	This layer structures the information to/from various applications. This layer may also perform format conversion, data authentication, etc. if implemented.
Layer 7. Application	This layer interfaces to the various applications such as data transfer, configuration downloading, application software monitoring, remote diagnostics, etc.

The MDLC protocol is intended for operation in point-to-multipoint links, such as two-way radio or multidrop wireline, as well as in point-to-point communication networks. The protocol facilitates communications among all sites in the system, including extensive diagnostic messaging. MDLC is transparent and liberates the system engineer from the technical constraints and complexities of network operations thus allowing the intended application to be the item of focus.

MDLC uses a semi-synchronous data format on two-way radio and an asynchronous format on wire lines. It is not correct to refer to message size in byte notation because of the 16-bit architecture; the data may not be sent in asynchronous format—no start and stop bits—but it is not true synchronous format, because there is no single network-provided clock signal. Instead, each CPU has a clock that is entirely adequate to provide the synchronize signal for data transfer. It is therefore better to refer to MDLC in terms of data words where each word may be variable in length, consist of both header and body components, and contain up to 80 16-bit variables within the body. A physical message may consist of a single word or may consist of a concatenated series of words (packets), each word addressed to one or more destination sites with some or all words requiring subsequent store-&-forward operation by the recipient site(s). The concatenated data words may be any combination of the supported functions, i.e. data upload to the SCADA Manager, error logger data to the STS/Easy Configurator., etc.



The lower three layers of the MDLC protocol stack are commonly known as Network Services. These layers only are used when communicating with intermediary sites which make it possible to pass any data through the system and not require the total system to know the details of the data. Each layer adds (removes) data to what was received and thereby communicates with equivalent layers in the destination (source) site—see figure above.

RTU-to-RTU communications suppress the Presentation, Session, and Transport layers; all layers are present for SCADA Manager-to-RTU communication and for communications with the STS.

MDLC Data Transfer Methods

Three messaging methods are commonly used by the Motorola RTU: Contention (transmission upon change-of-state; also called burst), Polling (interrogation), and Report-by-Exception. The Contention method has the RTU report upon a change-of-state (COS) of conditions/values without waiting for a poll from the SCADA Manager. The

RTU recognizes a COS and reports relevant data to the SCADA Manager or to another site as soon as the shared communication medium becomes available. The RTU will repeat the data message until confirmation of reception is received. The RTU listens to the shared communication medium before sending a message and then uses a slotted channel acquisition method to avoid synchronized message collisions. This is the messaging method most often used by Motorola RTUs because it uses the shared communication medium properly.

The Polling (interrogation) method is a periodic activity used to confirm the proper operation of the normally silent RTUs and/or to update the SCADA Manager database at specified intervals or when manually instructed by the operator. The Report-by-Exception method has the RTU report only the conditions/values that have changed since the last poll. The SCADA Manager retains all data conditions and values in a local database for instant use.

Communication Links

ACE1000 Communication Interfaces

The ACE1000 unit includes the following set of communication interfaces, for MDLC communication (between the FEP-RTU and RTU-RTU) and for non-MDLC communication (general communication with the FEP or RTU.)
Note: On the IRM1100, only the USB OTG (for configuration), Ethernet, and RS232 (for GPS) ports are in use.

- Micro USB 2.0 On-the-Go port (maximum inrush current 100mA) (USB1)
  - ➢ Console port (device)
  - ➢ MDLC Communication via radio: ASTRO 25 APX IV&D, MOTOTRBO
- LAN Ethernet 10/100 Mb/s port (ETH1)
  - ➢ Ethernet communication (MDLC and non-MDLC)
  - ➢ Non-MDLC MODBUS communication: SCADA Center slave, PLC master/slave
  - ➢ User defined communication: user application/user device
- Configurable RS232 or RS485 serial port (SI1/UART1)
  - ➢ Cellular, General PPP connection (MDLC and non-MDLC)

    Certified with: Sierra wireless -AirLINK FXT edge, Maxon – Intelimax, Telit- Gate Tel GT-HE910-EUD
  - ➢ Serial data modem communication: MDS SD 4710 modem (MDLC and non-MDLC)
  - ➢ External null modem communication: Westremo (MDLC and non-MDLC)
  - ➢ Communication via radio: TETRA MTM5200 radio (MDLC and non-MDLC)
  - ➢ Serial RS232 communication (MDLC and non-MDLC)
  - ➢ Serial RS485 multidrop communication (MDLC and non-MDLC)
  - ➢ Non-MDLC MODBUS communication: SCADA Center slave, PLC master/slave IP/Serial
  - ➢ Non-MDLC DNP communication: PLC master/slave IP/Serial
  - ➢

- Time synchronization via GPS and Network Time Protocol.
- Time synchronization via MDLC in non IP media.
- User defined communication: user application/user device

- USB 2.0 Host port (USB2)
  - MDLC communication via radio: ASTRO 25 APX IV&D, MOTOTRBO

The following additional port can be added to the CPU on an optional plug-in board:

- RS232 serial port (P1/UART3) on plug-in board
  - Cellular, General PPP connection via modem: Siarra wireless - AirLINK FXT edge, Maxon – Intelimax, Telit- Gate Tel GT-HE910-EUD (MDLC and non-MDLC)
  - Serial data modem communication: MDS SD 4710 modem (MDLC and non-MDLC)
  - External null modem communication: Westremo (MDLC and non-MDLC)
  - Communication via radio: TETRA MTM5200 radio (MDLC and non-MDLC)
  - Serial RS232 communication (MDLC and non-MDLC)
  - Non-MDLC MODBUS communication: SCADA Center slave, PLC master/slave
  - User defined communication: user application/user device
- RS232 serial port (P2/UART5) on plug-in board
  - for communication with a External modem (Westremo) (MDLC and non-MDLC)
  - for serial RS232 communication (MDLC and non-MDLC)
  - for non-MDLC communication with a PLC, with a SCADA Center, with a User device

RS232 Ports

On ACE1000 CPU modules, Serial Port 1 and up to two additional RS232 Plug-in ports can be installed on the CPU module (on PI1 and PI2 plug-in ports). The RS232 ports can be configured to Async or Sync operation mode and they enable local connection of a PC with the ACE36000 STS to the RTU, direct connection of another RTU, connection of modems, digital radios, data radios, third party PLCs and other devices. In addition, the ACE1000 supports RS232 links to standard modem over PPP on the built-in serial ports and on the plug-in ports.

RS485 Ports

On ACE1000 CPU modules, Serial Port 1 (SI1) can be configured as RS485 port.
The RS485 ports permits up to 32 2-wire RS485 devices to be parallel-connected (multi-drop) onto one pair of wires for the exchange of data. A typical ACE1000 use for RS485 is the interconnection among multiple RTUs in the same site. RS485 is also used to connect various devices in the site to the RTU using the MODBUS protocol or a user defined protocol. The RS485 Connection Box is available to make this interconnection; or the installer may make the cables by using the small handset-size connectors commonly found on modular telephones. The RS485 port may operate at data speeds up to 115200 460 kbps (depending on the total wire length).

The RS485 specification calls for the circuitry to be capable of communicating at 10 Mbit/s for 40 feet (12 meters). At 4000 feet (1200 meters), maximum cable length, the data rate is reduced to 100 Kbit/s. There are other factors involved including the network configuration; wire characteristics, the device used, biasing resistors and termination resistors (see later) that can influence the data rate. One of the most frequently asked questions and one of the most difficult to answer is the speed/distance/number of drops tradeoff.

Different studies in the industry have given some of the following (often conflicting) results, however the table below provides a conservative estimate based on the assumption of a daisy chain topology with no stubs.

Data Rate (Kbps)	**Distance (feet)**	**Distance (meters)**
<100	4000	1200
200	2000	600
300	1000	300
400	800	240
500*	700	210

The following factors affect how far one can reliably transmit at a given data rate:

- Cable length: At a given frequency, the signal is attenuated by the cable as a function of length.
- Cable construction: Cat 5/6 24AWG twisted pair is a very common cable type used for RS485 systems. Adding shielding to the cable enhances noise immunity, and thereby increases the data rate for a given distance.

- Cable characteristic impedance: Distributed capacitance and inductance slows edges, reducing noise margin and compromising the ‘eye pattern’. Distributed resistance attenuates the signal level directly.
- Termination: A long cable can act like a transmission line. Terminating the cable with its characteristic impedance reduces reflections and increases the achievable data rate.

Although normally required at higher transmission frequencies, it is good practice to terminate the cable runs with a resistor equal to the characteristic impedance of the cable. This reduces the reflection of a signal when it reaches the end of the cable. Avoid adding a termination resistor at other locations as this can overload the driver and reduce the reliability of the data transfer. The distance can be increased by the use of repeaters.

IP Ports (MDLC over IP)

ACE1000 RTUs can use IP (Internet Protocol) technology to interface to advanced radio infrastructure (e.g.ASTRO 25 I&VD, Dimetra, or Connect Plus) and to standard private IP networks. Most benefits of the MDLC protocol are preserved. MDLC and IP networks can be integrated in the same system, as networking properties are preserved. MDLC applications need not be modified as the lower layers of the protocol support IP.

MDLC packets to be transmitted are enveloped inside UDP/IP datagrams and sent between remote RTUs or between an IP Gateway and an RTU over UDP port 2002. The UDP Port number is configurable for each port.

The ACE1000 RTU can have several MDLC over IP ports, each identified by its own link ID: MDLC over RS232 PPP ports, and MDLC over LAN/Ethernet ports that can have static or DHCP addressing modes; USB ports for the ASTRO 25 APX radio and MOTOTRBO radios using MDLC over USB (RNDIS). In some cases it is required that an MDLC over IP port have more than one link ID.

Each MDLC over IP port has its own unique link ID. An IP address identifies each port, and is set by the user in a static LAN port (fixed IP address). For DHCP and PPP this address is learned automatically (dynamic IP address), and the user does not need to define it.

A PC running STS can be connected to one of the RTU ports, to one of the serial ports of the FEP, to the Ethernet or via the USB OTG.

An MDLC over IP port can be used in one of four ways:

1. ACE1000 RTU port connected to a packet data radio/modem over PPP (Point to Point Protocol). The RTU can act as a remote unit or as a front end serving a SCADA control center (over PLC or user port).
2. ACE1000 RTU port connected to a LAN through one of its on-board or plug-in Ethernet port. A direct LAN connection exists between the Ethernet port and the radio infrastructure. The RTU an act as a remote unit or as a front-end, serving a SCADA center. This port can be configured as static LAN or as DHCP LAN.
3. ACE1100 FEP connected to LAN. An FEP serves as a front-end for a TCP/IP-based SCADA central and enables it to communicate with remote RTUs. The FEP can use MODBUS over RS232 or any other propriety protocol over RS232 or LAN to communicate with the SCADA. If a LAN is used, the LAN port can be used for a user protocol.

