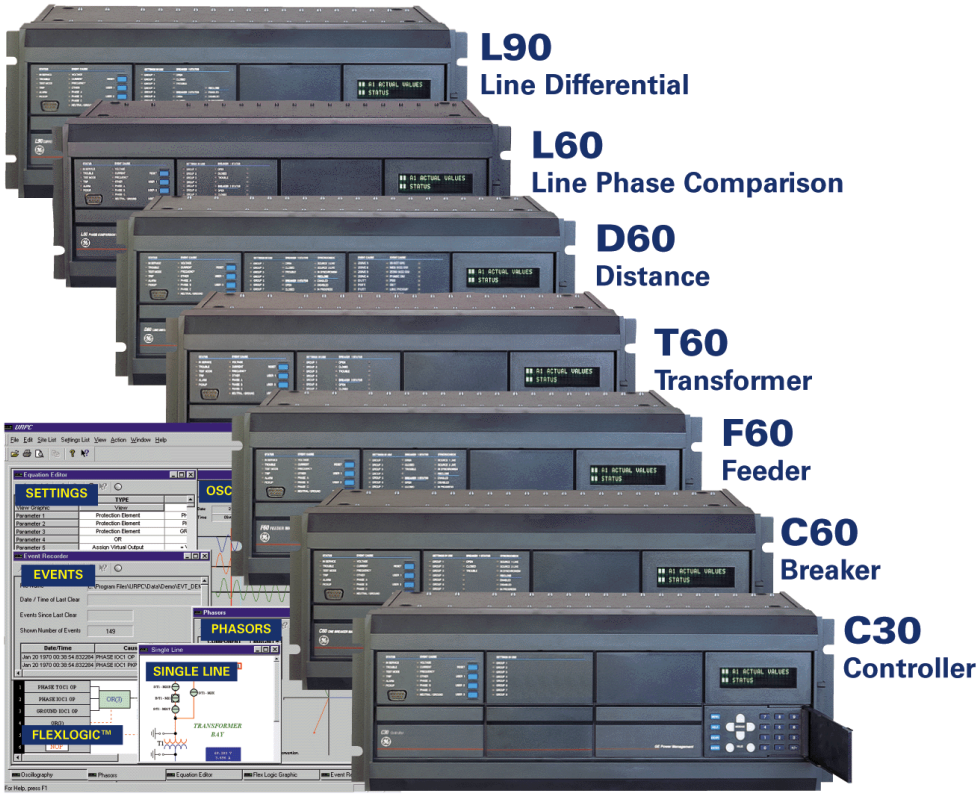
GESA

GE Substation Automation for the world



Agenda

Substation Automation

> Requirements

> Protective relay hardware

> Protective relay logic

> Relay to relay data communication

> Local/Bay control

> WAN

> SCADA

Requirements:

- Most up to date CPU's yet expect 20 to 30 year MTBF.
- Built in programmable controller functionality
- High speed relay to relay data communication
- Expandable:
    - I/O
    - Multiple CT and VT Modules with the ability to calculate virtual sources

Solution:

- Modularity

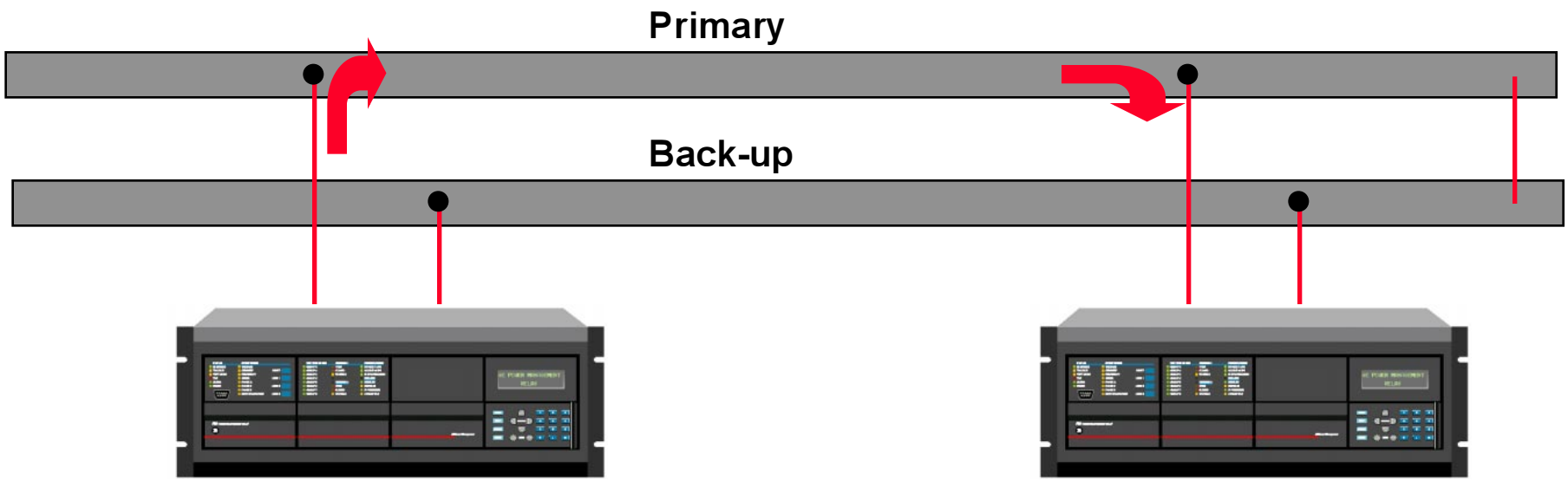
Requirements:

- Reusable code to reduced development time
- Reduce training requirements: family of protective relays with same touch and feel and common feel and common hardware components

Solution:

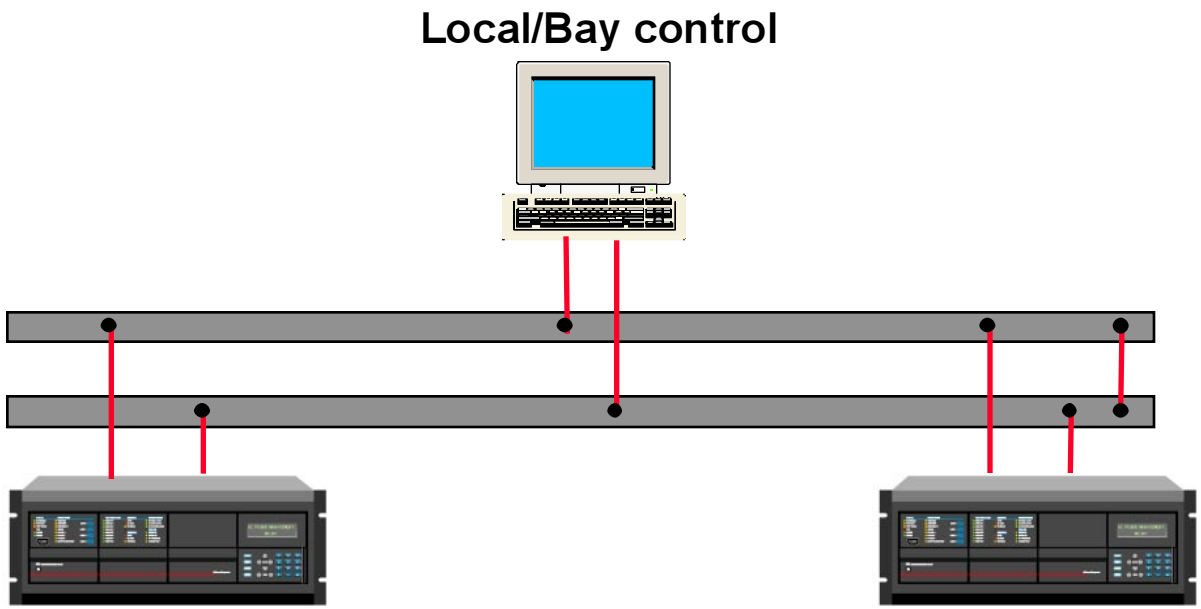
- Design must be based on a Platform

Relay to Relay Communications



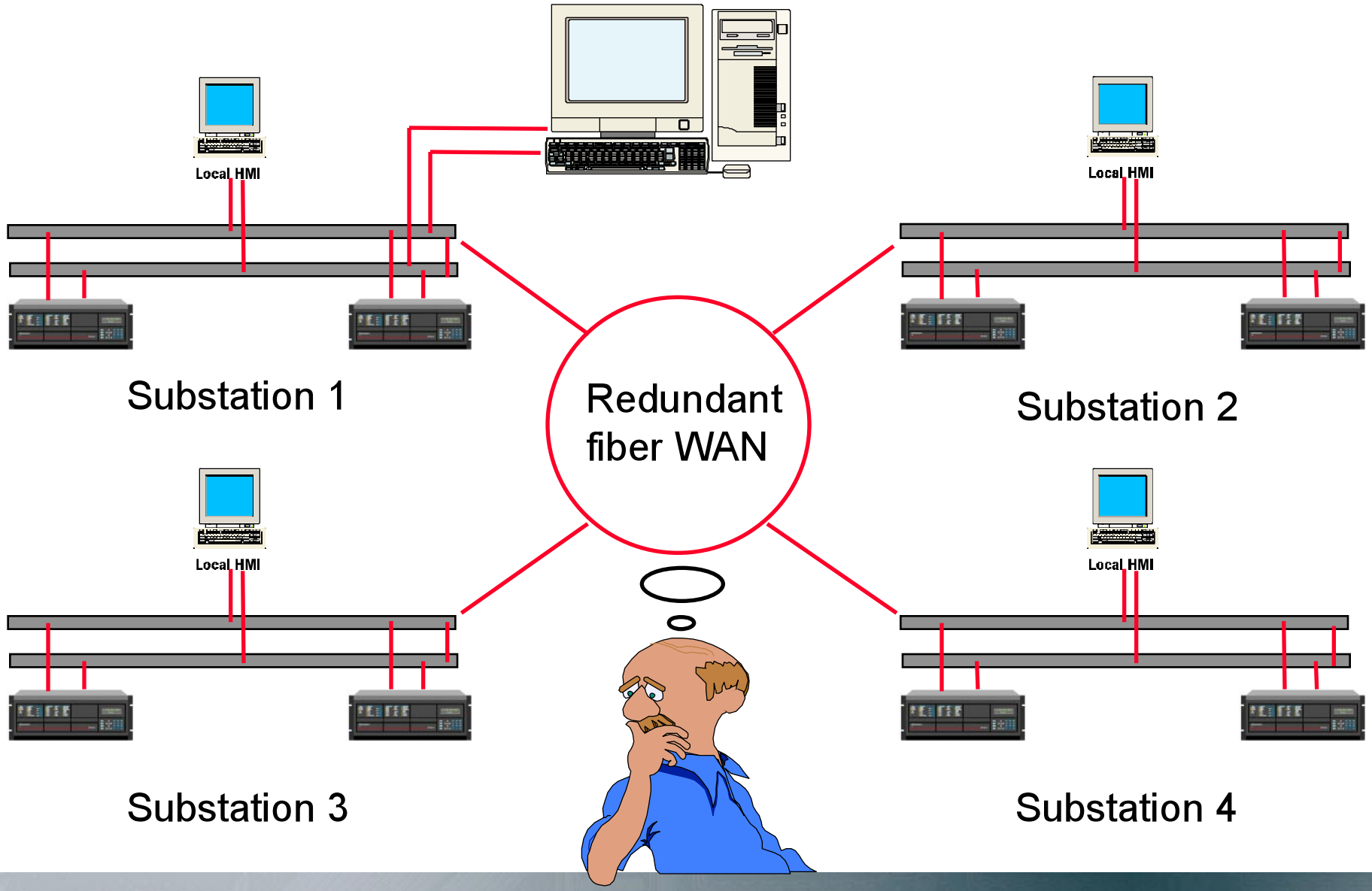
- High speed relay to relay service part of a protocol suite optimized for Utility applications
- Redundant Star fiber configuration:
  - elimination of single point failures
- Readily available proven LAN components
- Open Architecture

Local / Bay Control

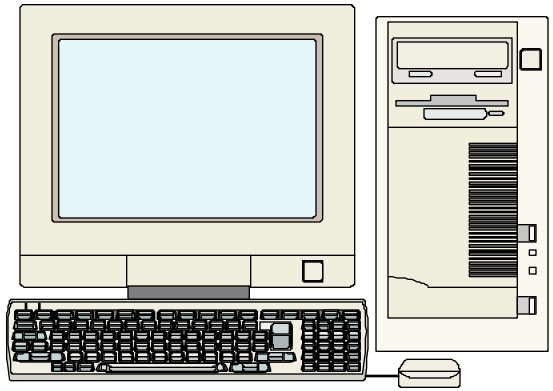


- High speed HMI **service** part of a protocol suit optimized for Utility applications.
- Standard naming convention
- Direct connection to high speed substation LAN.
- User configurable graphics display.
- Primary graphic, control and monitoring functions

WAN Requirements



Information not Data:



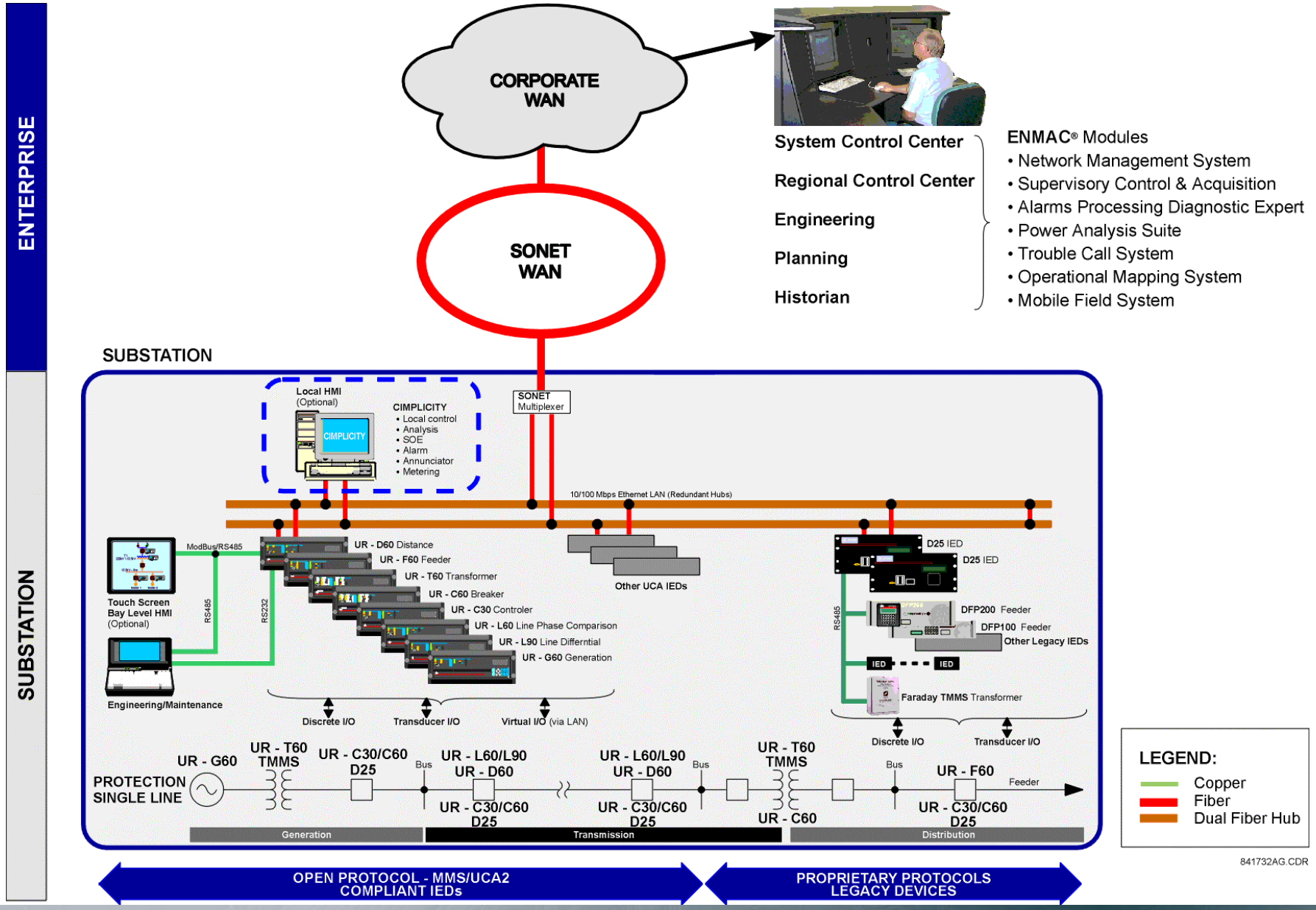
Enterprise

- Budget accurately
- Asses cost of service
- Allocate capacity
- Faster service response

Operations

- Remote status and control
- Analyze power quality
- Identify events
- Receive fault records
- Target Maintenance
- Loading trends

Data Communications Hierarchy



Substation Automation

> Requirements

> Protective relay hardware

> Protective relay logic engine

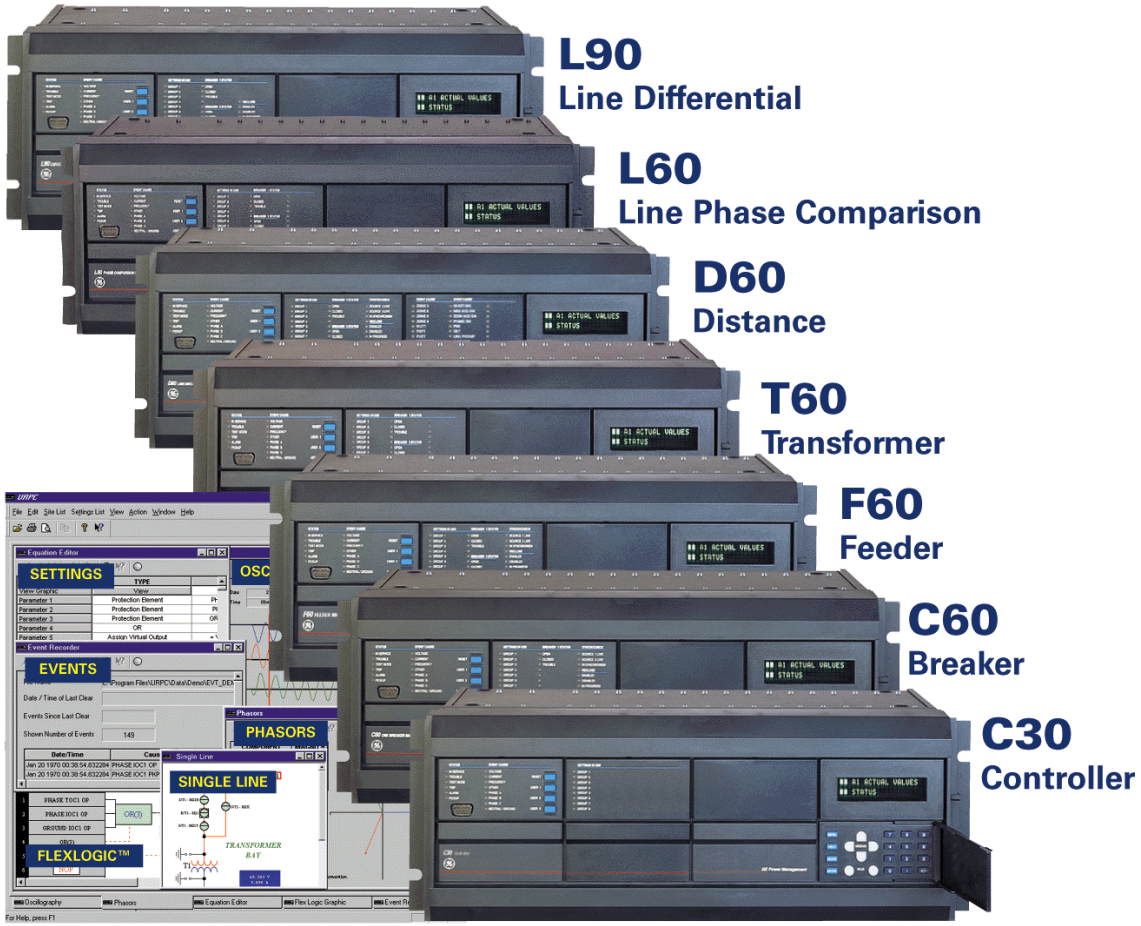
> Relay to relay data communication

> Local/Bay control

> WAN

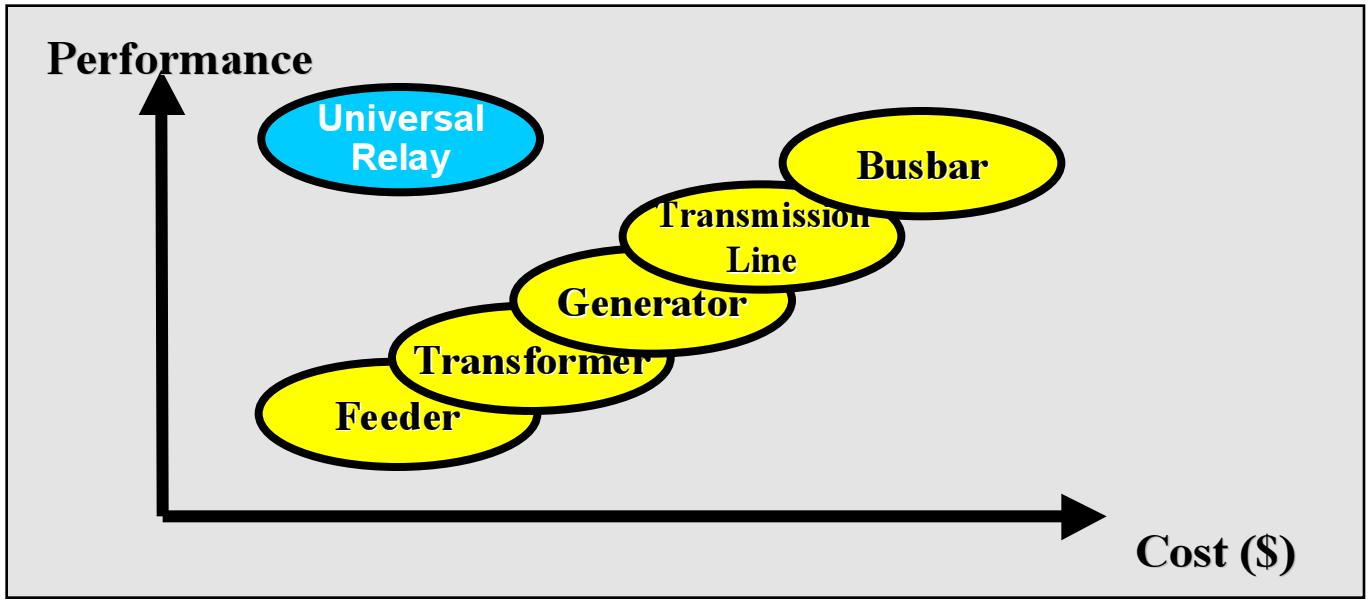
> SCADA

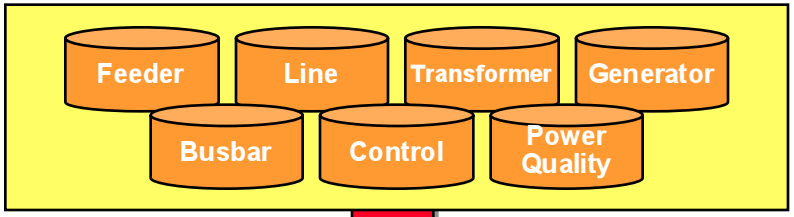
The 'Universal Relay' Family



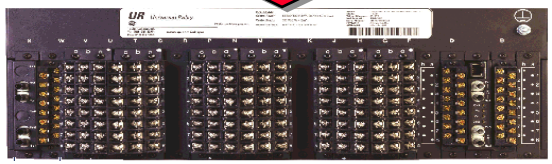
"The engine for substation automation"

The Challenges of the 'Universal Relay'

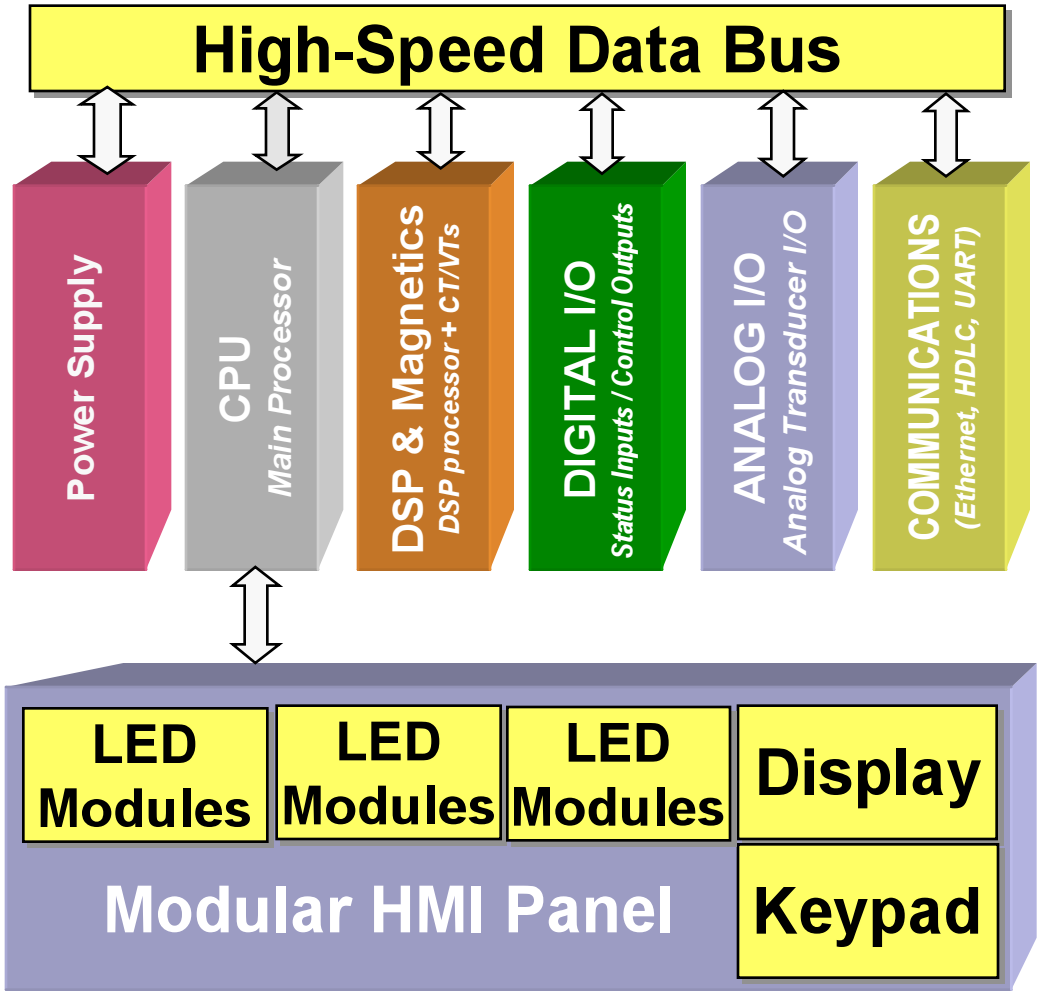




Application Software

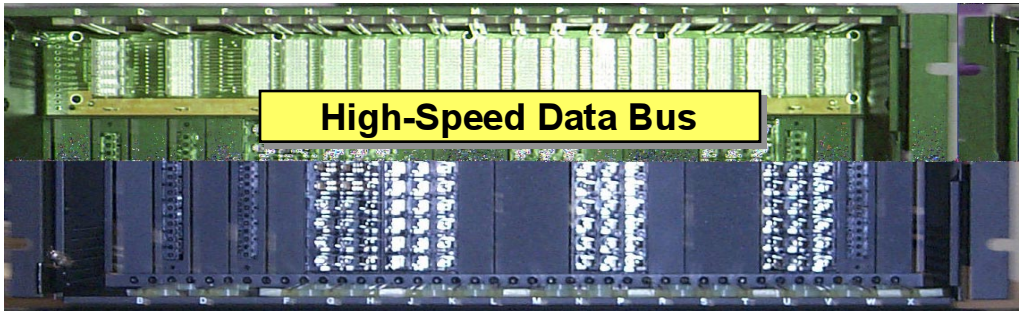


Universal Relay Architecture - 'Modularity'



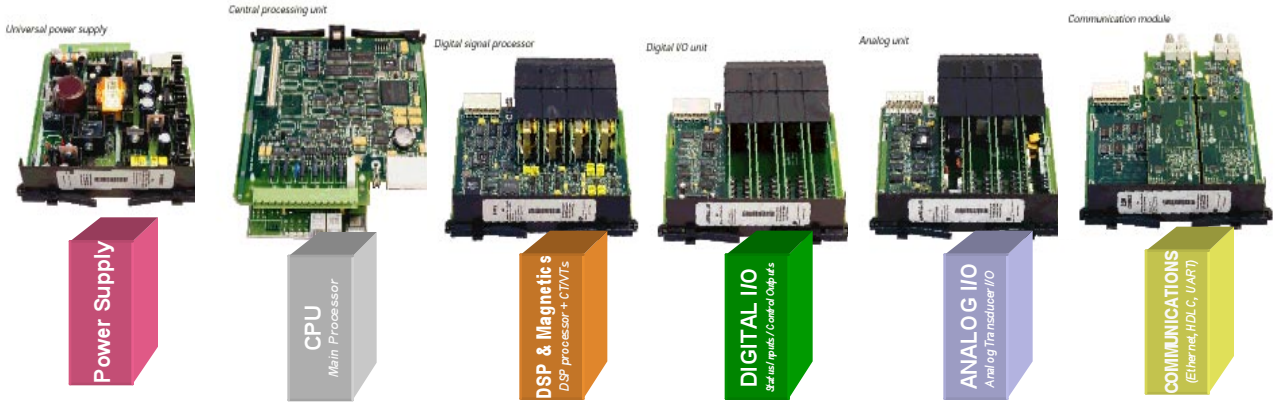
Six Basic Modules

Physical Realization



19” Chassis (4RU high)

Modules



Modular HMI

Modularity...

Power Supply

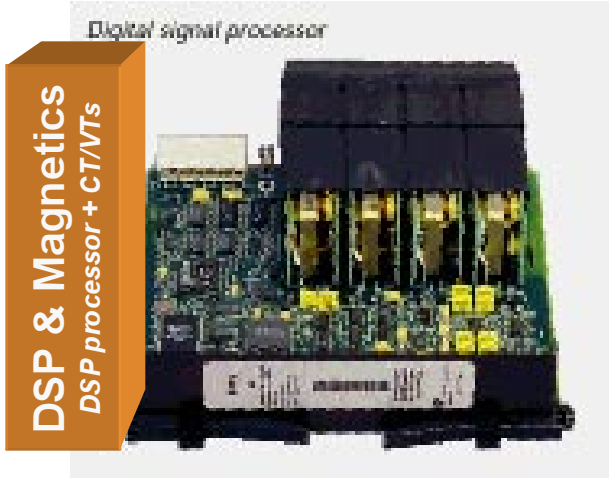
- Wide input range
  - 24 - 300 VDC
  - 20 - 265 VAC
- High Efficiency SMPS
  - > 80%

CPU

- High-speed 32-Bit RISC CPU
  - > 50 MIPS, up to 120 MIPS
- FLASH memory
  - Easy firmware upgrades

High-Speed Comms support
- 10/100Mbps Ethernet LAN
- Redundant Fiber

DSP + CT/VT



- Modular CT/VT configurations
  - up to 8 CT/VTs
- High-speed digital sampling
  - >16 Bit A/D
  - > 64 samples / power cycle
- High-speed 16-Bit DSP
  - > 32 MIPS, up to 80 MIPS

Modularity...

