SCADAPack E Series

Technical Overview

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SCADAPack E Series Technical Overview

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TABLE OF CONTENTS

Notes

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1 Introduction

This document introduces the E Series architecture, and Technical Documentation. It is recommended that the reader of this technical overview and technical reference manuals be familiar with the concepts of SCADA and distributed telemetry communications. It is intended for this manual to be used by technical personnel such as Systems Engineers, Control System programmers, Communication Engineers, Maintenance Engineers, and Field Technicians.

The E Series is a generic term for a Telemetry hardware product range designed and manufactured by Control Microsystems Inc.. This manual describes the architecture and functionality of particular software for E Series systems, known as "XXX series" software.

Provided by the E Series is an extensive set of communications and control facilities for use in Telemetry and Supervisory Control And Data Acquisition (SCADA) applications, including Internet communication protocol (TCP/IP).

1.1 Terminology

This section describes terms used throughout the E Series documentation.

Analog : - A variable quantity represented numerically

Applications Level: - The RTU programming environment in which the users applications programs are running (IEC 61131-3 and vendor specific programming environment)

Applications Program: - An ordered set of instructions prepared by the user which may be loaded into the RTU and, once initialised, will continuously execute or as triggered by other applications programs or events

Binary : - A quantity with two discrete states: ON (1) or OFF (0). This term is often used in conjunction with DNP3 communication protocol objects. See also Boolean, Digital

Boolean : - A quantity with two discrete states: TRUE or FALSE. This term is often used in conjunction with ISaGRAF application variable types. See also Binary, Digital

Boot Monitor : - Software contained in Flash memory executed on an RTU at start-up (boot) time for the purposes of verifying, loading or modifying the main operating system firmware

Current Value: - associated with a point indicating the current value or state of the point. The current value of some points is read-only, and may be non-volatile. The current value is neither a point attribute nor a point property

Derived Point: - internal data within an RTU, being either a User defined point or a System point

Digital: - A quantity with two discrete states: ON or OFF. This term is often used in conjunction with physical input and output states. See also Binary, Boolean

Expansion I/O Unit: - Device providing remote I/O to expand the capacity of a Main RTU Unit.

Firmware: - Boot Monitor software and RTU Operating System software stored in Flash memory

Fragment: - DNP3 protocol application layer data unit – Max 2048 bytes

Frame: - DNP3 protocol link layer data unit – Max 292 bytes

Intelligent Electronic Devices (IEDs): - A programmed or programmable electronic instrument or controller having a communications interface, and not a Master Station or a PC

Internet Protocol: - Communication protocols and applications from the TCP/IP suite, used in Internet and Intranet local area and wide area communication architectures.

Local Diagnostic Terminal: - A laptop or portable computer, connected directly to the RTU and is capable of executing CMI supplied applications to display and modify RTU parameters and user applications

Local Time: - Seasonally adjusted current time for the geographic location's time zone

Main RTU Unit: - RTU device responsible for communicating with a SCADA Master or Peer RTUs, executing user applications and controlling Remote I/O (see also Expansion I/O Unit)

Master Station: - The computer or computer systems that form the primary point of contact for communication to and from an individual RTU

Operating System Firmware: - Software contained in Flash memory on the RTU that controls all RTU facilities except the Boot Monitor

Peer: - A like device, possibly to who direct communications may be established

Physical Points: - RTU internal representation of electrical terminations on a Main RTU Unit or Expansion I/O Unit

Point: - an entity of data within an RTU corresponding to a physical or derived quantity

Point Attributes: - read/write field of a ***point configuration*** describing or controlling (to the RTU) a characteristic of the point

Point Index: - DNP3 point address of a point in the RTU point database

Point Properties: - read only field describing (to the SCADA Master or ISaGRAF user application) a status or characteristic of a point

Protocol: - communication description shared by multiple devices permitting interchange of information

Remote Engineering Workstation: - A computer workstation which is connected to the RTU through the telemetry network or dial up modem and is capable of executing CMI supplied applications to display and modify RTU parameters and user applications

Remote I/O: - RTU sub-system architecture providing I/O to expand the capacity of a Main RTU Unit. Units attached through serial or Ethernet communication channels and providing additional I/O capacity to a Main RTU unit are known as Expansion I/O Units.

RTU Sequence: - Same as applications program

Slave: - General term for a device that connects to a hierarchically higher level device for services (The higher level device is usually called by the General term "Master").

Slave RTU: - A Main RTU unit that utilises the communication link of another RTU for communications with a Master station.

Standard Time: - Non-seasonally adjusted current time for the geographic location's time zone

Summer Time: - Standard Time + 1 hour, when RTU is notified during gazetted summer months

System Points: - RTU internal data managed by RTU operating system software

Telemetry Computer (TC): - A Master Station communications server

User: - Any person responsible for the installation, programming, operation or maintenance of RTUs;

User Points: - RTU internal data created by a user defined configuration

User Program: - A compiled, end user written ISaGRAF application

UTC Time: - International standard time, not adjusted for local time zone or summer time

1.2 Glossary

This section describes acronyms used throughout the E Series documentation.

ACCM	Asynchronous Control Character Map (PPP negotiated option)
ACFC	Address and Control Field Compression (PPP negotiated option)
AH	Ampere Hour (Battery capacity rating)
AI	Analog Input
ARP	Address Resolution Protocol (TCP/IP Ethernet component)
BNC	physical connector type (for 10Base-2 Thin-Ethernet cabling)
BOOTP	Boot Protocol (TCP/IP application layer remote boot services)
CASE	Computer Aided Software Engineering (tools suite)
CCITT	international standards organization now known as ITU-T
CHAP	Challenge Authentication Protocol (PPP security component)
CI	Counter (Pulse) Input
CRC	Cyclic Redundancy Check (error checking algorithm)
CRO	oscilloscope (Test instrument)
CROB	Control Relay Output Block (DNP3 control object)
CSLIP	Compressed Serial Line Internet Protocol (TCP/IP serial data-link layer)
CTS	Clear To Send (RS232 signal)
DCD	Data Carrier Detect
DCE	Data Communication Equipment
DNP	Abbreviation for DNP3 protocol
DNP3	Distributed Network Protocol (SCADA / RTU communication standard)
DNS	Distributed Naming Service (TCP/IP application layer name resolution)
DO	Digital Output
DTE	Data Terminal Equipment
Flash	electrically erasable programmable read only memory
FSK	Frequency Shift Keying (data modulation technique)

FSM	Finite State Machine (PPP component)
FTP	File Transfer Protocol (TCP/IP application layer file transfer)
GPS	Global Positioning System (satellite system used for time synchronization)
HDLC	High-level Data Link Control (serial link layer protocol: PPP is based on this)
Hex	Hexadecimal (Base-16 numbers are followed by 'h' or preceded by '0x')
I/O	Inputs and Outputs
IC	Integrated Circuit
ICMP	Internet Control Message Protocol (TCP/IP data-link layer services)
IEC	International Electro-technical Committee (standards organization)
IEEE	Institution of Electrical & Electronics Engineers (standards organization)
IETF	Internet Engineering Task Force
IGMP	Internet Group Management Protocol (TCP/IP network layer services)
IP	Internet Protocol (TCP/IP network layer protocol)
IPCP	Internet Protocol Control Protocol (TCP/IP network layer services)
ISaGRAF	IEC61131-3 Sequencing & control used on E Series RTUs
ITU-T	International Telecommunications standards organization, formerly CCITT
LAN	Link Control Protocol (PPP component)
LLC	Link Layer Control (Ethernet MAC layer component)
MAC	Media Access Control (Ethernet communication layer)
MODBUS	PLC communications protocol (de-facto standard)
MRU	Maximum Receive Unit (PPP negotiated packet length option)
NTP	Network Time Protocol (time synchronization)
NV	Non Volatile (memory that retains its data when powered off)
PAD	Packet Assembler / Disassembler
PAP	Password Authentication Protocol (PPP security component)
PC	Personal Computer
PCB	Printed Circuit Board
PDS	CMI telemetry device

PFC	Protocol Field Compression (PPP negotiated option)
PING	ICMP echo utility for determining TCP/IP device functioning
PLC	Programmable Logic Controller
POP3	Post Office Protocol (TCP/IP application layer E-mail receiver client)
PPP	Point-to-Point Protocol (TCP/IP serial data-link layer protocol)
PSTN	Public Switched Telephone Network
PTT	Press To Talk (Radio)
RAM	Random Access Memory
RARP	Reverse Address Resolution Protocol (IP - Ethernet address resolution)
RFC	Request For Comments (TCP/IP standards documents)
RoC	**Rate of Change (signal processing)**
RoF	**Rate of Fall (signal processing)**
ROM	Read Only Memory
RoR	**Rate of Rise (signal processing)**
RTS	Ready To Send (RS232 signal)
RTU	Remote Terminal Unit (telemetry device)
RXD	Received Data
SCADA	Supervisory Control And Data Acquisition
SLA	Sealed Lead Acid (Gel Cell) Battery
SLIP	Serial Line Internet Protocol (TCP/IP serial data-link layer)
SMTP	Simple Mail Transfer Protocol (TCP/IP application layer E-mail sender client)
SNAP	Sub-Network-Access-Protocol (Ethernet MAC layer LLC fields)
SNMP	Simple Network Management Protocol (TCP/IP application layer protocol)
SPDT	Single Pole Double Throw (change-over relay contact)
TC	Telemetry Computer (DNP3 protocol Master station host)
TCP	Transmission Control Protocol (TCP/IP transport layer protocol)
TCP/IP	Acronym typically referring to the entire Internet Protocol suite
TFTP	Trivial File Transfer Protocol (TCP/IP appl. layer file transfer for BOOTP)
Telnet	Virtual terminal protocol (TCP/IP application layer virtual terminal)
TTL	Time To Live (IP packet life-time)
TXD	Transmit Data

UDP	User Data-gram Protocol (TCP/IP transport layer protocol)
UTC	Universal Coordinated Time (international time standard)
UTP	Unshielded Twisted Pair (10Base-T Physical layer Ethernet cabling)
V.23	**ITU-T standard (FSK modulated transmission)**
WAN	**Wide Area Network**
X.25	**ITU-T standard (packet switched network)**
X.29	ITU-T standard (serial communications to PAD for X.25 network)

2 References

The following references form the Technical Documentation set for the E Series RTU.

- SCADAPack ES Hardware Manual
- E Series Configurator User Manual
- E Series ISaGRAF User and Reference Manual
- E Series Modbus PLC Interface Manual
- E Series DF/1 PLC Driver Manual
- E Series Boot Monitor User Manual
- E Series Remote I/O Technical Reference
- DNP3 Distributed Network Protocol Basic 4 Document Set
- DNP3 Distributed Network Protocol Technical Bulletins
- DNP3 Distributed Network Protocol Subset Definitions
- Transporting DNP3 over Local and Wide Area Networks
- E Series DNP3 Technical Reference
- E Series DNP3 Device Profile
- E Series Data Concentrator Technical Reference
- E Series Configurator Technical Reference
- E Series Configuration File Format
- E Series RTU Communication Interfaces Technical Reference
- E Series Data Processing Technical Reference
- E Series Profiler Technical Reference
- E Series Trend Sampler Technical Reference
- E Series Operation Reference
- E Series TCP/IP Technical Reference
- IETF TCP/IP RFC documents

3 E Series RTU Architecture

3.1 RTU Hardware

The Control Microsystems E Series RTU hardware is based on state-of-the-art embedded microprocessor technology.