Broadcast and Setcalls

Most wireless packet data networks do no support broadcast IP. When transmitting a group call (Site 0), a separate frame is transmitted to each site specified in the IP Conversion Table over UDP/IP. If broadcast IP exists, this IP can be specified in the IP Conversion Table under Site 0 with the proper link ID (port). Sending to Site 0 with that link ID will transmit a single message, through that port, to all RTUs over UDP/IP using that address. Note that in ASTRO 25 IV&D, GPRS, Dimetra, Connect Plus, and most wireless media, this is not supported, so a separate message is transmitted to each site. It is preferable to transmit to each site separately, rather than send this set call.

Configuring NTP Servers

In non-mixed systems, an Ethernet or RS232 PPP or USB RNDIS port can be configured for NTP protocol. In this case, the RTU retrieves its time from a set of NTP servers specified by the user. The clock offset between the RTU and these servers depends on network delays, and may be up to 100 milliseconds in some wireless media.

User Protocol over IP

Unlike ACE3600, ACE1000 does not have a special C Toolkit API for user protocol over IP. Instead, the user is required to use the Linux native socket interface. Refer to the ACE1000 ‘C’ Programming SDK & Migration Guide for more information.

Dynamic IP Address

Many wireless networks do not allocate a fixed IP address to a PPP modem (such as the GPRS network). For the FEP to communicate with the RTU, it must know its address or host name. Since these networks do not provide a name for each modem, there is no option of setting them in the FEP beforehand. In this case, the FEP should not be assigned an IP conversion table with that link ID (port). The RTUs should be associated with a table which has the FEP’s IP address. If the network operator assigns a host name to the FEP instead of a numeric address, this can be set in the IP conversion table. When the RTU detects that its modem is connected, it will notify this address, the FEP, of its new IP address, thus updating its table in runtime.

Since this process does not guarantee that the FEP will be updated, it is highly recommended that user application periodically send a message to the FEP. For example, if the user application expects an interrogation every two minutes from the FEP, and it has not received that, it should send a message to the FEP. This will update the RTU address in the FEP.

In a non-mixed ACE1000-only system, where the FEP is the ACE1100, the user must use the ACE1000 Easy Configurator Web interface to configure the ports. In this case, each IP port (LAN, Cellular modem, Dimetra, ASTRO 25, and Capacity Max , Link capacity plus) has a public IP address. That address can be set to 0.0.0.0, meaning that it is dynamic, or to a fixed numeric IPv4 address, which is used by the FEP and RTU to communicate with each other. In a mixed system, using the ACE3600 STS, the user must use an IP conversion table as with ACE3600, instead of the Web interface.

MDLC over IP Port Routing

In the example mentioned in *Dynamic IP Address* above, for RTU-to-RTU (modem to modem) communication, set the 'Enable routing of MDLC over IP port' parameter in the FEP. Then assign to the RTUs an IP conversion table which lists the RTU site IDs as having the FEP IP address.

Note: The above is relevant only to mixed systems.

MDLC over IP/LAN Connections

The ACE1000 RTU can include one on-board 10/100 Ethernet BaseT port (ETH1.) The Ethernet port has its own link ID and network mask.

An Ethernet (LAN) port can be configured in one of several modes:

- Static IP address mode
- Dynamic (DHCP)

With static IP address mode, the user is required to set the link ID, IP address, subnet mask and default gateway.

Note: DNS and NTP server are not supported via STS. ACE1000 and ACE1100 do not support DNS at all, even with the Web interface.

In DHCP address mode, the user is only required to set the link ID for this port. If DNS servers are required, there is no need to set them, since they are learned from the network.

MDLC over LAN/Ethernet/Broadband

The ACE1000 RTU can communicate over Ethernet media, via the on-board Ethernet port.

The figure below illustrates an example of a SCADA system with IP Gateway OR ACE1100 FEP and ACE1000 RTUs connected to Ethernet LAN:

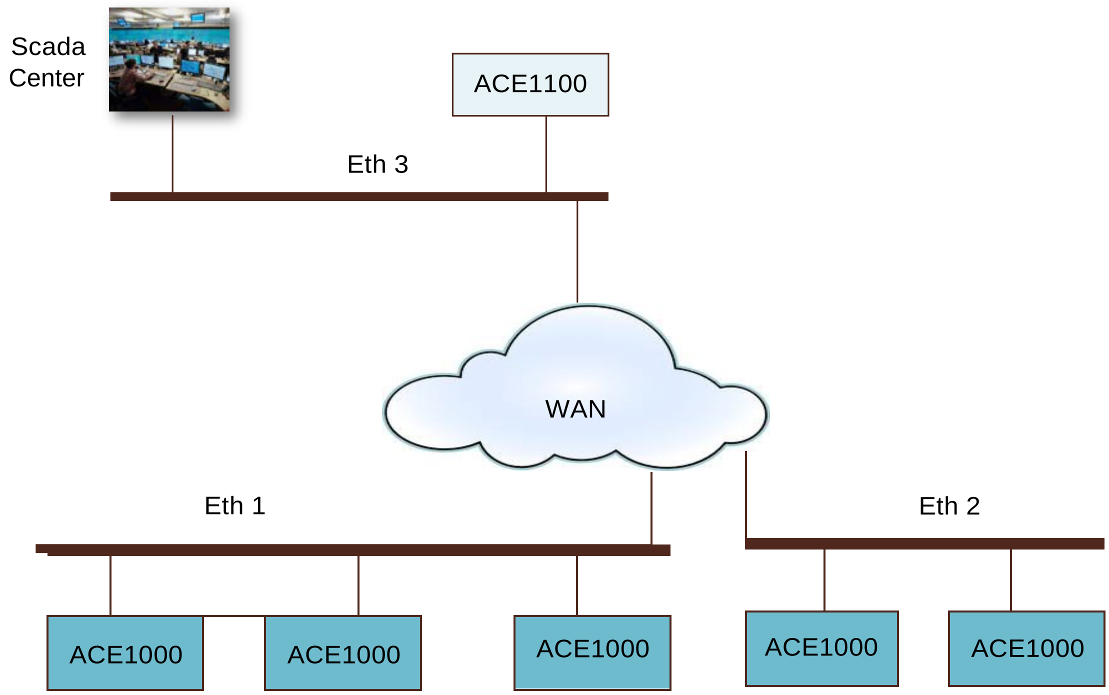


Figure 2-116 ACE1000 IP Network

When an ACE IP Gateway is used, an IPGW API in the SCADA PC is used to provide the SCADA with the current values of the RTU tables and with the events (Bursts) that are associated with each entity.

When an ACE1100 FEP is used, the connection between the SCADA to the FEP is via MODBUS, and the FEP mirrors all the information of remote RTUs.

A number of connection methods are available when configuring an Ethernet-based RTU:

1. Static IP address – The user sets the IP address within the configuration of the device in the STS. To use this method, follow the instructions for configuring an RTU in the Operation chapter in the *ACE1000 STS User Guide* or *ACE1000 Easy Configurator User Guide*.
2. DHCP-supplied reserved IP address – For every ACE1000 RTU, an IP address is reserved within the DHCP server. The link between the RTU and the reservation is based on a unique ID. In the DHCP Server, set the unique ID. The default unique is the MAC address. In the DHCP server, define a reservation for a specific RTU, based on its MAC address.

In order to comply with IP networks standards, all configuration methods described in this chapter are based on standard procedures used in IP networks.

MDLC over ASTRO 25 IV&D

With SCADA systems, ACE1000 RTUs can be connected to an ASTRO IV&D radio. The ASTRO 25 infrastructure and radio must support integrated voice and data (named IV&D). This is relevant to Motorola subscriber data radios such as the APX 6500Li mobile and APX 4000 portable.

The connection to ASTRO 25 IV&D can be made via LAN or via radio. The LAN is called a CEN (Customer Enterprise Network). In a mixed system, an ACE IP Gateway or ACE1100 FEP with an Ethernet port can be connected to the CEN. On the other end, an RTU can be connected to an ASTRO IV&D radio via USB (RNDIS). Note that a specific codeplug which supports the data option must be used when programming the radios.

In the figure below, the SCADA central and IP Gateway are connected via LAN to a Customer Enterprise Network (CEN). The CEN is connected via a border router gateway to the ASTRO 25 IV&D infrastructure. An RTU, running MDLC over IP protocol, is connected via APX 6500Li/APX 4000 radio using an USB cable. A unique IP address is assigned by the GPRS Gateway Support Node (GGSN) to each RTU according to its radio individual unit ID (UID), such that when a frame is transmitted from the CEN to that IP address, the Packet Data Router (PDR) and Radio Network Gateway (RNG) transmit it to the appropriate radio.

Unlike TETRA infrastructures, this IP address and radio unit ID cannot be retrieved for diagnostics from the radio. Instead a dummy IP Address is provided by the radio as it is configured using the CPS (Codeplug Programming Software).

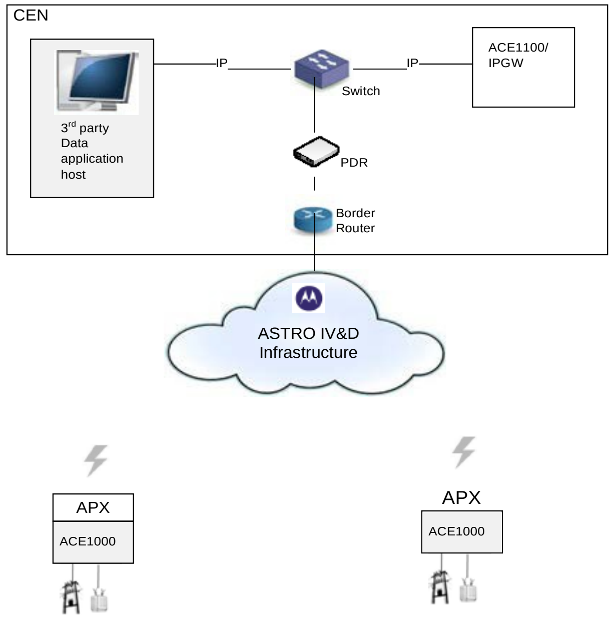


Figure 2-17 ASTRO 25 IV&D Topology

A PC running STS can be connected directly to an RTU, directly to a radio, or it can operate remotely over the CEN.

NOTE:
In Mixed Systems, ASTRO 25 IV&D supports group calls (RTU-to-RTU broadcasts) but with delays. To avoid delays when sending a frame to a group of sites, the application should send to each site individually, leaving a short wait time between each transmission (300-1000 milliseconds depending upon the communication used.)

Sending frames from one RTU to another when both are connected is not supported because of the ASTRO 25 IV&D's limited resources. It is recommended to have an RTU connected to LAN (CEN) that will route the information between them.

MDLC over MOTOTRBO Conventional, Capacity Plus, and IP Site Connect

With SCADA systems, ACE1000 RTUs and ACE 4600 IP Gateways or ACE1100 FEP can be connected to a MOTOTRBO radio in digital mode, to use MDLC over IP communication via the MOTOTRBO digital mode radio system. The MOTOTRBO radio is connected directly (not via hub) to one of the RTU/IPGW's USB host ports. The port connection between the RTU and the radio is a USB host running IP over RNDIS (Microsoft Remote NDIS protocol version Revision 1.1.) Note: The DHCP protocol is also used for obtaining an IP address from the radio. This IP address is internal within the USB connection and does not reflect the actual IP address over the air.