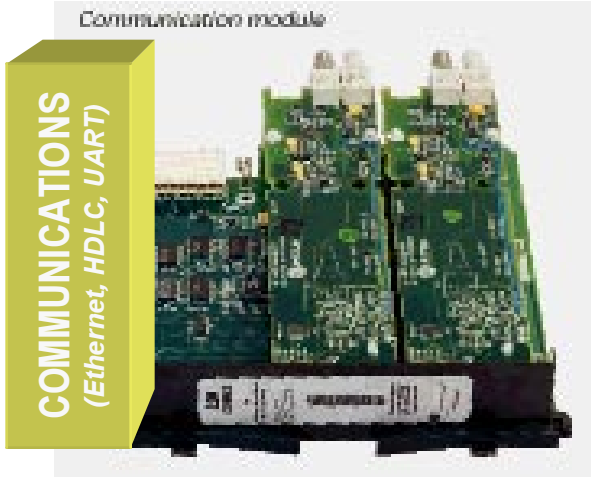
Digital I/O

- Control outputs
  - Solid State
  - Electromechanical - multiple types
  - Fast activation speeds (< 4ms)
- Status inputs
  - Dry and Wet contacts
  - 18 - 300 VDC
  - Fast detection speeds (< 4ms)

Analog I/O

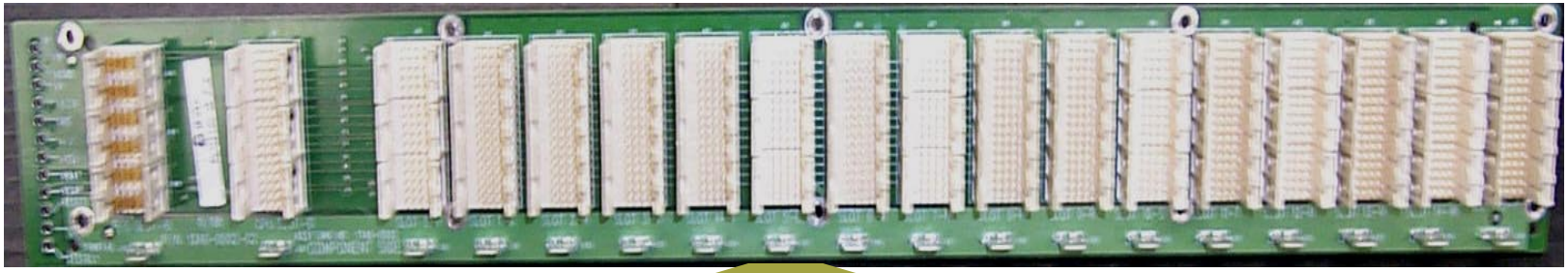
- Transducer type inputs
  - ± dcmA
  - ±Voltage
  - Resistive
- Outputs for Legacy SCADA
  - ± dcmA
- Support multiple I/O configurations

Communications



- High-speed Serial
  - Asynchronous (9600 - 115K Baud)
  - Synchronous (56K - 256K Bps)
  - Fiber Optical (Single/Multimode)
  - Channel Redundancy

High-Speed Data Bus



High-Speed *Parallel* Data Bus: 80 - 100 Mbytes/sec

High-Speed *Serial Communications* Bus: 10Mbps

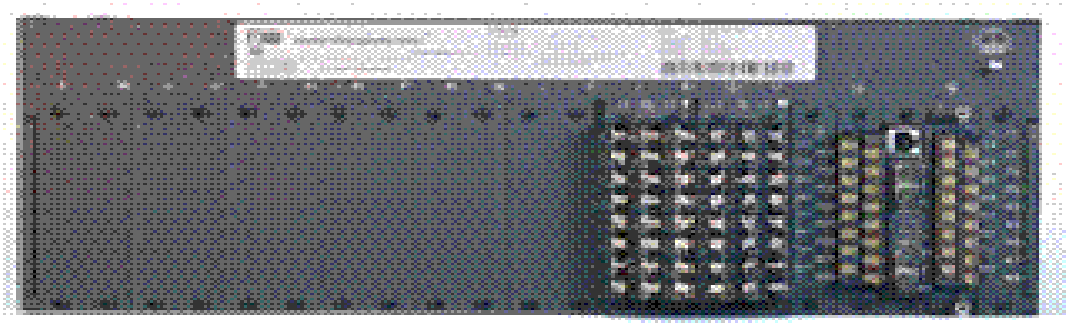
High-Speed *Inter-Processor Serial* Data Bus: 16Mbps

Multiple buses allow for high-performance:

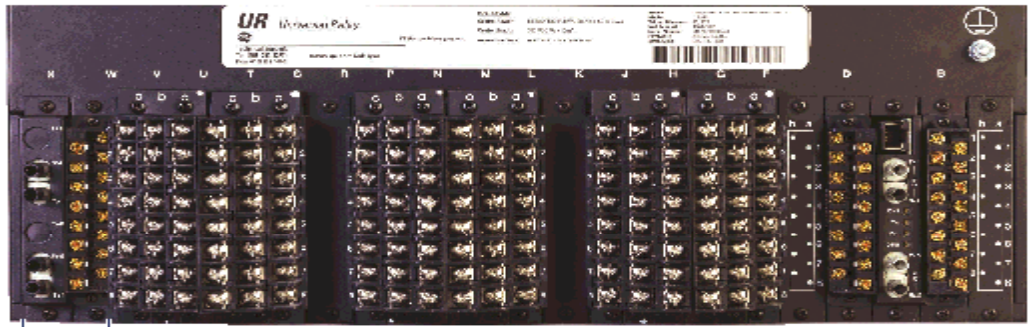
- ***Protection and communications without bottlenecks***

Scalability

Minimum



Maximum



'Box' Capacity

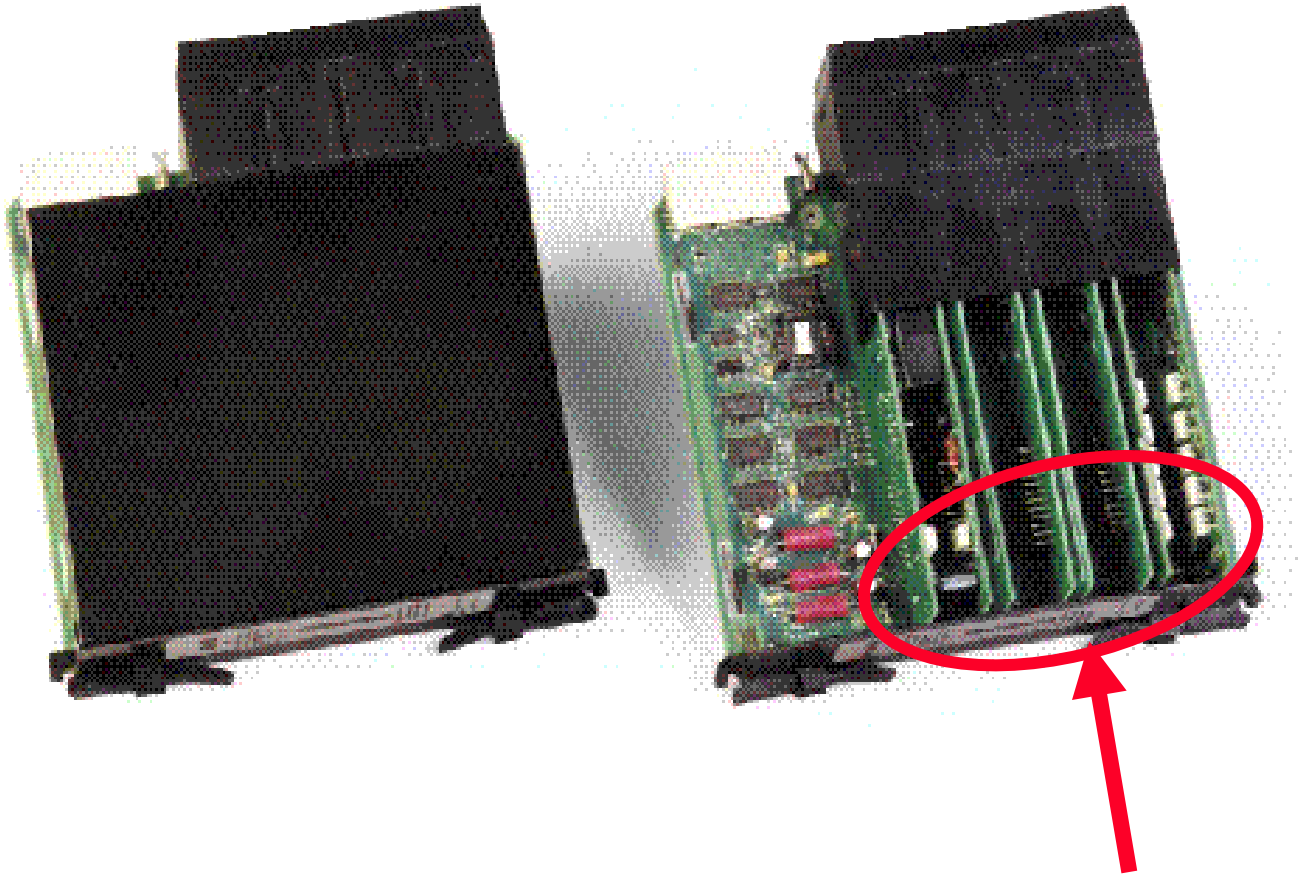
CT/VT (I & V) inputs → **24** *(max)*
up to 3 modules → ***8/module***

Status (Binary) inputs → **96** *(max)*
up to 6 modules → ***16/module***

Control (contact) outputs → **48** *(max)*
up to 6 modules → ***8/module***

Analog (Transducer) I/O → **48** *(max)*
up to 6 modules → ***8/module***

Configuration/Flexibility



Sub-Modules

Sub-Module Types

Current & Voltage → **CT, VT**

Future → ***Optical, Digital***

Control and Status I/O → **Form-A**
Form-C
Solid-State
Wet/Dry Input

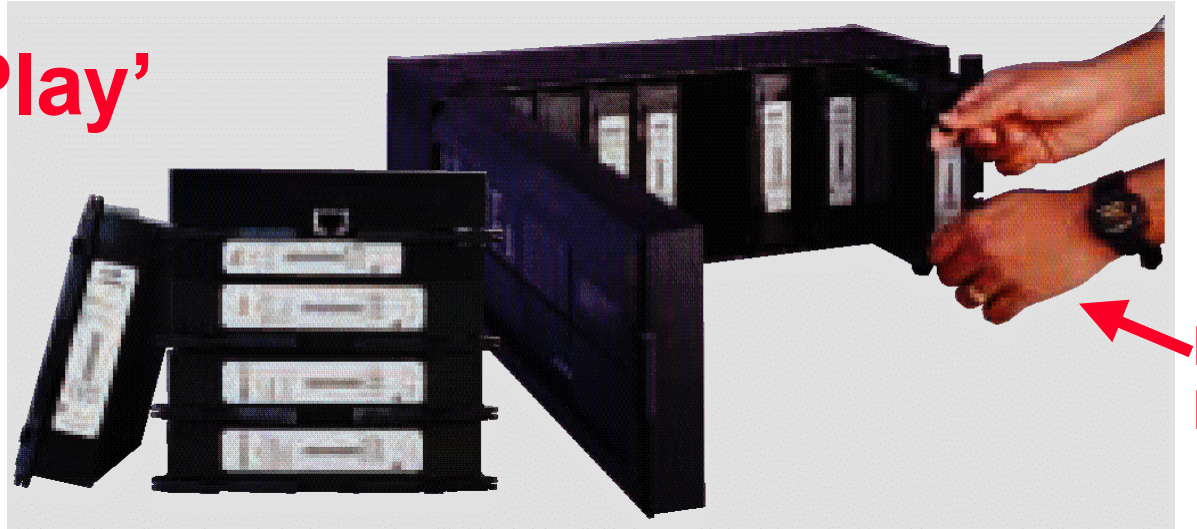
Future → ***Customer - ??***

Analog (Transducer) I/O → **±1mA, 4-20mA, 0-5mA**
RTD (Pt, Ni, Cu)
±5V, Resistive

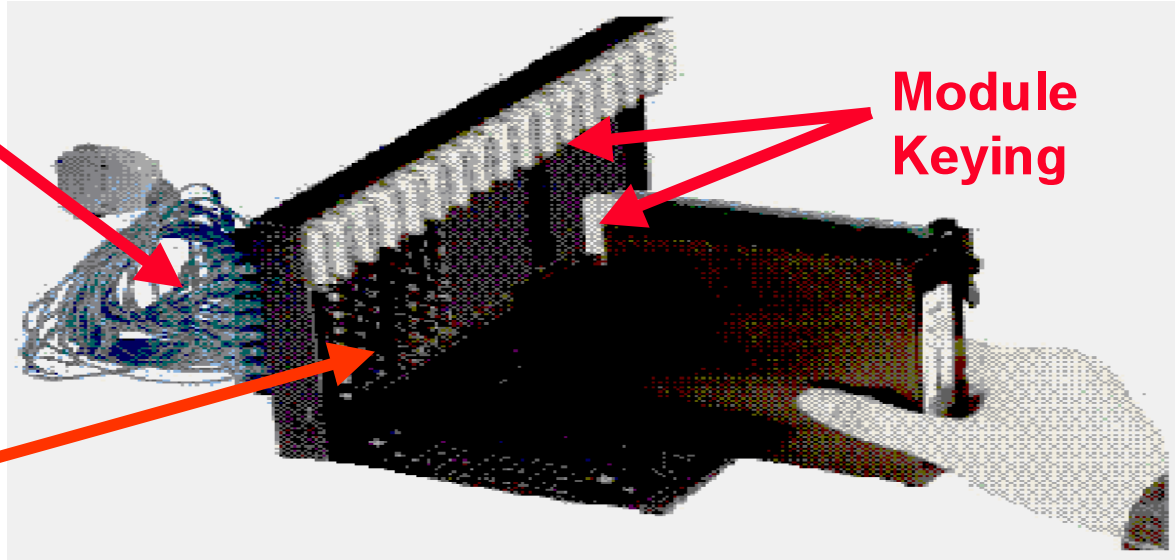
Future → ***Customer - ??***

‘Upgradeability’/Serviceability

‘Plug n Play’



Easy Module Draw-out



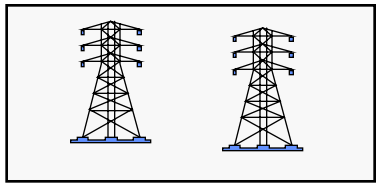
Field Wiring Undisturbed

Module Keying

CT Shorting ‘Clips’

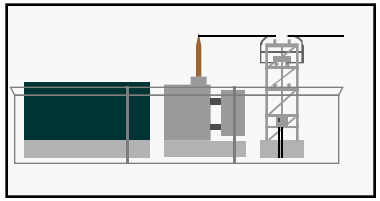
The UR Family - One Common Architecture

TRANSMISSION



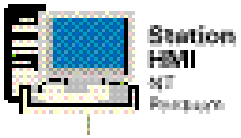
- L60 (Transmission Line: Phase Comparison)
- L90 (Transmission Line: Current Differential)
- D60 (Transmission Line: Distance)

DISTRIBUTION



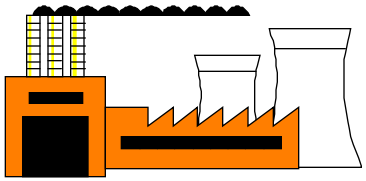
- F3x (Feeder: Multiple Feeders - Basic Protection)
- F60 (Feeder: Comprehensive w Hi-Z)
- T60 (Transformer: Comprehensive)
- C30 (Control IED)
- C60 (Breaker Management IED)

SYSTEMS SOFTWARE



- URPC (Entry Level HMI, Engineering Tool)
- PMCS (Full Featured Systems HMI)

GENERATION



(Available in 2000)

- *G60 (Generator: Comprehensive > 100MVA)*
- *B30 (Busbar: Basic 6 Feeder)*
- *B90 (Busbar: Comprehensive up to 30 Feeders)*

FEATURES

- FlexLogic™
- Distributed FlexLogic™
- Virtual I/O (reduce hardware cost)
- Expandable I/O
- Flash monory for field upgrades
- Drawout modules for serviceability
- Common modules (reduce spares cost)
- Test mode for forcing contact I/O states
- IRiG-B time synchronization

Substation Automation

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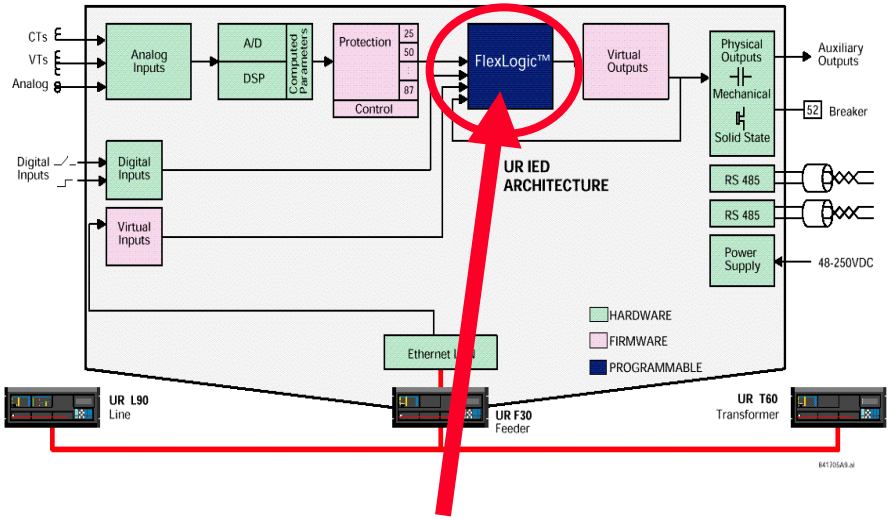
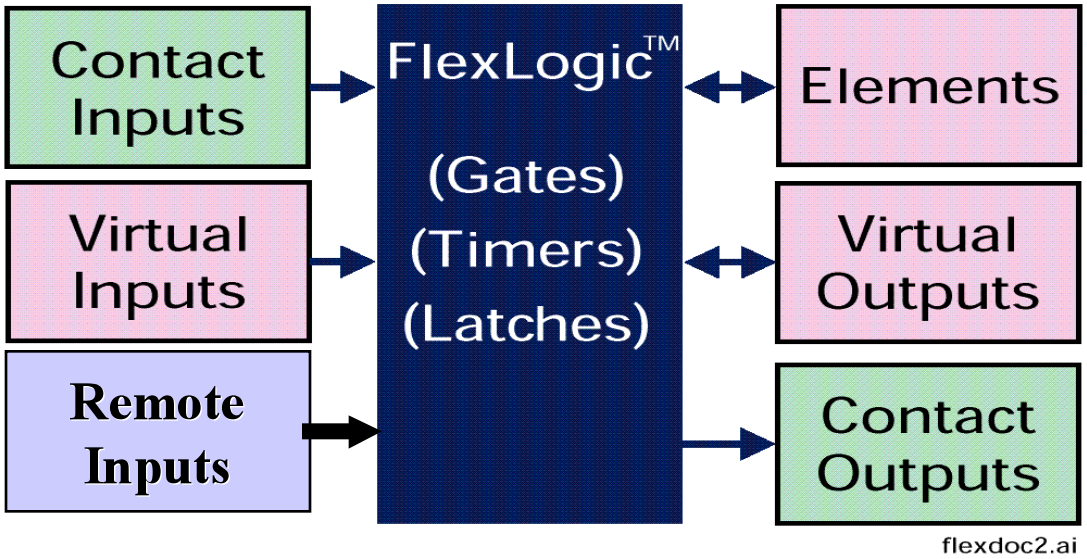
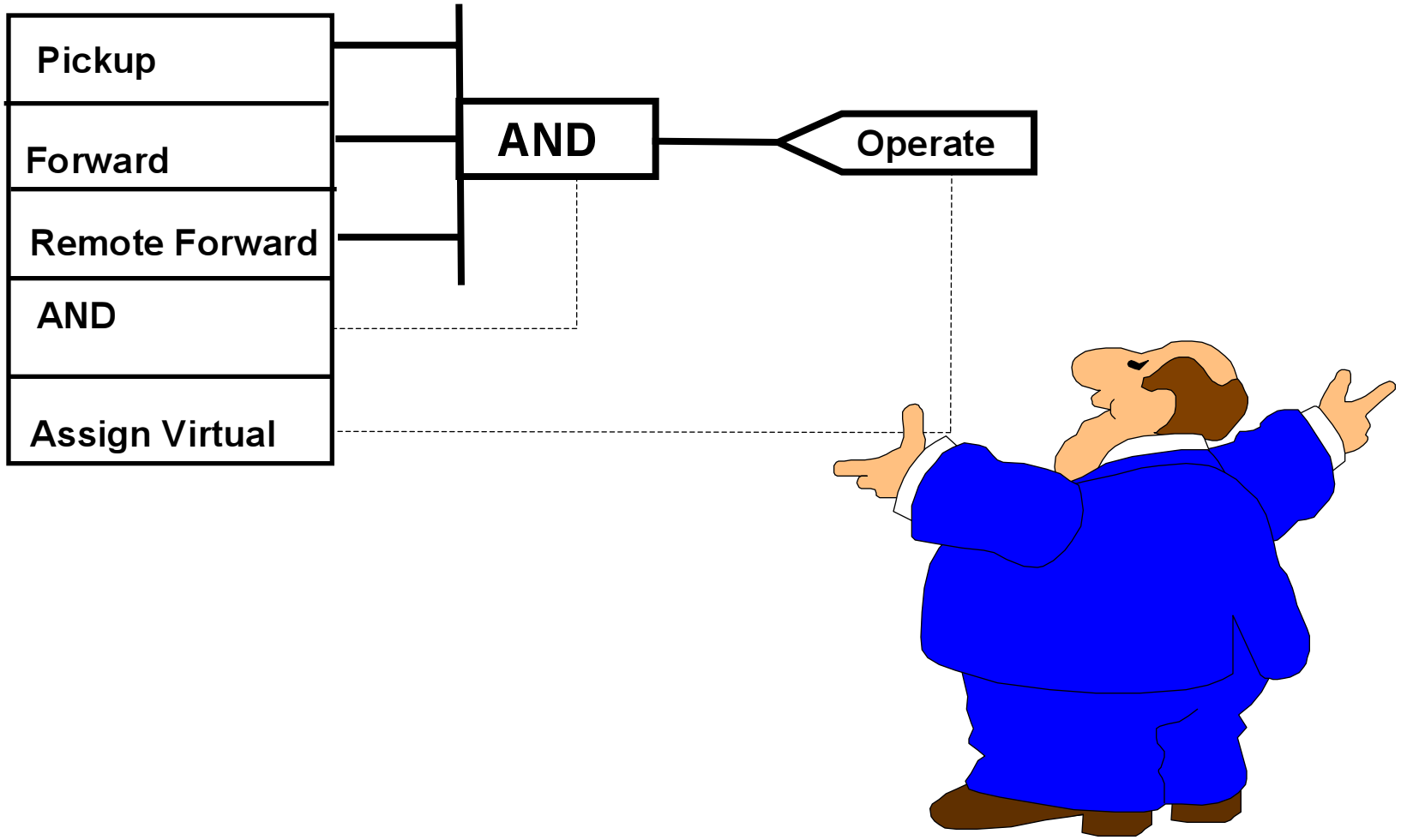
UR FlexLogic™ Engine

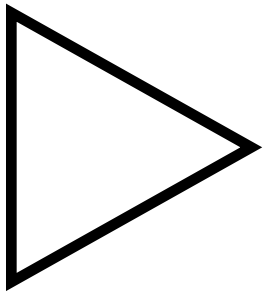




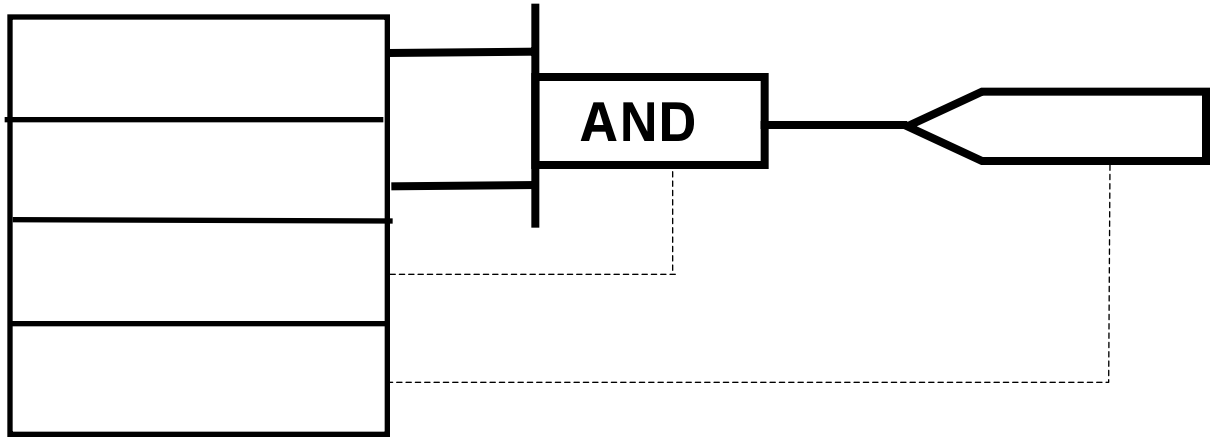
Introduction to Flexlogic



Introduction to Flexlogic

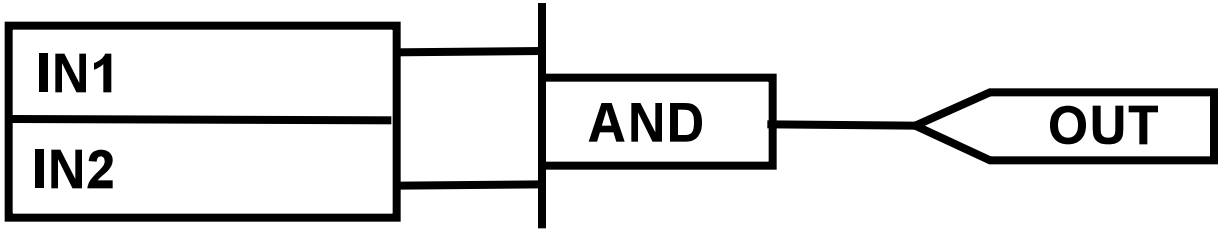
Function Inputs	Protection Element	Function Outputs
Enable		Pickup
Source		Operate
Block		Drop Out

Introduction to FLEX Logic

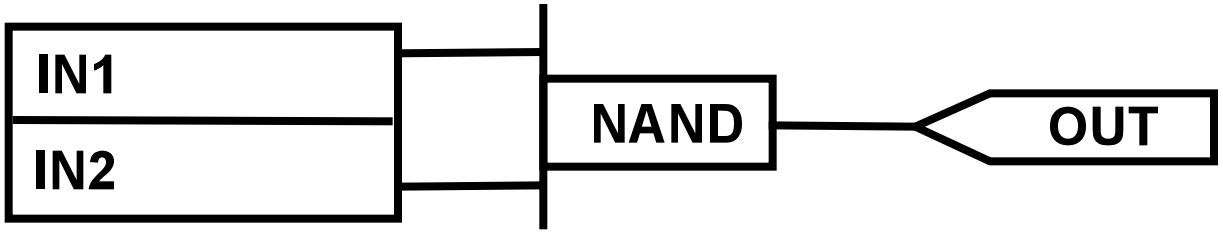


Gates	Number Of Inputs	Output Is ‘1’ (= On) If...
NOT	1	input is ‘0’
OR	2 to 16	any input is ‘1’
AND	2 to 16	all inputs are ‘1’
NOR	2 to 16	all inputs are ‘0’
NAND	2 to 16	any input is ‘0’
XOR	2	only one input is ‘1’