3.1.1 RTU Features

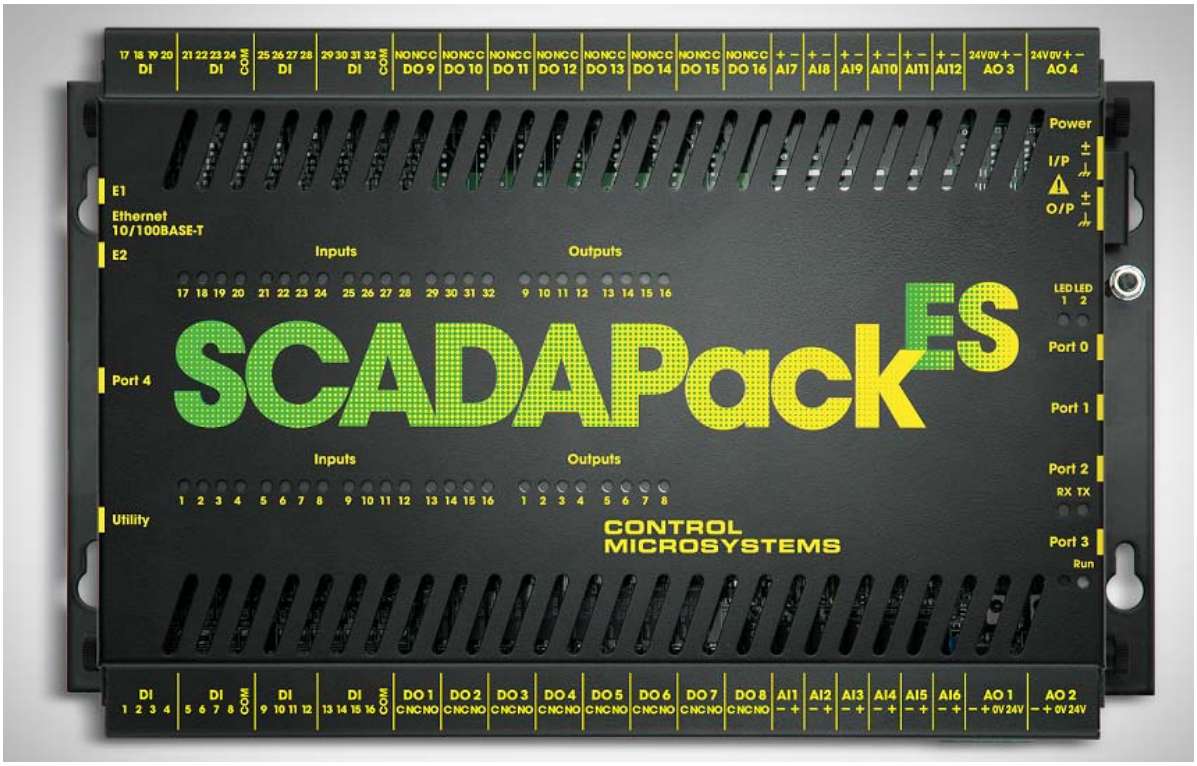


Figure 3-1: SCADAPack ES RTU

The E Series RTU hardware provides a wide range of facilities.

- Separate Processor and I/O Boards
- Isolated input power supply (various voltage ranges available)
- Input power supply voltage monitoring
- Boot Monitor for local / remote re-programming of Operating System Firmware
- Hardware Watchdog
- Serial Communication Ports
- Flash ROM and NV RAM
- Replaceable Lithium Battery
- Ethernet support : UTP
- Dual Ethernet interfaces

- Isolated secondary output power supply

The E Series RTU I/O Interface features:

- Optically isolated Digital Input channels
- Pulse inputs on each Digital Input channel
- De-bounce on each Digital Input channel
- High speed counter inputs on some Digital Input channels
- Relay Isolated Digital Output channels
- Digital Output channel Relay feedback
- Current / Voltage Analog Inputs selectable per channel
- Channel-to-Channel and Channel-to-Logic isolated Analog Input channels
- Channel-to-Channel and Channel-to-Logic isolated Analog Output channels
- A/D converter reference check

LED's on both the Processor Board and I/O Board provide visual indication of RTU operation. These indicate:

- Energized Digital Input channels
- Activated Digital Output relays
- E Series running
- E Series DNP3 Network communications activity
- Remote I/O communication activity
- PLC device communication activity
- TCP/IP LAN (Ethernet) and WAN (serial) communication activity
- UTP Ethernet connection active

For more information see the hardware manual

3.1.2 I/O Models

The SCADAPack E Series RTUs are available in a variety of models and options including:

- 9-30VDC input power
- 32DI, 16DO, 12AI, 4AO I/O model
- 16DI, 8DO, 4AI, 2AO I/O model
- 8DI, 2DO, 4AI I/O model
- Processor model with Ethernet + 5 serial ports (no I/O)
- ISaGRAF IEC61131-3 support
- TCP/IP communications support
- Ethernet support or Dual-Ethernet support

The SCADAPack ER RTU is a rack-based RTU which is available with a variety of options detailed as follows

- 24V DC power supply card (full-featured, isolated, and non-isolated versions available)
- 48V DC power supply card (full-featured and isolated versions available)
- 110V DC power supply card (full-featured and isolated versions available)
- Expandable I/O card rack-based system
- new 32 DI card available (**ER32DI)**
- new 16 RO card available (**ER16RO)**
- new 16 AI card available **(ER16AI)**
- support for existing SCADAPack ER I/O cards
- Expansion rack support
- Dual Ethernet + 5 serial ports
- Full hardware flow controlled RS232 port on Port 0 (DB9 connector)
- ISaGRAF IEC61131-3 support
- TCP/IP communications support.

3.1.3 Hardware Accessories

Available accessories for E Series RTUs include:

- External isolated power supply
- Battery backup power supply with charging / discharge / test capability
- Solar power supply
- PSTN dial-up modem
- Leased-line modem
- Audio radio
- Data radio
- GSM modem
- Satellite communications
- TCP/IP Internet / Intranet communications equipment
- GPS Receivers

3.1.4 Hardware User Servicing

The E Series hardware includes user serviceable parts on many of its external interfaces. These include:

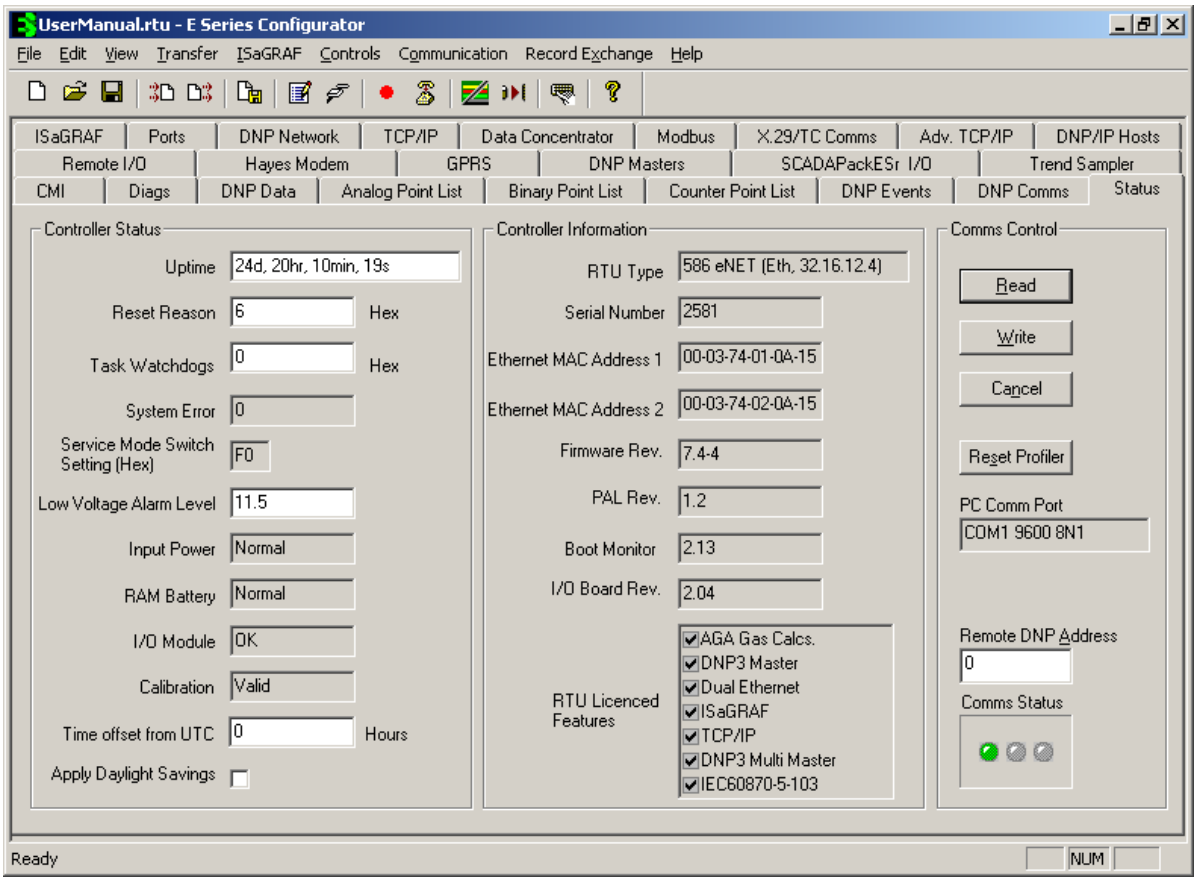
- Fuses on input power supply and secondary output power supply
- Fuses on Analog Input channels
- Field replaceable Lithium battery

Typical I/O schematics and Interface schematics are available through Control Microsystems upon request.

More information on hardware aspects of the RTU is available in the relevant E Series Hardware User Manuals.

3.2 E Series Configurator

The E Series RTU is maintained and diagnosed using the E Series Configurator software package. This package can also be used to build and load RTU configurations. The E Series Configurator executes on PC hardware using Windows ® 9 NT / 2000 / XP & 2003 and provides graphical user interfaces for configuring and diagnosing E Series operations. It also integrates with the ISaGRAF® Workbench for building and diagnosing IEC61131-3 sequences.



Three levels of user authorization are provided with E Series Configurator:

- User Mode
- Technician Mode
- Supervisor Mode

A systems administrator determines the authorization mode and license validity period for E Series Configurator.

The E Series Configurator can create and modify configurations on-line with an E Series RTU or off-line, saving configurations for loading into the RTUs at a later time. The E Series Configurator

supports a wide variety of communication media access for remote communication with RTUs. Supported communication links include:

- RS232
- PSTN dial-up
- X.29
- UDP/IP (across LAN/WAN networks)

Graphical forms are presented for all aspects of the RTU configuration. Ad-hoc user point enquiries may also be entered, and saved. Saved user data is associated with the RTU configuration file, so user data can be individually tailored for each RTU.

For more information on E Series Configurator refer to the *E Series Configurator User Manual*.

ISaGRAF Workbench CASE tools manage the configuration and debugging of E Series sequence and control applications.

Through on-line interaction with the ISaGRAF Workbench Debugger, the E Series Configurator provides the ability for user applications to be debugged, remotely across a SCADA communications network including DNP3 communications links. For more information see section 5.2 in this Technical Overview.

For more information on E Series ISaGRAF application programming interfaces see *E Series ISaGRAF User and Reference Manual*.

3.3 Boot Monitor

The Boot Monitor firmware on an E Series RTU resides in a separate Flash ROM on the processor Board. Its purpose is to start the E Series RTU, enable hardware peripherals, and to verify and start the main RTU Operating System Firmware.

It also provides facilities for re-programming the E Series Operating System Firmware and re-programming the Boot Monitor Flash ROM.

The E Series Configurator provides update Wizards permitting local firmware updates for operating system firmware, or boot monitor firmware.

The E Series Configurator can be used to load a ".BIN" binary image file, ".BIZ" compressed binary image file, or a ".BIP" compressed binary patch file into an RTU. These files are provided by Control Microsystems as firmware upgrades for the E Series RTU. The Boot Monitor re-programs the E Series RTU's operating system firmware Flash ROM's from these files. A Windows® utility is available on request from Control Microsystems to allow generation of BIZ compressed firmware files and BIP firmware patch files. Using these file formats permits remote upgrading of RTU firmware. Due to the nature of the BIP files being "difference patch" files of a relatively small size, RTU firmware can be upgraded across remote links, including DNP3 communications links.

The Boot Monitor can be forced to re-program the Flash ROM's at start-up rather than to start the RTU operating system firmware. This is achieved by starting the RTU with HEX Switches set to special mode "FF".

Upon verification of the RTU operating system firmware after re-programming the Flash ROM, the Boot Monitor starts the operating system firmware.

Whilst operating, the RTU Operating System firmware supports loading of ".BIZ" and ".BIP" compressed files across DNP3 communication links. Once remotely loaded, the Boot Monitor can also re-program the RTU Operating System Firmware Flash ROM from this file.

Note:	If the E Series Operating System Firmware is remotely modified, the RTU preserves configurations for ISaGRAF application(s), ISaGRAF retained variables, RTU point configurations, etc.

The Boot Monitor may itself re-program the Boot Monitor Flash ROM. To do this, the RTU HEX Switches must be set in special mode "F9" and E Series Configurator can be used.

Whilst operating, the RTU Operating System firmware supports loading of Boot Monitor firmware ".BIN" binary image files across DNP3 communication links. Once remotely loaded, the RTU Operating System firmware can re-program the Boot Monitor Firmware Flash ROM from this file. **Note that the E Series RTU is automatically restarted at the completion of the Boot Monitor update.**

For more information on the Boot Monitor see *E Series Boot Monitor User Manual*.