The user may perform STS operations such as loggers, download, hardware test, monitor, and set/get date & time (effective data throughput ~800 bps). MDLC time synchronization is not recommended, because of the long delays added by the radio/repeater. Network Time Protocol (NTP) provides better time synchronization accuracy, ~200 ms accuracy with a repeater but only with a non-mixed system via Web interface. By default, MDLC time synchronization is disabled, but it can be enabled in the port's advanced physical parameters.

A Radio ID in MOTOTRBO is a 24-bit number in the range of 1 to 16776415 written in decimal format in the CPS. In Capacity Plus and Linked Capacity Plus, the Radio ID is a 16-bit number in the range of 1 to 65535. It can be treated as a 24-bit number where the most significant 8 bits are zeros .For example, the Radio ID 16776415 is represented by a hexadecimal 24-bit number as FFFCDF. When broken into three 8-bit sections, it becomes FF, FC, and DF. They are represented in decimal format as 255, 252, and 223. A radio that is configured with an Individual ID of 16776415 and a CAINetwork address of 12 (the default), has a Radio Network IP address of 12.255.252.223.

In single repeater or IP site connect topologies, the unit attached to the MOTOTRBO radio may initiate or receive MDLC group calls over a single link ID. For example: If a radio network group ID=225, set site ID 0 to IP address 225.0.0.1. Note: Adding this feature requires changes in the CPS of the radio (adding a digital Call to the contact list, and referring to it in the RX Group list; marking the 'forward to PC' field in the network folder.) If using MDLC time synchronization, it is important to set a group IP address. For example if using Digital Call ID 1, set it to 225.0.0.1 in the STS.) Note: There may be delays, depending on the topology used.

IMPORTANT: For sending group calls, the default group IP address can be configured in the advanced link layer of the USB2 port tab, or in the IP conversion table for site ID 0 and the proper link ID. This is the only way a setcall can be delivered by MOTOTRBO in digital mode.

Each RTU or FEP has a fixed IP address. This address is derived from the radio to which it is connected. For example: If the radio ID=1 and the network ID=12, the address is 13.0.0.1. (13 because to access the unit specify the network ID 12 plus 1)
The network mask is always 255.255.255.0.

The unit learns the local radio IP address dynamically. For example: If 199.19.10.1 is configured in the radio CPS, this is not the real IP address transmitted over the air. The real IP is 13.0.0.1.

Unlike other infrastructures such TETRA, the radio's IP address and radio unit ID cannot be retrieved for diagnostics from the radio. Instead a dummy IP Address is provided by the radio as configured in its CPS.

The general steps of the MDLC over MOTOTRBO setup are like those of MDLC over IP setup.
Note that the data throughput over the MOTOTRBO system is up to 800 bps (less if the same frequency/slot is shared for voice and data).

MDLC over MotoTRBO Connect Plus

The SCADA 2015 release (Q3 2015) introduced support for Connect Plus MotoTRBO radios on the ACE1000 and ACE 3600 RTU products. Connect Plus offers a limited bandwidth data service compared to MotoTRBO DMR II digital operation, but even with its limitations, it can support several applications that do not require real-time reporting and control.

Connect Plus system versions 1.5 and above are certified and supported with the SCADA 2015 software release. Versions of ACE1000 RTUs prior to the SCADA 2015 software release do not support Connect Plus.

Direct RTU-to-RTU communication is not possible on Connect Plus. RTU communication is established with the ACE FEP. The data connection from the ACE FEP to the RTU is established between Connect Plus XRT 9000 Gateway and the XPR radio.

The Connect Plus system must be equipped with a dedicated XRT 9000 for use by the ACE 1100 RTU.

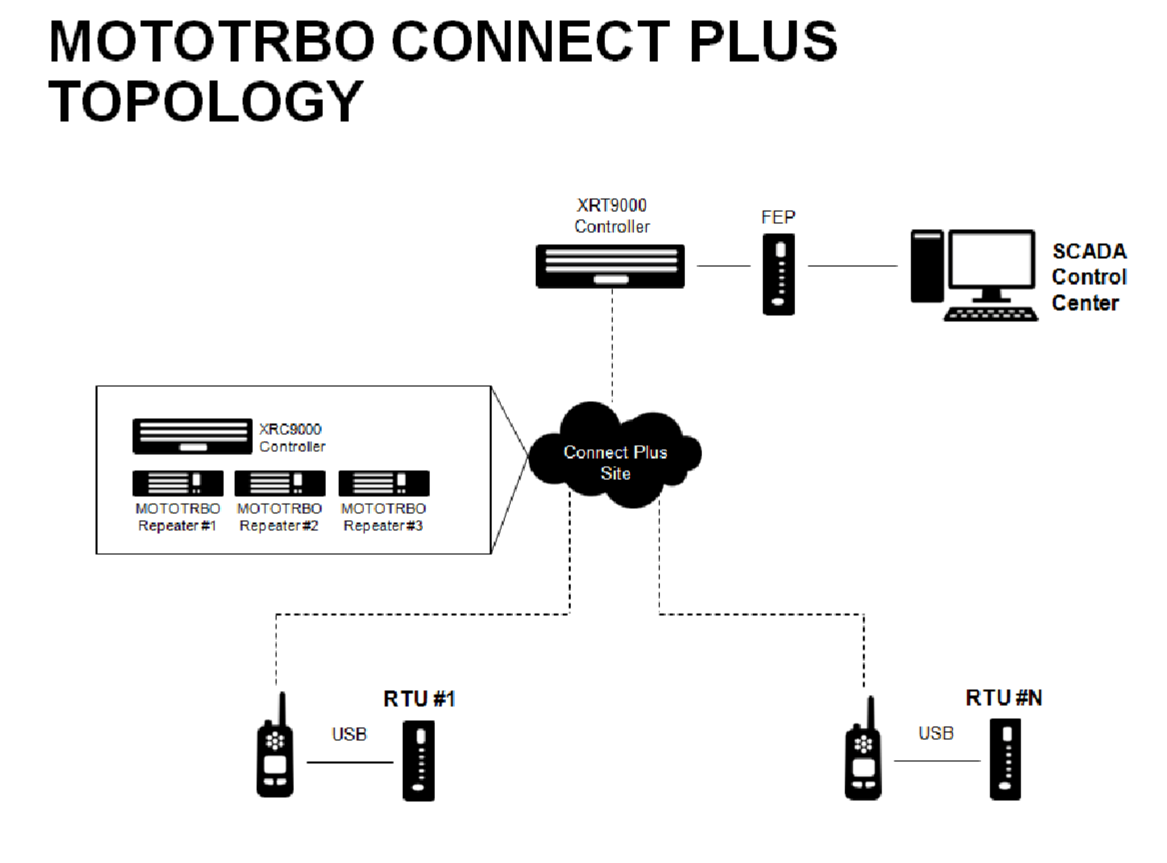


Figure 2-128 MotoTRBO Connect Plus Infrastucture

MDLC over TETRA

ACE1000 RTUs can be connected to a TETRA radio. TETRA infrastructure and radio should support packet data.

The connection to TETRA can be made via LAN or via radio. An IP Gateway or an ACE1100 FEP with Ethernet port can be connected to a LAN. In TETRA terms, an RTU that is connected through LAN is called a LAN RTU. An RTU that is connected to a radio is called a PEI (Peripheral Interface) RTU. A PEI RTU is connected to a radio through RS232 using standard PPP (Point to Point Protocol).

In the figure below, the SCADA central and IP Gateway or ACE1100 FEP are connected via LAN to TETRA infrastructure. Each RTU has an MTM5200 radio connected to its MDLC over IP Port using PPP (RS232). A unique IP address is assigned to each RTU according to its radio's identifier (SSI). All communication between RTUs and the IP Gateway involve sending datagrams in packets over the Internet (IP).
Note that the adapter used for connecting the RS232 is different than the one used by the ACE3600. Refer to the *ACE1000 RTU Owner's Manual* for more information.

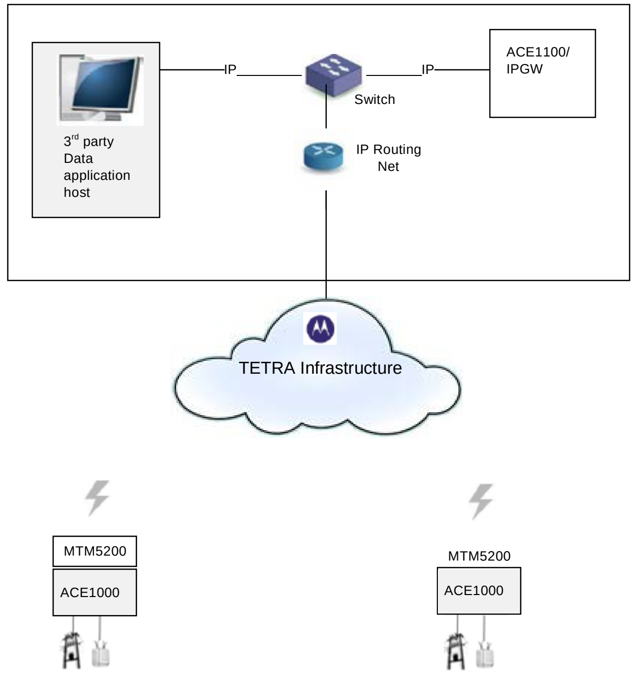


Figure 2-139 TETRA Infrastrcutre

The STS can communicate with remote RTUs over IP using the TETRA infrastructure. The PC running the STS is connected to the TETRA radio. For this purpose, the PC should have a TETRA PD installation (as specified in the CPS user manual).
After setting up the connection, the user should run the STS Communication Setup utility, select Ethernet port and specify in a focal point RTU/IP Gateway IP Address under ‘Local Site IP Address’.

It is important to note that RTU-to-RTU communication is routed through the infrastructure LAN system and not directly.

Note that a paging mechanism to each site (peer) in IP conversion table makes MDLC over IP more reliable. For details, see MDLC over IP Site Paging.

TETRA does not support group calls (RTU-to-RTU broadcasts). To send a frame to a group of sites, the application should send to each site individually, leaving a short wait time between each transmission (about 300 milliseconds).

MDLC over Cellular Network

An ACE1000 can be connected to GPRS (GSM) and later networks through a LAN or through a radio. An IP Gateway/FEP or an RTU with an Ethernet port can be connected to the LAN.

The SCADA central and IP Gateway are connected via LAN to the GPRS infrastructure. Each RTU has a cellular modem connected to its MDLC over IP Port using PPP. A unique IP address is assigned to each RTU according to its modem identifier (IMSI). All communication between the RTUs and the IP Gateway/FEP involves sending datagrams in packets. The broadband infrastructure routes those packets directly between two RTUs, or between IP Gateway and an RTU.

Only a single Cellular modem can be connected to an RTU.