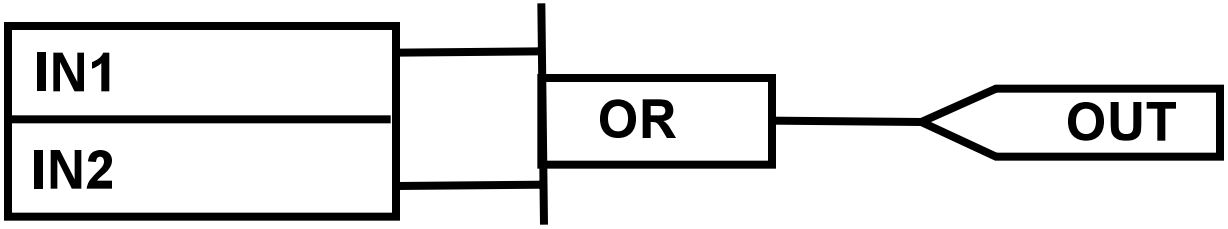
Truth Tables



In1	In2	OUT
0	0	0
0	1	0
1	0	0
1	1	1

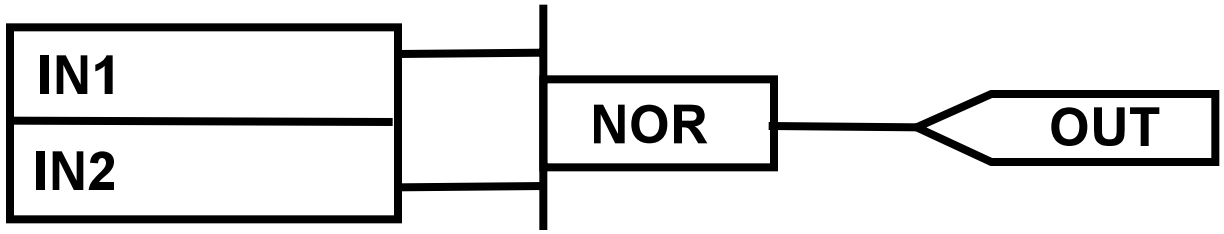


In1	In2	OUT
0	0	1
0	1	1
1	0	1
1	1	0

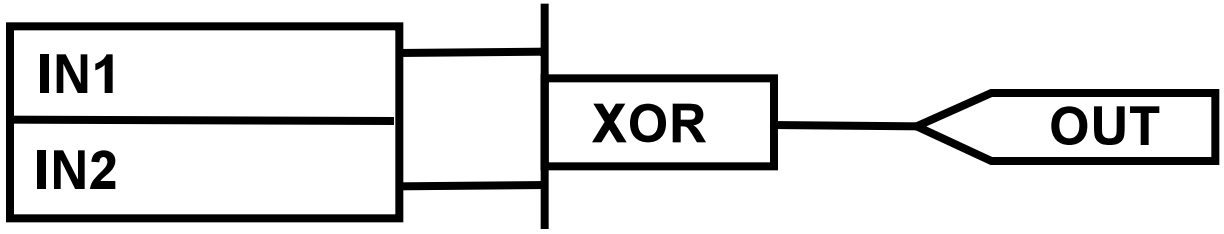


In1	In2	OUT
0	0	0
0	1	1
1	0	1
1	1	1

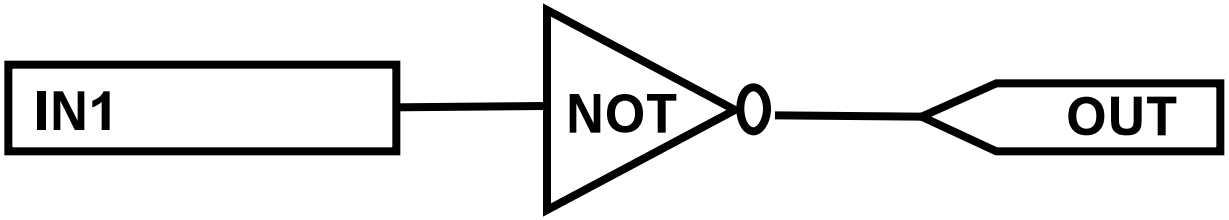
Truth Tables



In1	In2	OUT
0	0	1
0	1	0
1	0	0
1	1	0

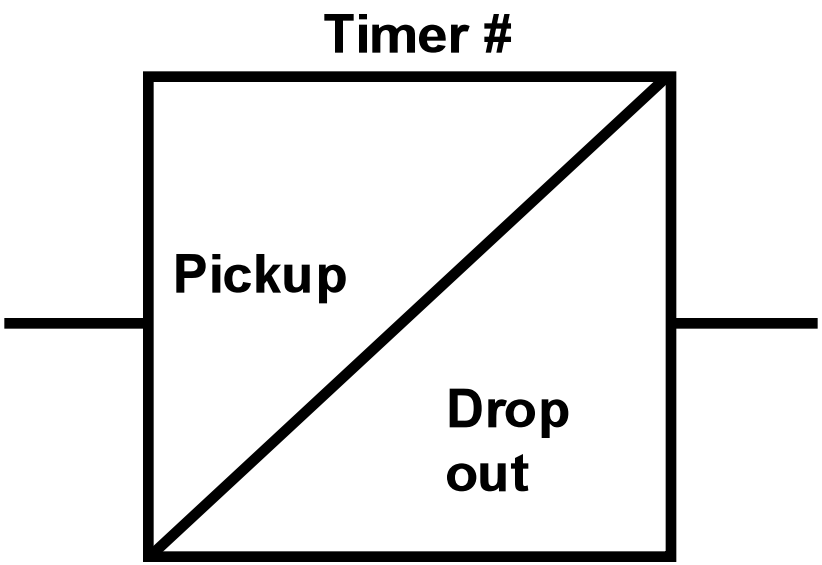


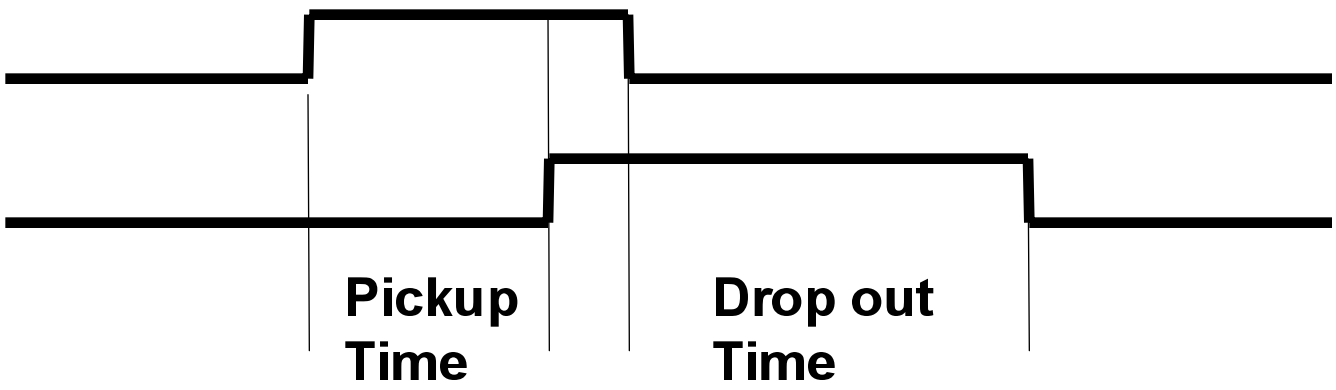
In1	In2	OUT
0	0	0
0	1	1
1	0	1
1	1	0



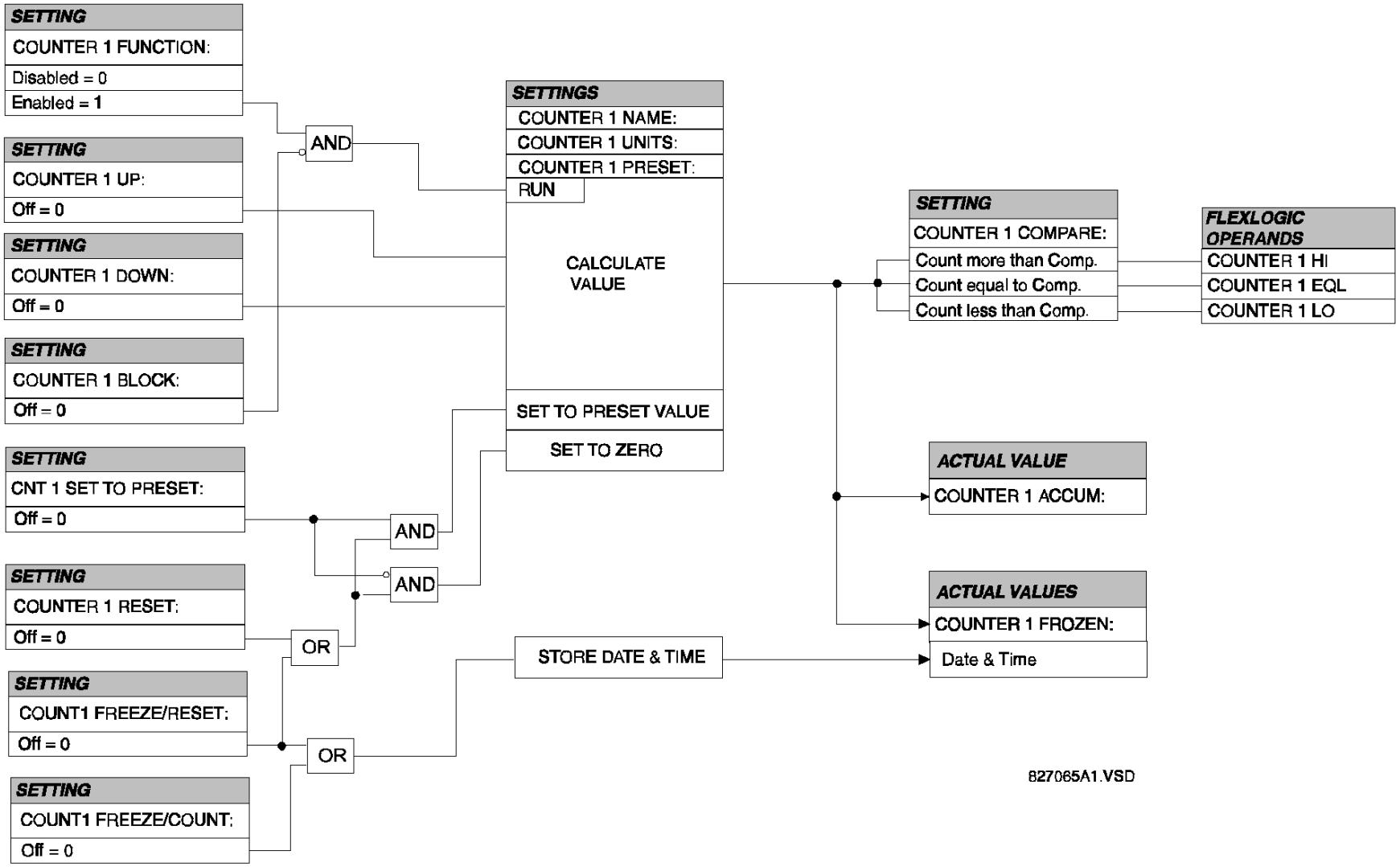
In1	OUT
1	0
0	1

Timers

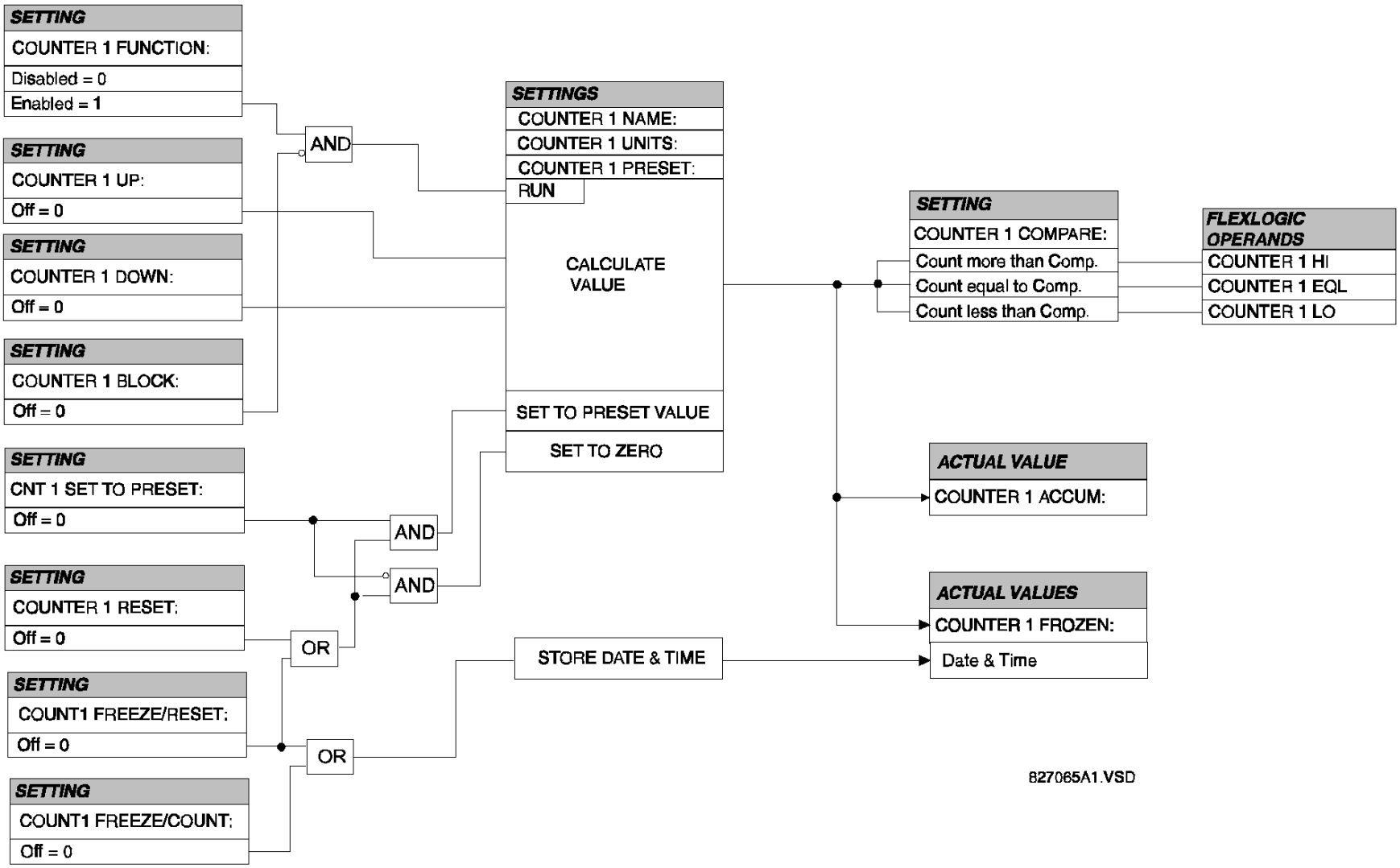




Counters


SETTING
COUNTER 1 FUNCTION:
Disabled = 0
Enabled = 1
SETTING
COUNTER 1 UP:
Off = 0
SETTING
COUNTER 1 DOWN:
Off = 0
SETTING
COUNTER 1 BLOCK:
Off = 0
SETTING
CNT 1 SET TO PRESET:
Off = 0
SETTING
COUNTER 1 RESET:
Off = 0
SETTING
COUNT1 FREEZE/RESET:
Off = 0
SETTING
COUNT1 FREEZE/COUNT:
Off = 0
AND
AND
AND
OR
OR
SETTINGS
COUNTER 1 NAME:
COUNTER 1 UNITS:
COUNTER 1 PRESET:
RUN
CALCULATE VALUE
SET TO PRESET VALUE
SET TO ZERO
STORE DATE & TIME
SETTING
COUNTER 1 COMPARE:
Count more than Comp.
Count equal to Comp.
Count less than Comp.
FLEXLOGIC OPERANDS
COUNTER 1 HI
COUNTER 1 EQL
COUNTER 1 LO
ACTUAL VALUE
COUNTER 1 ACCUM:
ACTUAL VALUES
COUNTER 1 FROZEN:
Date & Time
827065A1.VSD

Counters


SETTING
COUNTER 1 FUNCTION:
Disabled = 0
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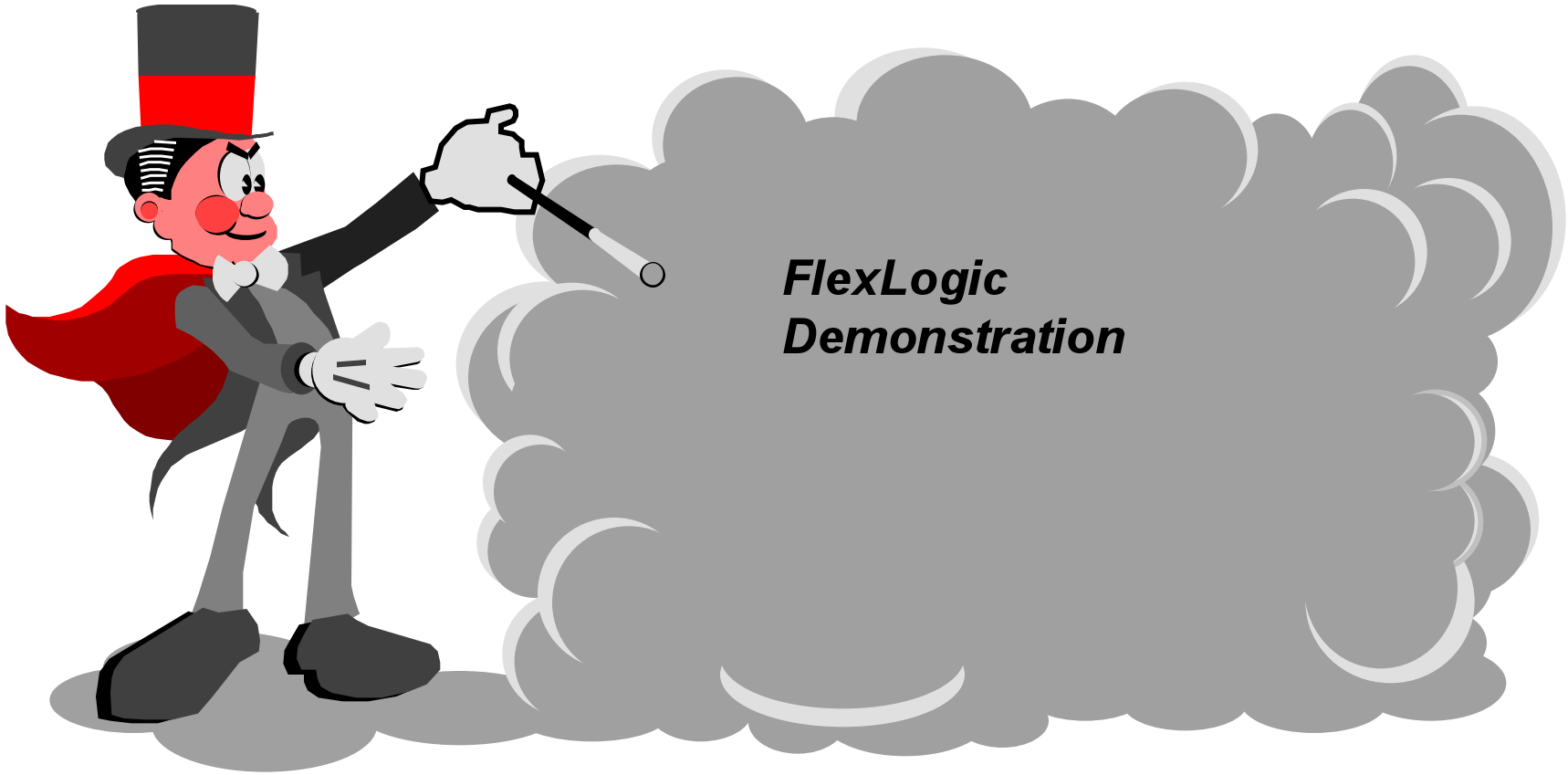
COUNTER 1 UP:
Off = 0
SETTING
COUNTER 1 DOWN:
Off = 0
SETTING
COUNTER 1 BLOCK:
Off = 0
SETTING
CNT 1 SET TO PRESET:
Off = 0
SETTING
COUNTER 1 RESET:
Off = 0
SETTING
COUNT1 FREEZE/RESET:
Off = 0
SETTING
COUNT1 FREEZE/COUNT:
Off = 0
AND
AND
AND
OR
OR
SETTINGS
COUNTER 1 NAME:
COUNTER 1 UNITS:
COUNTER 1 PRESET:
RUN
CALCULATE VALUE
SET TO PRESET VALUE
SET TO ZERO
STORE DATE & TIME
SETTING
COUNTER 1 COMPARE:
Count more than Comp.
Count equal to Comp.
Count less than Comp.
FLEXLOGIC OPERANDS
COUNTER 1 HI
COUNTER 1 EQL
COUNTER 1 LO
ACTUAL VALUE
COUNTER 1 ACCUM:
ACTUAL VALUES
COUNTER 1 FROZEN:
Date & Time
827065A1.VSD

FlexLogic Demonstration



FlexLogic™ Navigation

File Edit Site List Settings List View Action Window Help

- Site List
- UTS
  - New Device 2
    - Device Definition
    - Settings
      - Product Setup
      - System Setup
      - Flexlogic
        - Flexlogic Equation Editor
        - Flexlogic Timers
        - Digital Counters
      - Grouped Elements
      - Control Elements
      - Inputs/Outputs
      - Transducer I/O
      - Testing
    - Commands
    - Targets
    - Actual Values
      - Front Panel
      - Status
      - Metering
      - Records
      - Product Info
    - Maintenance
  - Site Event Recorder
  - Site Targets

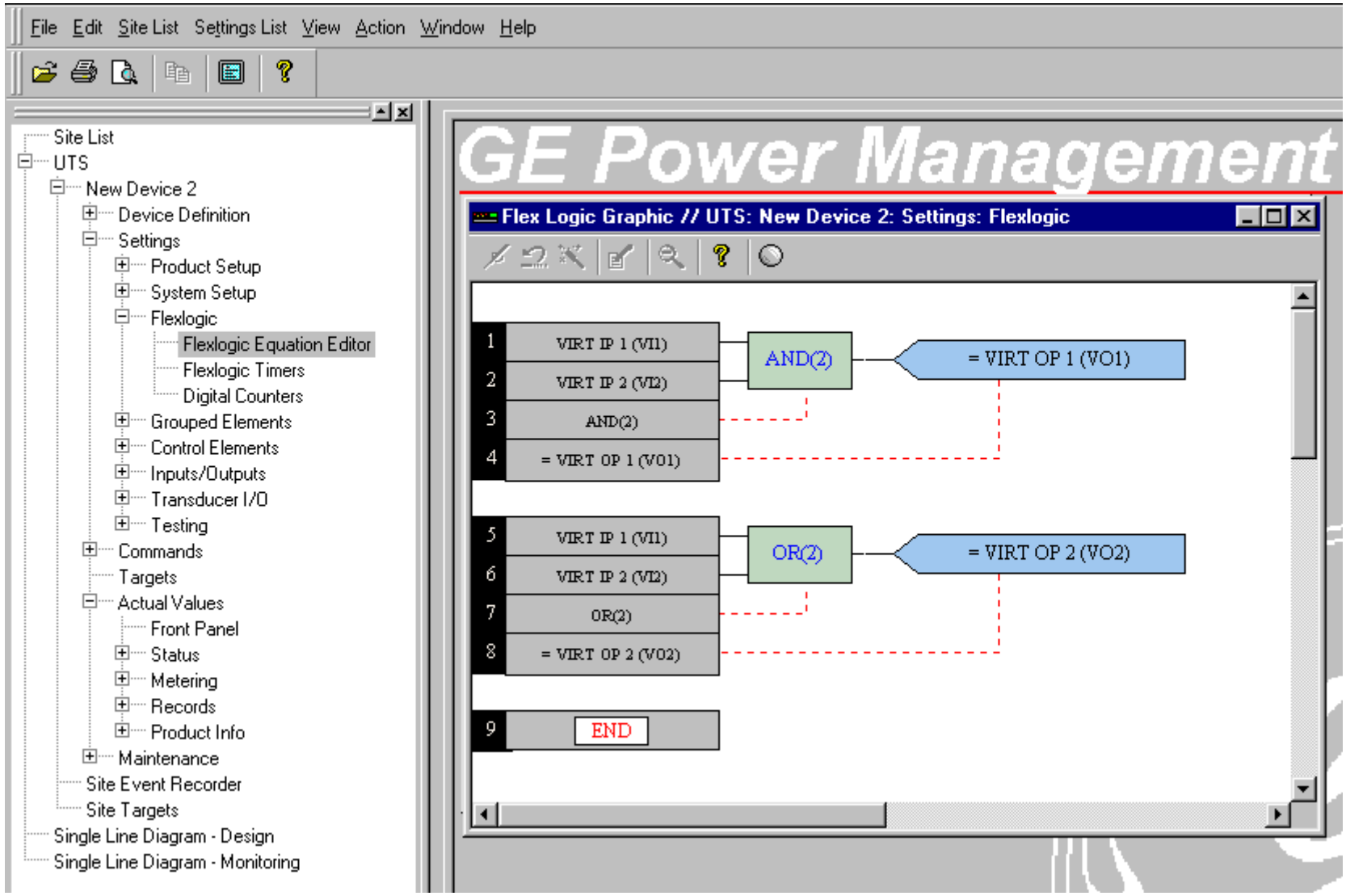
GE Power Managemen

Flexlogic Equation Editor // UTS: New Device 2: Settings: Flexlogic

FLEXLOGIC ENTRY	TYPE	SYNTAX
View Graphic	View	View
Flexlogic Entry 1	Virtual Inputs	Virt Ip 1 (VI1)
Flexlogic Entry 2	Virtual Inputs	Virt Ip 2 (VI2)
Flexlogic Entry 3	AND	2 Input
Flexlogic Entry 4	Assign Virtual Output	= Virt Op 1 (VO1)
Flexlogic Entry 5	Virtual Inputs	Virt Ip 1 (VI1)
Flexlogic Entry 6	Virtual Inputs	Virt Ip 2 (VI2)
Flexlogic Entry 7	OR	2 Input
Flexlogic Entry 8	Assign Virtual Output	= Virt Op 2 (VO2)
Flexlogic Entry 9	End of List	
Flexlogic Entry 10	End of List	
Flexlogic Entry 11	End of List	
Flexlogic Entry 12	End of List	
Flexlogic Entry 13	End of List	
Flexlogic Entry 14	End of List	
Flexlogic Entry 15	End of List	
Flexlogic Entry 16	End of List	
Flexlogic Entry 17	End of List	
Flexlogic Entry 18	End of List	

= Virt Op 1 (VO1)
= Virt Op 2 (VO2)
= Virt Op 3 (VO3)
= Virt Op 4 (VO4)
= Virt Op 5 (VO5)
= Virt Op 6 (VO6)
= Virt Op 7 (VO7)

FlexLogic™ Navigation



Contact Outputs

File Edit Site List Settings List View Action Window Help

- Grouped Elements
- Control Elements
- Inputs/Outputs
- Transducer I/O
- Testing
- Commands
- Targets
- Actual Values
  - Front Panel
  - Status
    - Contact Inputs
    - Virtual Inputs
    - Remote Inputs
    - Contact Outputs
    - Virtual Outputs
    - Remote Devices Status
    - Remote Devices Statistics
    - Digital Counters
    - Flex States
    - Clock

Virtual Inputs // UTS: New Device ...

VIRTUAL INPUT	STATUS
Virt Ip 1 (VI 1)	On
Virt Ip 2 (VI 2)	On
Virt Ip 3 (VI 3)	Off
Virt Ip 4 (VI 4)	Off
Virt Ip 6 (VI 6)	Off

Contact Outputs // UTS: New Devi...

CONTACT OUTPUT	STATUS
Cont Op 1 (H1)	On (VOff, IOff)
Cont Op 2 (H2)	On (VOff, IOff)
Cont Op 3 (H3)	Off

Substation Automation

> Requirements

> Protective relay hardware

> Protective relay logic engine

> Relay to relay data communication

> Local/Bay control

> WAN

> SCADA

Nomenclature

LAN: Local area network

WAN: Wide Area Network

Nomenclature

Protocol: A common set of rules to govern the exchange of data between nodes on a network.

It determines:

- Initialization of data link
- Services that are supported
- flow control
- Frame format and sync
- error control

Messaging Services

- Provides "Common Services" for communicating information including notification of delivery or non-delivery of a message and the reason why not

- Types of services:
  - -Initiate Communications
  - -Identify
  - -Define Data
  - -Write Data
  - -Program Invocation
  - -Etc.

- Existing Standards: FMS, MMS, DNP, IEC

Manufacturing Message Specification (MMS)

- Internationally standardized messaging protocol for real time exchange of data and supervisory and control information between networked devices.

- ISO 9506 standard

- Independents from the application function being performed

- Independents from the developer of the device or application

- Generic to be appropriate for a wide variety of devices and applications:
  - PLC
  - Robot
  - Protective relay

  MMS services and messages are identical

- Based on the OSI model

MMS Service Specification

- Defines a set of objects that can exist within a device.
- Defines a set of communication services to access and manipulate those objects.
- Defines the behavior of the device to those communication services.

MMS Services

- Get Object
- Change Object
- Determine Attributes
- Create Object
- Delete Object