3.4 RTU Operating System Components

The major components of the E Series Operating System Firmware are as follows:

Real Time Executive - responsible for scheduling internal RTU task operations and providing interfaces between other RTU system facilities. Most real time executive operations are transparent to the user, but some diagnostics are provided through the RTU's command line interface

Point Database - contains configurations and current values for RTU points

- contains Trend records for trend sampling

I/O Sub-system - receives data from physical input channels and controls data to physical output channels on the local RTU I/O

- performs low level I/O processing such as digital input de-bounce, digital input state inversion, pulse input counting, analog channel calibration

Remote I/O - expands the I/O capacity of an RTU by interconnecting multiple RTU devices

- utilizes Serial or Ethernet communication links between remote I/O units

- Remote I/O units are identified by E Series HEX Switch settings

ISaGRAF - provides user sequencing and control support using IEC61131-3 international standard programming languages

- interfaces with Point Database for access to I/O, derived data and configuration information

- interfaces with DNP3 for peer communication, manipulation of DNP3 communication parameters

- up to two (2) user applications may execute simultaneously on the

	same RTU
DNP3	- provides DNP3 Slave capability for RTU to SCADA Master Communication
	- up to three (3) DNP3 Master Stations may connect simultaneously to the same E Series RTU. This can be via individual serial links, a common serial link, PSTN, TCP/IP, etc.
	- provides DNP3 Master and Slave capability for RTU to RTU peer-to-peer communication
	- provides DNP3 Master capability for Data Concentrator facilities
	- manages historical record of point events for transmission to SCADA Master(s)
	- carries Master Station requests for controls, configuration
	- carries configuration and diagnostic data including E Series Configurator and remote ISaGRAF Workbench Debug communication
Comm Interfaces	- provides a number of communication interfaces for DNP3
	- includes PSTN dial-up, keyed RS-232, FSK modem, X.29
	- provides serial TCP/IP communications including PPP
Peripheral Interface	- provides external communication services with peripheral equipment such as PLC's (typically, RTU is Master, PLC is Slave), I/O bricks
	- interfaces with ISaGRAF for configuration and exchange of data
	- includes protocol drivers for Rockwell DF/1 Master, MODBUS RTU Master, MODBUS RTU Slave, MODBUS/TCP Client and MODBUS/TCP Server communications
I/O Processor	- provides integrated data processing and manipulation
	- uses Point attributes to drive the data processing and sets Point properties with the results of the processed data
	- interfaces with DNP3 for event generation, storage and transmission
Profiler	- manipulates point attributes or point values based on loaded time schedule configurations
Trend Sampler	- summarizes and stores historical records of point data for Transmission to a SCADA Master
File System	- stores RTU data such as configuration files, profiles, sample files, ISaGRAF applications, and logged data files.

Command Interface	- provides user access to RTU commands and diagnostic information
TCP/IP	- provides communication facilities and applications on the RTU for Internet or Intranet networks through Ethernet (LAN) or serial (WAN) RTU interfaces.
	integrates RTU facilities with standard TCP/IP applications for
	remote management of the E Series RTU.
	provides advanced facilities such as NTP time synchronization.
	GPRS (always on IP over GSM) is supported natively

Figure 3-2summarizes the relationship between these major E Series RTU Operating System components, with Figure 3-3 showing the relationship between RTU system components and TCP/IP services. (The system component relationships shown in Figure 3-2 are implied for Figure 3-3, but these are not shown for clarity).

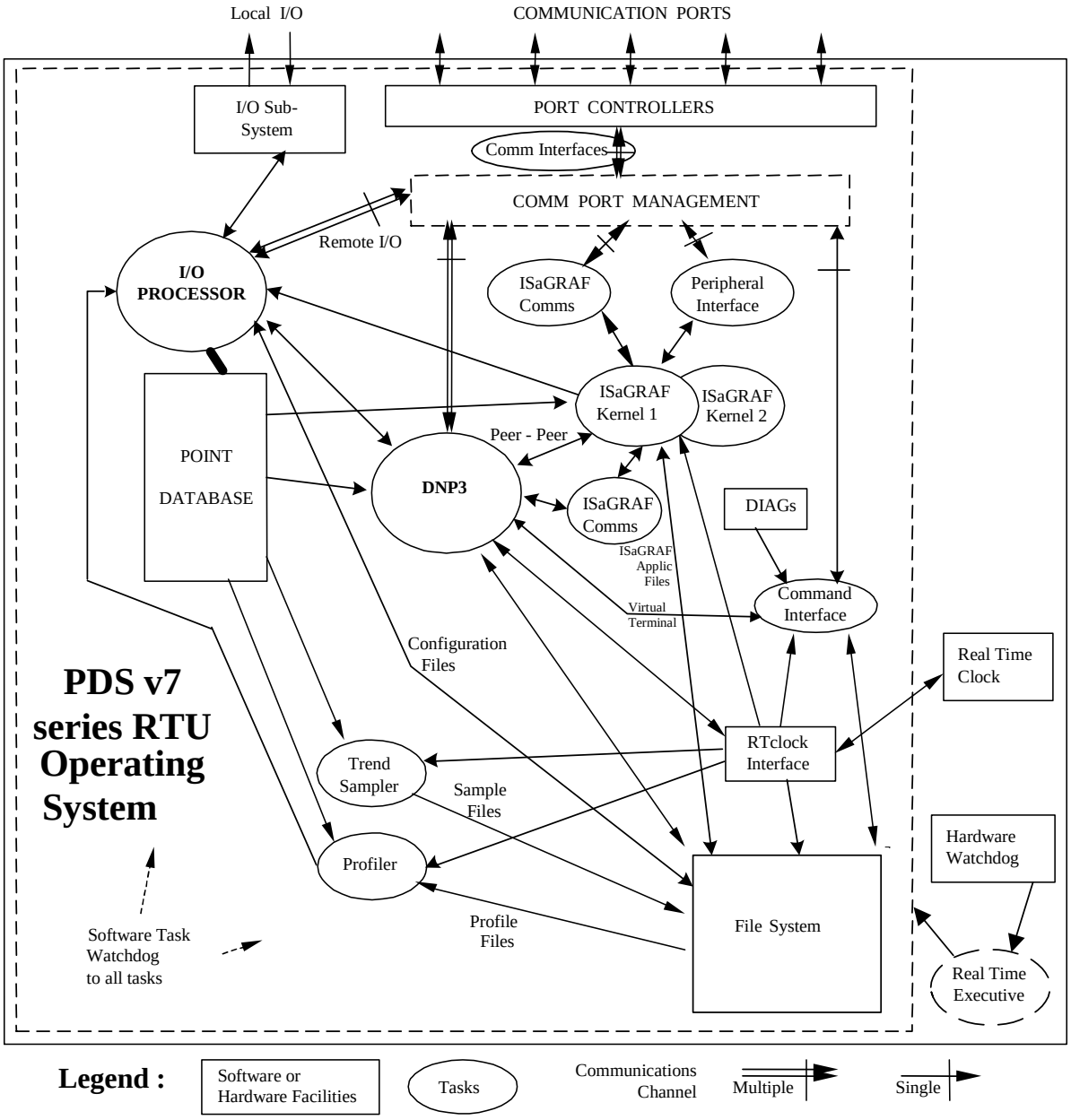


Figure 3-2: RTU Operating System Architecture

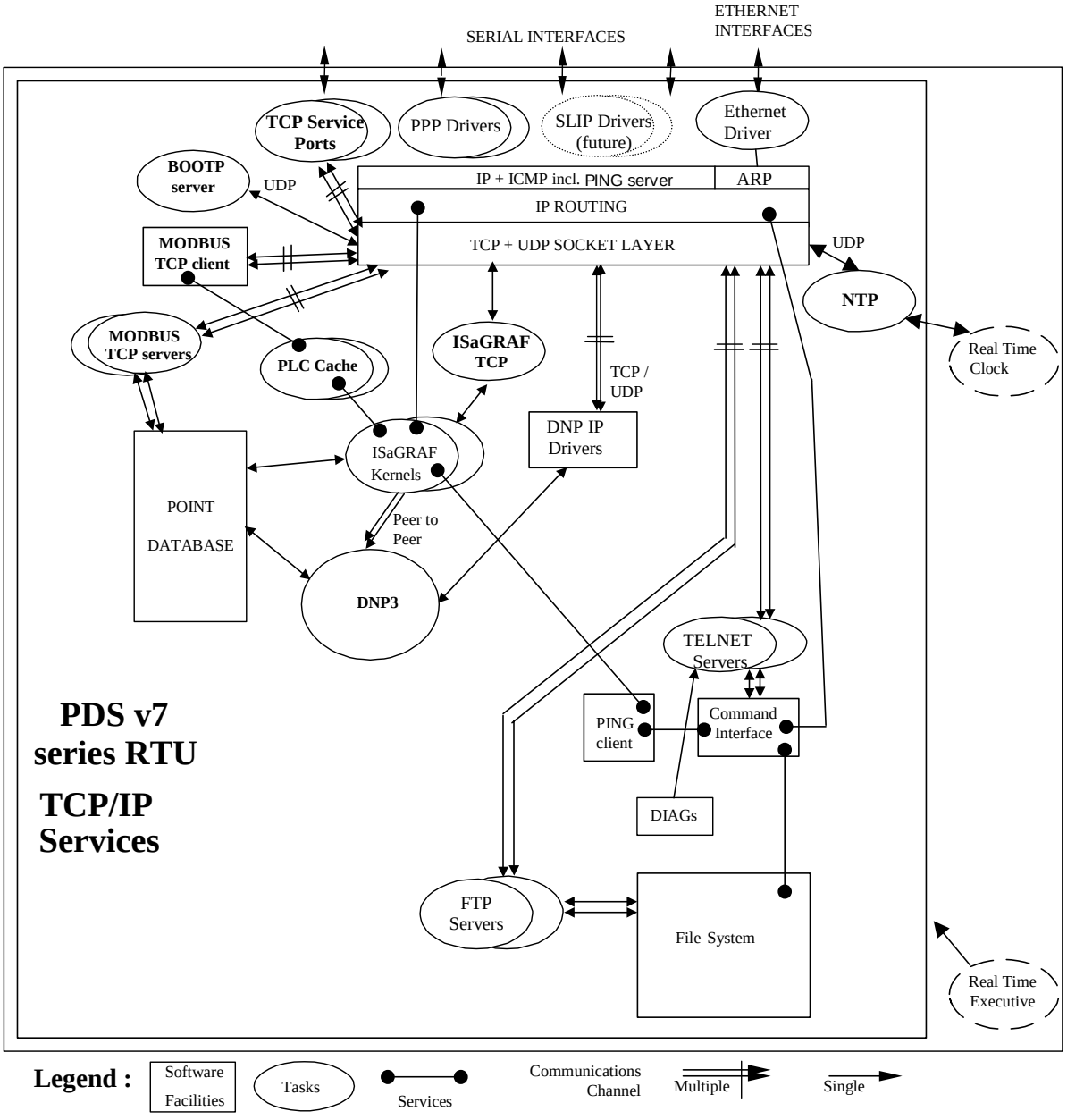


Figure 3-3: E Seriesv7 series RTU TCP/IP Services Architecture

3.5 Types of RTU Input

"Points" are used in the RTU to access data and most RTU system configurations. Each RTU point is accessible through DNP3 protocol, but points are not necessarily presented to the SCADA Master. All points fall into one of two categories:

Physical Points: - RTU internal representation of electrical terminations on a Main RTU Unit or Expansion I/O Unit. These may be either **Input Points** or **Output Points**.

Derived Points: - RTU internal data. These may be either **User Points** (created by a user defined configuration) or **System Points** (managed by the E Series operating system)

Various point types are supported by the E Series RTU. "Point Type" and "Point Number" uniquely identify each point in the E Series RTU. See the *E Series Configuration Technical Reference Manual* for information on Point Numbering methodologies.

"Point Type" may be one of the following:

- Digital Point (also referred to as "Binary Point" throughout the DNP3 protocol documentation and E Seriesv7 series RTU documentation). These may be Input, Output, User or System points.
- Analog Point. These may be Input, Output, User or System points.
- Counter Point. These are Input points on the RTU.
- String Point. These are System points on the RTU.

4 Remote I/O

Remote I/O is the mechanism provided by the E Series RTU that expands the I/O capacity of a Main RTU unit. Note that the SCADAPack ER RTU is not currently supported as a Remote I/O RTU.

In a Remote I/O system, an E Series RTU may be a “Main” RTU unit or an “Expansion or Remote I/O” unit. Each Remote I/O system “group” must have only one “Main” RTU unit, and up to 15 “Expansion or Remote I/O” units. RTU HEX Switches select between “Main” and “Remote” unit numbers.