It is recommended that the operator provide an APN (Access Point Name) for a fixed IP address and enable one modem to communicate with another over UDP port 2002. However it is not always possible, so the following steps can be taken:

1. The assigned FEP must have a fixed IP or host name. Make sure the operator supports UDP port 2002 from the modem to FEP and vice versa.
2. In the application, each RTU should transmit periodically to the ACE IP Gateway/FEP, so it learns the recent address (recommended interval is every 2 minutes.) See the ACE1000 Easy Configurator Guide for additional information. Or else wait for a timeout and if nothing is received from the FEP, send it a message.

Cellular modems do not support group calls (RTU-to-RTU broadcasts). To send a frame to a group of sites, the application should send to each site individually, leaving a short wait time between each transmission (about 300 milliseconds).

Note: Each SIM Card has unique identifiers for a GPRS/GSM modem. Placing a given SIM card on different modems causes the same settings to be retrieved from infrastructure (phone number, IP Address etc.) regardless of the modem.

Note: ACE1000 and ACE1100 FEP do not support modem configuration file. It is up to the user to configure these modems offline, and save the settings in the modem.

Radio Installation Kits

Customers in the North America region can order an ASTRO 25 or MotoTRBO radio with the ACE1000. For customers with existing radios or radios purchased via other channels and customers outside of North America, there are several radio installation kits offered with the ACE1000.

APX 6500 and APX4000 radio installation kits are offered for ASTRO 25 SCADA installations. XPR5000 series (Matrix) radio installation kits are offered for MotoTRBO SCADA installations. The ACE1000 does not ship as an assembled unit.

IP Conversion Tables in a Mixed System

When using the ACE1000 Easy Configurator tool to set up the system, a default (fixed) IP conversion table is created automatically for the RTUs in the system when the user specifies a public IP address per each IP port via the Web. No IP conversion table is set up manually by the user. When using the STS to set up the system, an IP conversion table is created and can be modified using the “IP Conversion table manager” which is part of the STS.
Note that unlike the network configuration, there is no default, and in a mixed system using STS, any IP conversion tables must be created manually. The IP conversion table maps sites in the system (site ID+link ID) to IP addresses or host names. Each site ID/link ID pair can have one unique entry in the table, though an IP address can appear in more than one row. A site ID of 0 is reserved for a group call.

In RS232/PPP/RNDIS and Ethernet DHCP, the IP address is read from the network once it is connected to the RTU. In ASTRO 25 IV&D, this is not the real IP address set by the infrastructure; rather, it is a dummy address configured in the radio via the CPS Mobile Computer IP address which is (by default 192.168.128.2). In the IP conversion table do not specify this address, but use the actual IP address assigned by the infrastructure operator.

The ACE1000 IP conversion table format resembles the ACE3600. It includes a link ID column which allows more than one port in the same site to be connected to LAN/PPP/RNDIS. Any legacy MOSCAD RTU or IP Gateway in the network must defined using its own Toolbox IP Conversion Table utility.

Digital Trunked Radio Systems

In digital trunked radio systems such as ASTRO 25 IV&D (P25), MotoTRBO Connect Plus, and Dimetra (TETRA), the ACE1000 uses the packet data capability of the system. The digital trunked radio system behaves as an IP network. The ACE1000 interfaces to the digital radio using an USB-RNDIS for ASTRO 25 systems and RS232-PPP for Dimetra systems.

Communication Network

The ACE1000 system network consists of RTUs communicating with one or more computerized control centers and/or with other RTUs. Each control center is connected to the communication network.

System which includes ACE1000 RTUs and ACE1100 FEP are relatively simple, comprising several RTUs which communicate with the FEP directly and one or more control centers. Up to two link media are allowed for these systems. Systems which include ACE1000 RTUs without an FEP (mixed systems) can be modularly expanded to a more hierarchical system, where several sub-systems (comprising intelligent RTUs and/or sub-centrals controlling their peripheral RTUs) communicate with a central computer.

The communication network is flexible, enabling each RTU to communicate with hierarchies above it (RTU-to-central), parallel to it (RTU-to-RTU), under it (another RTU), and also relaying messages through it (when the RTU serves as a communication node).
Each RTU may be configured to serve as a far-end terminal or as a regional center. The RTU may function as a regional center either by definition or only after loss of communication with the central. In a mixed system it also can act as a communication node (an interconnection point between two or more different links) while performing its other tasks.

The RTU network uses the MDLC protocol, which incorporates all seven layers of the OSI model adapted for SCADA. It supports multiple logical channels per physical port, enabling simultaneous central-to-RTU and RTU-to-RTU sessions. It also enables each RTU to simultaneously run several kinds of communication applications, such as reporting alarms by contention, on-line monitoring, performing diagnostics checks, etc. The MDLC protocol is discussed later in this manual.

The ACE3600 System Tools Suite (STS) and FEP (ACE1100) Web based Easy Configurator (configuration/monitoring tool) may perform system level monitoring, modification, diagnostics, error logging, etc., on any RTU in the system from any RS232 port in the system.

Network Configurations

The ACE1000 system supports both simple and complex communication networks. When the system is configured via the Easy Configurator only a simple network is supported. The system consists of new ACE1000 RTUs and an ACE1100 FEP only. In this case the RTUs can communicate with the FEP directly with one primary link and an additional redundant link per RTU.
In systems that are comprised of ACE1000 and ACE3600 RTUs, the configuration is done via the STS and in this case complex networking can be achieved.

The following sections describe various configurations from different aspects.

Simple networking – ACE1000 only system
A simple system comprised of a central FEP and RTUs connected over one or more communication link, is shown in the following figure:

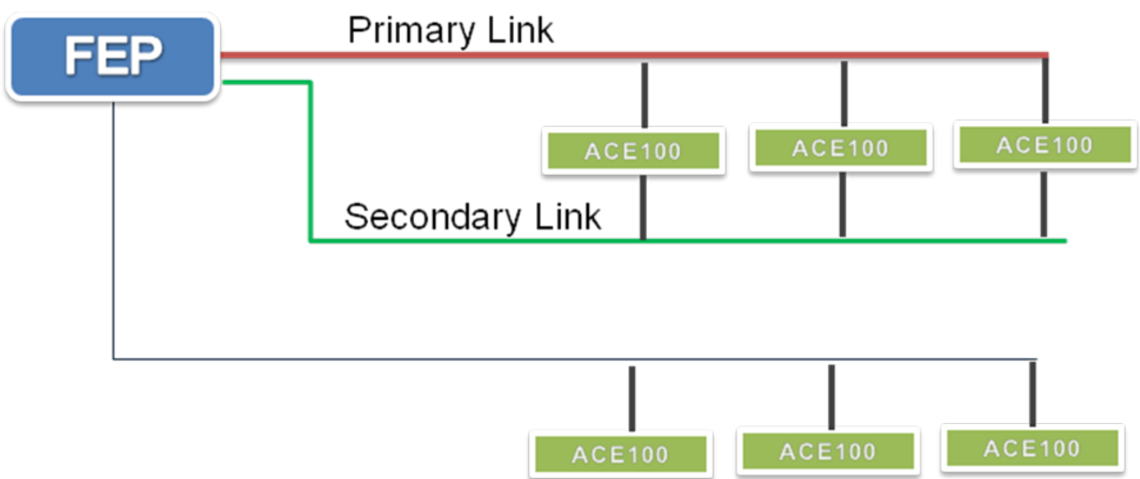


Figure 2-2014 ACE1000 New System Network Configuration

A multi-link system is a network that uses several link types. The figure above illustrates a system where one branch of RTUs is connected to the FEP via primary link and redundant link (secondary Link), and an additional branch connects a number of RTUs to the FEP via a different link.

Multi-zone System

This topology can be achieved when using the STS to configure the ACE1000 in a mixed system.

A two-zone system that uses conventional MAS digital radio over a single frequency is described in the following figure:

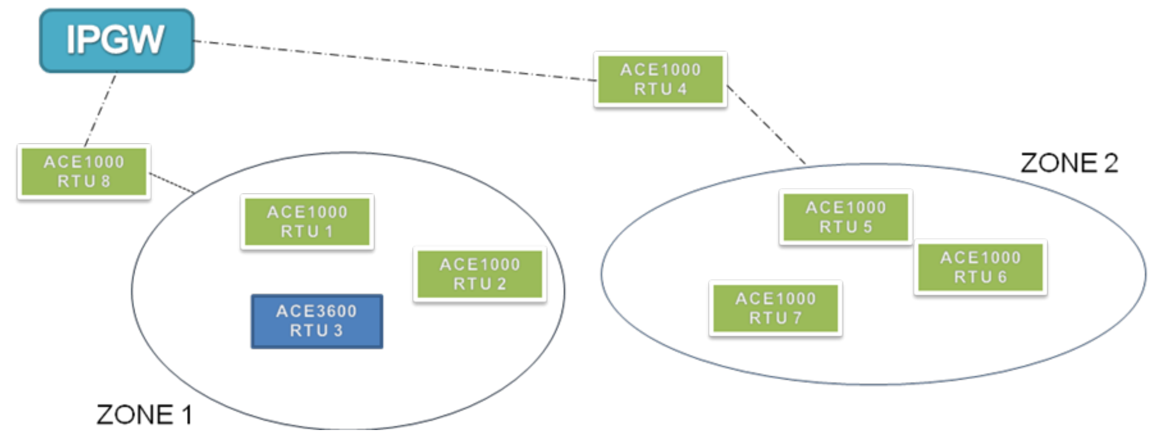


Figure 2-151 Separate Multi Zone System

In this configuration the system assumes that the two nodes, RTU 4 and RTU 8, are on a different port, hence they cannot communicate with each other. (They can communicate via the SCADA or another RTU that will serve as a store & forward unit, as described below.)

So ZONE 1 and ZONE 2 will be referred to as different networks.

In the figure below, RTU 8 acts as a “bridge” between ZONE1 and ZONE2, so any unit in the network can communicate with any other unit.

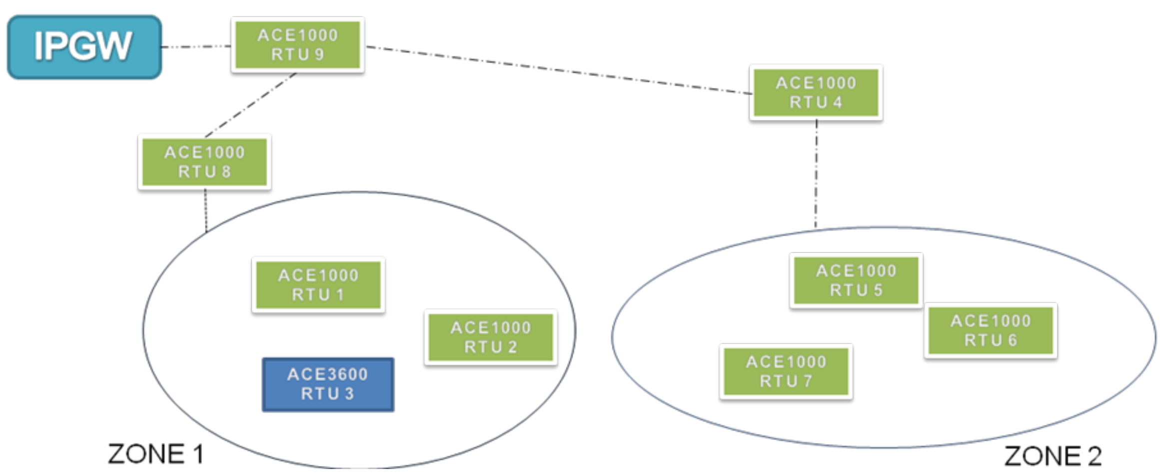


Figure 2-162 Multi Zone System

Clock Functions and Synchronization

RTU Clock

The ACE1000 RTU has one time source, an internal system clock. This time source is updated using a backup source of the RTC hardware component.