Basic Communication Relationships

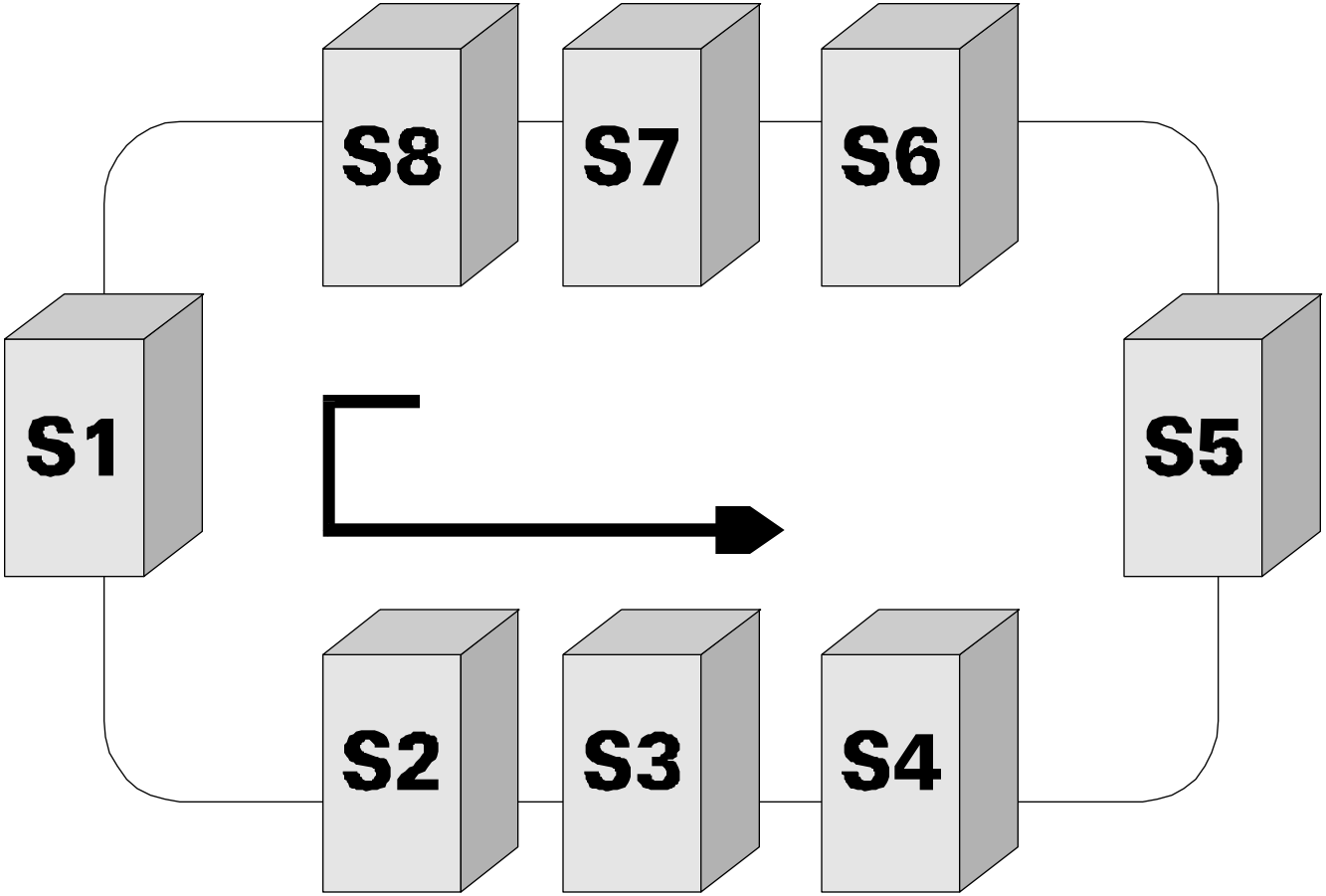
Peer to Peer

- Client / Server
- Publisher/ Subscriber

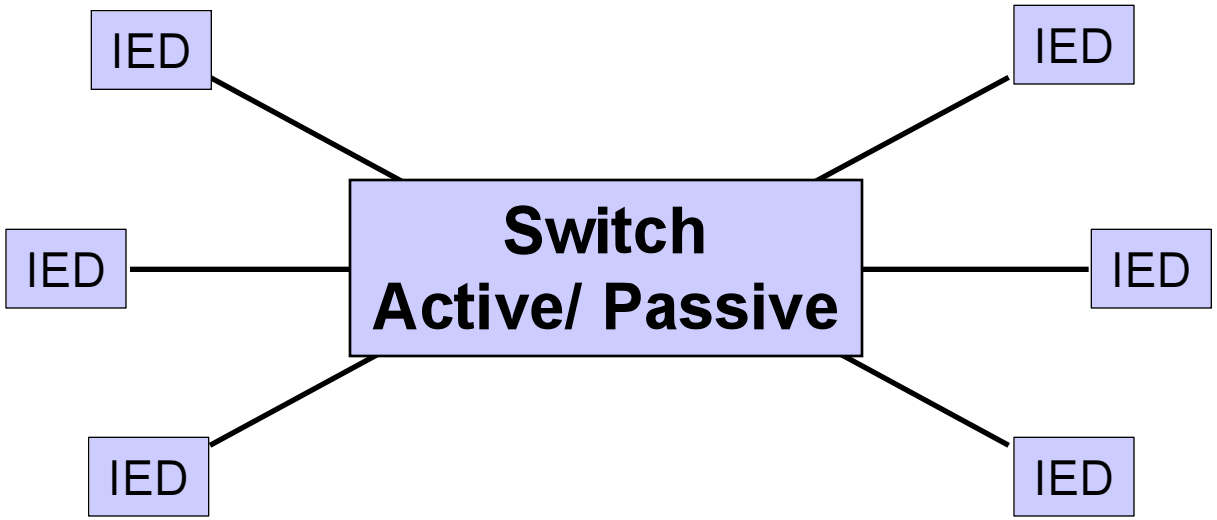
Master / Slave

- Request / Response
- Response Only

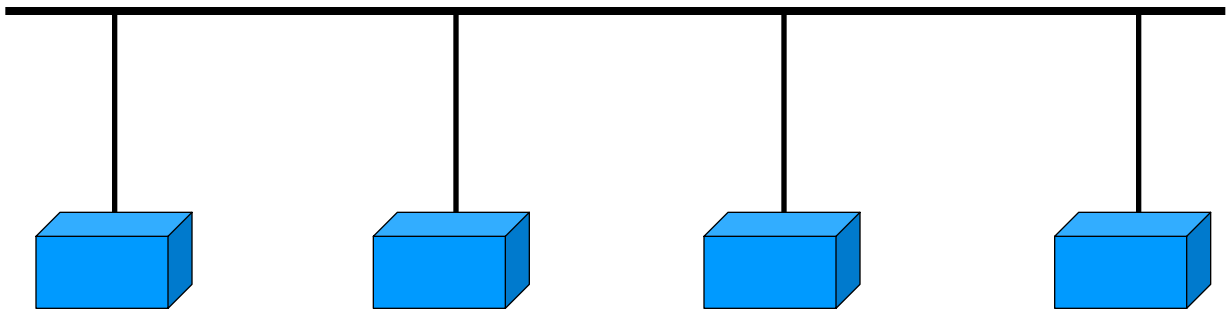
LAN Topology: Token RING



LAN Topology: STAR

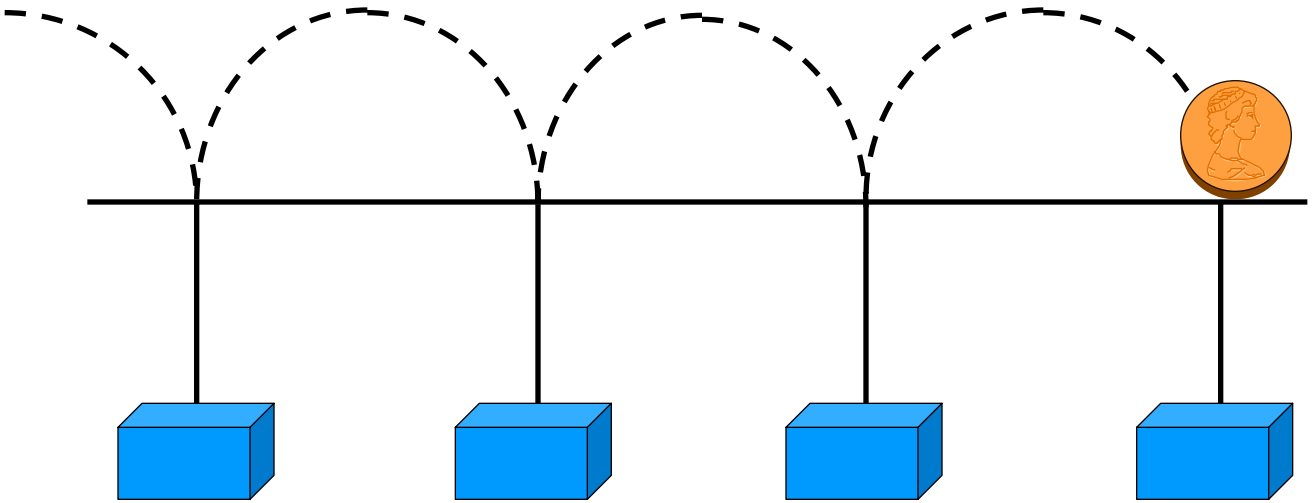


Architecture: Token Bus

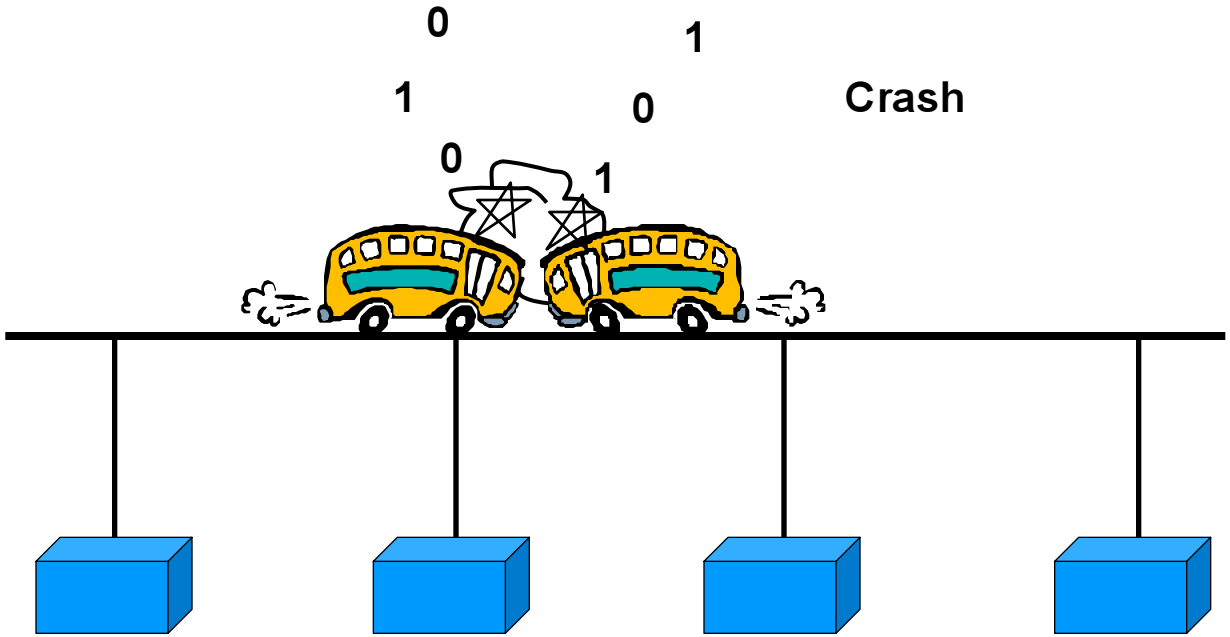


- **TOKEN to gain access to LAN**

LAN Access: Token



LAN Access: CSMA/CA

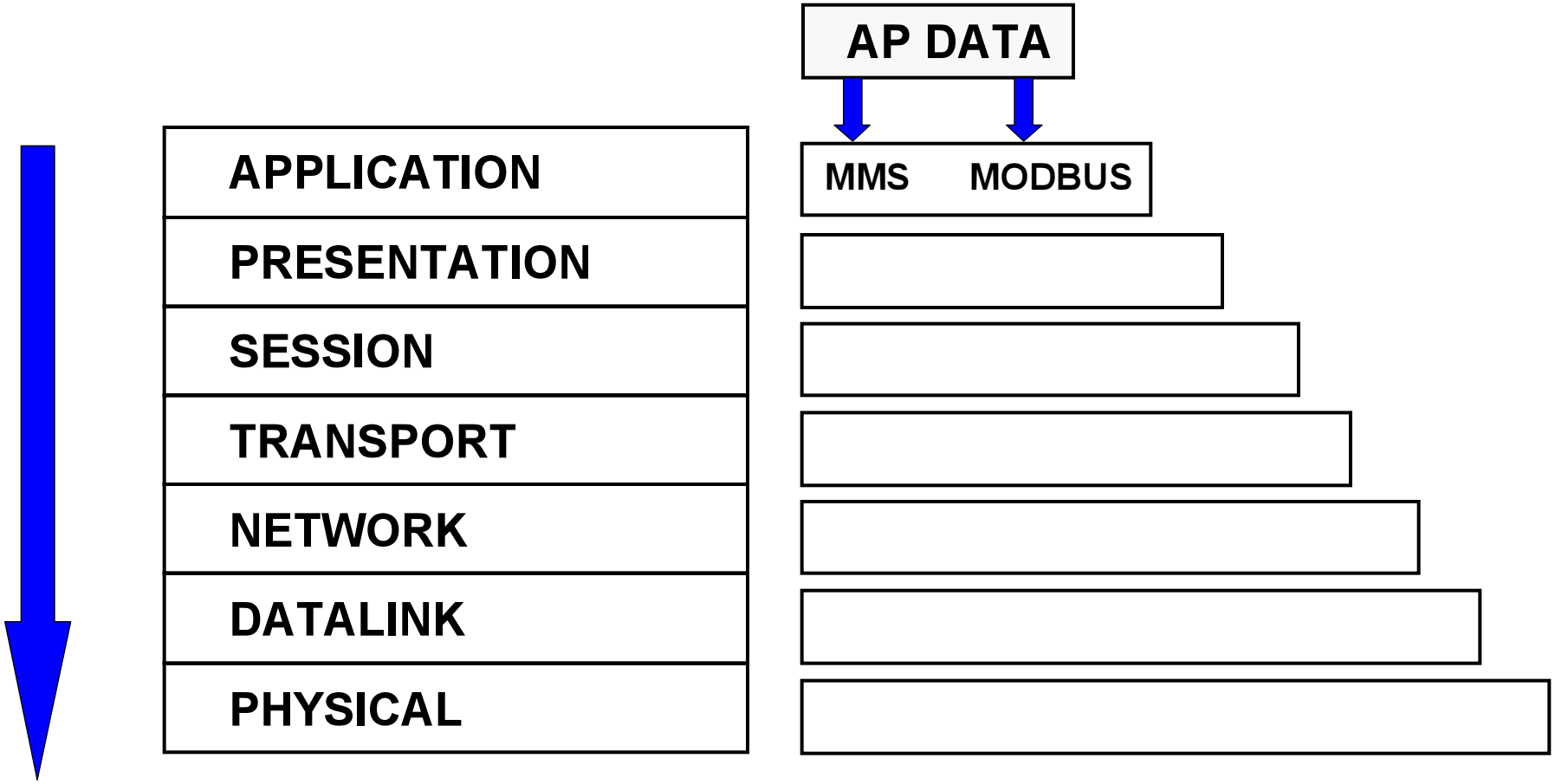


- CSMA / CA
- Carrier science multiple access with crash detection

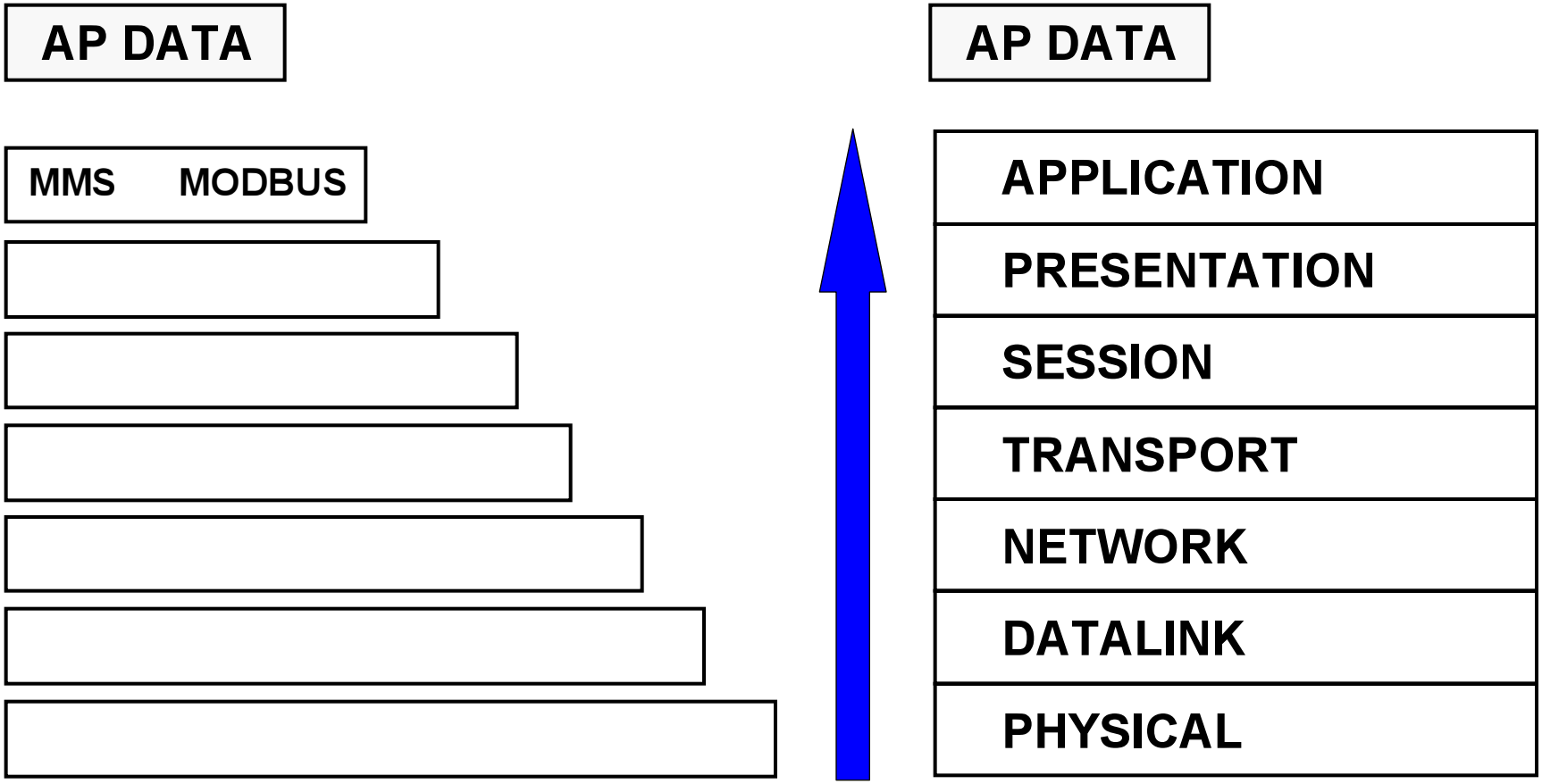
Communications: OSI Model

APPLICATION
PRESENTATION
SESSION
TRANSPORT
NETWORK
DATALINK
PHYSICAL

Communications: OSI Model



Communications: OSI Model



Utility Communication Architecture (UCA) and Substation Automation

Utility Communications Architecture Version 2

Objective:

- Establish a suite of protocols to meet utility communications needs

Participating UCA Vendors

- GE Power Management
- Basler
- Cooper
- Beckwith
- Tasnet
- SEL
- GE Harris
- Siemens (HMI)
- L&G
- Doble
- Dranetz / BMI
- Modicon / Square D
- ABB
- Alston

Utilities Participating in UCA

- American Electric Power (AEP)
- Indianapolis Power & Light
- Ontario Hydro
- Northern States Power
- Tampa Electric
- ComEd
- Cinergy
- Baltimore Gas & Electric
- GPU
- Nuon
- Enetergy
- TVA
- Duke
- Boston Edison
- Union Electric
- Florida Power Corp
- Southern California Electric
- Wisconsin Electric
- ESKOM
- Polish Power Grid

UCA 2.0 is defined by a set of Documents

- Introduction
- Communication Profiles
  - TCP/IP
  - OSI
  - Serial
- CASM

  Common Application Service Models

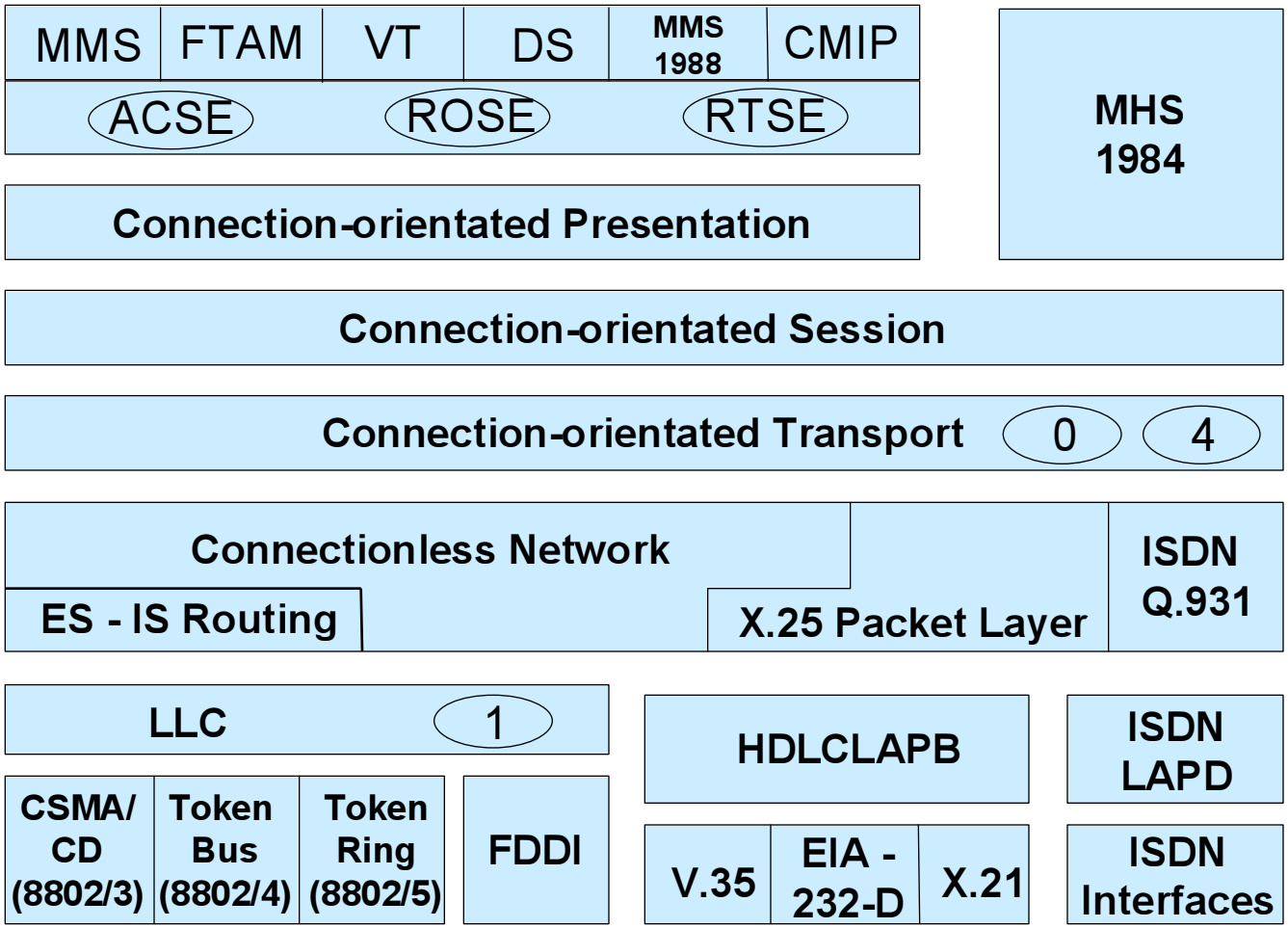
  How MMS Services are used (MMS = Manufacturing Message Specification)
- GOMSFE

  Generic Object Models for Substation and Feeder Equipment

UCA Features

- Client/Server Multiple Connections
- Common Data Objects that can be extended by each vendor
- File Services
- Time Sync
- Reporting
- GOOSE (*Generic Object Oriented Substation Event)*
- Peer to Peer Communication (Remote I/O is a cast message)

7-LAYER UCA MODEL



UCA Data Access (Name - based)

Data Object Class	Functional Component	Data Item	Attributes r/w m/o
IOC	ST		
	SG	Pu	
		PuDelTim	
		DoDelTim	
	CO		
	CF		
	DC		

To access the Phases IOC 1 Pickup
Read PhsIOC1.SG.Pu

GOMSFE

Generic Object Models for Substation and Feeder Equipment

Models defined for:

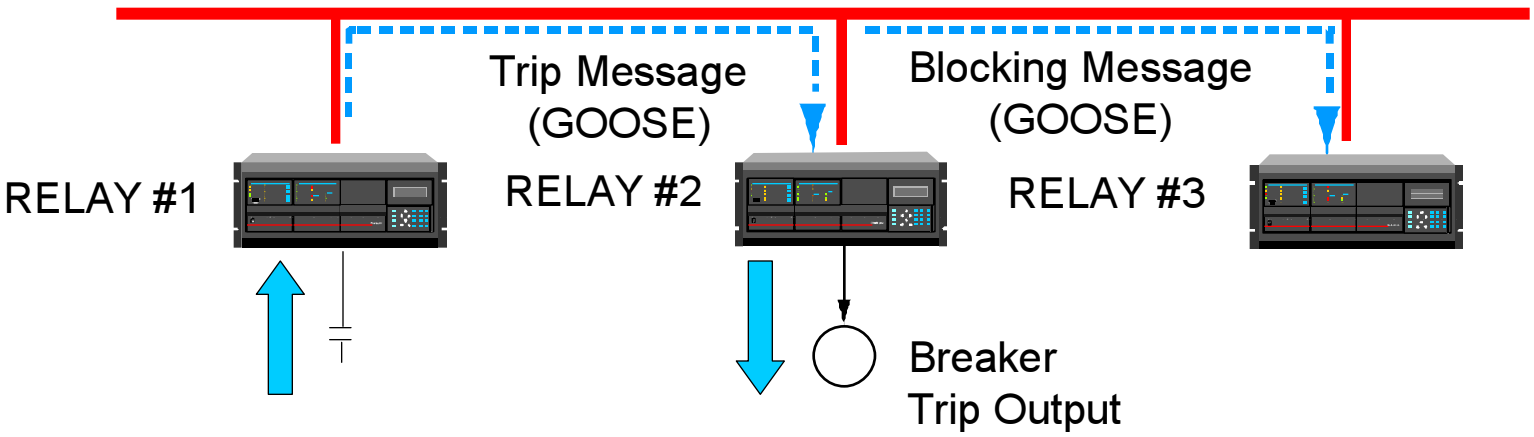
Protection Elements
- P IOC
- PTOC
- PDIS
- RSYN
- etc.

Metering - PXMU

Generic Analog/Digital I/O

etc.

UCA 2.0 GOOSE MESSAGE

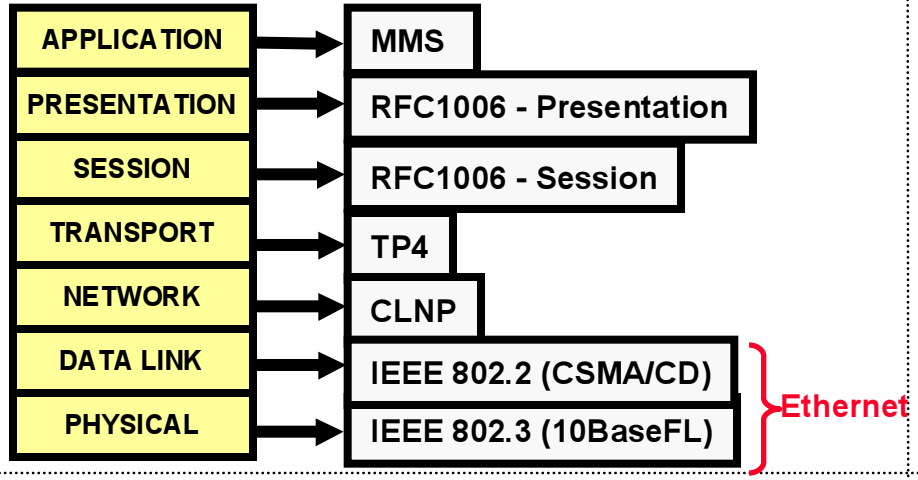


External Trip Delay: **Input delay (4ms at present)**
+
Tx/Rx and processing (Typically < 4ms at present)
+
Output delay (0.6 ms for Fast Form C)

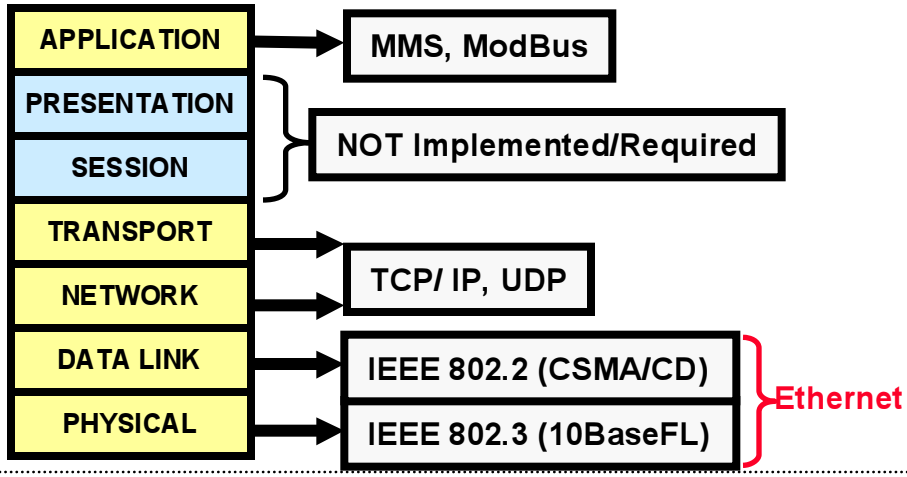
= 8.6 ms

UR Communications Profiles

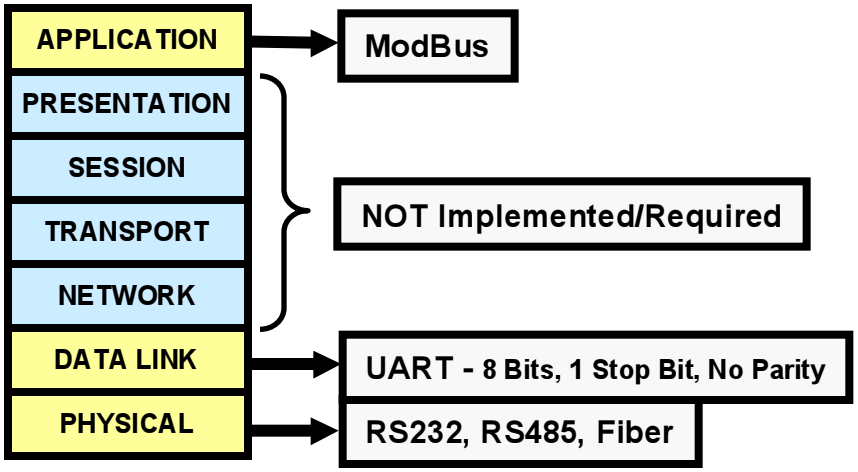
UCA 2.0 (MMS/Ethernet)



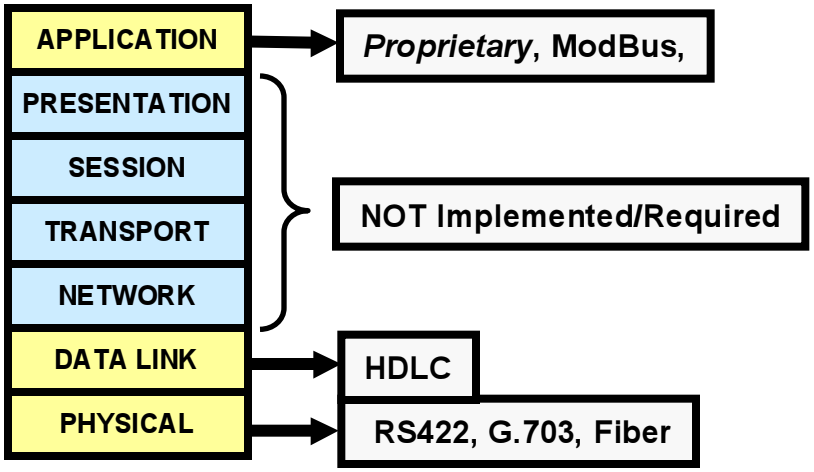
Modbus/TCP/IP/Ethernet



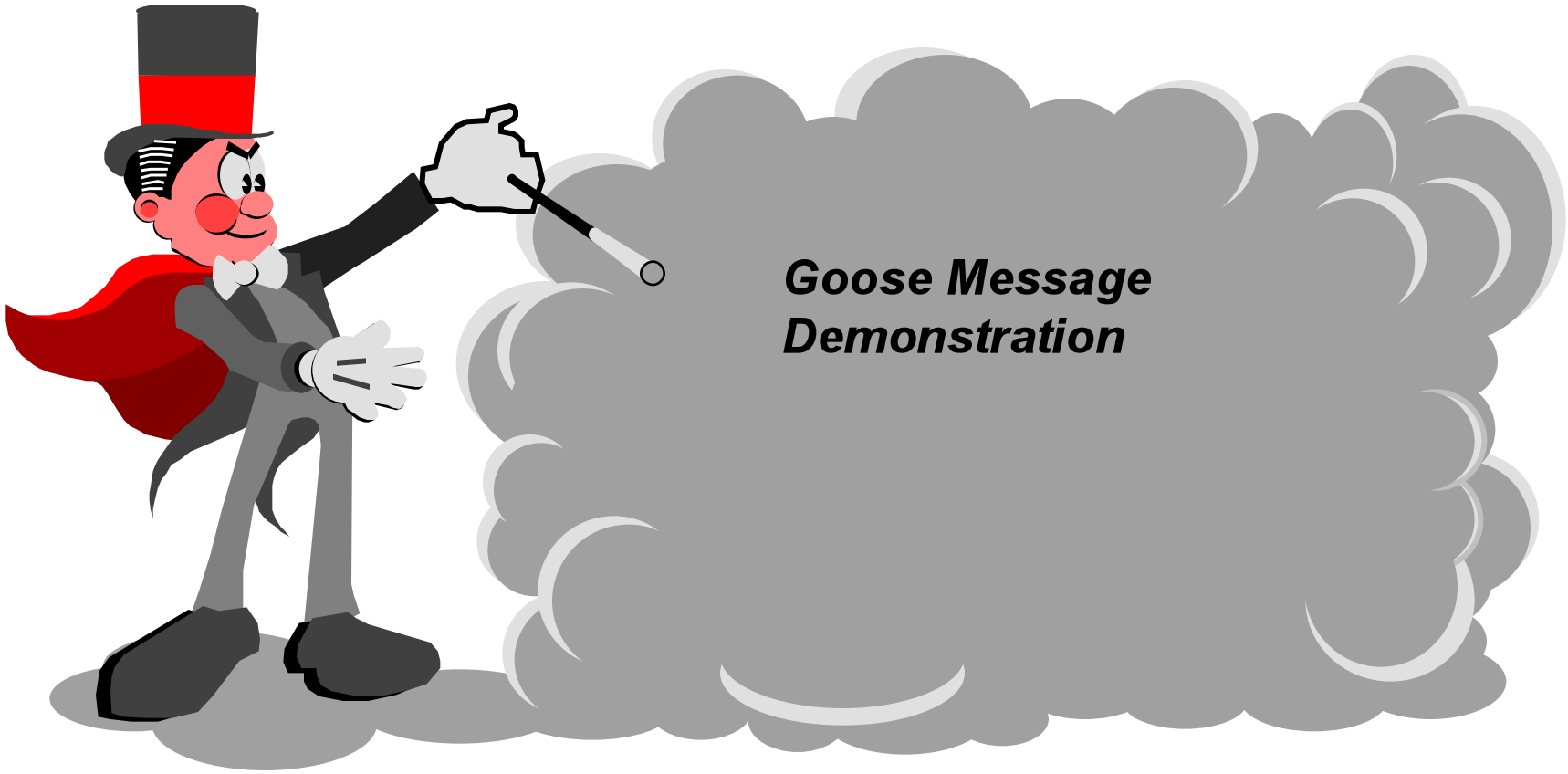
Modbus/UART/(RS485, RS232, Fiber)