A Main RTU unit is a normal RTU, providing the full range of RTU services. Expansion I/O units provide facilities for monitoring and controlling I/O on behalf of the Main RTU. The Expansion I/O units do NOT provide normal RTU facilities, such as ISaGRAF user applications, data manipulation, Profiling, Trend Sampling, etc.

I/O on Expansion I/O unit(s) is accessed through additional I/O points in the Main RTU point database. All facilities provided by the local RTU (Main unit) on its I/O are also provided by Expansion I/O units. This includes de-bounce, invert, and pulse counter functions. Note that calibrations must be performed on each RTU unit individually prior to connection in a Remote I/O system.

Communication links are established between a Main RTU unit and its Expansion I/O unit(s). Remote I/O communications is supported on Serial links RS-232 or ETHERNET between E Series RTUs.

A “Main” RTU unit may be configured with multiple Remote I/O ports if necessary.

“Expansion I/O” units require no configuration other than the HEX switch settings. As previously detailed, they do require individual RTU hardware calibration.

Remote I/O using Ethernet links on the RTU uses IEEE 802.3 framing and may be connected to a standard Ethernet LAN using 10/100-BaseT (UTP) for the SCADAPack E Series RTUs.

Multiple Remote I/O system “groups” are supported by the E Series RTU on the same communication link. RTU HEX Switches select the “Group” number as well as the “Unit” number. This is particularly useful for ETHERNET communications where up to 15 Groups may be present on the same ETHERNET LAN, with each group having 1 main RTU unit and up to 15 Expansion I/O units.

Figure 4-1 shows an example Remote I/O configuration using ETHERNET.

For more information on Remote I/O see *E Series Remote I/O Technical Reference Manual*.

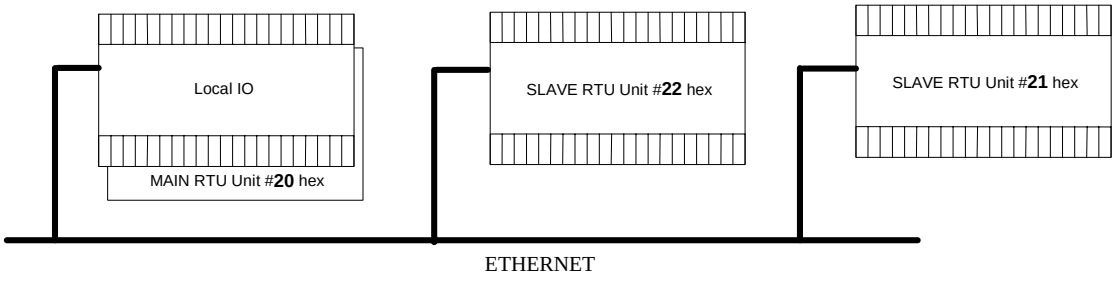
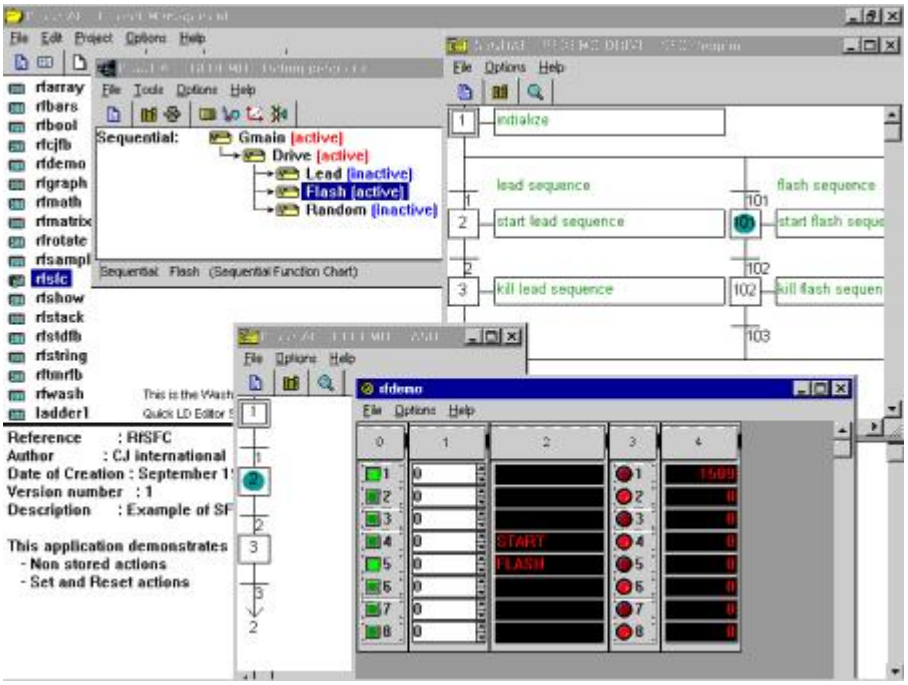


Figure 4-1: Typical E Series System using Remote

5 IEC61131-3 ISaGRAF

5.1 ISaGRAF Workbench Software

ISaGRAF Workbench software is used to create, manage and simulate sequencing and control applications using all five (5) IEC61131-3 international standard programming languages. ISaGRAF Workbench CASE Tools provides an environment for complete off-line application development. ISaGRAF Workbench is compatible with Windows NT / 2000 / XP.



The ISaGRAF Workbench debugger transfers ISaGRAF application programs to the target (E Series RTU in this case) and also provides on-line target application debugging facilities.

For more information see *E Series ISaGRAF User and Reference Manual.*

5.2 ISaGRAF Workbench Communication

The ISaGRAF Workbench debugger operates with E Series RTUs directly on an RTU serial port configured as “ISaGRAF” and via TCP/IP LAN/WAN in the RTU processor board. In addition, E Series RTUs provide the ability for the ISaGRAF workbench debugger to be operated remotely via the RTU’s DNP3 data communication channels. The remote debugging facility uses DNP3 protocol ‘Virtual Terminal’ objects. The E Series Configurator software (as well as providing a configuration interface for setting parameters such as RTU port functions & data rates, SCADA data configuration, DNP3 configurations, etc) provides a software connection to the ISaGRAF Workbench debugger running on the same PC. The E Series Configurator transports ISaGRAF Workbench debugger communications via DNP3 protocol to the ISaGRAF target in the remote RTU. Similarly, the DNP3 driver in the remote RTU sends ISaGRAF target data via DNP3 protocol to the E Series Configurator, which returns the data to the ISaGRAF Workbench debugger. For more information see the *E Series ISaGRAF Technical Reference Manual* and the *E Series Configurator* user manuals.

5.3 The ISaGRAF Pre-Processor

Control Microsystems provides an ISaGRAF pre-processor for the ISaGRAF Workbench to assist in defining constants for use with the E Series Telemetry system.

The ISaGRAF Pre-Processor allows the use of a string “define” in place of a DNP Point Number as an input parameter to some CMI ISaGRAF function blocks. It is most useful for the following function blocks: “SETATR_I”, “SETATR_R”, “RDFLD_I”, and “RDFLD_R”

When installed, the ISaGRAF pre-processor is transparent to the user and automatically generates application definitions for the DNP3 point index of ISaGRAF variables connected to DNP3 I/O boards. If an ISaGRAF I/O variable is moved on an I/O board, the pre-processor re-generates the definition string automating the link between an I/O variable and its DNP3 point index.

For more information see the *E Series ISaGRAF User and Reference* guide.

5.4 ISaGRAF LIBRARY

CMI provides a set of ISaGRAF Library modules for use with the ISaGRAF Workbench. These provide the interfaces between the Workbench and CMI’ OEM target facilities, i.e. they provide ISaGRAF user application access to RTU software and hardware facilities through standard IEC61131 interfaces. The Library modules include:

- I/O Board definitions
- I/O Complex Equipment definitions
- Common Defines
- Function definitions
- Function Block definitions, including TCP/IP interfaces

For more information see the *E Series ISaGRAF Technical Reference manual* and the *E Series ISaGRAF Function Block Reference manual*.

5.5 ISaGRAF Target

The E Series RTU is equipped with ISaGRAF target kernel software. This allows the RTU to perform PLC control functions using the IEC61131-3 international standard. The control functions provided by the ISaGRAF targets are completely autonomous of any supervisory (SCADA Master) system or communications network (e.g. DNP3). The ISaGRAF application operates on the RTU regardless of the state of remote communications.

The ISaGRAF target version supported by the E Series processor is 3.20, which is compatible with ISaGRAF Workbench versions 3.20 and later.

E Series RTU firmware supports the simultaneous execution of up to two ISaGRAF target kernels on the same RTU. This allows up to two independent ISaGRAF applications to execute simultaneously on the same RTU. The two ISaGRAF targets within the RTU have ISaGRAF Slave addresses of 1 and 2 respectively. The Workbench "Slave Number" communications parameter must be set to match the E Series RTU’s ISaGRAF Slave address for the appropriate target kernel prior to connecting the ISaGRAF Workbench debugger to the RTU.

The ISaGRAF Workbench software running a PC connects to an RTU serial port selected for ‘ISaGRAF’ communications mode. This port can also support MODBUS RTU Slave Protocol communications.

5.5.1 ISaGRAF Status

The following RTU system points are provided to indicate the status of each of the ISaGRAF Target tasks and applications within the RTU:

- ISaGRAF Target Application Halted
- ISaGRAF Target Task Started
- ISaGRAF Target Appl. Incorrect Checksum
- ISaGRAF Target Application Version
- ISaGRAF Target Application Size
- ISaGRAF Target Application Load Time
- ISaGRAF Target Application Checksum

5.5.2 ISaGRAF Storage

The E Series RTU provides several storage mechanisms for ISaGRAF applications and application data.

ISaGRAF uses the RTU file system in Non-volatile memory and FLASH memory to store its applications. An application transferred from the Workbench Debugger will be stored in the following files when validated by the ISaGRAF Targets on the RTU:

RTU ISaGRAF Application File: **isa11** (first ISaGRAF target)

RTU ISaGRAF Application File: **isa21** (second ISaGRAF target)

The executed version of each ISaGRAF application is loaded from the RTU file system if present. The FLASH memory copy will be used to load the user application if file system application cannot be loaded. In addition, the FLASH memory copy is used to regenerate the application file if it can not be loaded.

ISaGRAF application *Retained Variables* for each ISaGRAF target are also stored in RTU non-volatile memory.

5.6 Transferring ISaGRAF Applications

ISaGRAF applications can be transferred to the E Series target in one of several ways:

- Connect Workbench Debugger to the RTU “ISaGRAF” port
- Connect Workbench Debugger to the RTU via Ethernet or TCP/IP WAN
- Use Workbench Debugger, through the E Series Configurator, via the DNP3 communication network
- Transfer the ISaGRAF application TIC code file via the DNP3 communication network (DNP3 file transfer)
- Use the E Series Configurator “Download ISaGRAF Application” tool

The first three of these methods is described in Section 4.2 of this Technical Overview.

An ISaGRAF application produced by the Workbench for an E Series RTU target is stored in the following file on the PC (for Intel targets): **ISAWIN\APL\appl-name\appli.x8m**

This file can be copied to a file called **isa11** or **isa21** and transferred across the DNP3 link using the DNP3 File Object into the RTU (e.g. using E Series Configurator, by the SCADA Master Station, etc). Once the file has been successfully transferred to the RTU, the ISaGRAF task(s) can be restarted to activate the new application. The E Series Configurator provides a toolbar facility that automatically performs all of these steps.

5.7 ISaGRAF Diagnostics

The format of the Diagnostic Display of ISaGRAF user applications errors is as follows:

```
ISaGRAF Warning: XXX:YYY
```

Where XXX is the ISaGRAF error code number, and YYY is an information number provided to the Workbench. This meaning of the information number depends on the particular error code, and indicates the ISaGRAF Target number for some error codes.

See *E Series ISaGRAF User and Reference Manual* for a complete list of ISaGRAF Application Error Codes.

6 DNP3 – Distributed Network Protocol

6.1 DNP3 SCADA Protocol Standard

DNP3 *(Distributed Network Protocol)* is an industry standard SCADA communications protocol. It originated in the Electricity Industry in the USA and was based on drafts of the IEC870-5 SCADA protocol standards (now known as IEC60870-5). DNP3 is now in widespread use in many industries across the world and is managed by the internationally represented DNP User Group.

DNP3 describes standards for SCADA protocol facilities such as polling, ad-hoc data requests, controls, report by exception (RBE) and Unsolicited communications. Master-slave and Peer-to-Peer communication architectures are supported by DNP3.