In addition, external clocks, such as GPS and NTP servers can be used as a time source. See NTP Clock Synchronization and Global Positioning System (GPS) below.

The time resolution of the system clock is hour, minute, second.
The date resolution is day, month, year. Leap year support is automatic.

When the RTU first starts up, the system clock is set according to the RTC, which always retains its time in seconds (even when the RTU is powered down.) The RTU time can then be set using a number of mechanisms.

The ACE1000 includes standard configurable time zone support, where RTUs in one time zone can adjust messages received from another time zone. The time zone is commonly used in conjunction with NTP servers and GPS receiver. These servers operate in UTC (Universal Time Clock) which is in the (Greenwich Mean Time) GMT time zone. Setting time zone in a unit will adjust it to the local time.

The ACE1000 also supports daylight savings time as part of the time zone. Daylight savings time is used only in conjunction with a time zone.

Time Adjustment and Synchronization

MDLC time synchronization of the RTU clock can be performed locally or remotely, using MDLC protocol over a variety of communication media, including RS485, and RS232. Synchronization is accurate to 500 milliseconds. With IP media, this feature can be enabled, but because its accuracy/delay is unpredictable, it is not recommended. NTP, the recommended method of obtaining the time over IP media (PPP, RNDIS or Ethernet), allows accuracy of to 500 milliseconds depending on the media.

In ACE1000 RTUs, the same ACE3600 MDLC extended time synchronization can be enabled which includes the synchronizing RTU’s password. In this case, all RTUs in the system must use the same password. This extended time synchronization also enables synchronizing two RTUs in different time zones, and better accuracy than the MOSCAD MDLC legacy synchronization. Note that by default, the ACE1000 uses MOSCAD MDLC legacy synchronization (to support IP Gateway and MOSCAD RTUs) which does not include the time zone and password features.

Note: An extended time synchronization of two RTUs, where only one is configured for time zone, will proceed as if both RTUs are in the same time zone.

The RTU clock can be synchronized during runtime using a number of methods. Before synchronizing the clock, make sure that the appropriate parameters have been configured properly.

- STS Date & Time utility – From the STS, the user sets the RTU date/time to the PC's date/time (which is limited to second accuracy.) For information on using the Date & Time utility, see the Operation chapter of the *ACE3600 STS User Guide*.
- STS Sync utility – From the STS, the user instructs the local RTU to synchronize (in milliseconds accuracy) the date/time of other RTUs attached to one or all links. It is recommended to synchronize all links, so that the entire system has the same date/time. For information on using the Sync utility, see the Operation chapter of the *ACE3600 STS User Guide*.
- FEP sync utility – From the FEP Web interface, the user can instruct the FEP to synchronize the remote RTUs with the FEP clock. See the *ACE1000 Easy Configurator User Guide* for more information.

System Time Control Actions

- GPS Connection – An RTU which is connected to a GPS receiver continuously polls the GPS time and synchronizes itself. Because the clock source is reliable, this RTU can be used to synchronize the rest of the system. See the Global Positioning System (GPS) section below.

- NTP Connection – An RTU which is connected to an NTP server continuously polls the NTP server(s). Because the clock source is reliable, this RTU can be used to synchronize the rest of the system. The accuracy of NTP time depends on the link to the NTP server.

If the synchronizing RTU is in a different time zone than the RTU being synchronized, the system will adjust the time accordingly; the receiving RTU will add the time zone of the sender to the global time (UTC) and use this. If only one of the two RTUs involved is configured for time zone support, the synchronization will proceed as if both sites are in the same time zone.

Note: A legacy MOSCAD RTU is treated as an RTU which is not configured for time zone support.

NTP Clock Synchronization

In a non mixed system, with an ACE1100 FEP, the Network Time Protocol (NTP) can be used as an external clock source to synchronize the ACE1000 RTU over IP with one or more NTP servers or with the ACE1100 FEP.

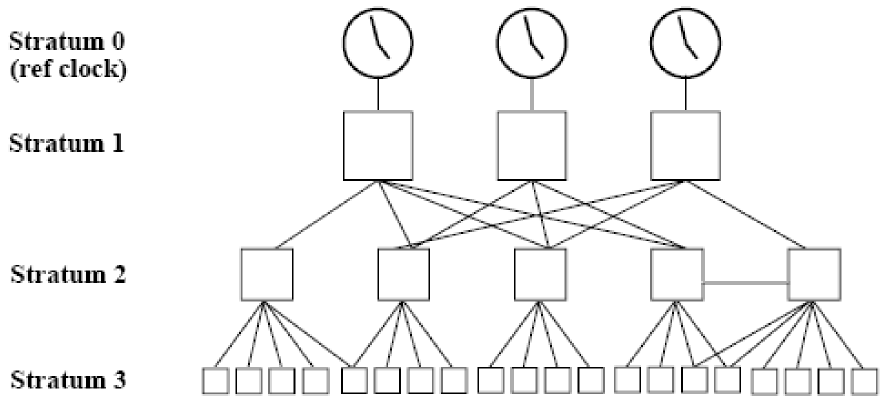
The NTP works in client/server mode, in which a client RTU polls another server and gets a reply. The server can be another RTU operating NTP, or a host (PC, Unix, Linux). NTP polls the server RTU every 2 seconds, every 4 seconds, every 8 seconds, and so on, up to a poll every 17 minutes. NTP provides client accuracies typically within a millisecond on LANs and up to 500 milliseconds on WANs (Internet, GPRS etc). Any RTU (usually the FEP) can act as a server. This enable setting its time via MDLC time sync, for example, and having other RTUs specify it as an NTP server and obtain their time from it.

NTP synchronizes the clock both in time and frequency. NTP synchronization in time, means it makes its clock offset as close as possible to the server. NTP synchronization in frequency, means it learns the server drift (time between "ticks") in order to avoid polling it every few seconds. An example, not related to NTP, is an ACE1000 sending an MDLC Sync over radio to another ACE1000.

The user can set one or more NTP servers. NTP operates under the assumption that each server's time should be viewed with a certain amount of distrust. NTP really prefers to have access to several sources of lower stratum time (at least three) since it can then apply an agreement algorithm to detect insanity on the part of any one of these. Normally, when all servers are in agreement, NTP will choose the best of these, where "best" is defined in terms of lowest stratum, closest (in terms of network delay) and claimed precision, along with several other considerations.

As the below figure shows, at the top of any NTP hierarchy are one or more stratum 0 reference clocks. These are electronic clocks such as GPS signals, radio signals, or extremely accurate frequency control. Reference clocks are assumed to be accurate. In ACE1000 a GPS port can be configured, it will serve as a reference clock for that RTU.

FIGURE 1 NTP Strata



NTP Architecture

As the above figure shows, time is distributed from an NTP subnet of servers. Each server comprises a ***stratum,*** which designate its location in terms of hops to the ***UTC source***. The ***stratum*** 1 is the most accurate server of which all servers should be synchronized to. Up to 15 *stratum* levels may exist. ***Stratum 16*** means server unreachable.

The accuracy of other clocks is judged according to how "close" a clock is to a reference clock (the *stratum* of the clock, the network latency to the clock, and the claimed accuracy of the clock. The accuracy of NTP thus depends on the network environment. Because NTP uses UDP packets, traffic congestion could temporarily prevent synchronization, but the client can still self-adjust, based on its historic drift. Under good conditions on a LAN without too many routers or other sources of network delay, synchronization to within a few milliseconds is normal. Anything that adds latency, such as hubs, switches, routers, or network traffic, will reduce this accuracy. The synchronization accuracy on a WAN is typically within the range of 10-100 ms. For the Internet/GPRS synchronization accuracy is unpredictable, so special attention is needed when configuring a client to use public NTP servers. Testing with the ACE1000 connected with the Internet gains accuracy of 20-30ms, but theoretically it may be even 100ms.

NTP uses UTC time base (Coordinated Universal Time). UTC evolved from Greenwich Mean Time (GMT). GMT is based on the earth's rotation, which is not constant enough to be used for detailed time measurements. UTC is based on a standard second length determined by the quantum phenomena. There is a difference of a few seconds between the two (14seconds in 2006), so every several years add one more second (called leap second) to UTC. This is built in NTP protocol.

To translate the UTC time into local time, user can configure Time zones and Daylight Savings in RTU. Note however, that if setting NTP server to another stand alone ACE1000, which has no time zone, both will operate with the same local time if no time zone set. If that ACE1000 is connected to a GPS or to another NTP server then there is a need to set a time zone.

Global Positioning System (GPS)

The ACE1000 system can use a GPS receiver precise time measurement application for synchronization purposes, to synchronize the RTU with other SCADA systems.

The ACE1000 RTUs use GPS timing receivers equipped with a 1 Pulse per Second (PPS) output. The receivers are connected to an RTU port. In case of a satellite failure, the time is manufactured internally and the receiver indicates its inability to trace the satellite.

Appendix A: ACE1000 Specifications

ACE1000 General Specifications

The ACE1000 general specifications are listed below.