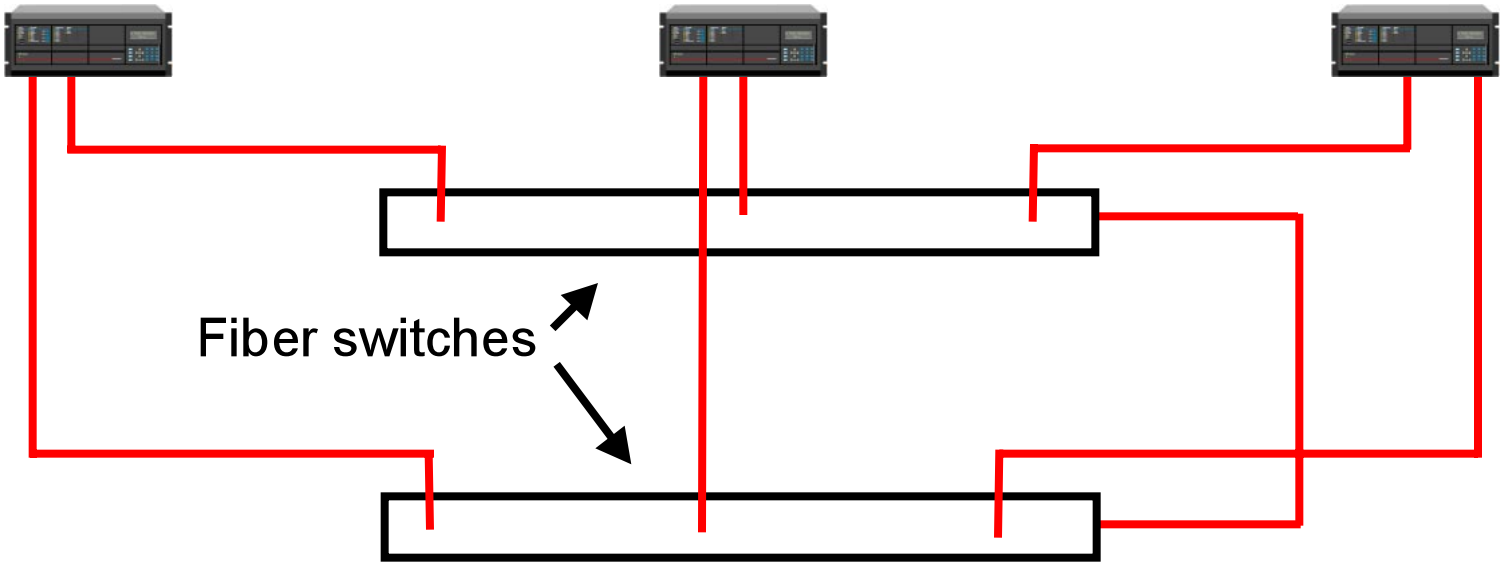
Telecom: DS0 (64kbps), T1, E1



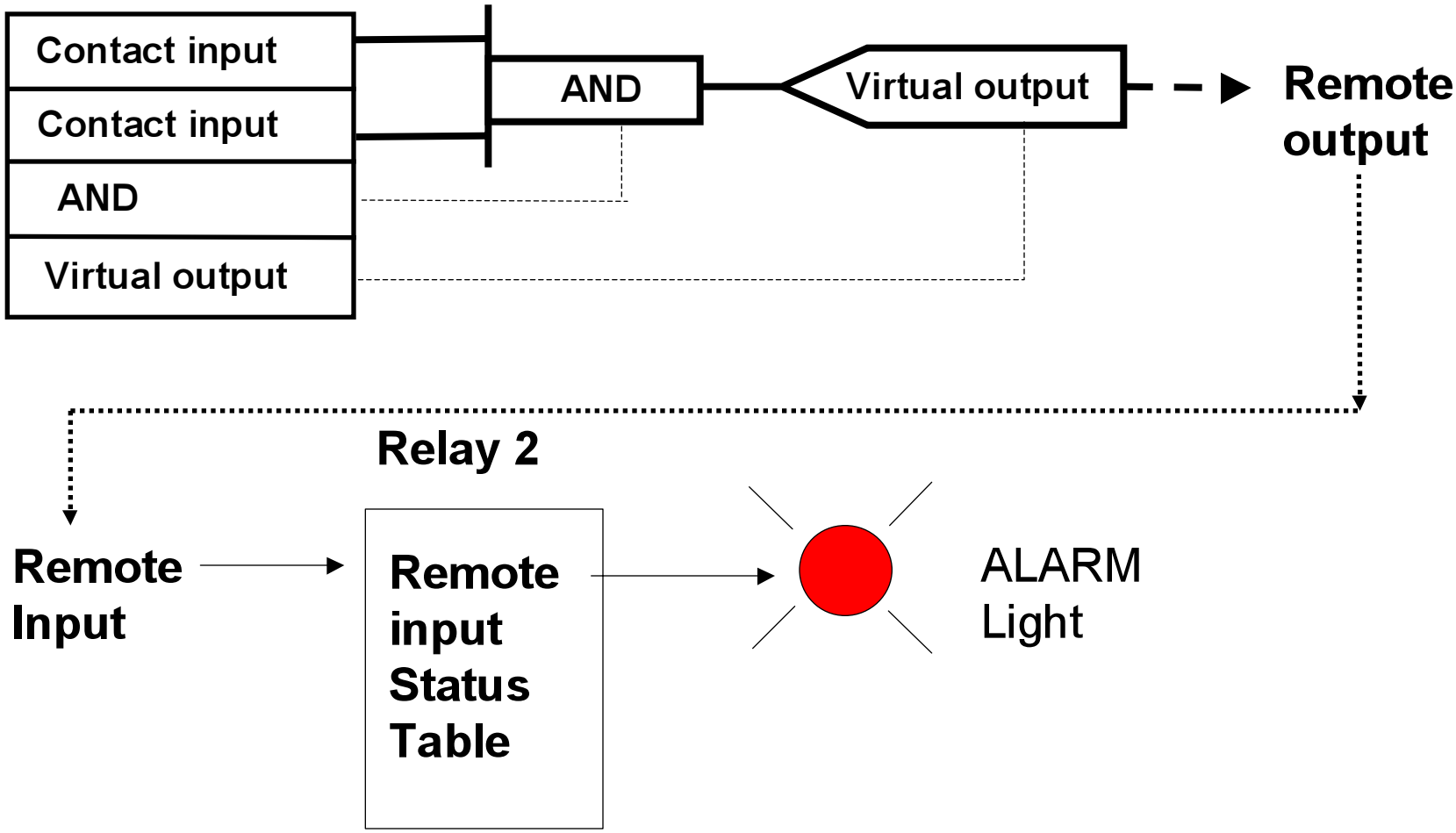
Goose Message Demonstration:



Redundant 10 Base F Bay LAN Topology



FlexLogic: Relay 1



Substation Automation

> Requirements

> Protective relay hardware

> Protective relay logic engine

> Relay to relay data communication

> Local/Bay Control

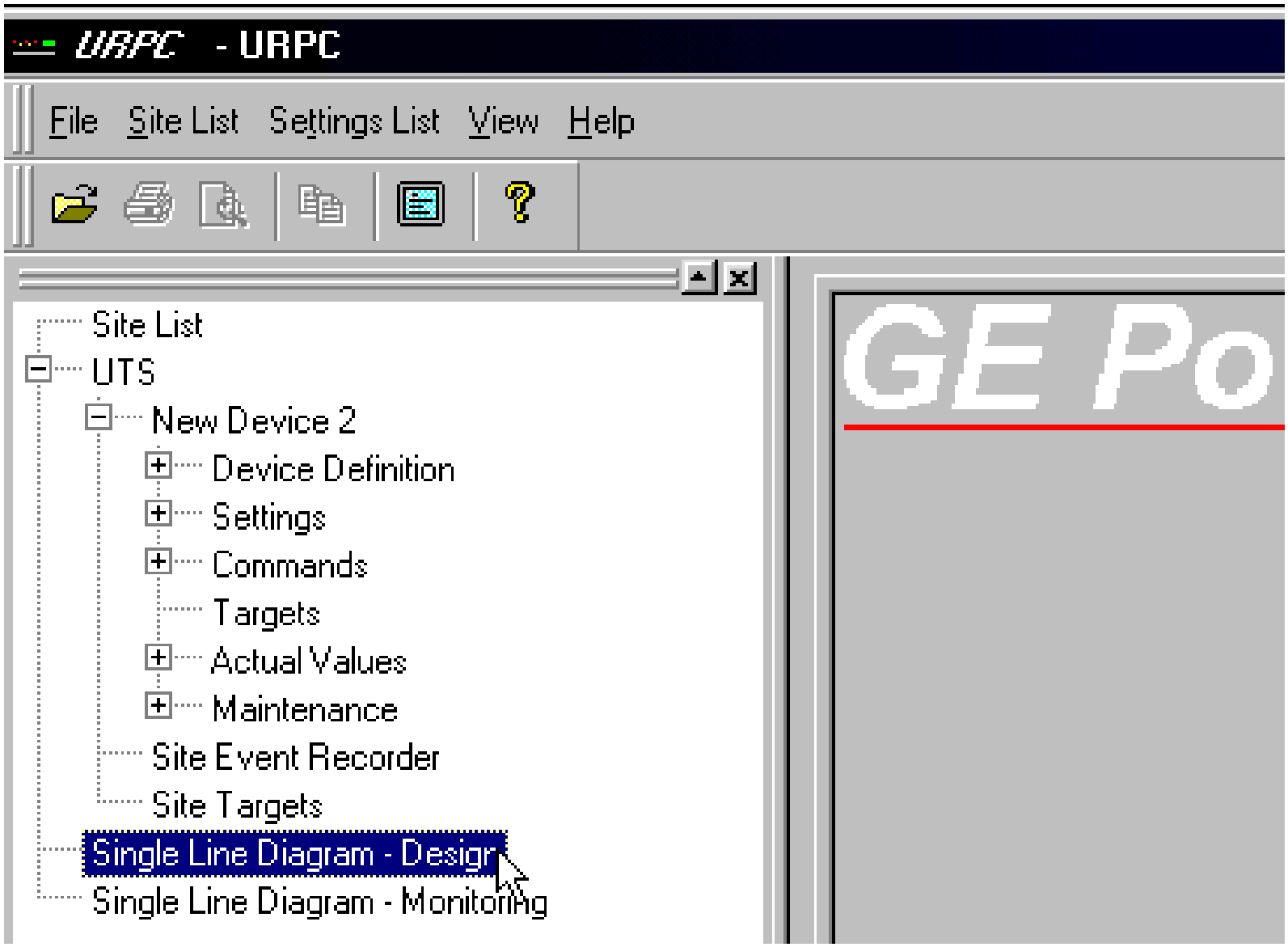
> WAN

> SCADA

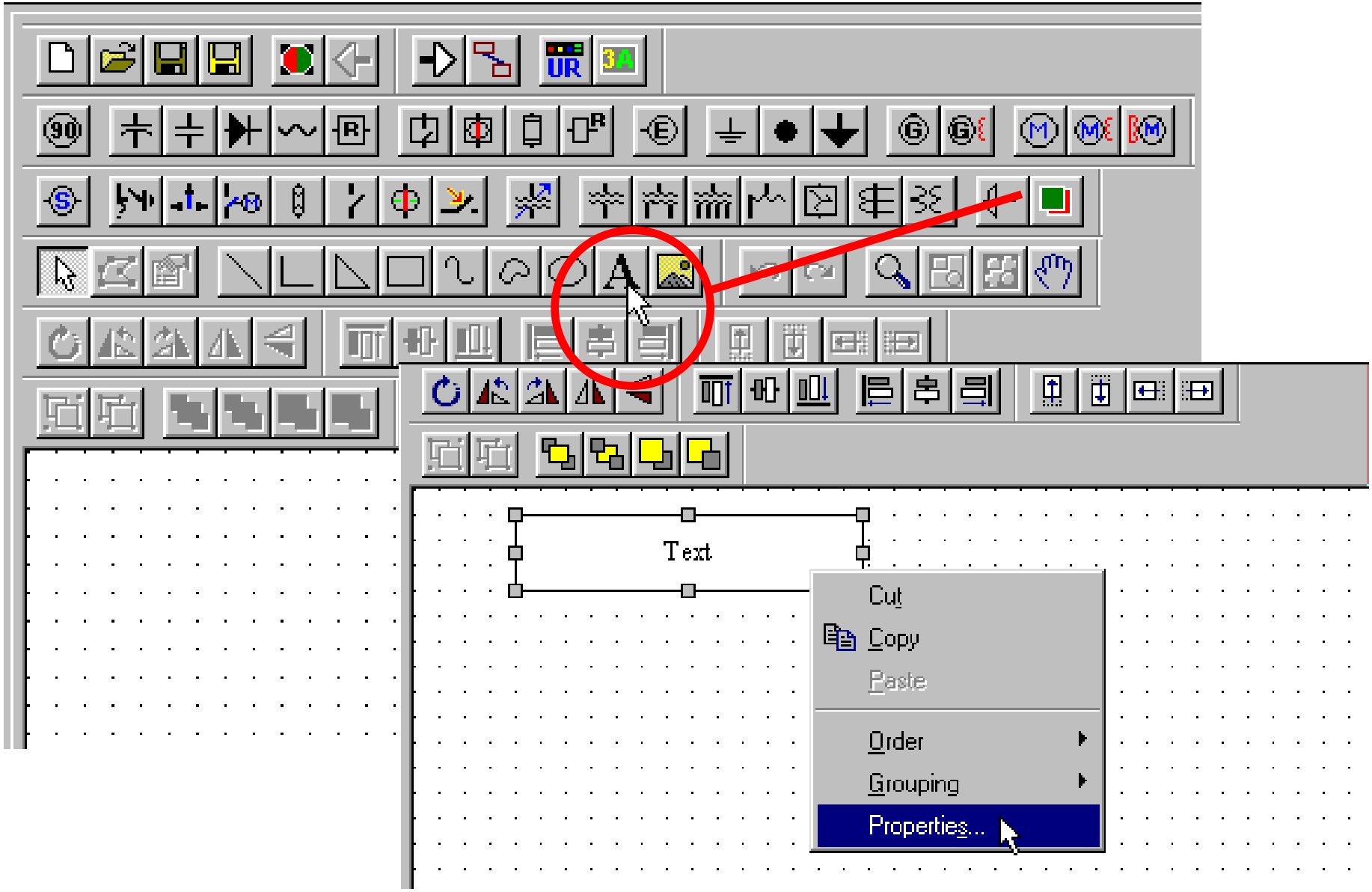
Universal Relay Human Machine Interface - HMI

HMI Demonstration:

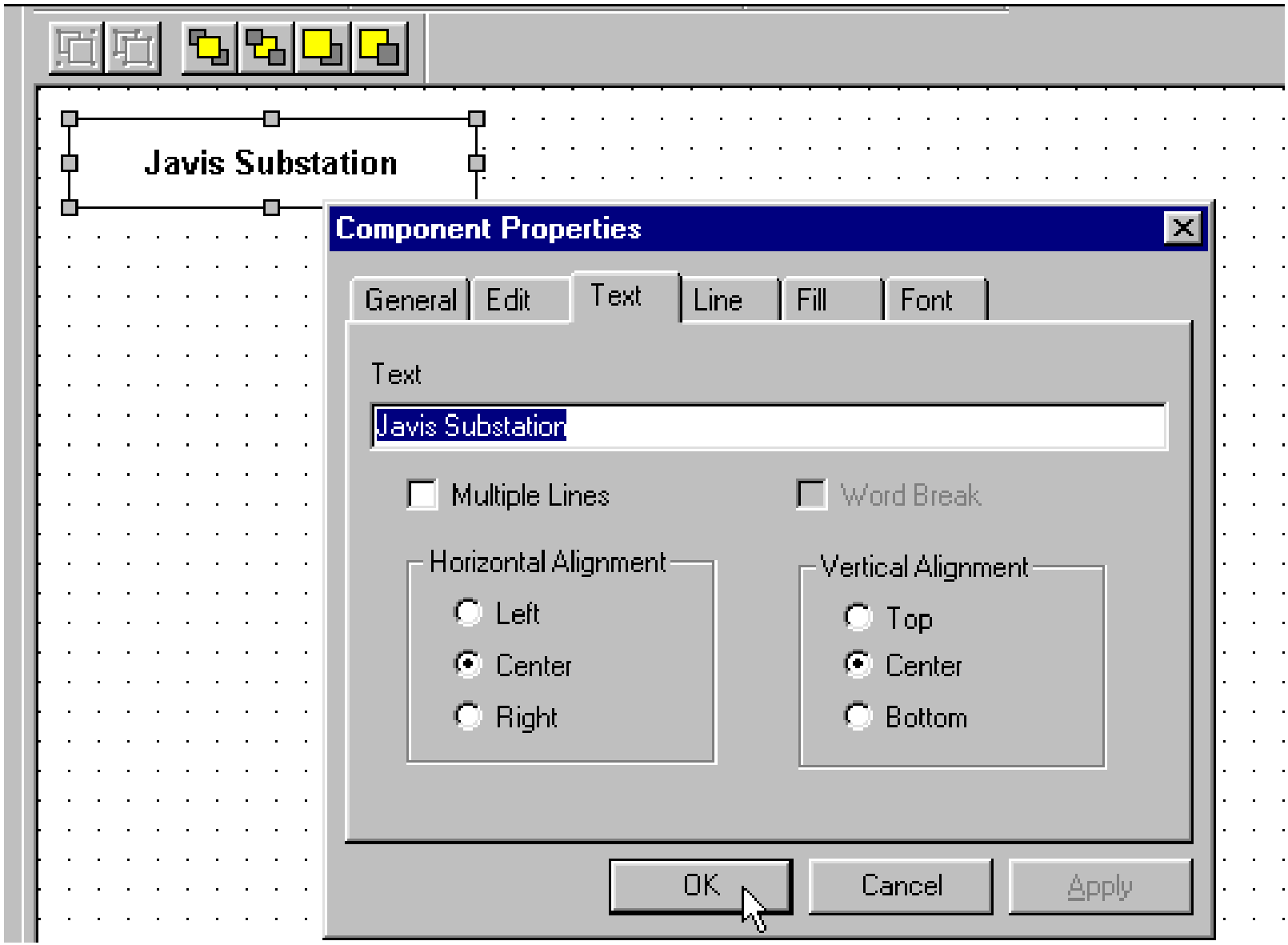
- Static Text and Graphics
- Importing bit maps
- Change screens
- Analog signal monitoring
- Push buttons
- Lamps


URPC - URPC
File Site List Settings List View Help
Site List
UTS
New Device 2
Device Definition
Settings
Commands
Targets
Actual Values
Maintenance
Site Event Recorder
Site Targets
Single Line Diagram - Design
Single Line Diagram - Monitoring
GE Po