Inter-operability is one of the key aspects of DNP3. It is enforced by way of minimum implementation subsets to which vendors must adhere. Currently, the DNP3 standard is supplemented by Subset Definitions document describing 3 minimum subset levels. In addition, a vendor's DNP3 implementation must be provided with a *Device Profile* document describing information required by the DNP User Group, including details of the implementation of one of the three minimum subset levels, and other protocol information.

The DNP3 protocol also caters for expansion & evolution of the standard without detracting from the strengths of inter-operability that it promotes. This is achieved by an object-oriented approach to the data. Data objects can be added to the DNP3 Standard without affecting the way that devices inter-operate.

For further information see the DNP User Group Web Site at www.dnp.org, the *DNP3 Basic 4 Document Set*, *DNP3 Technical Bulletins* and *DNP3 Subset Definitions*.

6.2 SCADAPack E Series DNP3 Support

The E Series RTU supports as a minimum, DNP3 communication protocol facilities to DNP3 Subset Level 2 with a range of additional features being provided from the DNP3 standard.

The RTU supports DNP3 communication across TCP/IP interfaces in accordance with the DNP3 User Group *"Transporting DNP3 over Local and Wide Area Networks"* document.

In summary the E Series RTU provides the following facilities for use of DNP3:

- Polling, Report by Exception, Unsolicited Response transmission to SCADA Master
- RTU configurations for data reported to SCADA Master
- Up to three (3) SCADA Master Stations supported with points individually configured for exposure to each Master (licensing required). See section 15 for more information regarding DNP3 Multi-Master support.
- DNP3 Slave address can be individually set for each Master Station
- Simultaneous DNP3 Master, Slave and Peer operation on the same E Series communication Port, or on multiple communication Ports
- Networking (Routing) of DNP3 frames
- Peer-to-Peer interchange of data between RTU nodes, including point quality
- Control and file operations from SCADA Master or Peer nodes
- Wide range of DNP3 data objects including:
- Integrated support for DNP3 object status flags

- integer and floating point analog objects
- counter objects
- file identifier object
- virtual terminal objects

An E Series RTU, including Remote I/O architecture, is presented as a single DNP3 node to a wide area telemetry network. Each E Series RTU on a DNP3 network must have a unique DNP Node Address to identify it. This node address is set as part of the RTU configuration, through the E Series Configurator. A single RTU can have up to three DNP3 node addresses. 2 or 3 different addresses are typically used when the E Series connects to multiple DNP3 Master Stations (licensing required).

Valid DNP3 node addresses are in the range 0-65519. (DNP3 node addresses 65520-65535 are reserved for broadcasting). It is recommended that DNP3 device Address '0' not be used in E Series RTU as this is the default DNP3 address when an RTU is set to its factory default configuration.

For more information on DNP3 and operation of the RTU, see the *E Series DNP3 Technical Reference Manual* and *E Series DNP3 Device Profile*.

6.3 DNP3 Networking

Communications received by the E Series RTU may be re-directed to other E Series RTU communication ports based on routing (packet forwarding).

Each DNP3 data-link layer frame contains both a Source and Destination DNP node address. This addressing scheme, by identifying both the sender and receiver of DNP3 frames, allows peer-to-peer RTU communication, and allows DNP data-link layer frames to be routed.

The E Series RTU networking facility determines if the destination node for a received DNP3 frame appears in a network routing table. The network routing table contains user configured Static Route entries that fully qualify received DNP3 frame source information (including RTU port and DNP3 source node address) and DNP3 frame destination node address, resolving a destination E Series communication channel. If a received frame, through serial or TCP/IP interfaces, qualifies the route filtering configuration in the network routing table's static entries, the DNP3 frame is routed for transmission to the DNP3 communication link on the specified E Series physical channel.

DNP3 frames are discarded if they are not for this node & not to be routed by this RTU to another node.

Any E Series RTU is capable of routing DNP3 frames, and can be configured with network routing table entries for this purpose. The RTU continues to provide all RTU facilities and at the same time can perform routing functions. Typically, though, only a small number of nodes in a DNP network are required to route frames. These nodes usually have two or more DNP3 communication ports.

An E Series RTU can potentially route DNP3 frames to one of multiple DNP3 communication links on the RTU, including via TCP/IP interfaces. This is achieved most efficiently and with a minimum of configuration when DNP3 node addresses on each DNP3 communication link are in small fixed address range, rather than addresses being randomly scattered across multiple links.

Note that some network communications infrastructure or Master Station implementations may restrict the routing capabilities.

For more information see the E Series DNP3 Technical Reference Manual

Figure 6-1 shows a typical E Series RTU network using E Series RTU routing of DNP3 frames. Where network communications infrastructure will support it, the E Series RTUs may send Peer messages to any other E Series RTU in the network. For example, DNP #200 can communicate with Peer DNP #301. In this case, E Series RTUs DNP #101 and DNP #103 route the DNP3 frames between the various communication sub-networks. The Master station may also communicate transparently with all nodes in the communication network, with DNP nodes #101 and #103 routing DNP3 frames to RTUs on different communication sub-networks, as required.

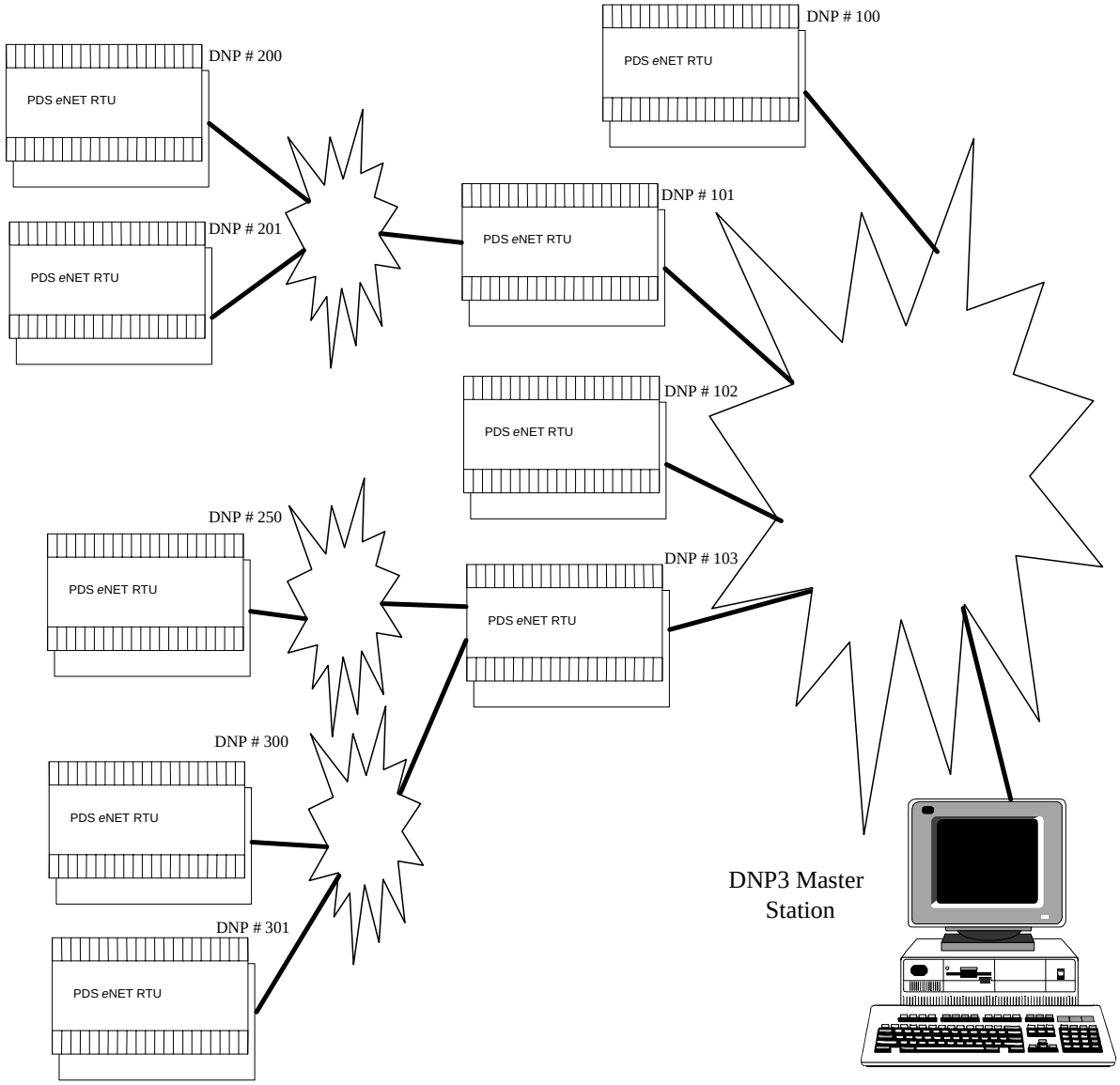


Figure 6-1: Typical E Series Network using DNP3 Routing

7 RTU Communication

7.1 DNP3 Communication Interfaces

Communication with the E Series RTUs via DNP3 protocol can be accomplished through several physical interfaces: Direct physical interfaces, Multi-drop physical interfaces, Hayes Modem interfaces and ETHERNET interface.

Each RTU physical port has a *Port Interface Type* parameter to select the appropriate interface. E Series RTUs support direct physical communication using RS232 and RS422 interface standards.

Note that RS485 operation is only supported on Ports 2 and 3 on the E Series RTUs. Detailed information on RTU communication interfaces are provided in the *E Series Communication Interfaces Technical Reference*.

7.1.1 Direct Communication Interfaces

Port Interface types using direct communication interfaces are:

- RS232
- RS485 4-wire Master (Same as RS422)

7.1.2 Multi-drop Communication Interfaces

Port Interface types using multi-drop communication drivers are:

- Keyed RS232
- FSK modem (option)
- RS485 4-wire Slave
- RS485 2-wire

7.1.3 Hayes Modem Communications

The E Series RTU can provide DNP3 network communications using Hayes Modem communications. This type of RTU communication is often called “PSTN” (Public Switched Telephone Network) or dial-up communication, and requires the use of commercial modem equipment. Hayes modem devices on wireless networks are supported including GSM and CDMA. GPRS and 1X wireless networks are also supported. Also see section 7.1.5 and 11.

The E Series RTU supports DNP3 network operations using Hayes compatible modems. Both dial-in and dial-out operation is supported, both on the same communication channel. Similarly, the same modem can be used for dial-out and dial-in DNP3 Peer-to-Peer communication between RTUs, or for dial-in for configuration or diagnosis using E Series Configurator. A DNP3 Route Table ‘static entry’ can be associated with a Modem Dial number. This allows an RTU to contact an individual DNP3 such as a Peer RTU, Master station, etc. Where groups of nodes are contacted through the same modem phone number, route entries with DNP address ranges can have a single phone number. Multiple route entries for DNP nodes can have the same phone number, or any combination can be used.

The RTU firmware include specific support for low power modems.

7.1.4 X.29 Communications

RTU communications on X.25 packet switched networks is supported. DNP3 communication protocol is transported using X.29 protocol to X.25 PAD equipment. Special provision is made in the RTU for use of X.29 protocol in conjunction with leased-line modems between the RTU and X.25 PAD.

RTU to Master Station DNP3 communications is supported via X.29 including X.25 address handling where multiple backup Telemetry Computer systems use different X.25 addresses. RTU to RTU communications is also supported via X.29 using DNP3 protocol for Peer-to-Peer calls.

The E Series Configurator supports X.29 communications through direct serial connection to an X.29 port on an X.25 PAD, or PSTN dial-up into a X.29 port on an X.25 PAD.

For more information on E Series interfaces to X.29 see *E Series X.29 Interface Technical Reference*.

7.1.5 TCP/IP Communications

The E Series RTU supports communications on Internet or Intranet TCP/IP networks. DNP3 communication protocol is transported using TCP and/or UDP transport in accordance with the DNP User Group LAN/WAN specifications. TCP/IP communications is supported via Ethernet, PPP (including GPRS), and/or SLIP interfaces on the RTU.

RTU to Master Station DNP3 communications is supported via TCP/IP, including to multiple backup Telemetry Computer systems use different IP addresses. RTU to RTU communications is also supported via TCP/IP using DNP3 protocol for Peer-to-Peer calls.

The E Series Configurator supports TCP/IP communication to remote RTUs using DNP3 over UDP via Windows® TCP/IP communication stack. For more information on the RTU interfaces to TCP/IP see *E Series TCP/IP Technical Reference Manual*.