Table A-1 ACE1000 General Specifications

Attribute	Specifications
CPU MODULE	
Processor	TI Sitara Cortex A8 AM3356 microprocessor
Frequency	600 MHz (default), 300 MHz in Low Power mode configuration
MEMORY	
Flash	256 MB, at least 32 MB available for user data
DDR	256 MB LPDDR memory, at least 32 MB available for user data
SD Card Slot	Micro SD, up to 32 GB (card not supplied)
Optional user-supplied flash drive	Up to 32 GB on Sandisk Cruzer Blade (SDZ50-032G) or 4GB on Sandisk Cruzer Blade (SDZ50-004G) (not supplied)
Operating System	Linux (Kernel version 3.2.20)
Real Time Clock	Hardware clock with year, month, date, day, hour, minute, and second supported.
Internal Backup Battery	The backup battery can maintain the RTC for at least 30 days@ +25ºC, when main power is disconnected.
RTC crystal accuracy	±20ppm@25C or 2sec per day (24hours) @ 25C
RTC crystal drift	$\pm 0.04 ppm/(^{0}C)^{2}$
POWER IN	
Input Voltage	9-30 V DC
Power In Connector	5mm pitch, Maximum 12 AWG
Power Consumption	CPU module: max 300 mA/typical 150 mA @12V (w/o SD card and USB) Input module: max 180 mA @12V/typical 100 mA@12V Output module: max 450 mA @12V/typical 250 mA @12V Sleep mode: typical 5.5 mA @12V
Auxiliary DC Power Out Connector	Optional auxiliary power output • Configurable to: 0 V (default), 5V/2A, 7.5V/2A, 9.5V/1.9A, 12V/1.5A, |Vout – Vin|> 2V Vout = Vin/2A @12V • Output voltage accuracy: ± 20%

ENVIRONMENTAL	
Physical Dimensions	7.6 cm (W) x 15.9 cm (H) x 11.8 cm (D) (3" x 6.3" x 4.7") (WxHxD) The depth of the unit including the front cover is 14.59 cm (5.74"). The depth to the tip of the grounding screw is 13.73 cm (5.41").
Weight	Approx. 0.5 Kg
DIN Rail	Maximum thickness 1.0 mm Minimum length 26 cm
Operating Temperature	-40 ºC to +70 ºC (-40 ºF to 158 ºF) /-20 to+60 ºC for ATEX Model
Storage Temperature	-55 ºC to +85 ºC (-67 ºF to 185 ºF)
Operating Humidity	5% to 95% RH @ 50 ºC for 8 hours without condensation. For an uncontrolled humidity enviroment, it is recommended to use a NEMA enclosure.
Housing Sealing	IP30
Mechanical Vibrations	Per EIA / TIA 603 Base-station, Sinusoidal 0.07mm @ 10 to 30 Hz, 0.0035 mm @ 30-60 Hz
Operating Altitude	-400 to +4000 meter (-1312 to + 13120 ft)

Communication Ports	Serial RS232/RS485 port (configurable) - RS-232 up to 115.2 Kb/s - RS485 up to 460.8 Kb/s USB ports: - USB 2.0 On-the-Go - USB 2.0 Host Ethernet port : -10/100 Mb/s Optional plug-in ports with two RS232 ports: - Up to 115.2 Kb/s 2 isolated (2500V)
CPU ON-BOARD I/OS	
<u>Digital Inputs</u>	
Total Number of Inputs	3 DI Wet inputs
DI Fast Counter Input Mode	Max 2.0 kHz (minimum pulse width 250 µS)
Max. DC Input Voltage	30V DC
“ON” DC Voltage Range	+6 to 30V DC
“OFF” DC Voltage Range	0 to +3V DC
Input Current	Max 8 mA@30V DC
DI Isolation to CPU	2500 V

Digital Output	
Total Number of Outputs	1 Magnetically Latched (ML)
DO Max. Contact Ratings	2A@30VDC or 0.6A@30VAC
DO Isolation	1500V
Maximum Number of I/O Expansion Modules	2
PROTOCOL SUPPORT	
MDLC	Serial/Ethernet/USB
MODBUS Master	Serial/Ethernet
MODBUS Slave	Serial/Ethernet
DNP3 Master	Serial/Ethernet
DNP3 Slave	Serial/Ethernet
CONFIGURATION & PROGRAMMING TOOLS	
ACE1000 Easy Configurator	Unit/System Configuration & Logic Rules
ACE3600 STS	Configuration (Mixed System only)
CodeSys Programmer	IEC61131-3 compliant application
‘C’Programming SDK	‘C’ Language API
Time Synchronization	NTP, MDLC Ext. GPS/GLONASS, NMEA-0183, 1PPS, RS232
Security	HTTPS, SSL, SSH

ACE1000 Input Module Specifications

The ACE1000 input module (mixed DI/AI) specifications are listed below.

Table A-2 ACE1000 Input Module Specifications

Attribute	Specifications
Total Number of Inputs	12 DI wet inputs 8 AI: 0-20 mA (4-20 mA), 0-5 VDC differential inputs
Digital Inputs	
DI Fast Counter Input Mode Frequency	Max 2.0 kHz (minimum pulse width 250 µS)
Max. DC Input Voltage	30V DC
“ON” DC Voltage Range	+6 to 30V DC
“OFF” DC Voltage Range	0 to +3V DC
Input Current	Max 8 mA@30V DC
DI De-bouncing Filter	10, 20, 30, 40, 50 msec
Diagnostic LEDs	Status LED per each input
User Connection	2 Terminal Blocks, with maximum 12 AWG
DI Isolation to CPU	2500 V
Analog Inputs	
A/D resolution	16 bit (including sign)
AI Accuracy	± 0.1% of full scale
AI Temperature Drift	±25PPM/C
AI Smoothing	User configurable
AI Scaling	User configurable (positive range only)
AI Fast sampling	User configurable: No filtering – 10 samples /sec 60 Hz filtering – 7.5 samples /sec 50 Hz filtering –6.25 samples /sec
Impedance	Voltage channels - range 0 -5 V, 200K input impedance or Current channels - range 0 -20 mA, 250 Ω input impedance
Physical Dimensions	7.6 cm (W) x 15.9 cm (H) x 11.8 cm (D) (3" x 6.3" x 4.7") (WxHxD) The depth of the unit including the front cover is 14.59 cm (5.74"). The depth to the tip of the grounding screw is 13.73 cm (5.41").
Weight	approx. 0.5 Kg (1.64 Lb)
Power Consumption	Input Module Max 180 mA @12V/typical 100 mA@12V

ACE1000 Output Module Specifications

The ACE1000 output (mixed DO/AO) module specifications are listed below.

Table A-3 ACE1000 Output Module Specifications

Attribute	Specifications
Total Number of Outputs	8 DO: 4 ML/4 EE Form C (SPDT) 2 AO: current (0-20 mA) or voltage (0-10 V)
Digital Outputs	
DO Frequency	Max 10 Hz
DO Max. Contact Ratings	2A@30VDC or 0.6A@30VAC
DO Isolation	1500V
Output Arrangement	0-20 mA or 0-10 V DC voltage; no isolation between channels
D to A Resolution	12 bit
AO Accuracy	±0.1% of full scale @ 25 ºC
AO Temperature Stability	±0.5% of full scale @ all range
AO Internal Settling Time	1mS
AO Load	Voltage: >1K Ω Current: <1K Ω
Output Protection	Voltage output: short circuit current, max. 35mA Current output: No-load voltage max. 31V DC
User Connection	2 Terminal Blocks, with maximum 12 AWG
Isolation to CPU	1.5 kV between output and module logic
Physical Dimensions	7.6 cm (W) x 15.9 cm (H) x 11.8 cm (D) (3" x 6.3" x 4.7") (WxHxD) The depth of the unit including the front cover is 14.59 cm (5.74"). The depth to the tip of the grounding screw is 13.73 cm (5.41").
Weight	approx. 0.5 Kg (1.64 Lb)
Power Consumption	Output module: max 450 mA @12V/typical 250 mA @12V

ACE1000 Mixed I/O Module Specifications

Table A-4 ACE1000 Output Module Specifications

Attribute	Specifications
Total Number of Outputs	6 DO: 2 ML/4 EE Form C (SPDT) 1 AO: current (0-20 mA) or voltage (0-10 V)
Digital Outputs	
DO Frequency	Max 10 Hz
DO Max. Contact Ratings	2A@30VDC or 0.6A@30VAC
DO Isolation	1500V
Analog Output	
Output Arrangement	0-20 mA or 0-10 V DC voltage; no isolation between channels
D to A Resolution	12 bit
AO Accuracy	±0.1% of full scale @ 25 ºC
AO Temperature Stability	±0.5% of full scale @ all range
AO Internal Settling Time	1mS
AO Load	Voltage: >1K Ω Current: <1K Ω
Output Protection	Voltage output: short circuit current, max. 35mA Current output: No-load voltage max. 31V DC
User Connection	2 Terminal Blocks, with maximum 12 AWG
Isolation to CPU	1.5 kV between output and module logic
Total Number of Inputs	7 DI wet inputs 4 AI: 0-20 mA (4-20 mA)
Digital Inputs	
DI Fast Counter Input Mode Frequency	Max 2.0 kHz (minimum pulse width 250 µS)
Max. DC Input Voltage	30V DC
“ON” DC Voltage	+6 to 30V DC

Range	
“OFF” DC Voltage Range	0 to +3V DC
Analog Input	
Input Current	Max 8 mA@30V DC
DI De-bouncing Filter	10, 20, 30, 40, 50 msec
Diagnostic LEDs	Status LED per each input
User Connection	2 Terminal Blocks, with maximum 12 AWG
DI Isolation to CPU	2500 V
Analog Inputs	
A/D resolution	16 bit (including sign)
AI Accuracy	± 0.1% of full scale
AI Temperature Drift	±25PPM/C
AI Smoothing	User configurable
AI Scaling	User configurable (positive range only)
AI Fast sampling	User configurable: No filtering – 10 samples /sec 60 Hz filtering – 7.5 samples /sec 50 Hz filtering –6.25 samples /sec
Impedance	Voltage channels - range 0 -5 V, 200K input impedance or Current channels - range 0 -20 mA, 250 Ω input impedance
Physical Dimensions	7.6 cm (W) x 15.9 cm (H) x 11.8 cm (D) (3" x 6.3" x 4.7") (WxHxD) The depth of the unit including the front cover is 14.59 cm (5.74"). The depth to the tip of the grounding screw is 13.73 cm (5.41").
Weight	approx. 0.5 Kg (1.64 Lb)
Power Consumption all on	194.4mA@12V
Power Consumption Idle	64mA@12V

ACE1000 Regulatory Specifications

The ACE1000 regulatory specifications are listed below.

Table A-7 ACE1000 Regulatory Specifications

Standard	Specification
Safety	UL 60950-1 (UL listed) CSA 22.2-950-1 EN60950-1 AS/NZS 60950-1
Emission	CFR 47 FCC part 15, subpart B (class A)
EN61000	EN61000-3-2 EN61000-3-3 EN61000-4-2, level 3 EN61000-4-3, 10V/m EN61000-4-4, level 3 EN61000-4-5, level 3 EN61000-4-6, level 3 EN61000-4-8, level 1 EN61000-4-11
Immunity	Per EN55024
Housing Sealing	IP30
Protection Level*	ATEX EX nA IIC T4 (Cat 3/Zone 34 2) per IEC 60079-0 and 60079-15 standards, for a non-sparking (nA) and protected sparking (nC) system.

*Special model can be ordered.

**Check availability with Motorola representative

Microhard n920 Modem Interface Board Specifications

The specifications listed below are for the interface board to the third party Microhard n920 modem.

Table A-8 Microhard n920 Modem Interface Board Specifications

Attribute	Specification
INTERFACES	
UART (Radio Interface) (at TTL Level)	CTS RTS DTR RxD TxD DCD
RS485 (User Port) RS232 (User Port)	A,B (Half duplex) Rx,Tx (Software selectable)
LEDs (Radio)	3xRSSI Tx Rx Firmware download indication
POWER	
DC Input	12 V
DC Output (to modem)	3.3 V
Power Consumption	with n920 module – full power profile 170 mA without n920 module – low power mode 65 mA (average) without n920 module – sleep mode 6 mA (average)
GENERAL	
Operating Temperature	-40 ºC to + 70 ºC (-40 ºF to 158 ºF)
Storage Temperature	-55 ºC to + 85 ºC (-67 ºF to 185 ºF)
Operating Altitude	-400 to +4000 meters
Module Size (WxHxD)	79.2 x 79.2 x1.6 mm (3.12" x 3.12" x 0.63")

Specifications subject to change without notice.