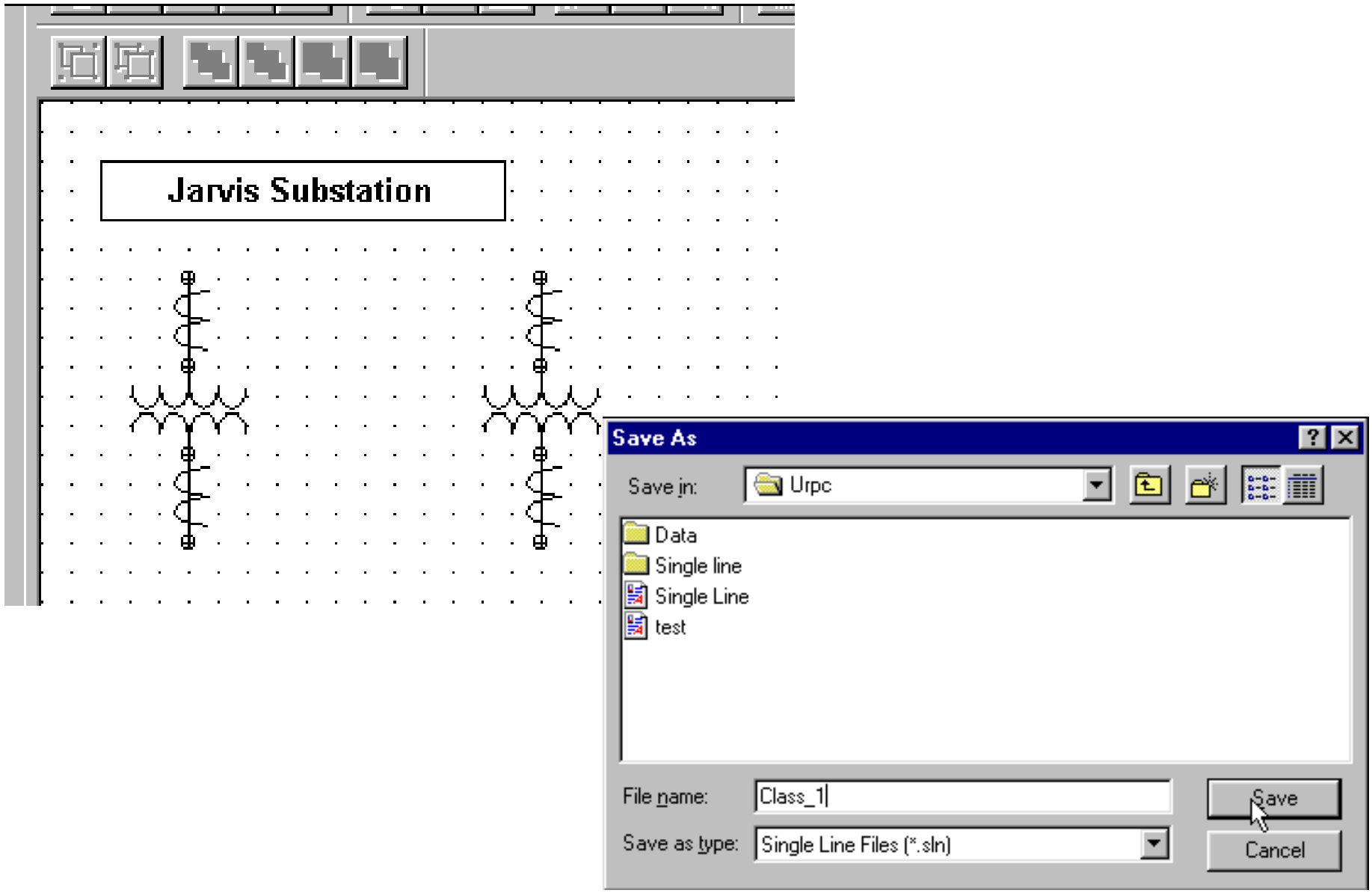
Static text and graphics



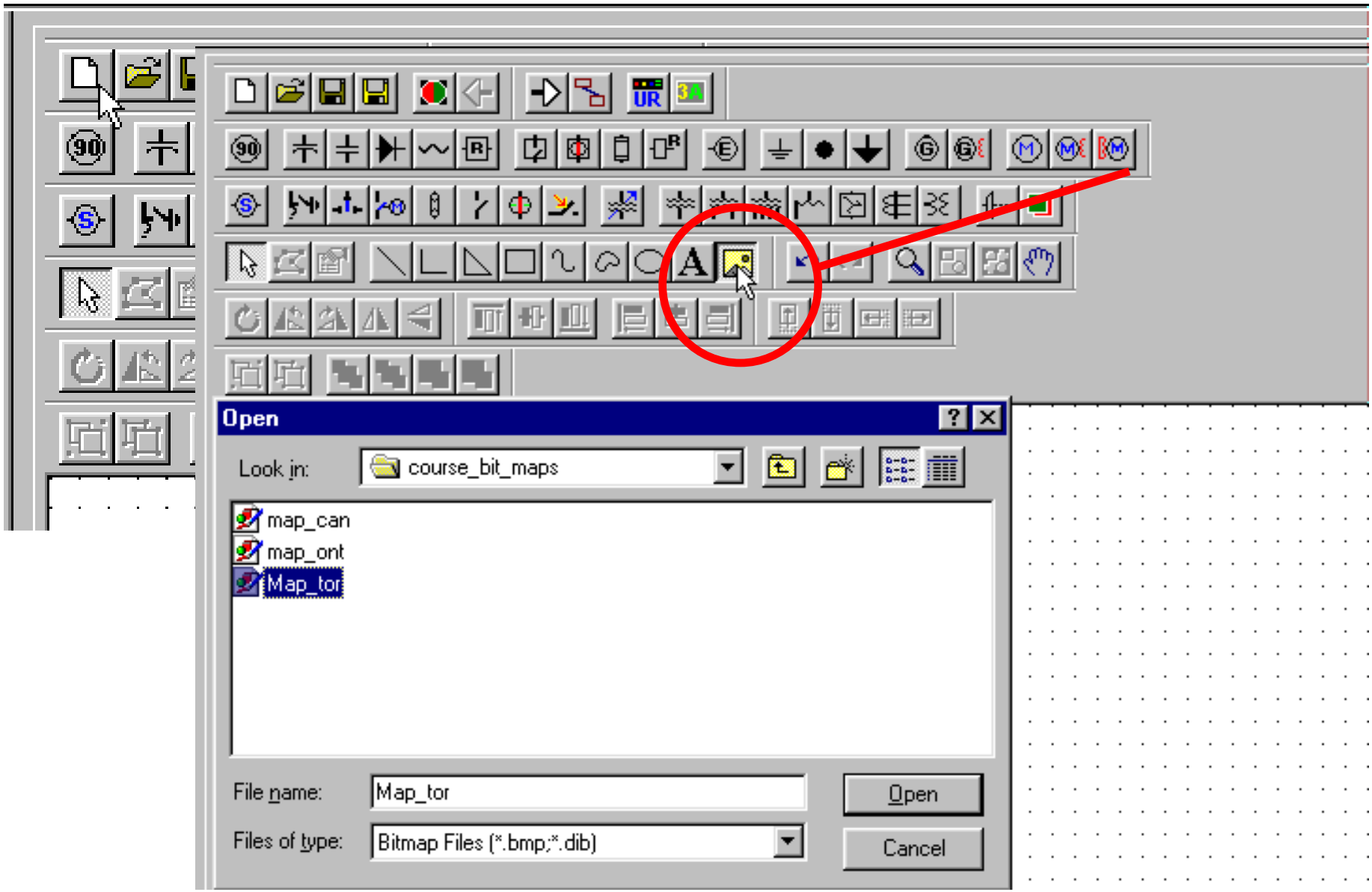
Static text and graphics



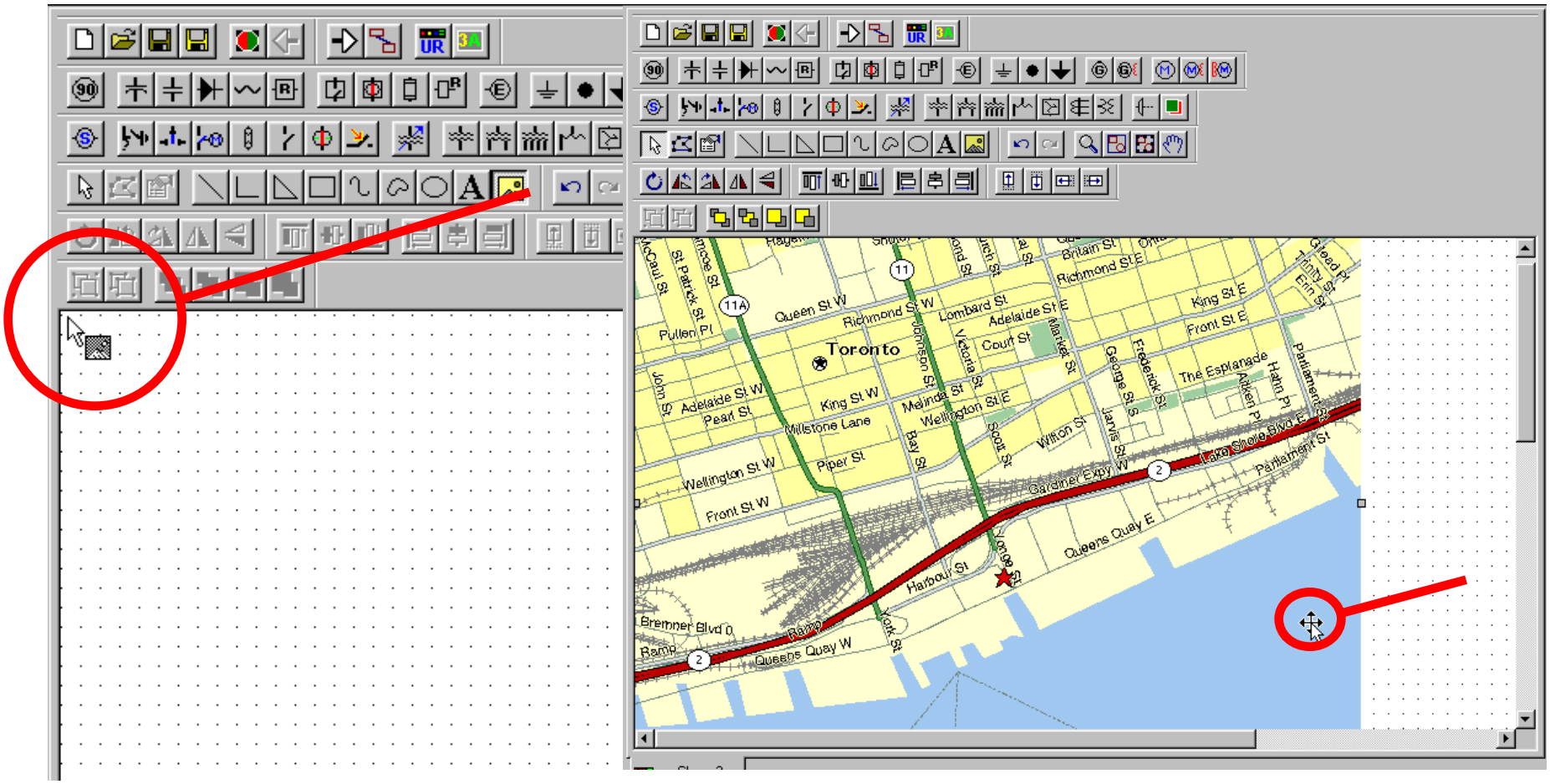
Static text and graphics



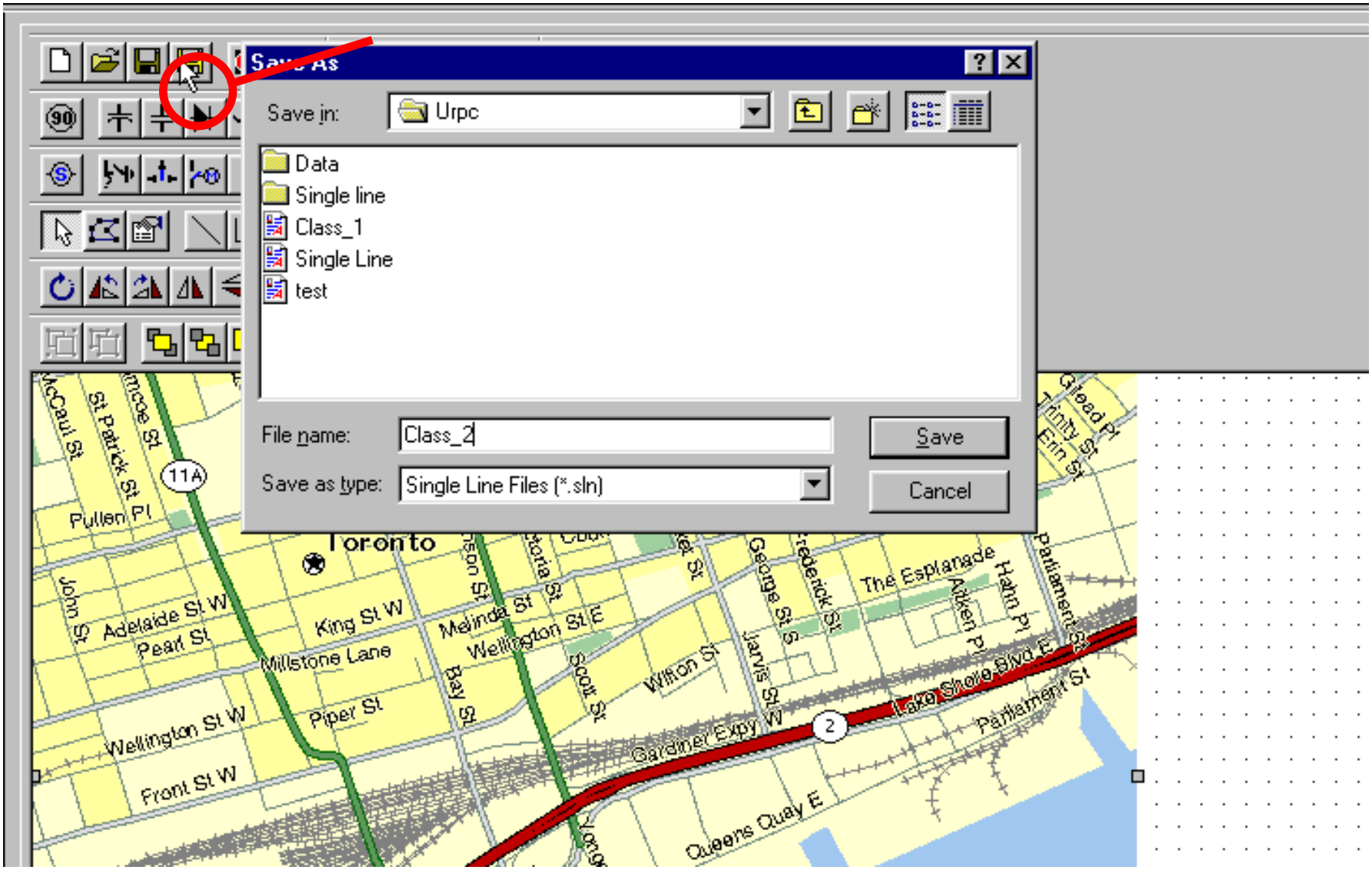
Importing bit maps



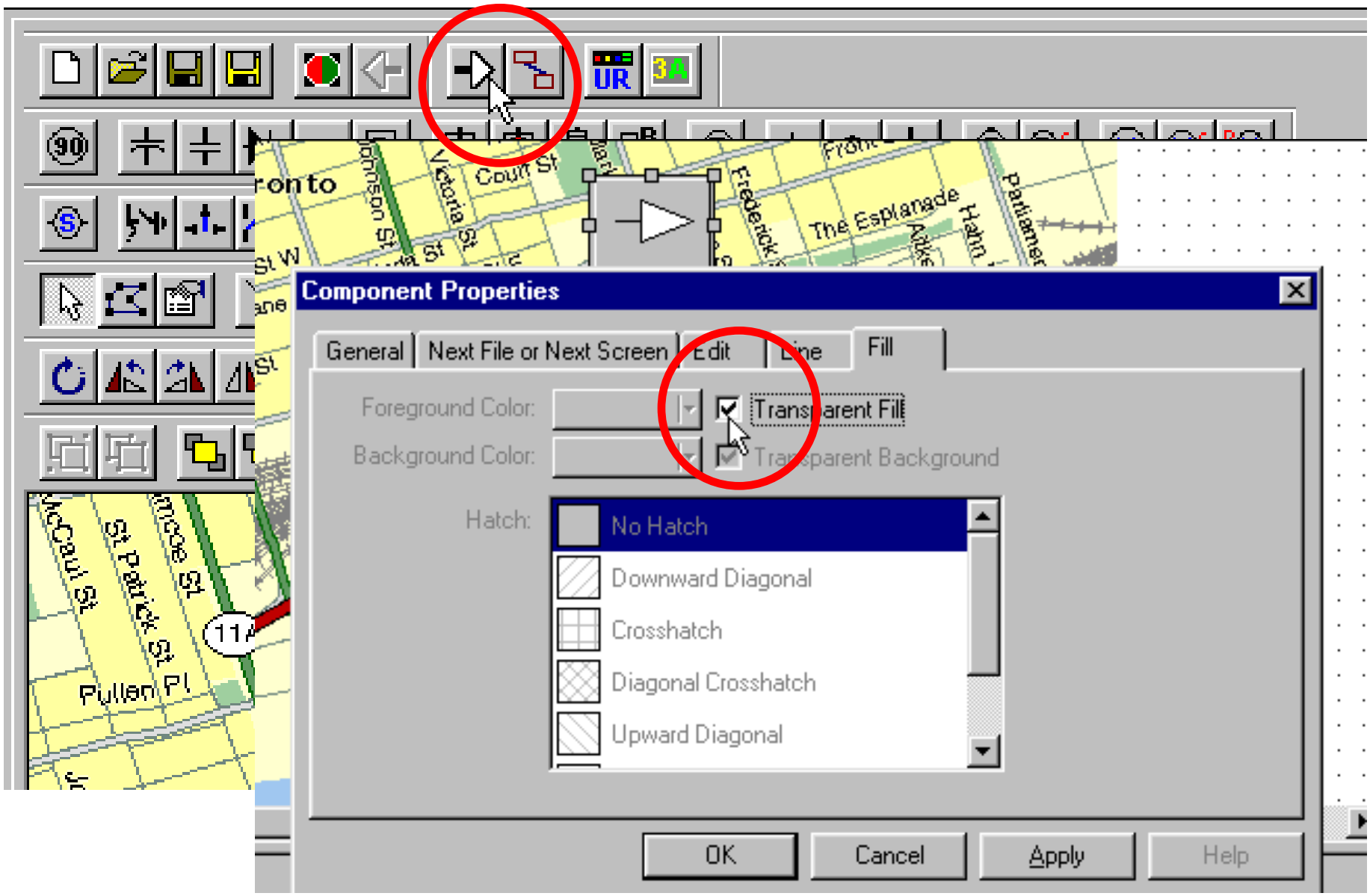
Importing bit maps



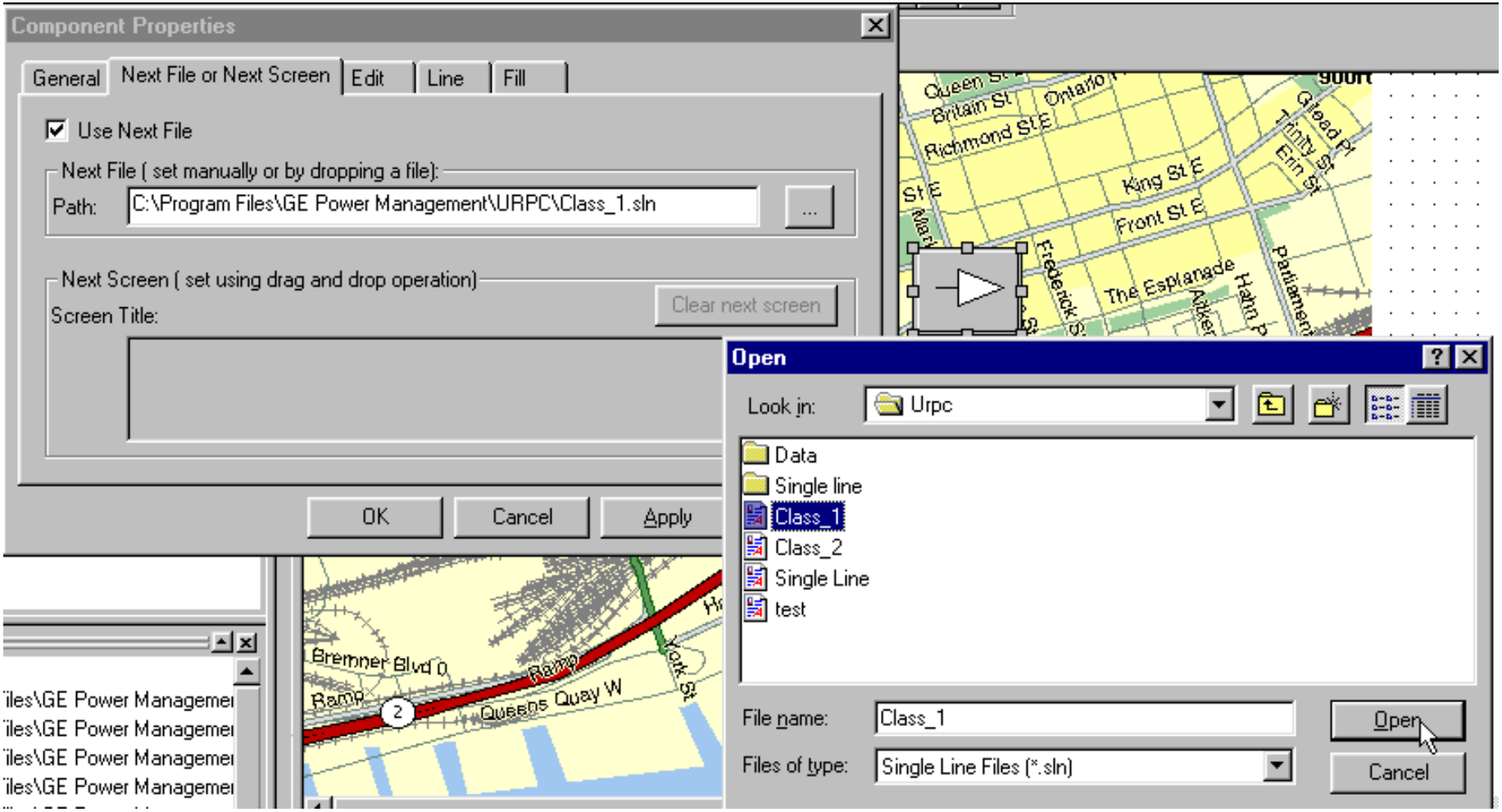
Importing bit maps



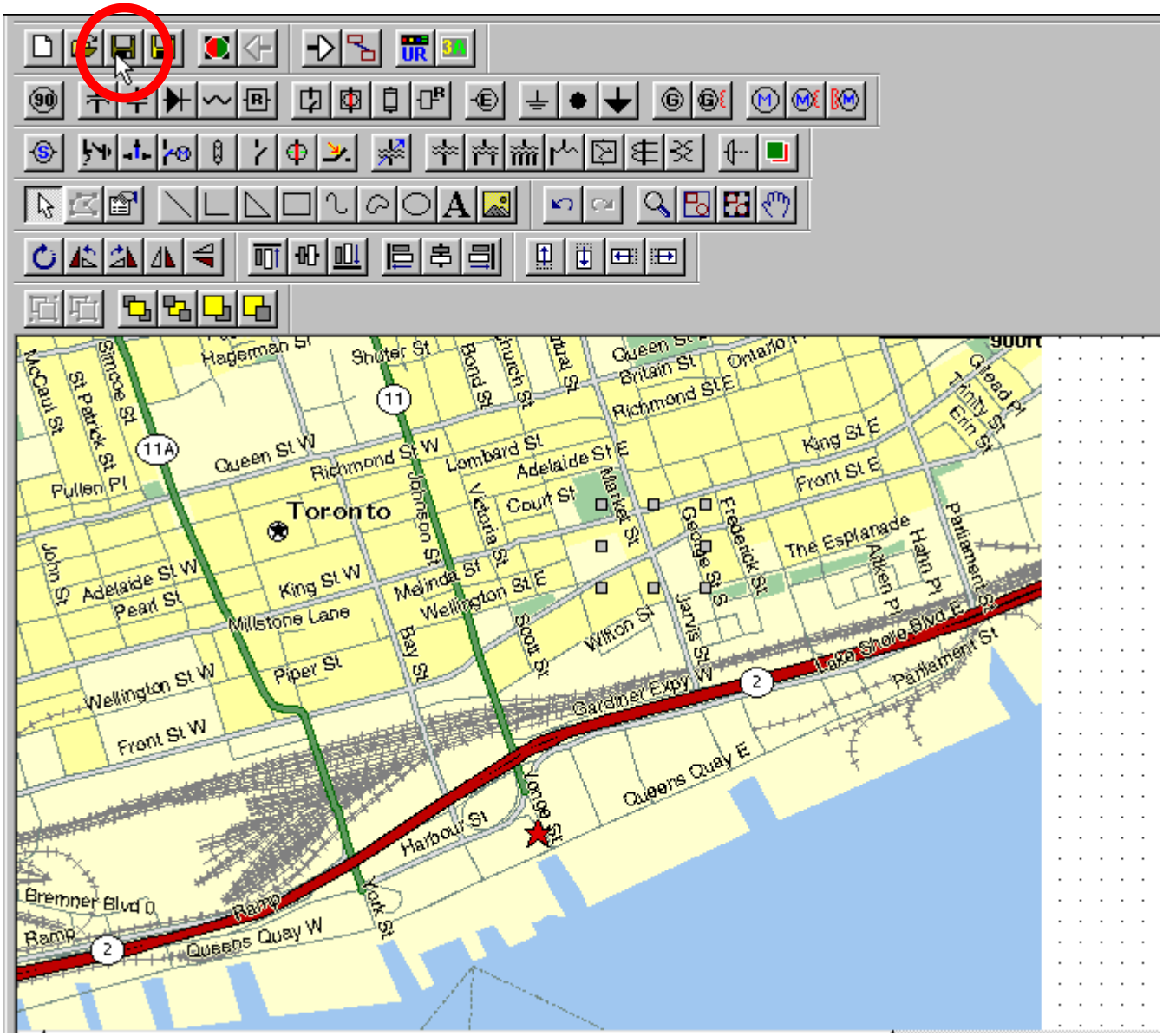
Change Screens



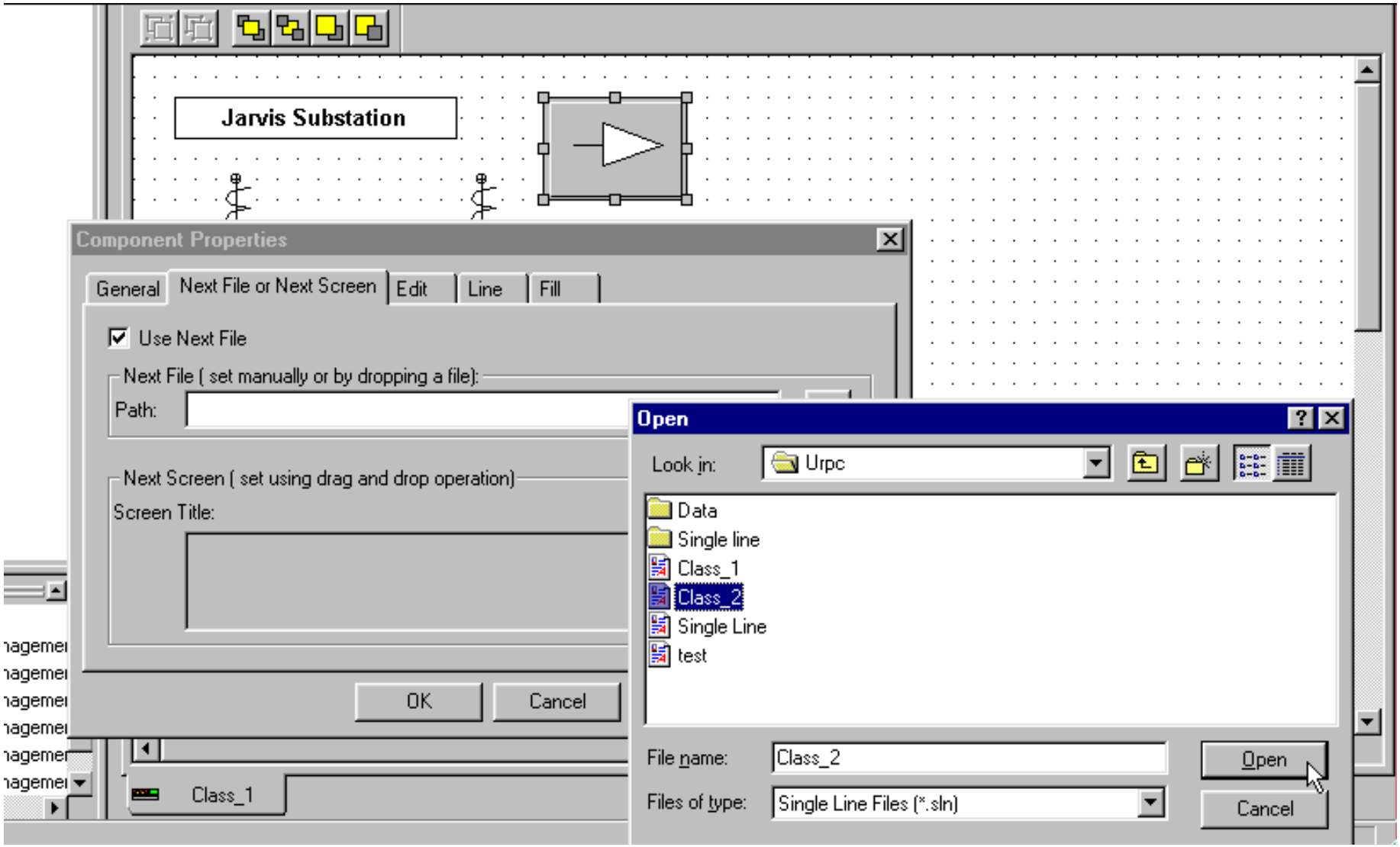
Change Screens



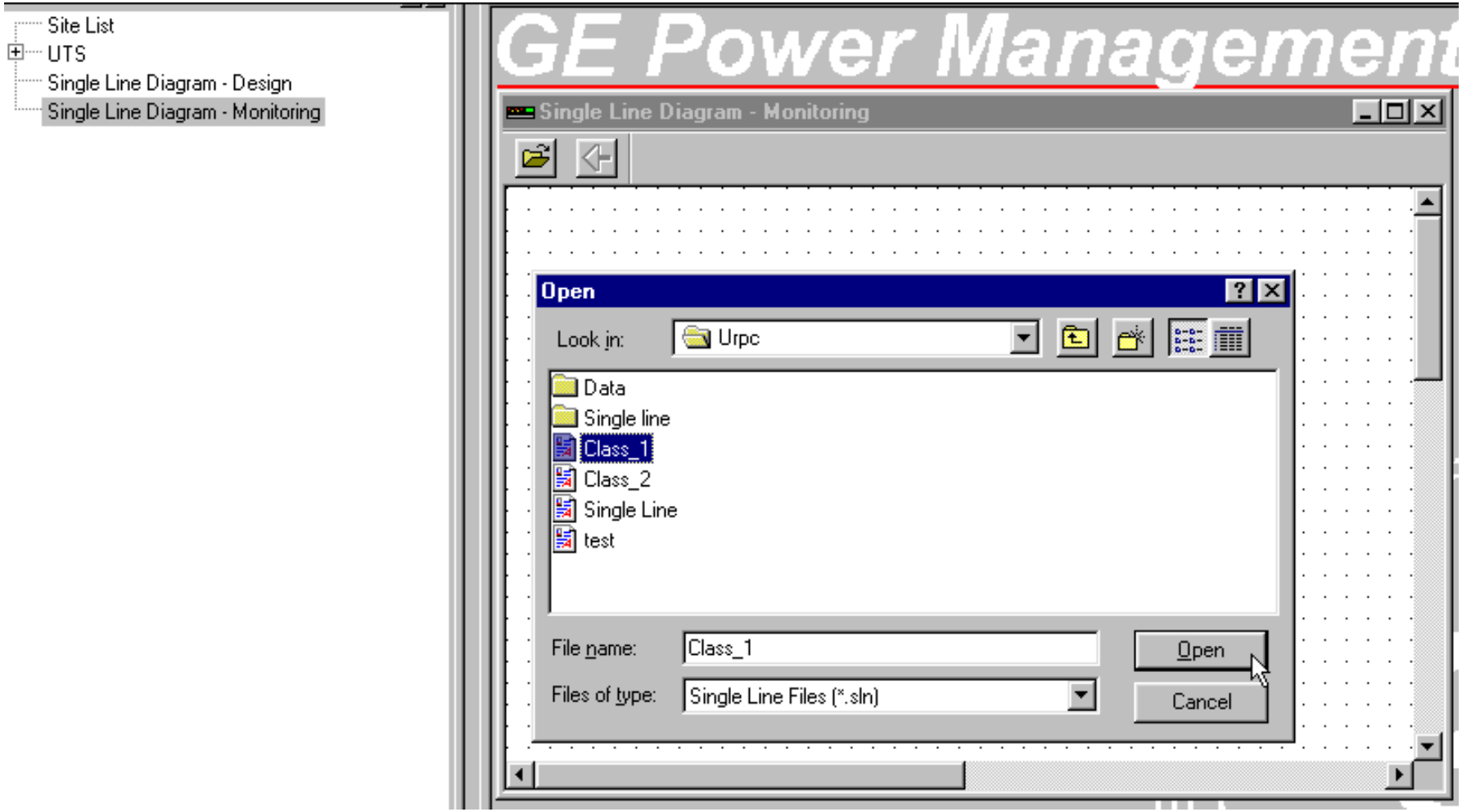
Change Screens



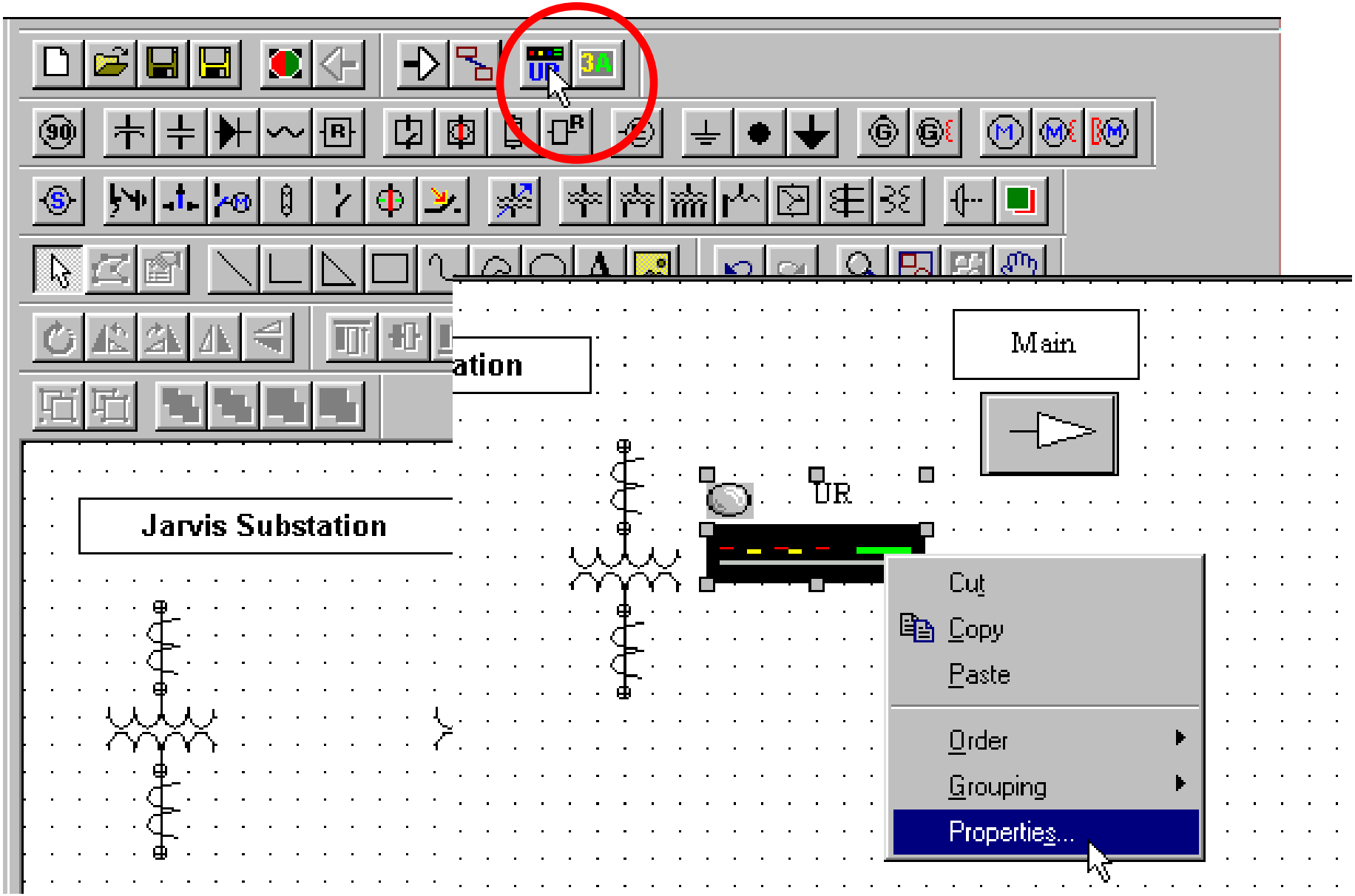
Change Screens



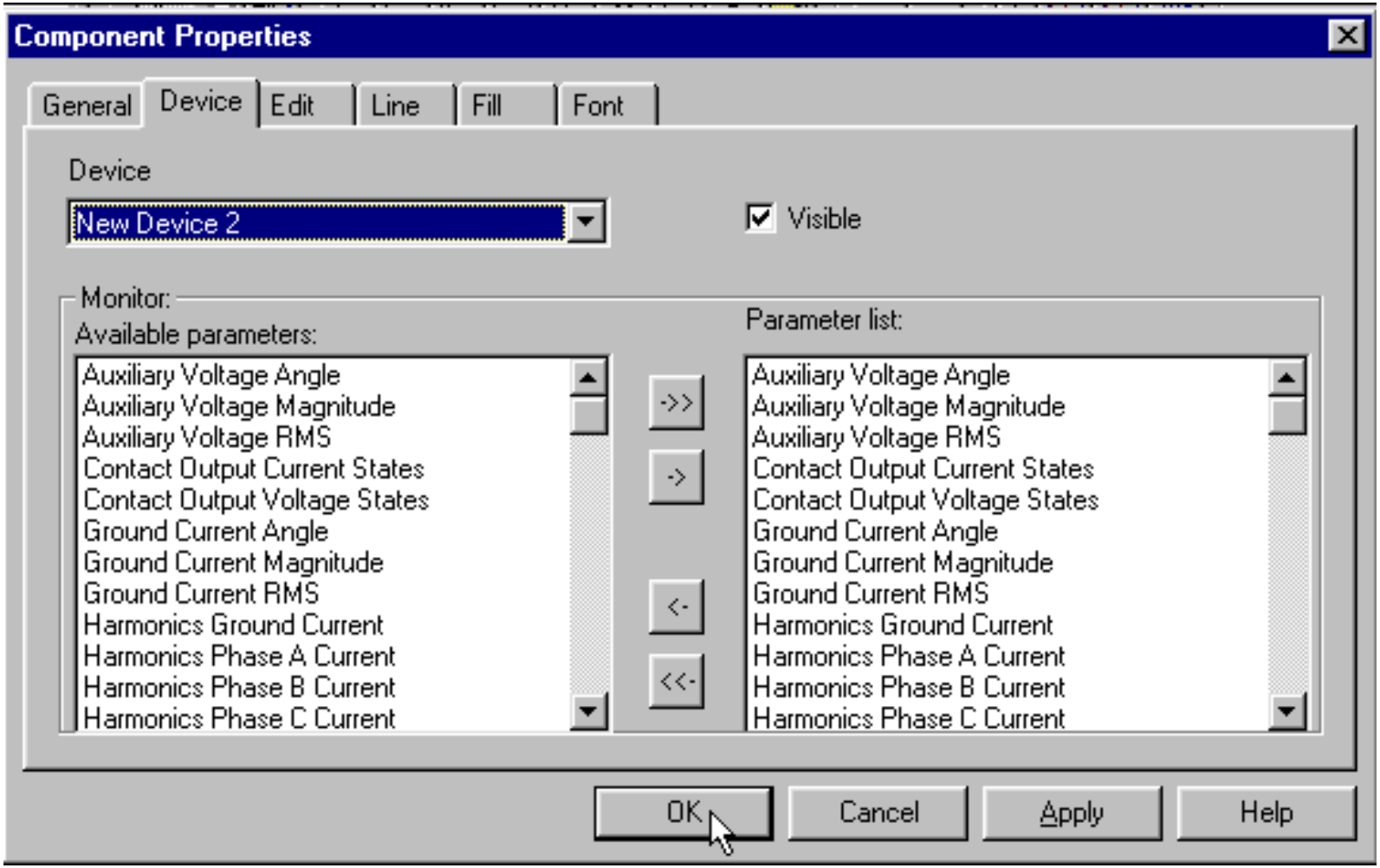
Change Screens



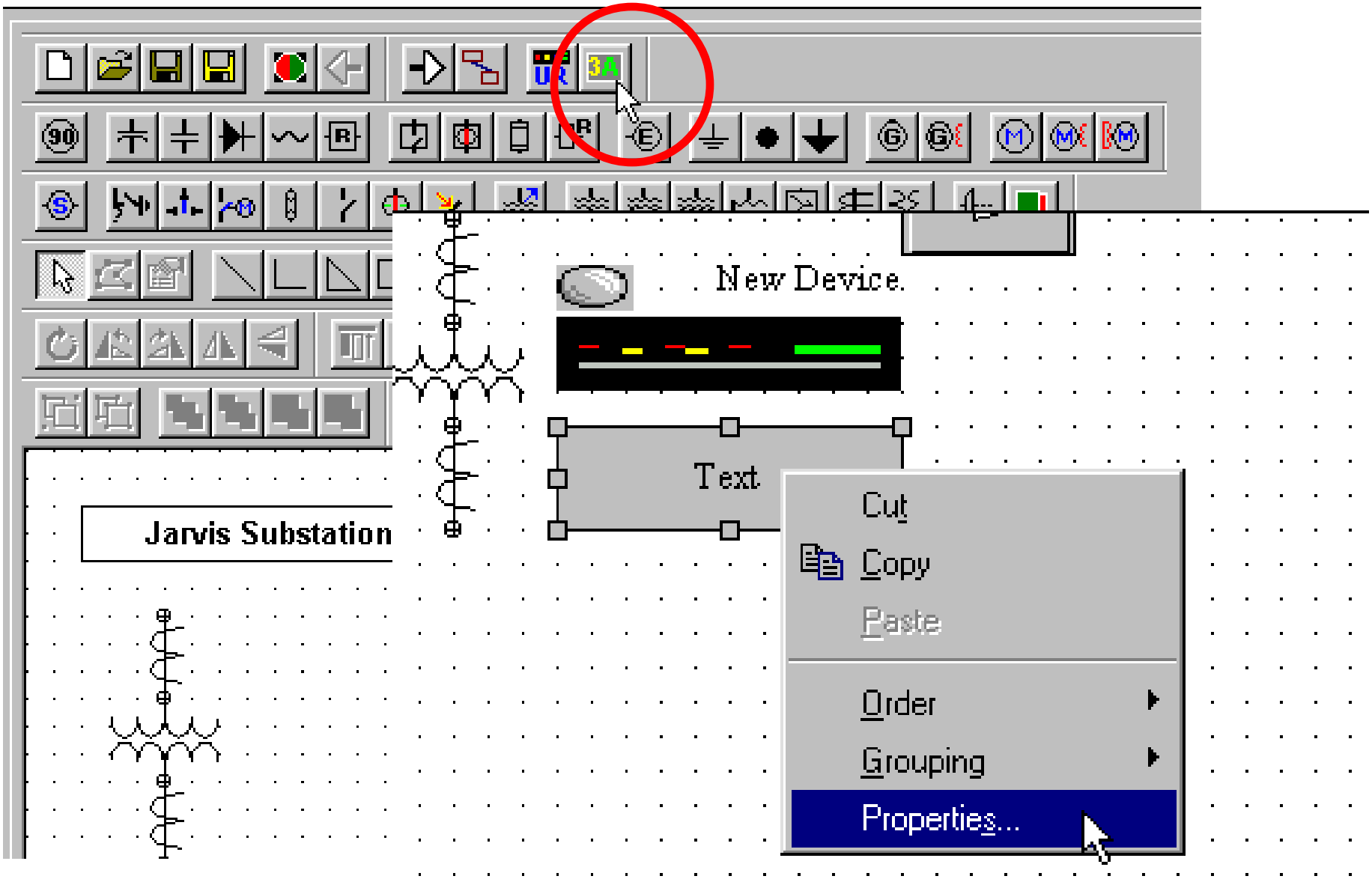
Inserting a Relay



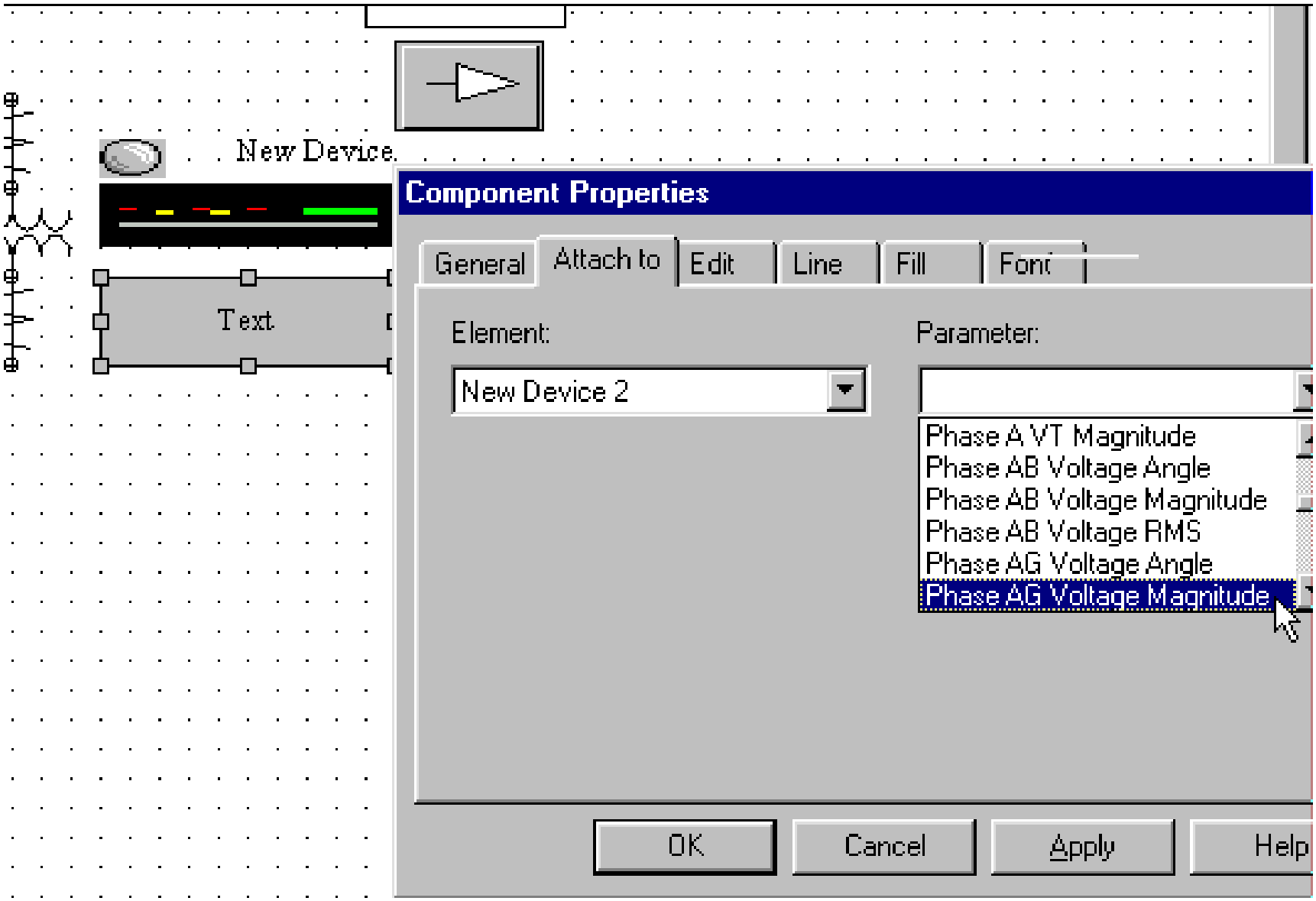