7.2 Peripheral Device Communication Interface

The E Series RTU can communicate with Peripheral devices, such as PLC's, in various ways. In-built drivers for MODBUS protocol, for example, provide both serial and TCP/IP communications for Master, Slave, Client & Server protocols. The user can also implement their own communications with ASCII devices

7.2.1 MODBUS/TCP Client Operation

MODBUS/TCP Client operation allows an E Series RTU to utilize ISaGRAF PLC I/O boards to generate requests to MODBUS/TCP server devices such as PLCs, block I/O devices, etc. This is similar to serial MODBUS Master operation described in Section 7.2.4.

For example, the RTU can read data from, or write data to Conformance Class 0 or Class 1 Open Modbus/TCP Ethernet PLCs. Many data formats are supported including 984 discrete, IEC discrete, IEC UINT, INT, DINT, REAL & swapped Real formats.

In addition, BOOTP server facilities are supported by the RTU for providing Ethernet network configuration of devices such as block I/O units.

For example, Schneider Automation TSX Momentum I/O blocks can be used as remote I/O for the E Series RTUs. Up to 20 TSX Momentum I/O blocks can be connected to the same E Series RTU.

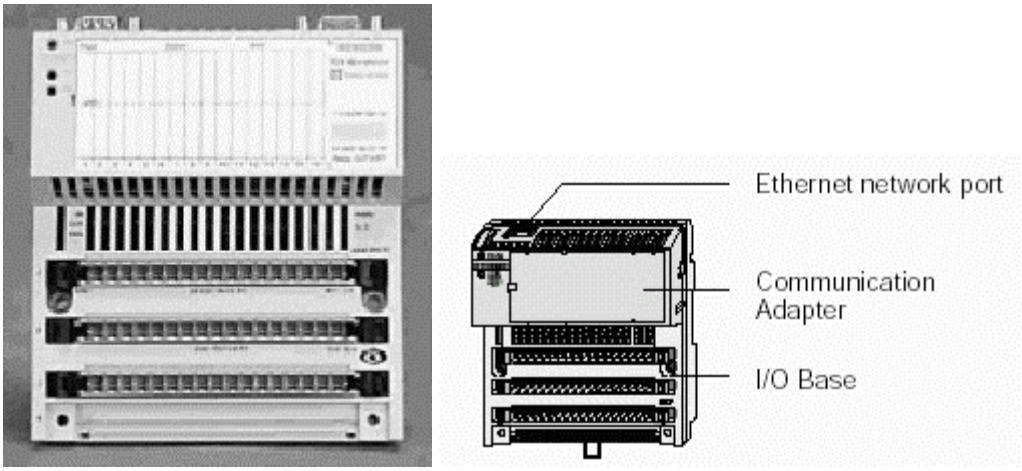


Figure 7-1: Schneider Automation TSX Momentum

7.2.2 MODBUS/TCP Server Operation

MODBUS/TCP Server operation allows E Series RTU data (I/O and/or derived data) to be made available to MODBUS/TCP client devices such as a local SCADA master station, or Ethernet PLCs. Using this facility, the RTU can be used like a full-featured Ethernet PLC, or like an I/O module. Other than enabling the MODBUS/TCP Server, no additional configuration is required to access RTU point data. RTU physical, derived and system points can be accessed and controlled via the MODBUS/TCP server.

The RTU MODBUS/TCP server supports simultaneous access to multiple clients, utilizing any TCP/IP link (e.g. Ethernet, PPP, etc.). It supports Open MODBUS/TCP Conformance Class 0 & Class 1 device function codes: 1, 2, 3, 4, 5, 6, 7, 15 and 16. Modbus/TCP data requests are served directly from the RTU point database, supporting IEC discrete, UINT, INT, DINT, UDINT & REAL formats.

7.2.3 Serial MODBUS Slave Operation

The E Series RTU supports a driver for native MODBUS RTU Slave protocol. The RTU can be configured to have multiple Modbus Slave ports functioning simultaneously. This MODBUS Slave implementation maps directly into the RTU's point database and supports MODBUS function codes: 1, 2, 3, 4, 5, 6, 7, 15 and 16. Consult the *E Series Modbus PLC Interface* document for more information.

7.2.4 PLC Driver Master Operation

As an extension of the data interface provided by the E Series RTU, access by ISaGRAF applications to external PLC or peripheral device data is supported. Standard ISaGRAF I/O boards access RTU I/O points and RTU database points. An additional set of ISaGRAF boards is provided for the RTU that allow data to be extracted from external PLC device(s) into ISaGRAF variables.

When using ISaGRAF I/O boards for peripheral device communication, ISaGRAF is a protocol Master, communicating with Slave PLC or Slave peripheral devices on one or more RTU communication ports. Various protocols can be supported between the RTU and slave peripheral devices via the ISaGRAF Slave PLC I/O boards mechanism. Use of slave peripheral device drivers is subject to their installation in the Operating System firmware.

An LED on the E Series RTU indicates communication activity with external peripheral device(s).

7.2.5 Rockwell DF/1 PLC Driver

The E Series ISaGRAF DF/1 Slave PLC I/O Boards communicate to slave PLC's using Rockwell (Allen Bradley) DF/1 Master communications protocol. DF/1 protocol is also known as Data Highway protocol. Multi-drop PLC's are supported. The RTU DF/1 driver supports communication with a wide range of Rockwell (AB) PLCs including: PLC5, SLC/500 and Generic DF/1 devices. Communication modes supported include: Half/Full Duplex, BCC/CRC error checking. Data types supported are: SLC500 Discrete, SLC500 INT, SLC500 REAL, PLC5 Discrete, PLC5 INT, PLC5 REAL, Generic Discrete, Generic INT. For more information see *E Series DF/1 PLC Driver* manual.

7.2.6 Modbus RTU Master Driver

The E Series ISaGRAF MODBUS Slave PLC I/O Boards communicate to slave PLC's using MODBUS RTU Master communications protocol. Multi-drop MODBUS PLC's are supported provided that interface adapters, external to the RTU, permit it. The RTU *Port Function* must be set to "PLC Device" and the RTU "Port Baud" and port parity settings must match those of the PLC device for correct operation.

ISaGRAF Slave PLC I/O Boards specify MODBUS device address and MODBUS register address. ISaGRAF Slave PLC Input Boards also specify input data update rate. ISaGRAF Slave PLC Output Board data is updated upon change, and at a periodic background rate. The RTU ISaGRAF MODBUS Slave PLC I/O Boards generates communication link requests for MODBUS function codes: 1, 2, 3, 4, 5 and 6.

7.2.7 ASCII Serial Communications

The ISaGRAF user application may optionally open an RTU port, or multiple RTU ports, as ASCII communication port(s) to serial devices supporting ASCII communication protocols. The user's ISaGRAF application can send and receive ASCII message strings, and interchange information with peripheral devices. The user has complete control over the process, and can create ASCII protocol drivers within the IEC61131-3 ISaGRAF sequencing and control application.

Examples where the ASCII serial communications facility has application includes: LCD display terminals, Personal Digital Assistant (PDA) palm-top devices, instrumentation interfaces, data logger interfaces, other ASCII devices.

7.2.8 Virtual Terminal Serial Communications

Serial ports on E Series RTUs can be used as remote DNP3 Virtual Terminal service ports. This allows a DNP3 Master Station supporting Virtual Terminal functions to send and receive ad-hoc byte oriented data to RTU serial port(s) across DNP3 communication links. Upon receiving a virtual terminal Write from a DNP3 Master, the RTU will transmit this to a local serial communications port. Upon receiving data from the local serial communications port, it will generate DNP3 virtual terminal event data, which can be polled or unsolicited to the DNP3 Master station. For more information see the *E Series DNP3 Technical Reference* manual.

7.2.9 IEC 60870-5-103 Protocol

The IEC 60850-5-103 protocol is designed for data transmission between protection equipment and control systems. The E Series RTU supports communications using the 608870-5-103 protocol on all serial ports, and is supported for RS485/422* and RS232 modes whereby the RTU behaves as a 60850-5-103 Master. The configurations for the 60850-5-103 Slaves devices are defined in the v7 Data Concentrator configuration interface (see §14). These configurations define communication fundamentals such as the Slave address, RTU serial port for slave communications, poll intervals, etc.. These configurations also define how the information object identifiers (i.e. function type and

information number) are mapped to configuration points in the RTU. The support for the IEC 60850-5-103 protocol is discussed in more detail in the *E Series Data Concentrator Technical Reference.*

* Note: RS485 is supported on Ports 2 and 3 on the E Series RTUs.

7.2.10 IEC 60870-5-101 Protocol

The IEC 60850-5-101 protocol is designed for data transmission between protection equipment and control systems. The RTU supports communications using the 608870-5-101 protocol on all serial ports, and is supported for RS485/422* and RS232 modes whereby the RTU behaves as a 60850-5-101 Slave. The configurations for up to 2 60850-5-101 Master devices are supported. These configurations define communication fundamentals such as the Master address, RTU serial port for Master communications, poll intervals, etc. These configurations also define how the information object identifiers (i.e. function type and information number) are mapped to configuration points in the RTU. The support for the IEC 60850-5-101 protocol is discussed in more detail in the *E Series IEC 60870-5-101 Slave Technical Reference Manual* and the *E Series IEC 60870-5-101 Slave Interoperability* document.

* Note: RS485 is supported on Ports 2 and 3 on the E Series RTUs. .

8 RTU Configuration

8.1 RTU Configuration File Format

The E Series RTU Configuration file is a human readable ASCII text file that enables the RTU to build, modify, or restore its configuration. The configuration file is can created by the E Series Configurator or by a SCADA Master station. It can be created and edited with a standard text editor, or database application. Additionally, a configuration file can be built from the current configuration of an E Series RTU.

The configuration file can be loaded or activated in the RTU in two possible ways – full configuration or incremental configuration. The file format and content is identical for the two configuration techniques, the differences being the affect upon the RTU when the configuration is activated. A full configuration removes all current RTU configurations and re-loads the new configuration, whereas an incremental configuration modifies existing configurations in the RTU. Activation of a configuration will produce the file "config.log" in the RTU, which summarizes the activation of the configuration and any errors encountered.

For details on the configuration file format see the *E Series Configuration File Format*.

8.2 Point Configurations

Points are configured by means of *Point Attributes* that describe information used by various RTU facilities. RTU facilities take the Point Attributes, current point state or value, information from other RTU facilities, and derive the *Point Properties*.

Point Attribute and Point Property information is described in detail in the *E Series Configuration Technical Reference Manual*.

8.2.1 Point Attributes

Point Attributes are read/write fields of point configurations describing (to the RTU) and potentially controlling a characteristic of a point.

All configurable points in the RTU share a common set of point attributes. Individual point types have unique point attributes in addition to the common point attributes.

8.2.2 Point Properties

Point Properties are generally read only point database fields describing (to the SCADA Master, E Series Configurator and ISaGRAF application) a status or characteristic of a point.

9 RTU Data Processing

9.1 Integrated RTU Data Processing

Integrated RTU data processing is managed by the I/O Processor. It is directed by configurations defined for each point, mostly through point attributes. The data processing facilities provided in the E Series RTU includes:

- Physical I/O Point Processing
- Derived Point Processing
- Configurable System Point Processing
- Data Manipulation Processes

The role of the I/O Processor is central to the primary functionality of the E Series RTU. It interacts with other services to provide data processing and co-ordination of data distribution within the RTU. While, in general, all RTU services read point properties and attributes directly from the Point Database, tasks changing (writing) point attributes and properties use the I/O Processor to validate and co-ordinate the change.

For each potential change to point fields (attributes or properties), the I/O processor considers the impact of the changed value, processing interlocks and dead-bands where necessary, and initiating or stopping timers, performing floating point maths, etc.

9.2 RTU Data Processing Facilities

The following list summarizes the data processing facilities that are integrated with the E Series RTU.

- Physical Digital Input De-bounce (provided by I/O sub-system)
- Physical Digital Input Invert (provided by I/O sub-system)
- Software Counters with de-bounce & Invert (provided by I/O sub-system)
- Integer scaling range & Engineering scaling range
- Rate Of Rise, Rate Of Fall, No Change detection
- Over-range detection, Under-range detection
- Multiple Engineering Alarm Limits
- Into Alarm Time dead-band
- Out-of-Alarm Time dead-band
- Out-of-Alarm Value dead-band
- Alarm Inhibit, Trend Inhibit
- Point Quality
- Remote Control Interlock
- Output Pulse time
- Event generation on Significant Change Deviation
- Set Point properties to User binary points

Detailed information on all RTU data processing facilities is presented in the *E Series Data Processing Technical Reference Manual*.