ACE1100 FEP Capacity Requirements

ACE1100 Front End Processor maximum configuration size is 20 MB.
Per this limit, the user needs to allocate the configuration resources between additional IO EXP, Third-party protocol MODBUS Master and its slaves, and ACELogic entities.
To calculate the actual size of a certain configuration consider the following components size:
One RTU with no I/O Expansion – 25 kB + one I/O Expansion 6 kB – 31
One MODBUS Master and 1 slave – 110 kB
One Entity (with 50 action and states and 4 rules) – 35 kB
The following table lists the capacity for a basic configuration: 250 RTUs with two I/O Expansion units plus up to one MODBUS Master with seven slaves per a single RTU and up to 340 entities per single RTU.

Number of MODBUS Masters with Seven Slaves	**Number of Entities**
X	**Y**
109	0
108	5
106	10
104	15
103	20
101	25
100	30
98	35
96	40
95	45
93	50
92	55
90	60
88	65
87	70
85	75
84	80
82	85
80	90
79	95
77	100
76	105
74	110
73	115
71	120
69	125
68	130
66	135
65	140
63	145

61	150
60	155
58	160
57	165
55	170
53	175
52	180
50	185
49	190
47	195
45	200
44	205
42	210
41	215
39	220
38	225
36	230
34	235
33	240
31	245
30	250
28	255
26	260
25	265
23	270
22	275
20	280
18	285
17	290
15	295
14	300
12	305
10	310
9	315
7	320
6	325
4	330
3	335
1	340

The following table lists the capacity for a basic configuration: 250 RTUs with two I/O Expansion units plus up to one MODBUS Master with one slave per a single RTU and up to 340 entities per single RTU.

Number of MODBUS Masters with One Slave	**Number of Entities**
X	**Y**
249	236
238	241
226	246
214	251
203	256
191	261
179	266
168	271
156	276
144	281
133	286
121	291
109	296
98	301
86	306
74	311
63	316
51	321
39	326
28	331
16	336
4	341

The following table lists the capacity for a basic configuration: 250 RTUs (main CPU only) plus up to one MODBUS Master with one slave per a single RTU and up to 541 entities per single RTU.

Number of MODBUS Masters with One Slave	**Number of Entities**
X	**Y**
249	436
238	441
226	446
214	451
203	456
191	461
179	466
168	471
156	476
144	481

133	486
121	491
109	496
98	501
86	506
74	511
63	516
51	521
39	526
28	531
16	536
4	541

Appendix B: Cables and Adaptors

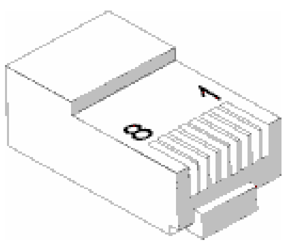
General

This appendix provides the information required for connecting an ACE1000 RTU and ACE1100 FEP to various interfaces, as detailed below:

- Connection to a computer via RS232
- Connection to a modem via RS232
- Connection to a PLC/RTU/FEP via RS232
- Connection to a PLC/RTU/FEP via RS485
- Connection to a computer via Ethernet
- Connection to a computer via USB
- ACE1000 CPU to ACE1000 I/O Expansion Module Connection

NOTE

Note: On the ACE1000 RJ45 RS232 connector, the numbering of the pins is different than the ACE3600, as shown in the figure below. Pin 8-1 are left to right. Therefore, only original Motorola ACE1000 cables should be used.



For information on connecting the ACE1000 to a radio via USB or RS232, see "ACE1000 Radio Types and Installation Kits" in *ACE1000 RTU Owner's Manual*.

Connection to a Computer via RS232

Use this connection to configure an ACE1000 mixed system using the ACE3600 STS. To connect the unit's RS232 serial port to a computer, use the RS232 data cable (FKN0022), which includes an RJ45-to-RJ45 cable (FKN8803) and an adaptor (0189968V32) with a male 9-pin, D-type connector. Add a null modem cable (female-to-female) which is not provided. See the figure below.

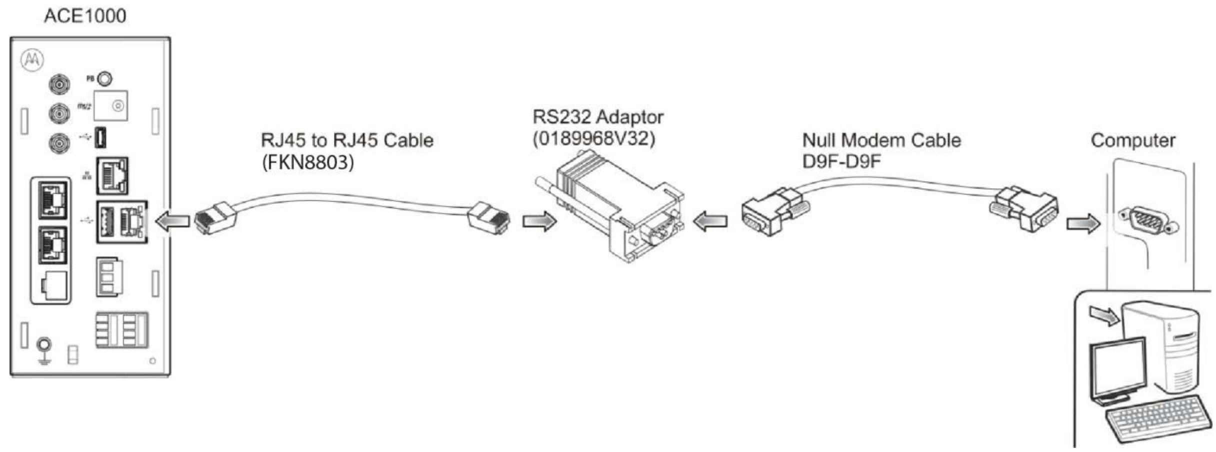


Figure B-17 Computer-RS232 Connectivity

The unit port is defined as an MDLC protocol port. The Flow Control parameter of the PC serial port should be set to None.

The signals that appear on the male 9-pin D-type connector are according to the RS232 standard. See the following table.

Table B-1 RS232-Computer Connection Pin Out

8-pin Connector (on RTU)	RS232 Adaptor (0189968V32) 9-pin D-type	Null Modem 9- pin Female (No flow control)	9-pin Male (on Computer/ Terminal)
7 (Rx) ←	2	3	3 (Tx)
8 (Tx) →	3	2	2 (Rx)
4 (DCD) ←	1	NC	7 (RTS)
1 (DTR) →	4	NC	8 (CTS)
2 (NC)	NC (not connected)	NC	6 (DSR)
5 (GND)	5	5	5 (GND)
6 (CTS) ←	8	NC	4 (DTR)
3 (RTS) →	7	NC	1 (DCD)
	NC	NC	9 (RI)

Connection to a Modem via RS232

Use this connection to communicate from an ACE1000 unit over a modem.

To connect the unit’s RS232 serial port to a modem, use the RS232 data cable (FKN0022), which includes an RJ45-to-RJ45 cable (FKN8803) and an adaptor (0189968V32) with a male 9-pin, D-type connector. See the figure below.

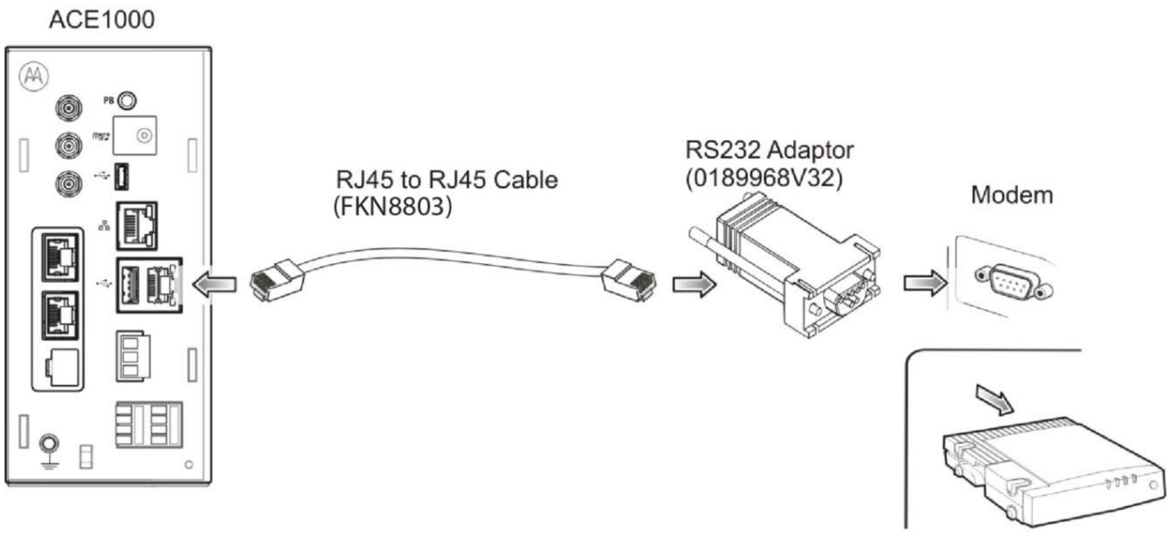


Figure B-18 RS232- Modem Connectivity

The unit port is defined as an MDLC protocol port.
The signals that appear on the male 9-pin D-type connector are according to the RS232 standard. See the following table.

Table B-2 RS232-Modem Connection Pin Out

8-pin Connector (on RTU)	RS232 Adaptor (0189968V32) 9-pin D-type	9-pin Female (on Modem)
7 (Rx) ←	2	2 (Rx)
8 (Tx) →	3	3 (Tx)
4 (DCD) ←	1	1 (DCD)
1 (DTR) →	4	4 (DTR)
2 (NC)	NC	6 (DSR)
5 (GND)	5	5 (GND)
6 (CTS) ←	8	8 (CTS)
3 (RTS) →	7	7 (RTS)
	NC	9 (RI)

Connection to a PLC/RTU/FEP via RS232

To connect the unit's RS232 serial port to a PLC/RTU/FEP, connect an RS232 data cable (FKN0022), which includes an RJ45-to-RJ45 cable (FKN8803A) and an adaptor (0189968V32) with a male 9-pin, D-type connector, to each unit. Add a null modem cable (female-to-female), which is not provided, between the two data cables. See the figure below.