Inserting a Relay



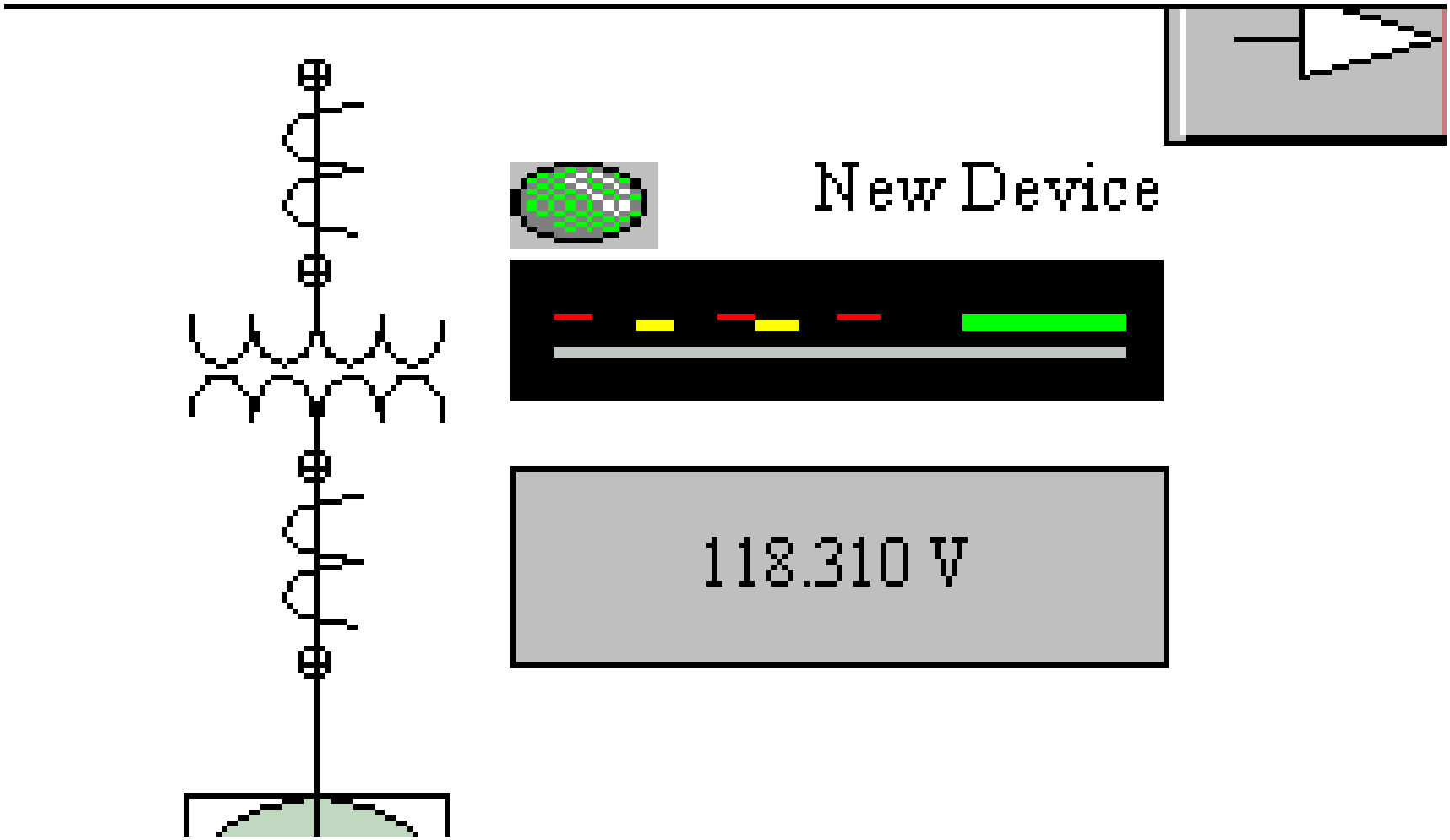
Analog Signal Monitor



Analog Signal Monitor



Analog Signal Monitor

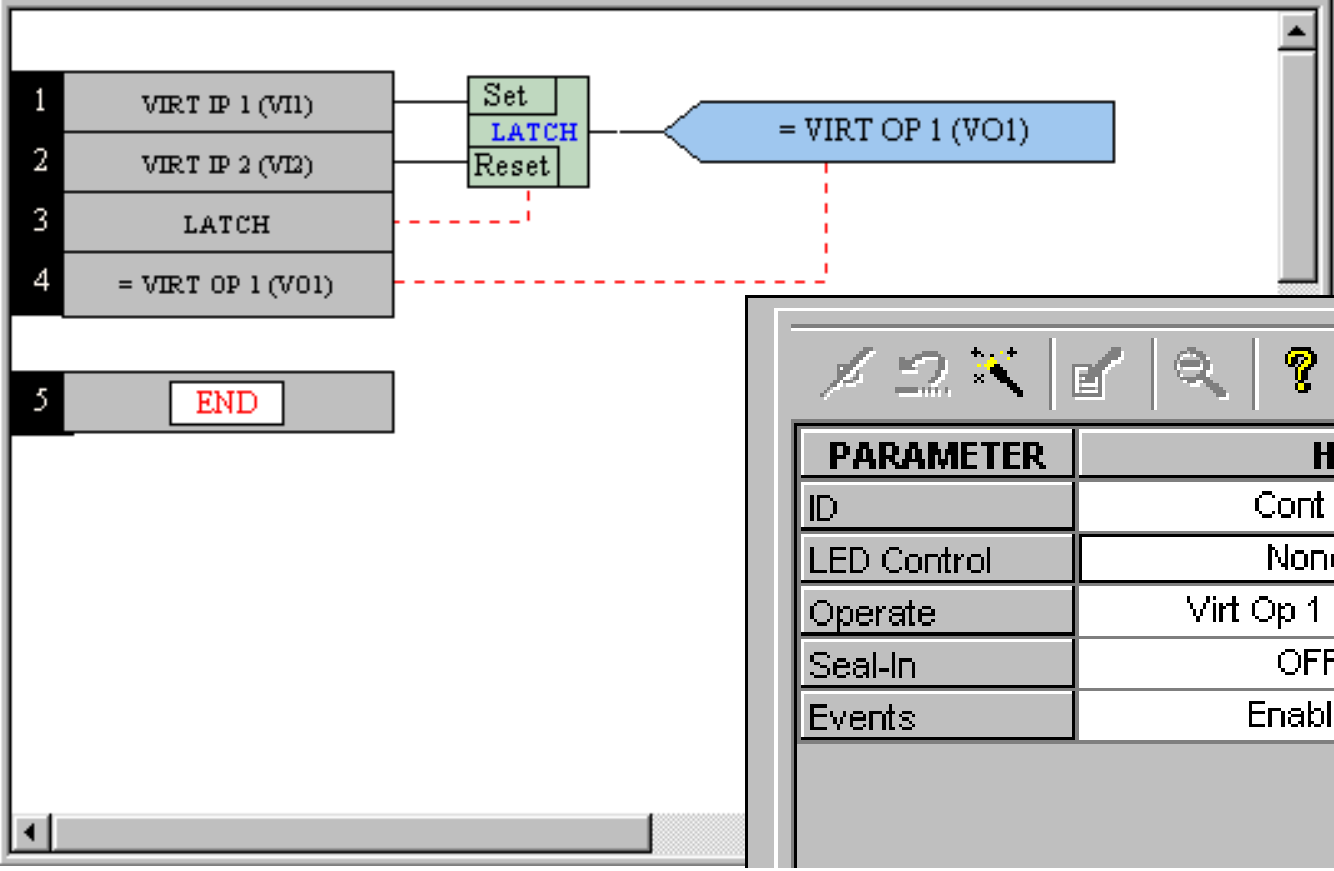


Analog Signal Monitor

Flexlogic Equation Editor // UTS: New Device 2: Settings: Flexlogic

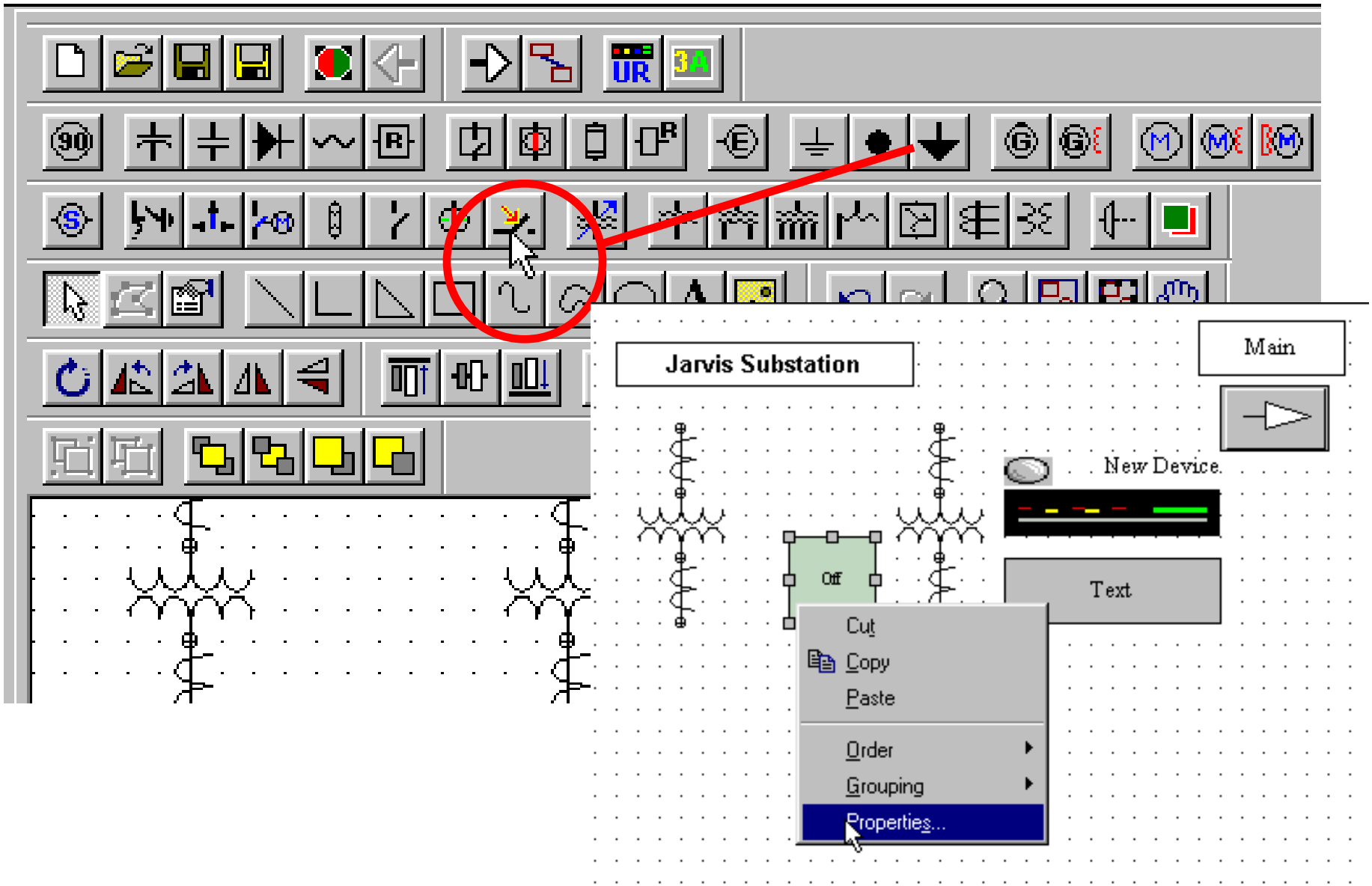
FLEXLOGIC ENTRY	TYPE	SYNTAX
View Gr		
Flexlogic		
Flexlogic		
Flexlogic		
Flexlogic		
Flexlogic		
Flexlogic		
Flexlogic		
Flexlogic		
Flexlogic		
Flexlogic		
Flexlogic		
Flexlogic		
Flexlogic		
Flexlogic		
Flexlogic		
Flexlogic		
Flexlogic		
Flexlogic		

Flex Logic Graphic // UTS: New Device 2: Settings: Flexlogic

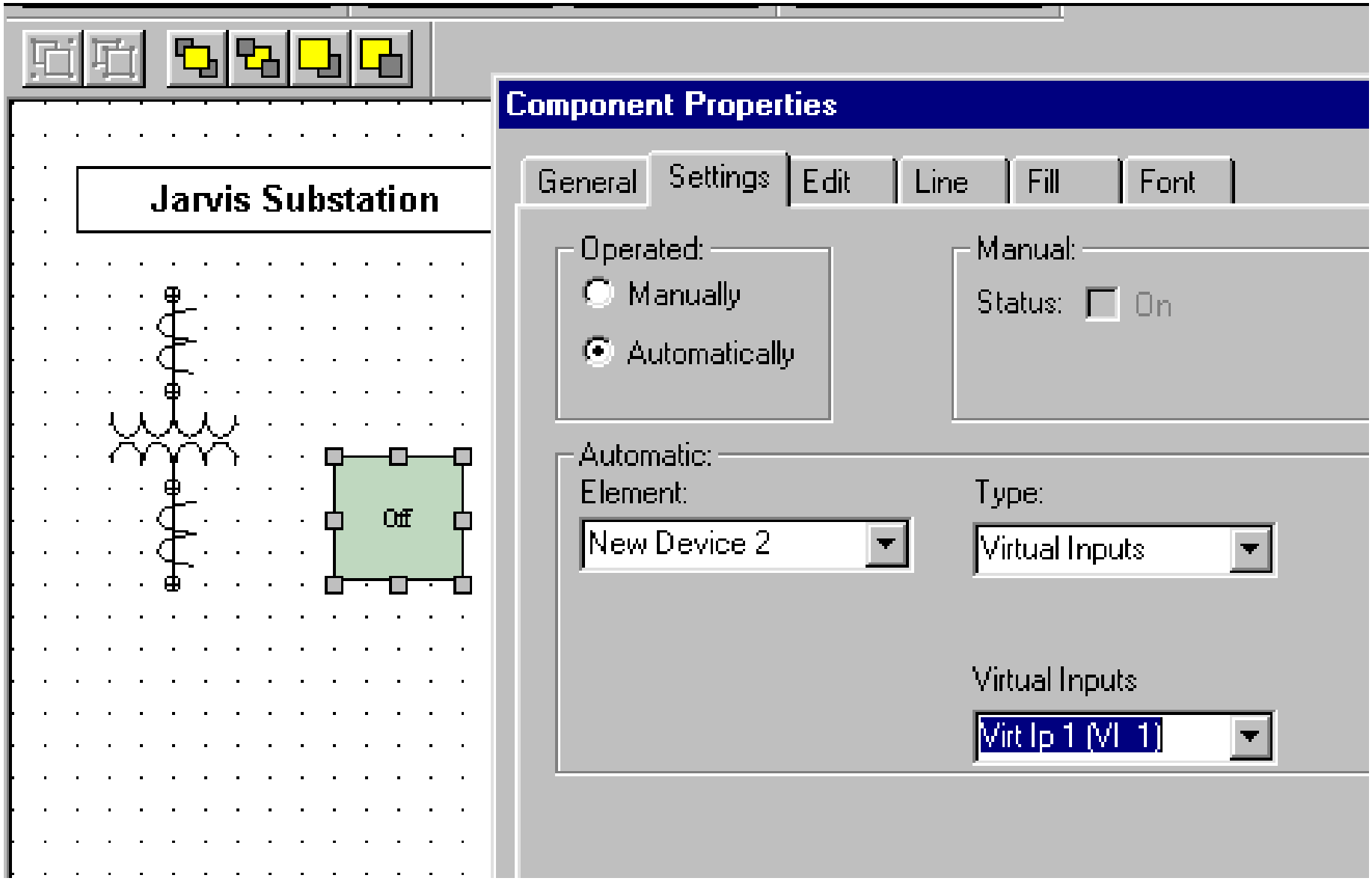


PARAMETER	H1
ID	Cont Op 1
LED Control	None
Operate	Virt Op 1 (VO1)
Seal-In	OFF
Events	Enabled