9.3 Profiler

The Profiler allows the RTU to manipulate values and attributes of binary, analog and counter data points based on time profiles. The Profiler provides time-based control of data points on a time-of-day and day-of-week basis. The time information is stored in files in the RTU File System that schedule changes to point attributes.

Point attribute or value changes controlled by the Profiler are synchronized to occur on the one minute boundary of the RTU real time clock. Profile operations are based on Local RTU time, and ARE affected by the RTU's Time Zone Modifier system point.

The Profiler can manipulate the following point attributes:

- Analog points: Current Value (integer or floating point), Alarm Limits 4L..4H
- Counter points: Current Value (integer), High Counter Limit
- Binary points: Current State

The user configuration interface for the Profiler is as follows:

- Database "Profile ID" field for each point used by the Profiler
- Profile files
- Restart the Profile task

For more information see E Series Profiler Technical Reference Manual.

9.4 Trend Sampler

The Trend Sampler allows RTU data points to be periodically sampled, the values being recorded in files in the RTU File System. The storage of data using this mechanism provides a more sophisticated and efficient data storage mechanism than is provided by DNP3 Event storage.

The E Series RTU's *TREND SAMPLER* provides selective storage based on deviation control for each sampled point, a binary trigger point for selective control of sampling, and a file format with some data reduction facilities.

Multiple trend streams on the same RTU point are supported. Trend samples may optionally include data quality flags.

Each data sample may be stored in one of various formats including 16-bit, 32-bit, signed, unsigned, floating-point format, with or without quality flags.

The Sampler requires the following user configuration information:

- DNP point index and point type of Point to sample
- Sample Rate (Secs)
- Deviation change for recording Analog or Counter samples
- Binary trigger point for controlling sampling
- Trend Stream (Statistic) Type

For more information see the E Series Trend Sampler Technical Reference Manual.

10 Using the E Series RTU

The *E Series Operation Reference Manual* describes operational aspects of using the E Series RTU, while the *E Series TCP/IP Reference Manual* describes specific aspects of using the RTU on TCP/IP networks.

10.1 E Series Parameter Changes

Other than RTU point database attribute changes, RTU parameter changes in general do not take effect immediately. The exception to this is the E Series DNP Network Routing table. Changes to entries in this table *do* take effect immediately.

Parameter changes relating to hardware configuration require hardware reset (e.g. power on or Cold Restart) of the RTU to take effect.

DNP3 parameter changes require Warm Restart (DNP3 initialization) or hardware reset to take effect (e.g. Cold Restart, hardware reset, power-on)

10.2 Time Conversion

The E Series RTU operates using Standard Time or UTC Time in the RTU Real Time Clock. If UTC Time is used, "Local Time Offset from UTC" is an offset number of hours away from UTC time (as set in float system point **63201**). Alternatively, Standard Time may be used in the RTU real time clock by setting the "Local Time Offset from UTC" system point to "0" and setting the real time clock to local (non-summer) time. Consider the following factors when choosing which time format is appropriate for an individual system:

- is SCADA equipment for the system located in multiple time zones ?
- is time synchronization such as NTP or GPS used to align RTU real time clocks ?
- does the Master Station require data reported from RTUs in UTC time ?

If the answer to any of these questions is yes, it is highly recommended that UTC time be used in the E Series RTU.

If Summer time activities are required, it is not necessary to adjust the RTU Real Time Clock. Rather, the "Time Zone Modifier" (Daylight Savings / Summer Time) system point (binary system point **50302**) can be activated that affects Local Time by 1 hour. This is normally the responsibility of the Master Station. The following RTU facilities use Local (Summer time adjusted) or UTC / Standard (Summer time independent) times as indicated.

RTU FACILITIES USING **UTC or STANDARD TIME** (Independent of Summer Time)
RTU Real Time Clock
Trend sample time-stamps
DNP3 event time-stamps
ISaGRAF OS_TIME Function

RTU FACILITIES USING **LOCAL TIME** (Adjusted for UTC offset and Summer Time)
Profile Task
ISaGRAF TIMEDATE Function Block
ISaGRAF TIME Function Block
ISaGRAF DAY_TIME Function

Times shown in RTU diagnostics	

10.3 Engineering Mode

Whenever a privileged "E Series Configurator" user sends a control or configuration information to the RTU, the RTU's ENGINEERING TIMER is started and the RTU's "ENGINEERING MODE" system binary point is activated. If set as an alarm point, this can report RTU re-configuration to the Master Station.

The E Series Configurator restarts the Engineering Timer value at 60 secs for each configuration or control sent to the RTU. When the Engineering Timer expires after 60 secs, the Engineering Mode alarm is de-activated.

10.4 RTU Configuration Revisions

The E Series RTU provides a revision number tracking facility for RTU configurations. Re-loading an entire RTU configuration results in the "CONFIGURATION MAJOR REVISION NUMBER" system point being incremented. Small configuration changes through Record Exchange with a Master Station or E Series Configurator results in the "CONFIGURATION MINOR REVISION NUMBER" system point being incremented.

For more information see *E Series Operation Reference Manual*.

10.5 Special HEX switch settings

RTU HEX Switch settings 00-EF are used for Remote I/O unit identification.

Switch settings F0-FF are used only for special RTU operational modes.

Changing the RTU switch settings ***to*** a value in the range 00-F0 will cause a reset (equivalent to a Cold restart).

Switching the addresses F1, F9, FB, FC, FE & FF will require the RTU to be separately reset (e.g. powered off & on) in order for the special operation to take affect.

Switch Settings (Hex)	Description
F0	Override RTU ports with DNP3 communications at node address "0" This mode can be used to locally establish communications with the RTU if its node address is not known. This mode also sets the Port 4 to 'Command Line' mode at 9600bps for alternative identification of the RTU via an ASCII terminal.
F1	Initialize ISaGRAF applications. Alternatively issue a command line "CLEAR ISaGRAF" or DNP3 File Exec "CLEAR ISaGRAF" command.
F9	Boot Monitor Re-program mode. See section 3.3 in this Technical Overview.
FA	Factory Test setting. Starts RTU test and calibration data interface. Control Microsystems use only.
FB	Command Line Mode. This mode forces the command line on the Port 4 (DIAG port) at 9600 bps. Note that the standard tasks are NOT started.
FC	Initializes all E Series configurations to Factory defaults.
FE	Calibrate E Series Hardware via ASCII terminal on Port 4
FF	Force Boot Monitor to operating system download mode, for using the E Series Configurator to load new operating system firmware on the Port 4

For more information on RTUHEX Switch settings see *E Series Remote I/O Technical Reference Manual* and *E Series Operation Reference Manual*.

10.6 Local I/O Status

The following RTU system points are provided to indicate operational status of local RTU I/O.

- Local I/O Module Failure
- Local Input Power Supply Low
- Local On-Board Battery Low
- Local Calibration Parameters Invalid
- Local Input Supply Voltage
- I/O Card Status (SCADAPack ER only)

Refer to the *E Series Operation Reference Manual* for details of these status system points.

10.7 Remote /O Status

The following RTU system points are provided for operational status indication on the Main RTU Unit for each Expansion or Remote I/O Unit.

- Remote I/O Module Failure
- Remote Input Power Supply Low

- Remote On-Board Battery Low
- Remote Calibration Parameters Invalid

Refer the *E Series Operation Reference Manual* for details of these status system points.

10.8 Port Assignments

Each RTU serial port can be configured for a variety of communications protocols, functions, speeds and data formats.

The configurable port functions are:

- DNP3 (multiple ports supported)
- ISaGRAF (workbench debug software) / MODBUS Slave / Command Shell
- ISaGRAF 2 (additional ISaGRAF port as detailed above)
- Modbus Slave (multiple ports supported)
- Command Line & Diagnostics (single port supported)
- ISaGRAF User - ASCII communications (multiple ports supported)
- PLC Device via ISaGRAF Slave PLC I/O board
- (E.g. MODBUS RTU Master protocol)
- Remote I/O (multiple ports supported – 57600 bps fixed format)
- PPP – TCP/IP (multiple ports supported)
- TCP Service (multiple ports supported – client or server mode)
- DNP VT Service (multiple ports supported)
- TT INMARSATC (single port supported)
- 60870-5-103 M (multiple ports supported)
- SLIP – TCP/IP (multiple ports supported) - *Future*
- CSLIP – TCP/IP (multiple ports supported) - *Future*
- NONE (port disabled)

The default port settings for the E Series RTUs are listed in the following tables.

10.8.1 Default Port Settings for the E Series RTUs

PORT 0	PORT 1	PORT 2	PORT 3	PORT 4	Ethernet 1	Ethernet 2
ISaGRAF	DNP3	DNP3	DNP3	Cmdline	Remote I/O + TCP/IP	Remote I/O + TCP/IP
RS232 (RTS On)	RS232 (RTS On)	RS232 (RTS On)	RS232 (RTS On)	RS232 (RTS On)		
9600 bps	9600 bps	9600 bps	9600 bps	9600 bps		

The default Port Format for each serial port is:

Port Format: 8-bit, No-parity, 1-stop-bit

Serial communication ports support data rates from 300 to 57600bps. RS232 interfaces are supported on all serial ports. RS485 interfaces are only supported on serial Ports 2 and 3.

11 TCP/IP Integration

The E Series RTU supports TCP/IP networking and communications integration. The RTU conforms to the relevant IEEE and TCP/IP RFC standards, and may be used in a wide range of LAN and WAN topologies, including systems using Routers, Bridges, Terminal Servers, Hubs, Switches, etc.

The following TCP/IP networking facilities are available with the E Series RTU.

- PPP serial communications including extensive options negotiation including IP address, ACCM character map, MRU, loop-back detection (via magic number) and ACFC & PFC compression negotiation
- PPP communications integrated with Hayes Modem commands for GPRS communications (always-on IP over GSM wireless networks) and 1xRTT communications (always-on IP over CDMA wireless networks)
- LCP echo (PPP link status) via command line & ISaGRAF function block
- SLIP and CSLIP serial communications (*Future*)
- Ethernet TCP/IP communications including ARP
- ICMP support including PING server
- PING client via command line & ISaGRAF function block
- IP forwarding between TCP/IP interfaces (e.g. PPP to PPP, PPP to ETH, etc.)
- IP routing table, configurable via RTU configuration, command line and ISaGRAF
- BOOTP server capability for configuring network device addresses across an Ethernet network, configurable via RTU configuration or command line
- TCP/IP diagnostics on the RTU diagnostic stream, including selectable filtering
- UDP and TCP transport over IP
- DNP3 integration with TCP/IP
    - UDP and TCP support as per DNP User Group requirements for DNP3 over LAN/WAN TCP/IP networks
    - Routing DNP3 frames between DNP3 serial and/or TCP/IP interfaces
- ISaGRAF Workbench debugger using TCP (e.g. via PPP links, Ethernet, etc)
- MODBUS/TCP client providing connectivity for E Series RTUs with Ethernet PLC systems and I/O brick units. The E Series RTU conforms with the Open Modbus/TCP specification for Class 0 and Class 1 devices.
- MODBUS/TCP server providing multiple simultaneous communication services to the Open MODBUS/TCP specification requirements for Class 0 and Class 1 devices.
- Telnet server accesses the RTU command-line and diagnostic stream (multiple users supported simultaneously)
- FTP server accesses the RTU file system (multiple users supported simultaneously)
- TCP service ports permitting remote connection to RTU serial ports for terminal-server style multi-protocol applications. Both Client & Server TCP service ports are supported in various configurations including Host client to E Series TCP service port server, RTU TCP service port

client to RTU TCP service port server & TCP service port client to remote TCP service port server.

- Security for denying and permitting RTU TCP/IP services
- NTP Network Time Protocol for synchronization of the RTU real time clock from time sources across a TCP/IP network (typically Ethernet). Includes correction for clock drift.
- Additional IP Security for denying and permitting RTU TCP/IP access (*Future*)

12 Diagnostics

A range of diagnostic information is provided by the E Series RTUs in order to facilitate trouble-shooting and understand RTU operation.

12.1 Diagnostic Display Information

The E Series RTU, through the Diagnostic Display session, may indicate exceptional RTU operating conditions. This is available from a "CmdLine" command line port on the RTU using "DIAG" command. Alternatively, access to the diagnostic display session is provided by a Command Line shell through an RTU "ISaGRAF" port, or via TELNET. Where a direct serial connection or TELNET is not available, diagnostics can be remotely acquired by directing the diagnostics to an RTU file. This is achieved using the FILEDIAG command described in *E Series Operation Reference Manual.* This diagnostics log file can then be retrieved using DNP3 file transfer for analysis.