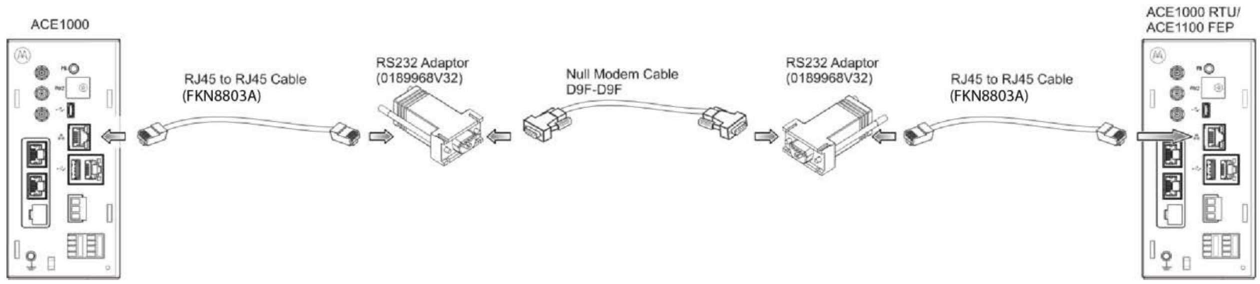


Figure B-19 RS232-RTU/FEP Connectivity

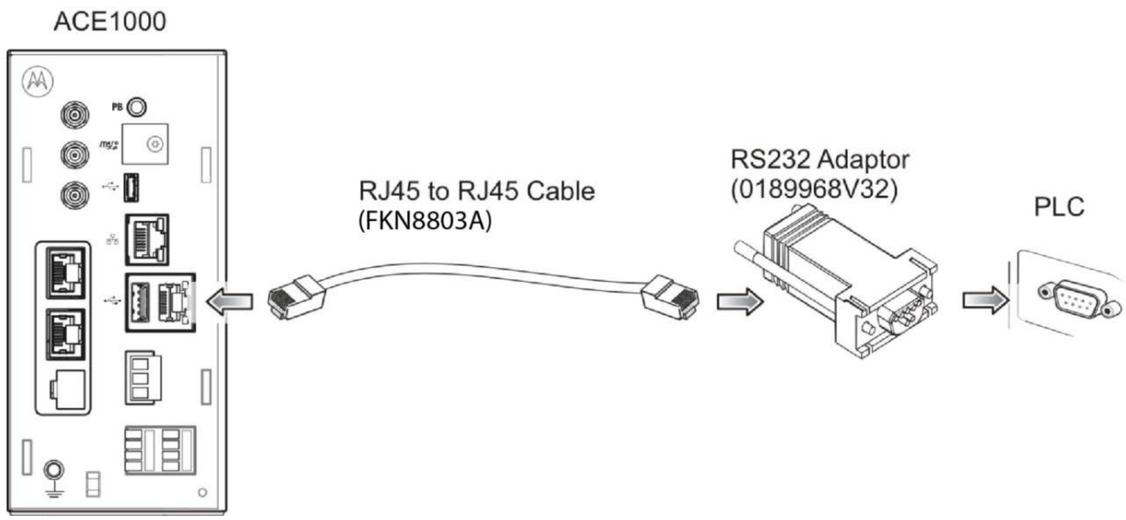


Figure B-20 RS232-PLC Connectivity

The unit port is defined as an MDLC protocol port. The connection between the RTUs/FEP can either be with partial flow control or with no flow control, based on the null modem setting.

The signals that appear on the male 9-pin D-type connector are according to the RS232 standard. See the following tables.

Table B-3 RS232-PLC/RTU/FEP Connection Pin Out without Flow Control

8- pin Connector (on RTU)	RS232 Adaptor (0189968V32) 9-pin D-type	Null Modem 9-pin Female (No Flow Control)	RS232 Adaptor (0189968V32) 9-pin D-type	8-pin Connector (on RTU/FEP)
7 (Rx) ←	2	3	3	8 (Tx)
8 (Tx) →	3	2	2	7 (Rx)
4 (DCD) ←	1	NC	1	4 (DCD)
1 (DTR) →	4	NC	4	1 (DTR)
2 (NC)	NC	NC	NC	2 (NC)
5 (GND)	5	5	5	5 (GND)
6 (CTS) ←	8	NC	8	6 (CTS)
3 (RTS) →	7	NC	7	3 (RTS)

8- pin Connector (on RTU)	RS232 Adaptor (0189968V32) 9-pin D-type	Null Modem 9-pin Female (No Flow Control)	RS232 Adaptor (0189968V32) 9-pin D-type	8-pin Connector (on RTU/FEP)
	NC	NC	NC	

Table B-4 RS232-PLC/RTU/FEP Connection Pin Out with Partial Flow Control

8- pin Connector (on RTU)	RS232 Adaptor (0189968V32) 9-pin D-type	Null Modem 9-pin Female (with Partial Flow Control)	RS232 Adaptor (0189968V32) 9-pin D-type	8-pin Connector (on RTU/FEP)
7 (Rx) ←	2	3	3	8 (Tx)
8 (Tx) →	3	2	2	7 (Rx)
4 (DCD) ←	1	NC	1	4 (DCD)
1 (DTR) →	4	NC	4	1 (DTR)
2 (NC)	NC	NC	NC	2 (NC)
5 (GND)	5	5	5	5 (GND)
6 (CTS) ←	8	7	7	3 (RTS)
3 (RTS) →	7	8	8	6 (CTS)
	NC	NC	NC	

Connection to a PLC/RTU/FEP via RS485

To connect the unit's RS485 serial port to a PLC/RTU/FEP, use the RS485 adaptor cable (FKN0030A - CB000207A01) which ends with a female 9-pin, D-type connector.

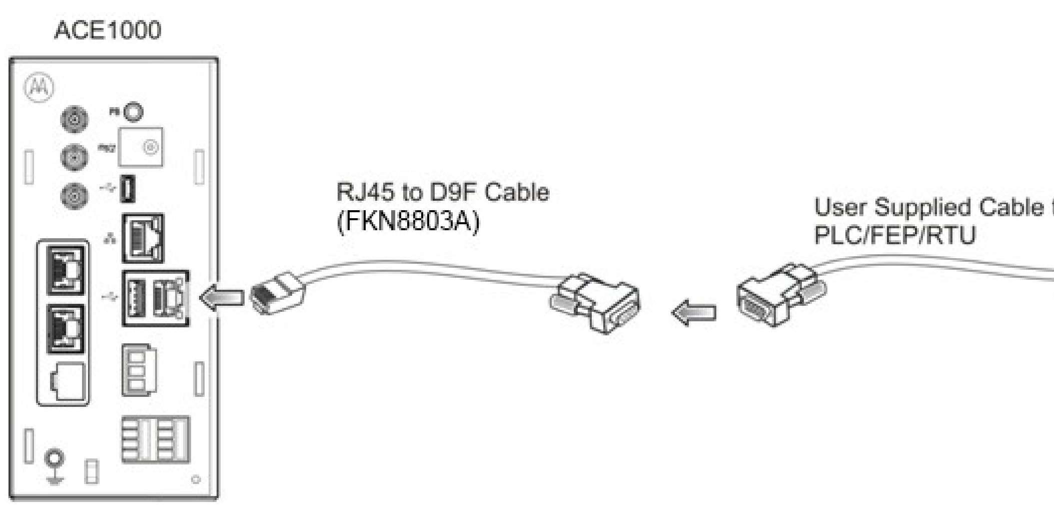


Figure B-21 RS485- PLC/RTU/FEP Connectivity

The unit port is defined as an MDLC protocol port.

The signals that appear on the female 9-pin D-type connector are according to the RS485 standard with internal 120 Ω resistance. See the following table.

Table B-5 RS485-PLC/RTU/FEP Connection Pin Out

8-pin Connector (on RTU)	9-pin Female on Adaptor Cable (CB000207A01)
1 (Tx/RX+) ←	3 (Tx/RX+)
2 (NC)	1 (NC)
3 (NC)	2 (NC)
4 (NC)	4 (NC)
5 (GND)	5 (GND)
6 (NC)	6 (NC)
7 (NC)	8 (NC)
8 (Tx/RX-) ←	7 (Tx/RX-)

Connection to a Computer (Ethernet)

Use this connection to configure an ACE1000 mixed system using the ACE3600 STS or to configure an ACE1000 system using the ACE1000 Easy Configurator.
To connect the RTU LAN port to a computer via Ethernet, use a standard Ethernet cable.

Connection to a Computer (USB OTG)

Use this connection to configure an ACE1000 mixed system using the ACE3600 STS or to configure an ACE1000 system using the ACE1000 Easy Configurator.
To connect the RTU USB OTG (as device) port to a computer, use a USB 2.0 cable with a Micro-B connector.

ACE1000 CPU to ACE1000 I/O Expansion Module Connection

To connect the ACE1000 CPU to an ACE1000 I/O expansion module, or to connect one ACE1000 I/O expansion module to another ACE1000 I/O expansion module, use the 26 AWG RJ50 cable (FHN0065A 30013144001.)

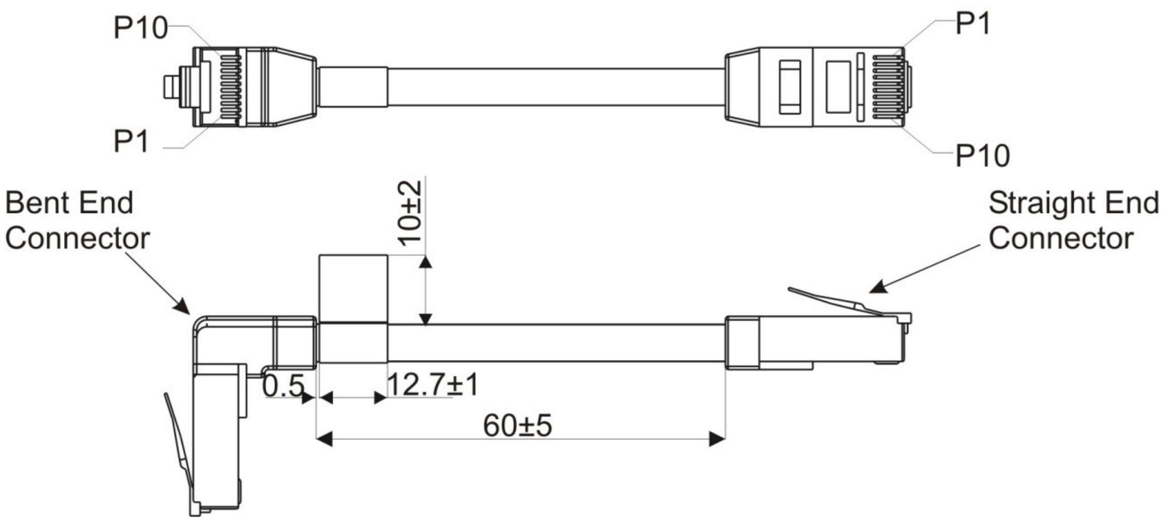


Figure B-22 ACE1000 CPU to ACE1000 I/O Expansion Module Connectivity

Table B-6 CPU-Expansion Module Connection Pin Out

Function	RJ50 Connector 1	RJ50 Connector 2
GND	1	1
GND	2	2
GND	3	3
CAN "-"	4	4
CAN "+"	5	5
CONFIG	6	6
RSV	7	7
PWR	8	8
PWR	9	9
PWR	10	10