RTU diagnostics are provided for all aspects of communications and exceptional RTU operating conditions. The following operational diagnostics are specifically supported:

- DNP3 diagnostics at each protocol layer including network routing
- TCP/IP diagnostics including DNP3 over IP, IP servers, TCP service ports, etc.
- PLC communication diagnostics including protocol packet displays, communication status and device errors for serial and network PLC services
- RTU system diagnostics
- NTP server/client and Receiver diagnostics
- 60870-5-103 diagnostics
- 60870-5-101 diagnostics

RTU diagnostics may indicate operational information that assists in trouble shooting. To sort these diagnostics from normal operational messages, it may be advantageous to disable DNP, TCP/IP, PLC and SYSTEM diagnostics using DNPDIAG, TCPDIAG, PLCDIAG and SYSDIAG commands from the command-line. Other RTU diagnostics use the following format to assist in identifying messages from various E Series tasks:

```
Task-name>>diagnostic text
```

12.2 Startup-Up Diagnostics

At start-up, the E Series RTU can display information about its start-up sequence and configuration. If a "CmdLine" command line port is configured on the RTU, ASCII text is displayed through this port as the RTU starts up. After completion of the RTU start-up, the E Series RTU usually terminates the diagnostic session and enters command mode. The entry to command mode after start-up can be optionally disabled, leaving the RTU in the diagnostic display session. This is achieved using the SYSDIAG "OVERRIDE" command described in *E Series Operation Reference Manual*.

12.3 Command Line Diagnostics

RTU command line operations & diagnostic display can be accessed using an ASCII terminal via an RTU port configured as "Cmd Line", or its "ISaGRAF" port. Telnet can also be used via TCP/IP links. The RTU also supports a "Remote Command Line" whereby the command line interface can be accessed for remote E Series units over DNP3 links. This uses DNP3 standard Virtual Terminal

capability. A “Remote Command Line (Virtual Terminal)” window is provided in E Series Configurator to access this functionality in the RTU.

At RTU start-up, configuration information and diagnostics are displayed on an ASCII terminal on the RTU’s “Cmd Line” port. The RTU then defaults to command line mode. *Diagnostic Display* mode can be connected by entering the *DIAG* command. To enter *Command* mode from *Diagnostic Display* press **<Escape**>. Note in SYSDIAG “OVERRIDE” mode, the RTU remains in Diagnostic Display mode after start-up rather than entering Command mode. To enter Command mode press **<Escape>**.

Command mode provides a wide range of commands for interrogating the operational status of an E Series RTU. These are detailed in the *E Series Operation Reference Manual*.

Command line operations and diagnostic display are also supported on the “ISaGRAF” workbench port. The RTU need not be configured with a “Cmd Line” port in this case. An ASCII terminal can be connected to the ISaGRAF workbench port, and after inputting **<Enter><Enter><Enter>**, the port enters Command mode. To return to ISaGRAF Workbench debugging mode, enter the command “BYE”.

Warning - The “**BYE**” command should be issued prior to disconnecting the ASCII terminal for correct ISaGRAF operation.

Note: Command line operations and diagnostic display are also supported via TCP/IP interfaces using TELNET. In addition, command line operations are also supported via DNP3 “Virtual Terminal”. The RTU need not be configured with a “Cmd Line” or “ISaGRAF” port in these cases. Multiple TELNET sessions may be established with the E Seriesv7 series RTU on the same TCP/IP interface, or multiple sessions may be established on multiple TCP/IP interfaces, simultaneously.

12.4 E Series Error Codes

Error codes are reported by the E Series RTU from various RTU facilities. RTU error codes fall into the following major categories:

- DNP3 communication errors
- PLC Device communication errors
- system errors
- ISaGRAF user application errors
- TCP/IP errors

Refer to the *E Series Operation Reference Manual* for details of these system error codes.

12.4.1 DNP3 Communication Errors

DNP3 communication errors are reported by the RTU through the Diagnostic Display session as DNP3 driver diagnostic information. These error codes are also reported through the ISaGRAF Peer Communication function blocks in the output STATUS variable.

The DNP3 communication errors are NOT reported via the RTU System Error Point.

See *E Series DNP3 Technical Reference Manual* for a complete list of DNP3 Communication Error Codes

12.4.2 PLC Device Communication Errors

Error codes reported from PLC Device drivers on the E Series RTU are through Analog System Points that represent an error code resulting from communication between an ISaGRAF Slave PLC I/O Board and a PLC Device.

The PLC Device communication errors are NOT reported via the RTU System Error Point.

These error codes are detailed in the following manuals:

- E Series ISaGRAF Technical Reference Manual
- E Series Modbus PLC Interface Manual

12.4.3 System Error Point

The E Series RTUs provide a system error code through an RTU Analog System Point.

The most recent error is retained as the value of the system error code. DNP3 event reporting may be configured for the system error code point to provide a time-stamped history of error codes.

RTU system errors are reported through the RTU System Error Point.

User defined error codes may be generated via ISaGRAF using RTUPARAM function block with the "SYS_ERR_CODE" parameter.

ISaGRAF user application errors are reported using the following RTU facilities:

- to the ISaGRAF Workbench Debugger if connected (locally or remotely)
- through the RTU System Error Point
- via the RTU Diagnostic Display session.

Error Code	Name	Description
0	No Error	No system errors on the RTU
1-100	ISaGRAF Target Errors	See the *E Series ISaGRAF Technical Reference* manual
100-999	User defined Errors	See the *E Series ISaGRAF Function Blocks Reference* manual -RTU_PARAM function block
1001-1009	ISaGRAF Application Load Errors	Error loading ISaGRAF application files or memory application for ISaGRAF Targets
1010-1019	Configuration Errors	Configuration File errors
1020-1029	Profile Errors	Profile configuration errors
1030-1039	Event & Trend Warnings & Errors	Event storage threshold warnings and errors
1040-1049	Data Processing Errors	Run time data processing error codes
1050-1059	Remote I/O Errors	Firmware mismatch error codes
1060-1099	IO Error (SCADAPack ER only)	I/O errors reported by main OS firmware
1100-1139	IO Error (SCADAPack ER only)	I/O errors reported by 386 IO Interface firmware
2000-2999	TCP/IP Errors	TCP/IP configuration & run-time errors

Error Code	Name	Description
		See the *E Series TCP/IP Technical Reference* manual

For “RTU System Error Point” details see the *E Series Operation Reference Manual*.

12.4.4 TCP/IP Errors

TCP/IP communication and configuration errors are reported by the E Series RTU through the Diagnostic Display session as TCP/IP diagnostic information. These error codes are also reported through the ISaGRAF TCP/IP function blocks in the output STATUS variable.

The TCP/IP errors are reported via the System Error Point for TCP/IP configuration problems.

See the *E Series TCP/IP Technical Reference Manual* for a complete list of TCP/IP Communication Error Codes.

12.5 RTU Status

The following system status points are provided by the E Series RTU to indicate status of various aspects of RTU operation.

Point Type	Description
System Binary Points	RTU Initialized
	RTC Time Synchronized
	RTC Time Invalid
	DNP3 Protocol Driver Running
	Engineering Mode
	Local I/O Module Failure
	Local Input Power Supply Low
	Local On-Board Battery Low
	Local Calibration Parameters Invalid
	E Series Hex Switch Settings Changed
	Task Software Watchdog
	Time Zone Modifier
	Configuration Corrupt
	Trend Storage Priority
System Analog Points	E Series Type
	E Series Firmware revision
	E Series Switch Setting
	E Series Processor Board PAL revision
	E Series Processor Board Boot Monitor revision
	I/O Board 1 Firmware revision
	I/O Board 2 Firmware revision
	E Series Up Time (Secs)
	E Series Up Time Delta (0-1000 mS)
	Reset/Error Reasons Mask
	Task Watchdogs Mask
	Engineering Timer
	System Error Code
	RTU Dynamic System Memory Free
	RTU Dynamic System Memory Size

Point Type	Description
	Configuration memory Size
	Configuration memory Slack
	File System Number of Files Used
	File System Bytes Used
	File System Bytes Free
	E Series Configurator Major Revision
	E Series Configurator. Minor Revision
	Local Time Offset from UTC
System Float Points	Input Supply Voltage
	Low Volts Alarm Level

For the SCADAPack ER there is also a range of I/O card status points available in order to provide information on a per slot basis. These system points along with the system points listed in the above table, are described in detail in the E Series Operation Reference Manual.

12.6 Communication Statistics

A variety of communication statistics are provided by the E Series RTU via System Analog points. These analog points may be read from the RTU using specific DNP3 point range read requests. Alternatively they may be read into an ISaGRAF user application via Input Boards, or Function Blocks.

Communication Statistic point values may be reset at any time by controlling the relevant System Point value and setting it to 0. This may be done by an ISaGRAF user application or via DNP3 point controls.

The Communication Statistics System Analog points cannot be directly added to the RTU point database and returned in DNP3 Class data polls. To map Communication Statistic points to a SCADA Master, the values may be imported in to an ISaGRAF user application, manipulated if required, then exported to a derived point which can be configured for access by a SCADA Master.

There are three types of communication statistic points provided by the E Series RTU.

- RTU (global) communication statistics
- Port communication statistics
- TCP/IP communication statistics

All Communication Statistics System Analog points may be accessed as 16-bit or 32-bit Analog Input points.

For “Communication Statistics” details see the *E Series Operation Reference Manual*.

13 RTU File System

The E Series RTU has an on-board file system. The capacity and available functions of the file system is dependant on the target hardware type. The file system is typically used to store the following information

- configuration files (RTU configurations, NTP configurations, license files, etc)
- configuration logs
- ISaGRAF application files
- Profile files
- Trend Sample files
- output data from specific tasks.
- Logged diagnostics

The file system is stored in FLASH ROM with a capacity of 12 MB, and discrete drives and directories are supported. Note that the file system supports a maximum filename length (including path) of 255 characters. Spaces in the filename (and or path) are not supported.

The file system also allows for COMPACT FLASH drives. The COMPACT FLASH drives are mounted but COMPACT FLASH cards are not typically connected for normal RTU operation.

These mounted drives and directories are listed as follows

- C drive. **Non-volatile drive**. Resides in FLASH ROM (capacity 12 MB).
- D drive (RAM disk). **Volatile drive**. Resides in RAM (capacity 1 MB).
- E drive. COMPACT FLASH Slot 1. *
- F drive. COMPACT FLASH Slot 2. * (SCADAPack ES only)

* The COMPACT FLASH slots are located on the main processor board of the RTU.

14 Data Concentrator

The E Series RTU can be configured as a Data Concentrator where the RTU manages the communications and polling regimes to other remote devices. This approach abstracts the SCADA master from the remote devices, and is often used to allow a SCADA master (or multiple SCADA masters) to regularly communicate with only the data concentrator. The data concentrator acts an intermediate master to the remote outstations.

The data concentrator configuration in the E Series RTU involves two configuration tables.

- The *Remote Devices* table details the necessary information for the data concentrator to communicate with the remote device, i.e.
    - communications protocol
    - device address
    - polling schedule

- The *Remote Points* table details the mapping of remote outstation points to points on the data concentrator.

The protocols currently supported for outstation communications are:

- DNP3
- 60870-5-103
- Remote I/O

Where supported by the protocol (for example DNP3), time-stamps and point quality data received from remote outstations are preserved within the data concentrator. A Master Station polling the data concentrator receives the original timestamps, quality flags and data (as generated by the remote outstation). In addition, the data concentrator modifies point quality flags on data mapped from remote outstations to reflect data concentrator information, such as point Offline, Comms Lost, etc.

Refer to the *E Series Data Concentrator Technical Reference* for more information regarding the Data Concentrator.

15 DNP3 Multi-Master

The E Series RTU supports DNP3 Multi-Master operations whereby acting as a DNP3 slave, the E Series fully supports communications with multiple DNP3 masters. Up to three DNP3 Masters may be configured.

The DNP3 addresses of the multiple DNP3 masters must be different for correct operation.

The DNP3 address of the E Series RTU (as a DNP3 slave) may be the same for each of the DNP3 masters, or alternatively may be configured to have a different DNP3 slave address for each DNP3 master. Communications to the multiple DNP3 masters may be on single or multiple communications ports

The RTU supports separate event lists for each DNP3 Master, and also allows configurations on a per point basis, allowing points to be selectively returned in poll responses for a given DNP3 Master, e.g. a given point may be configured as Class 1 for DNP3 Master 1, and Class 0 (static) for DNP Master 2, and so on.

The DNP3 Multi-Master functionality requires licencing. Refer to the *E SeriesDNP3 Technical Reference* for more information regarding DNP3 Multi-Master support.