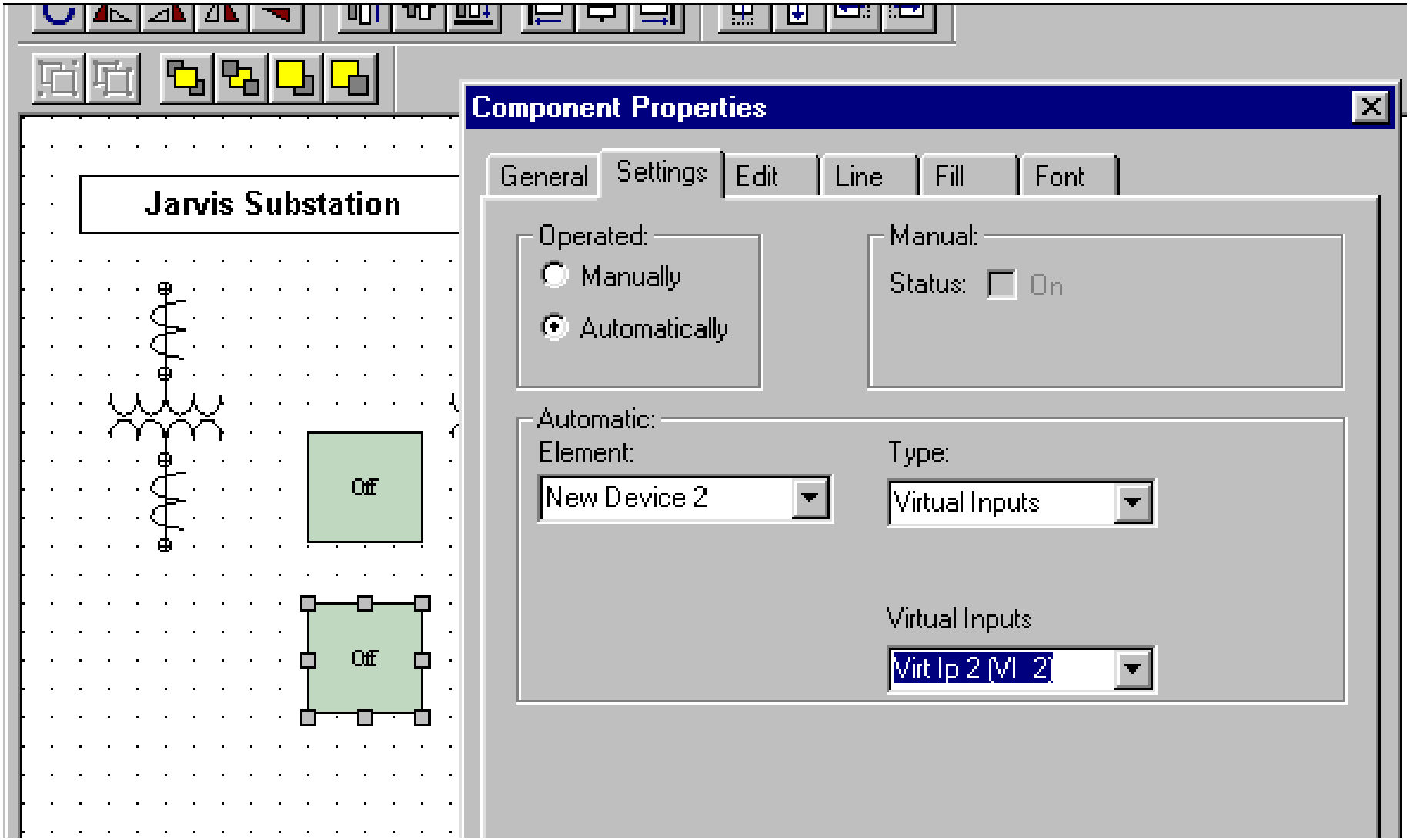
Standard Push buttons



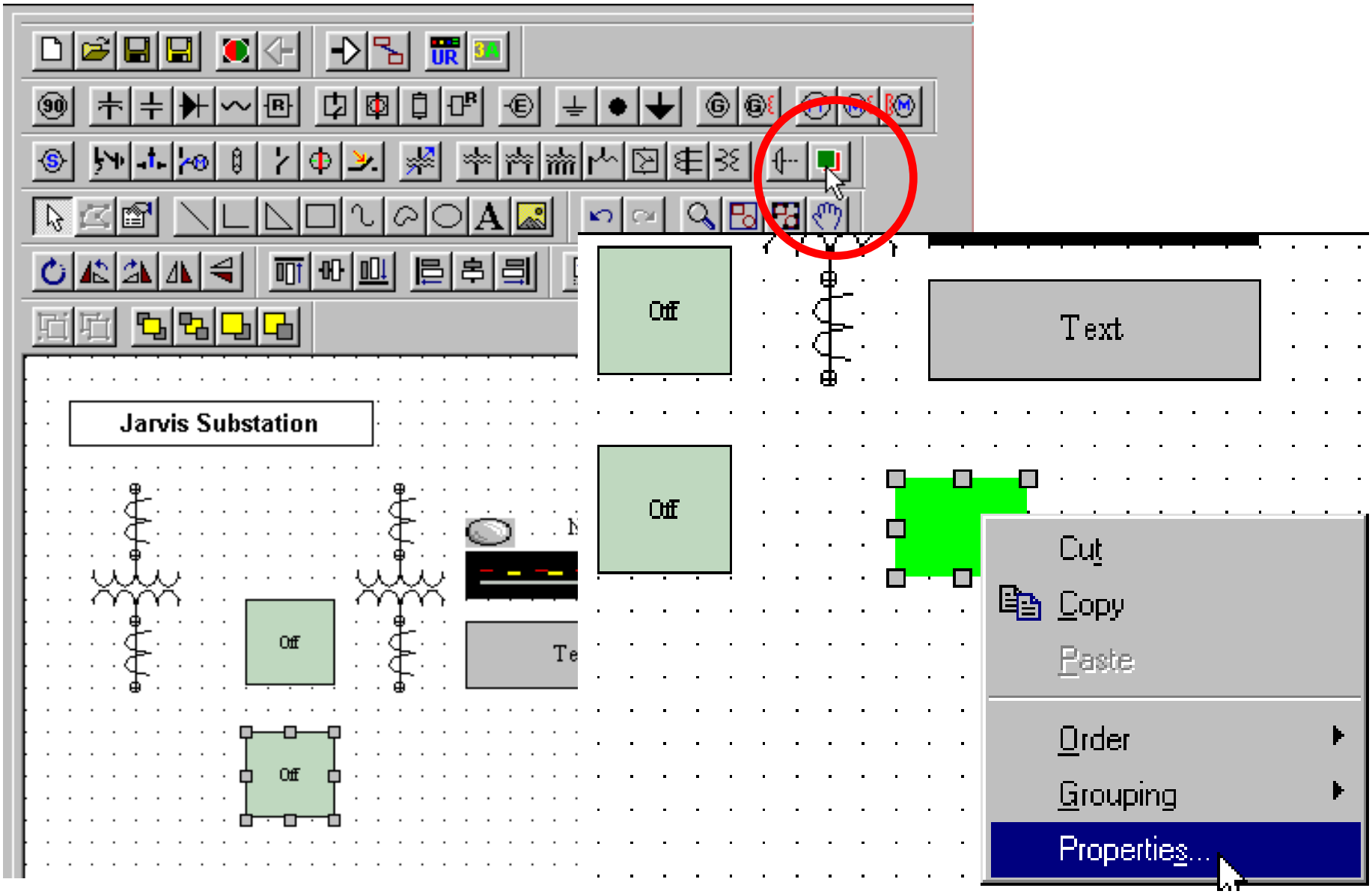
Standard Push buttons



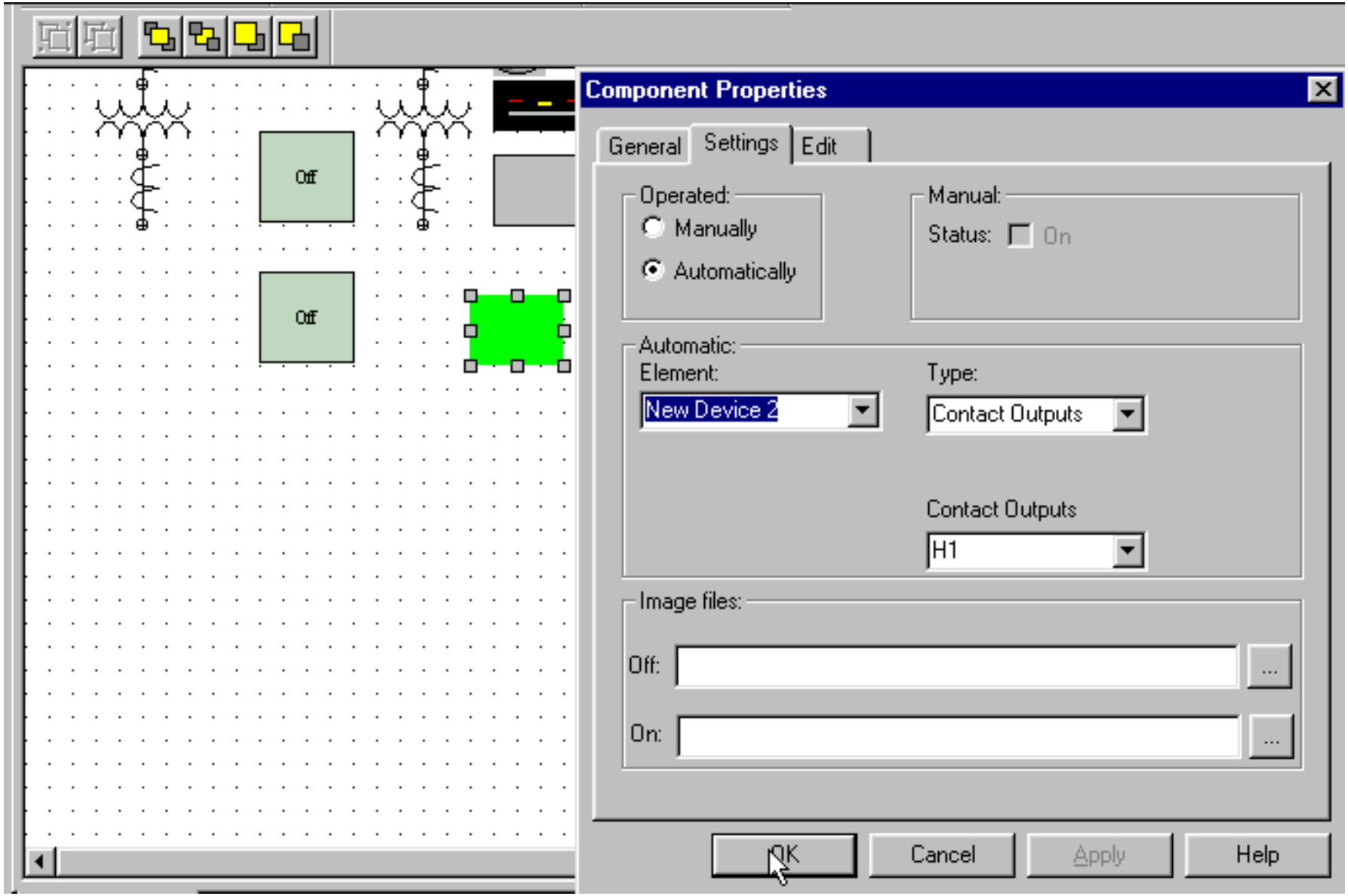
Standard Push buttons



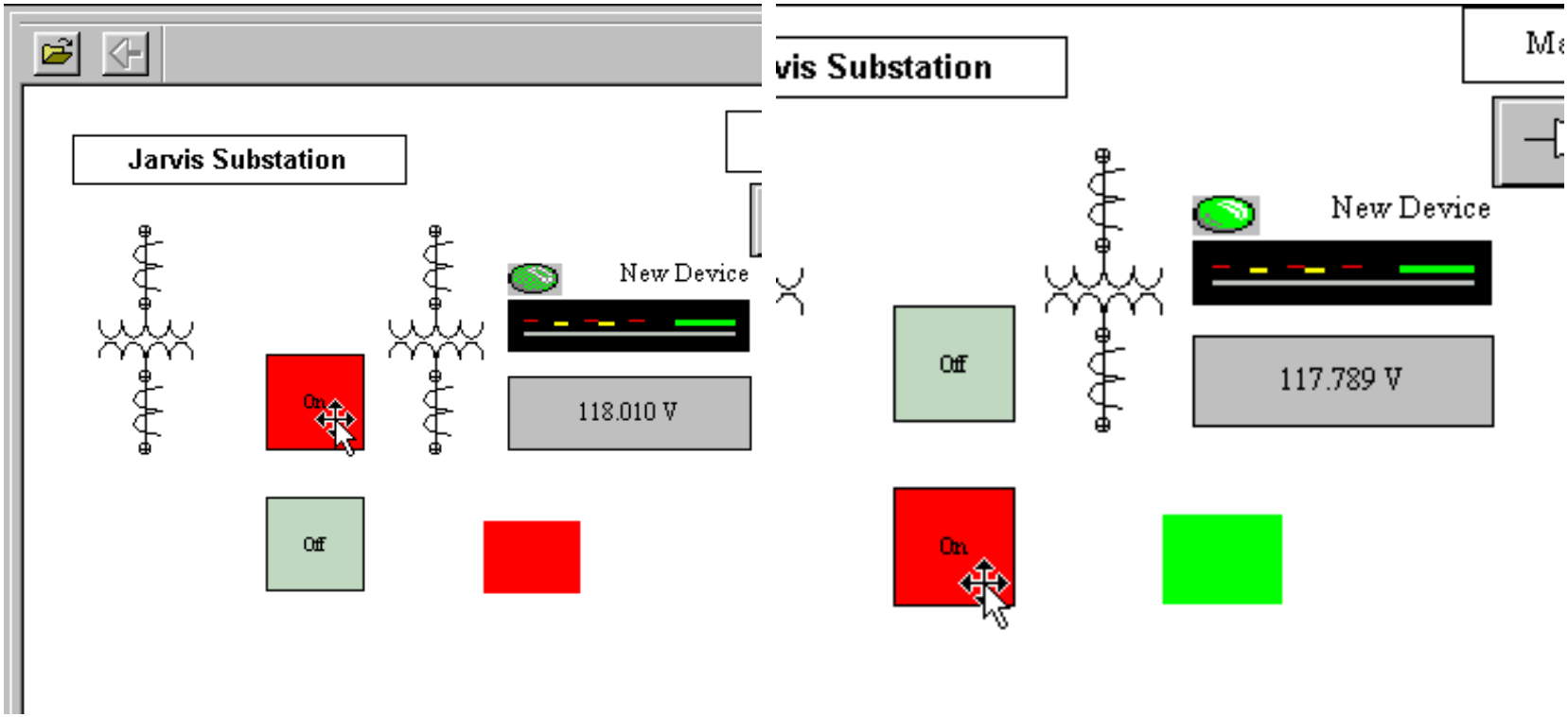
Standard Lamps



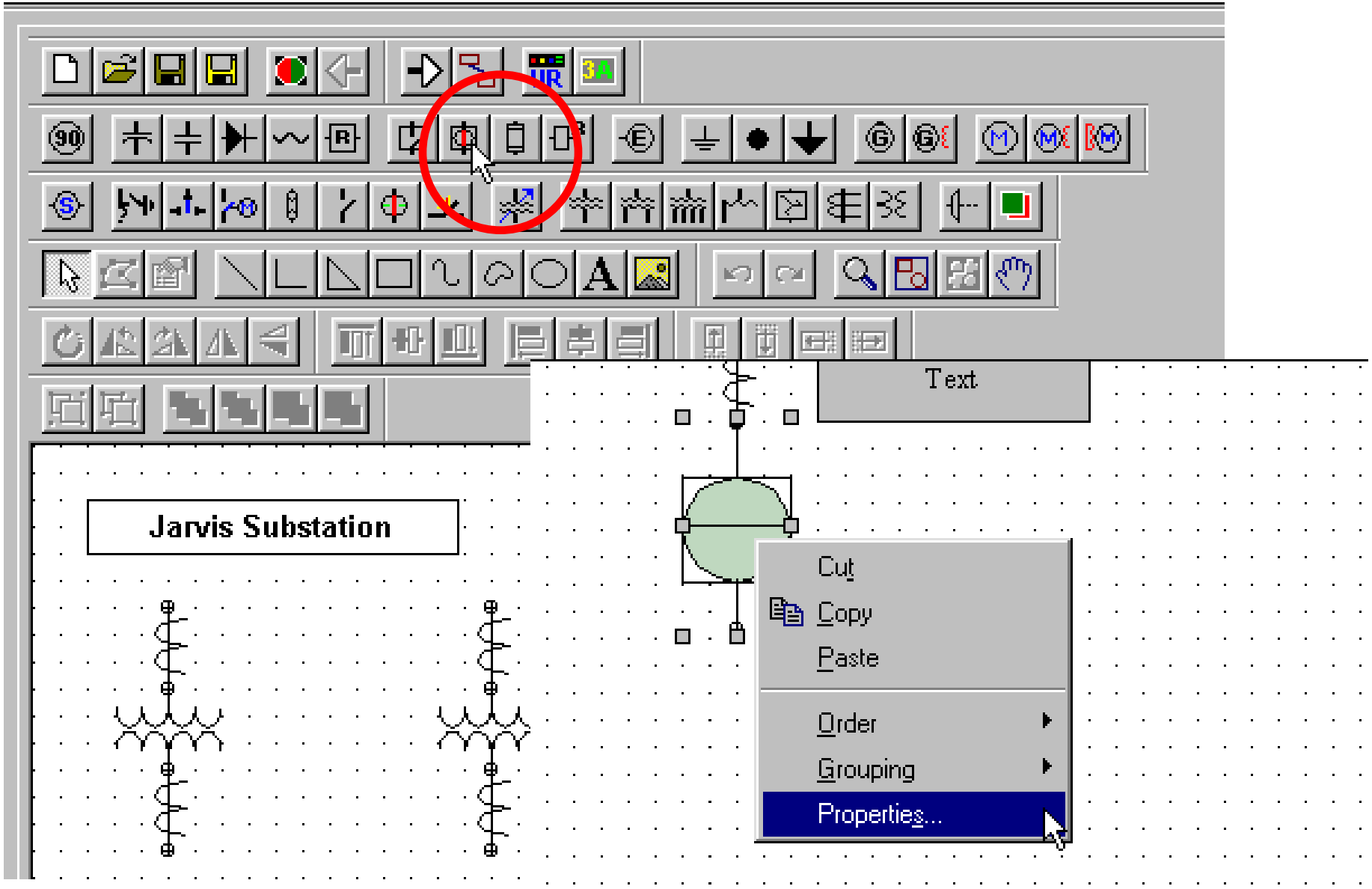
Standard Lamps



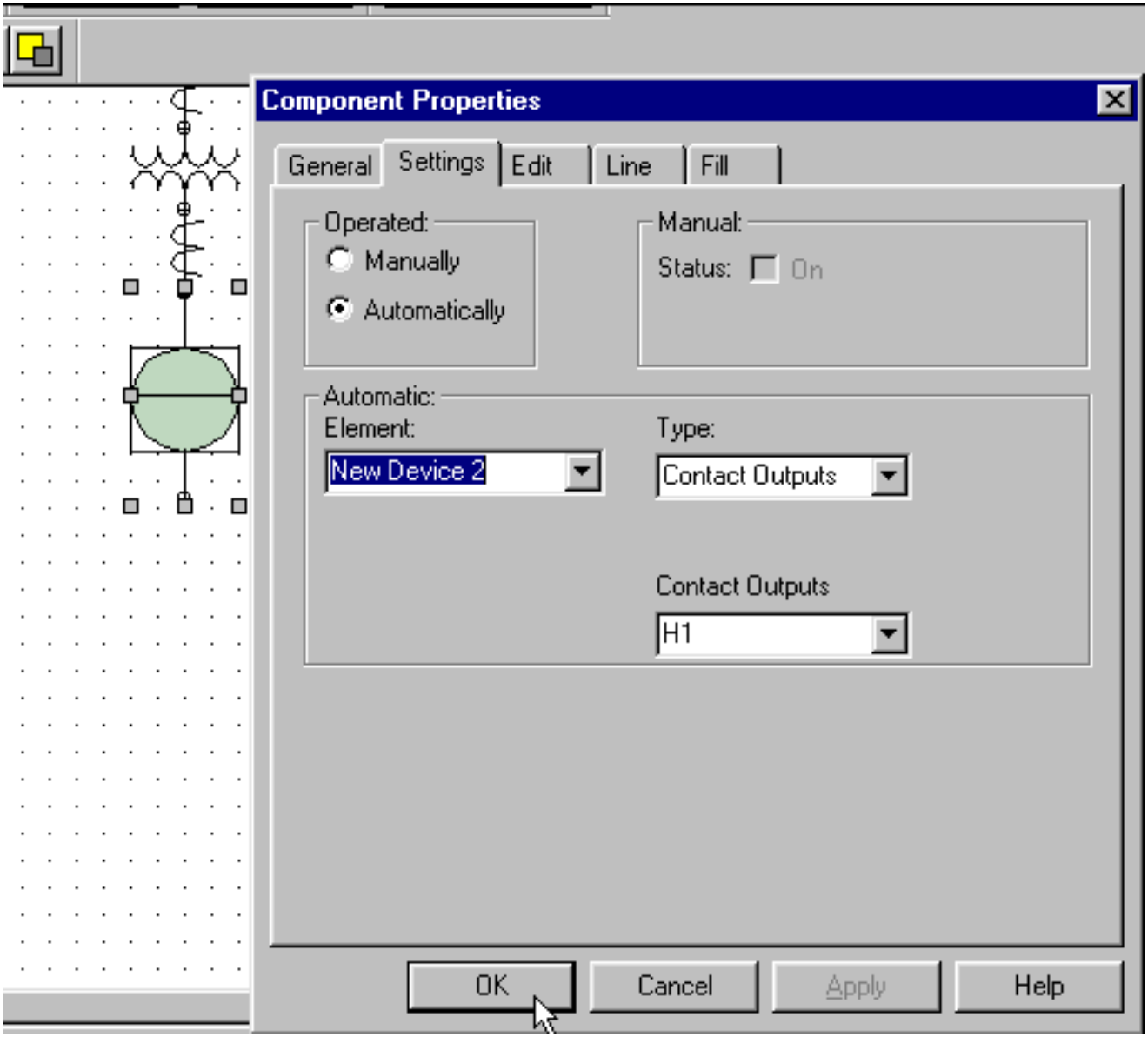
Standard Lamps



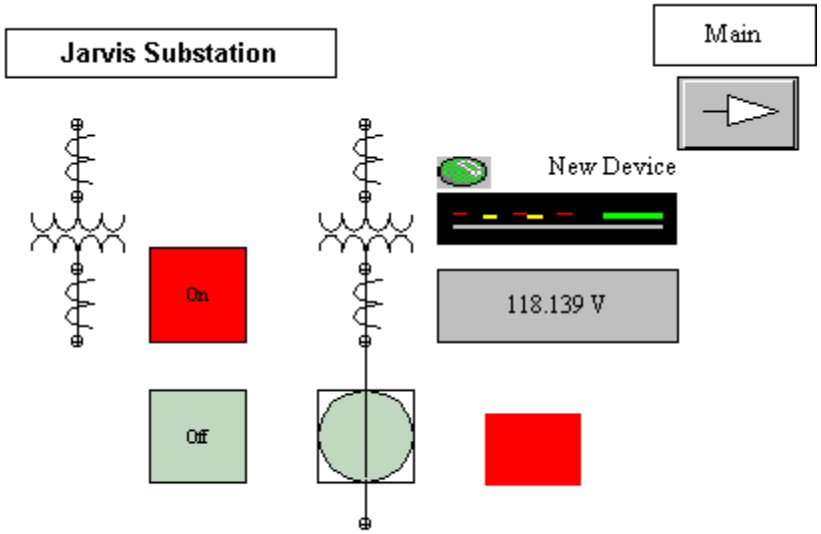
Breaker Symbol Animation

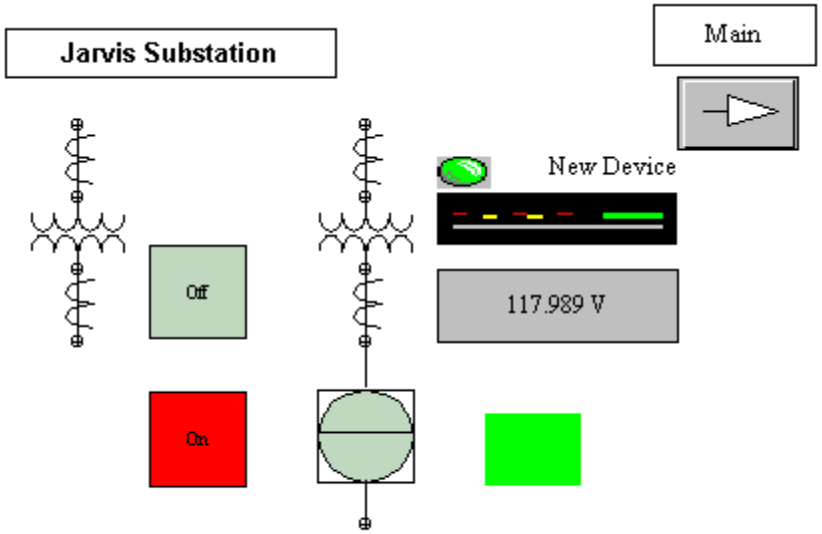


Breaker Symbol Animation

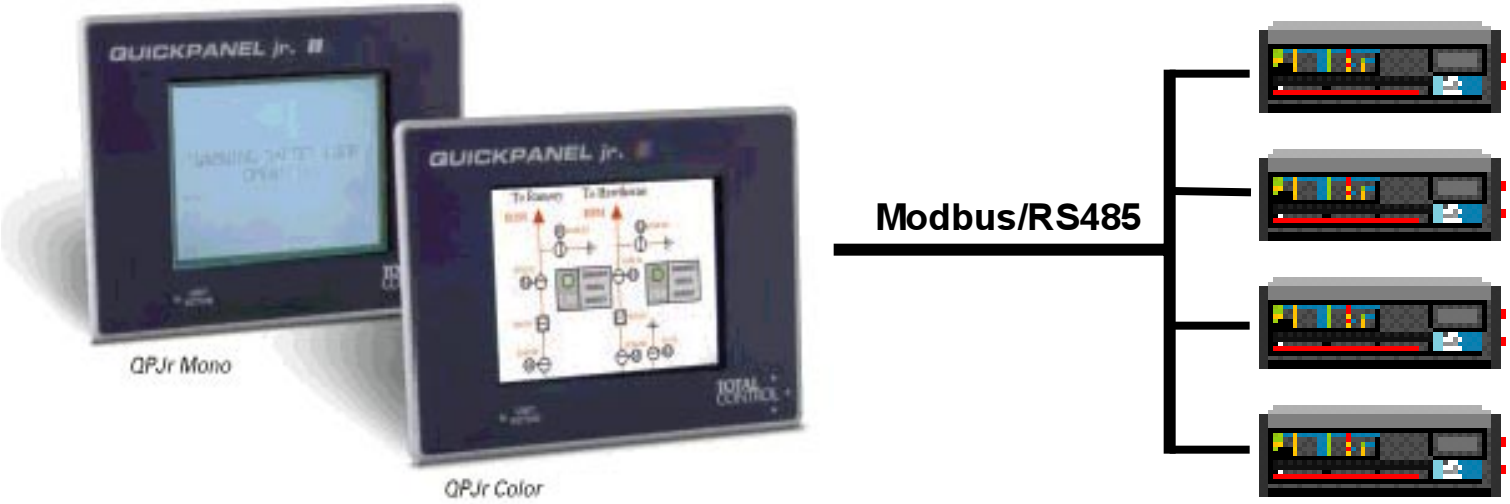


Breaker Symbol Animation





QuickPanel jr - Low Cost HMI



- **Control multiple devices: Modbus Master via RS485**
- **Graphical user interface: *single-line, metering, alarms***
- **Touch Screen: *alarms control buttons***

Substation Automation

> Requirements

> Protective relay hardware

> Protective relay logic engine

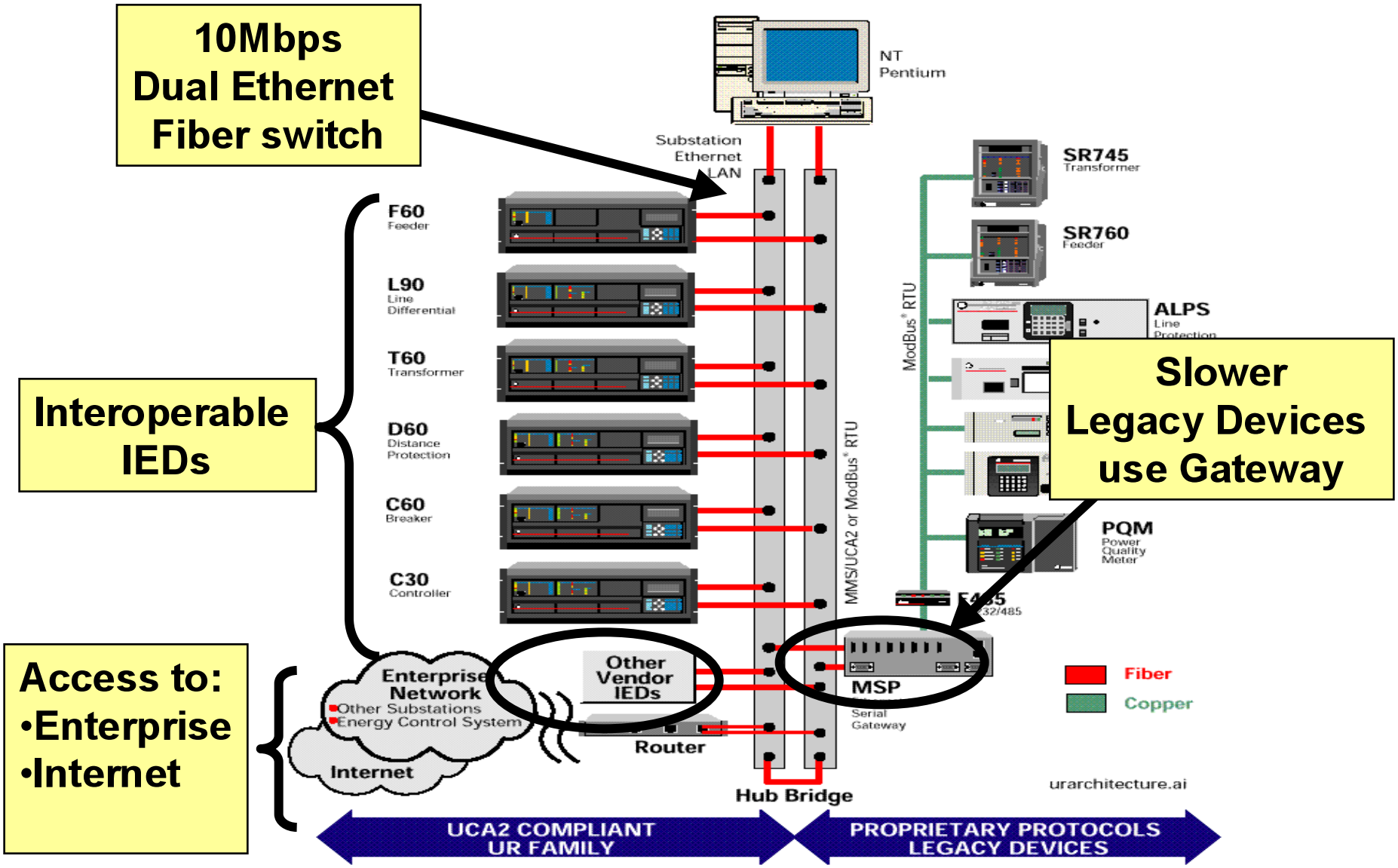
> Relay to relay data communication

> Local/Bay Control

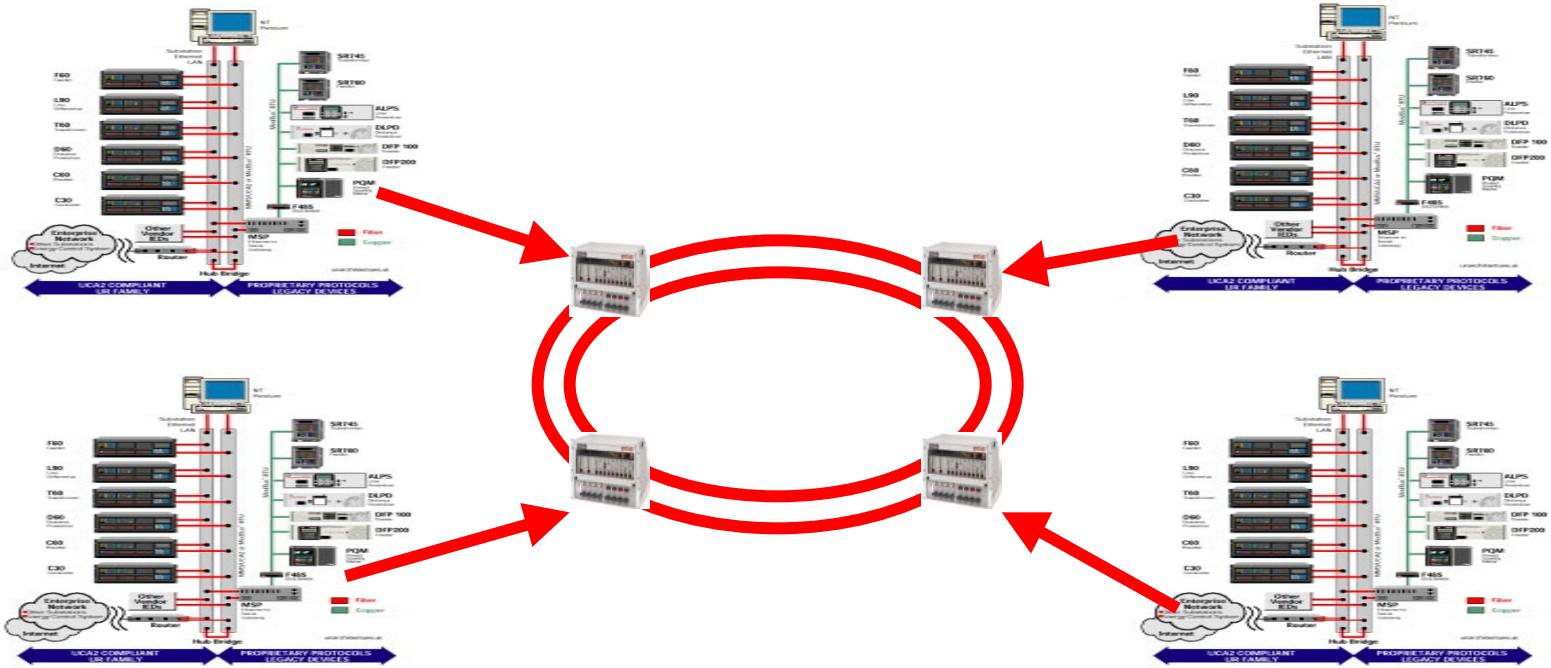
> WAN

> SCADA

The UCA Substation



Inter Substation Communications



FSC

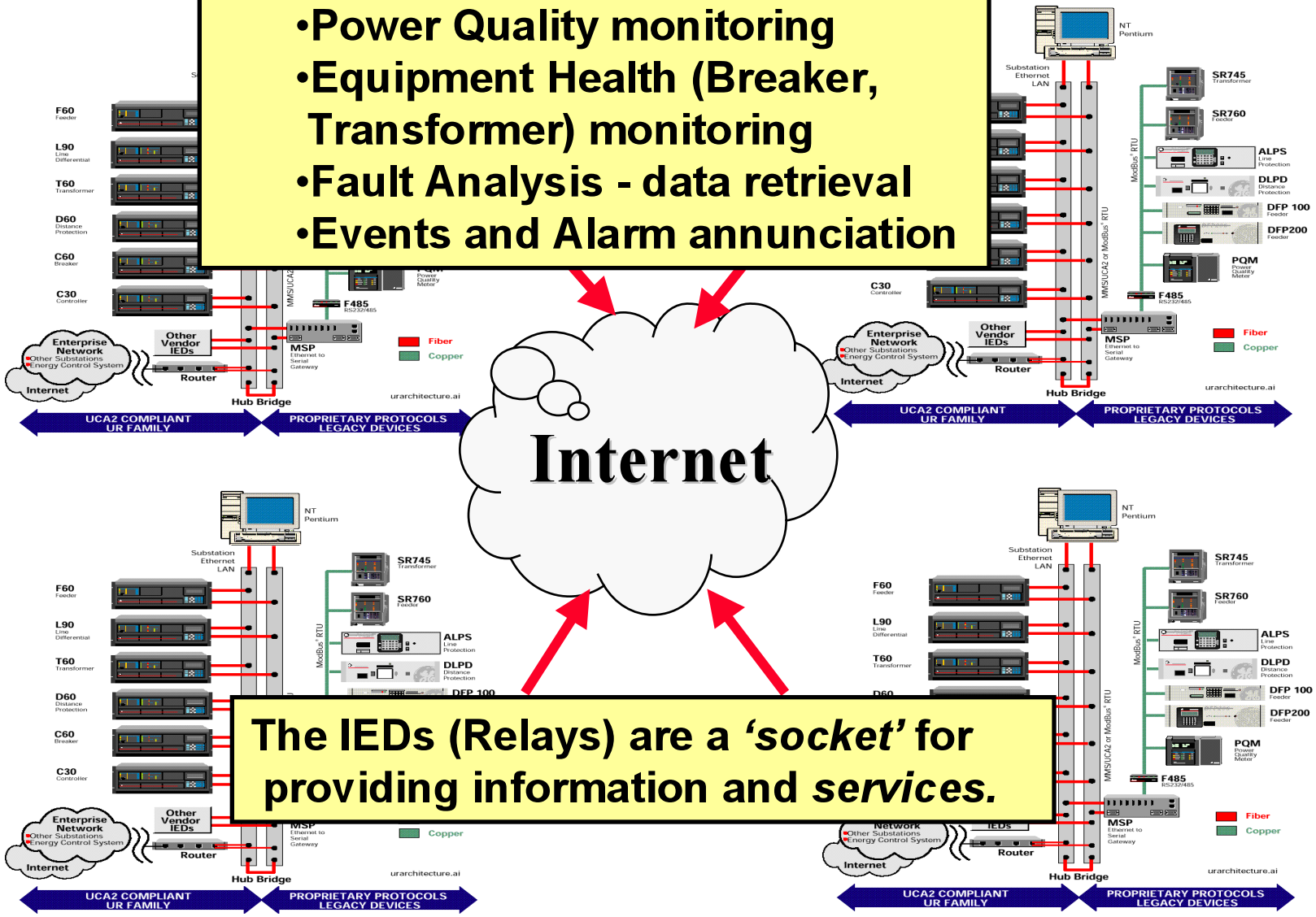
(Fiber Optic System Communications)

- **SONET Technology: 51/155 Mbps**
- **Ethernet LAN 'Bridging' capability**
- **Creates single Ethernet WAN**
- **Redundant channels ensure reliability**

UR + UCA + Internet = New Possibilities

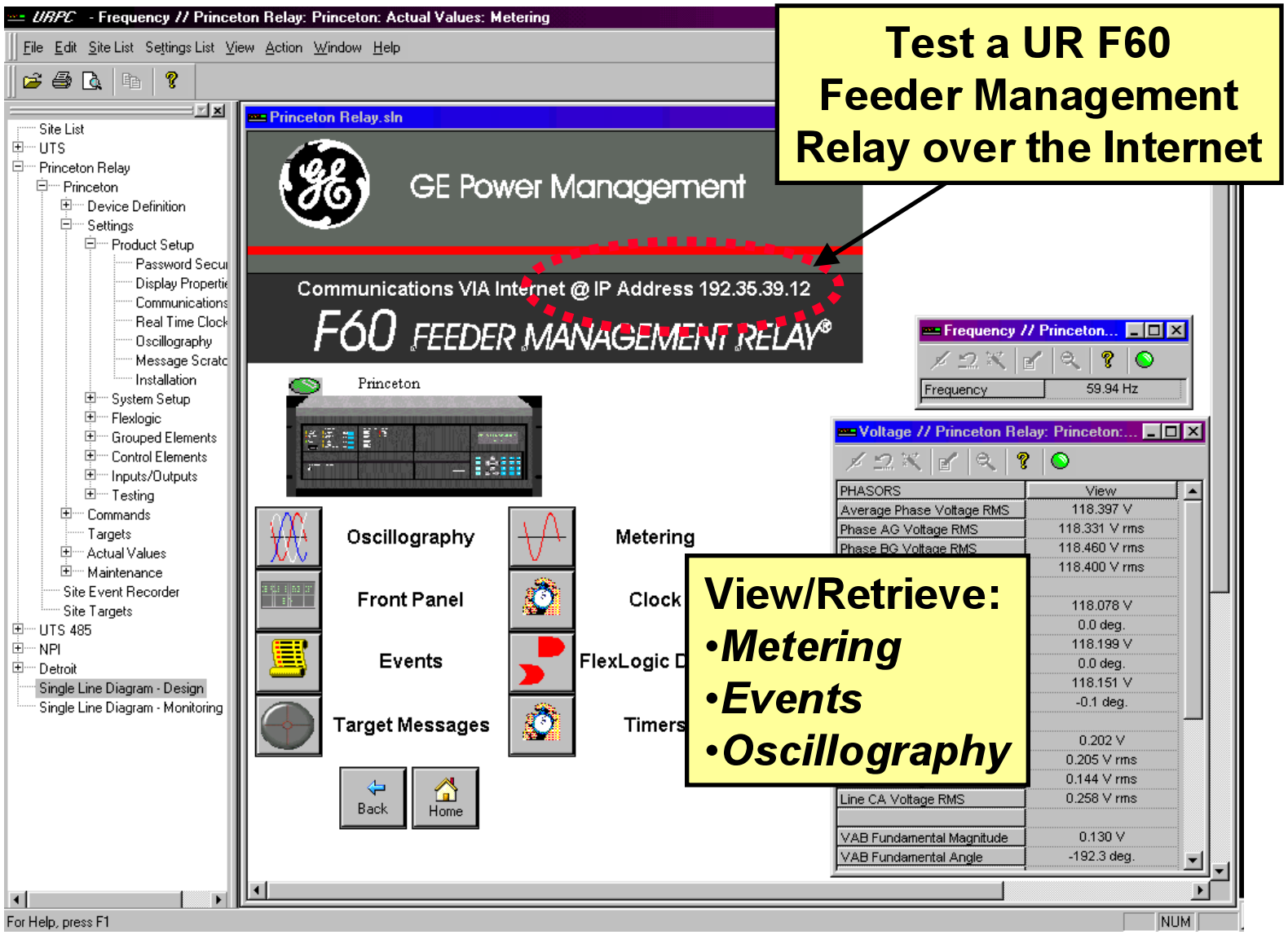
Remote monitoring and diagnostics:

- **Power Quality monitoring**
- **Equipment Health (Breaker, Transformer) monitoring**
- **Fault Analysis - data retrieval**
- **Events and Alarm annunciation**



The IEDs (Relays) are a *'socket'* for providing information and *services.*

Internet Communications NOW!



Test a UR F60 Feeder Management Relay over the Internet

View/Retrieve:
- ***Metering***
- ***Events***
- ***Oscillography***

Agenda

Substation Automation

> Requirements

> Protective relay hardware

> Protective relay logic engine

> Relay to relay data communication

> Local/Bay Control

> WAN

> SCADA

GESA 2000

GE Substation Automation System Solutions

- Providing innovative product and service solutions for markets and customers worldwide.

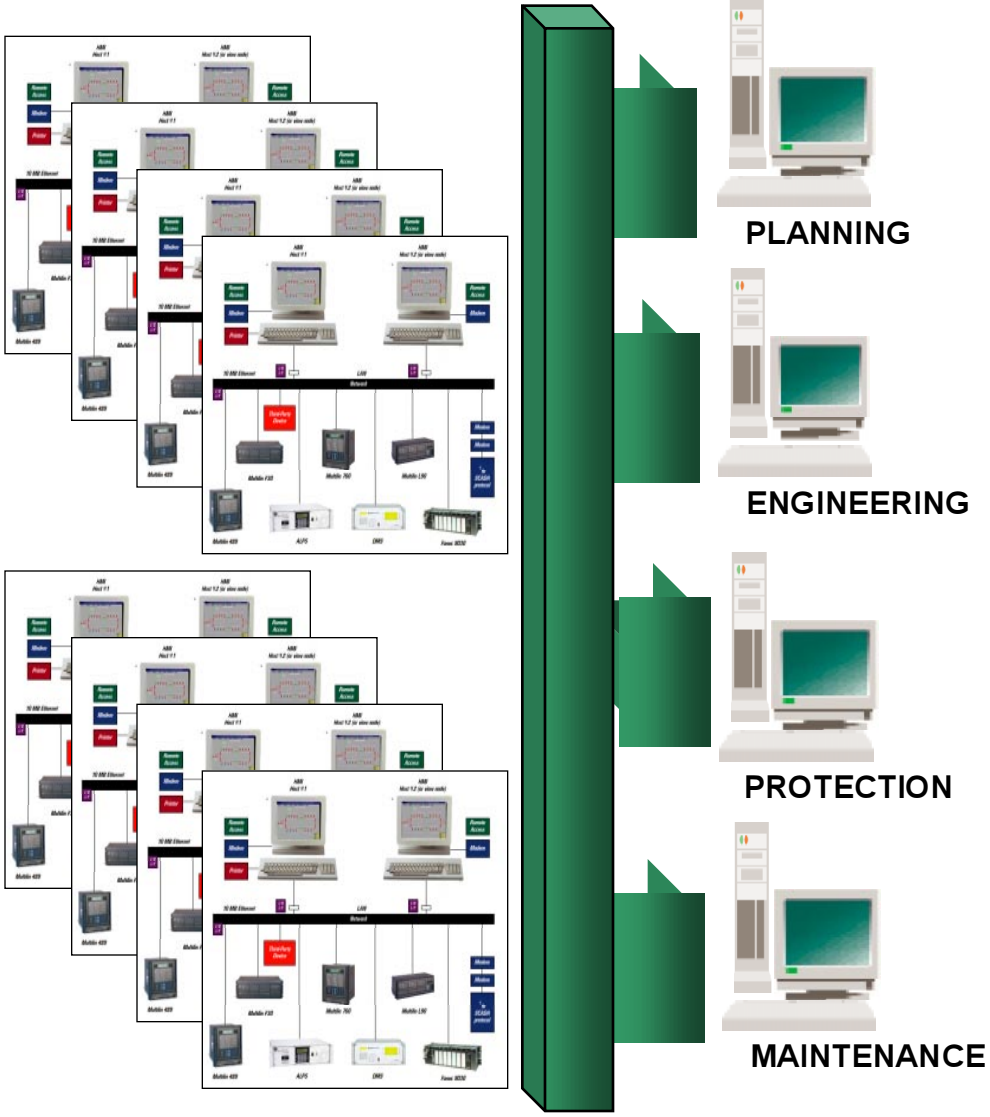
Why GE

- A Complete System Solution Supplier
- Global Focus With Engineering And Field Support
- Experience Over A Broad Range Of Industries
- A corporate commitment to six sigma quality
- Financial Strength

- Power system consulting
- Application design
- Project management
- Integration services
- Startup and comissioning
- Project financing
- Asset maintenance
- Remote diagnostics

Dedicated to bringing the best Automation solutions to our customers

GESA - A System Solution that Delivers Productivity



- More Effective Long Term Planning & Loading Decisions
- Real-time Analysis that Avoids Interruptions
- Reduction in the Need for Costly Field Visits
- Precise and Confident Operator Decisions in Restoring Service

Translating data into information at the users fingertips

The Challenge: Putting Information to Work

Enterprise

- Fine-tune planning
- Streamline settlements
- Budget accurately
- Asses cost of service
- Allocate capacity
- Faster service response

Operations

- Remote status & control
- Analyze power quality
- Identify events, SOE
- Receive fault records
- Target maintenance
- Monitor loading trends

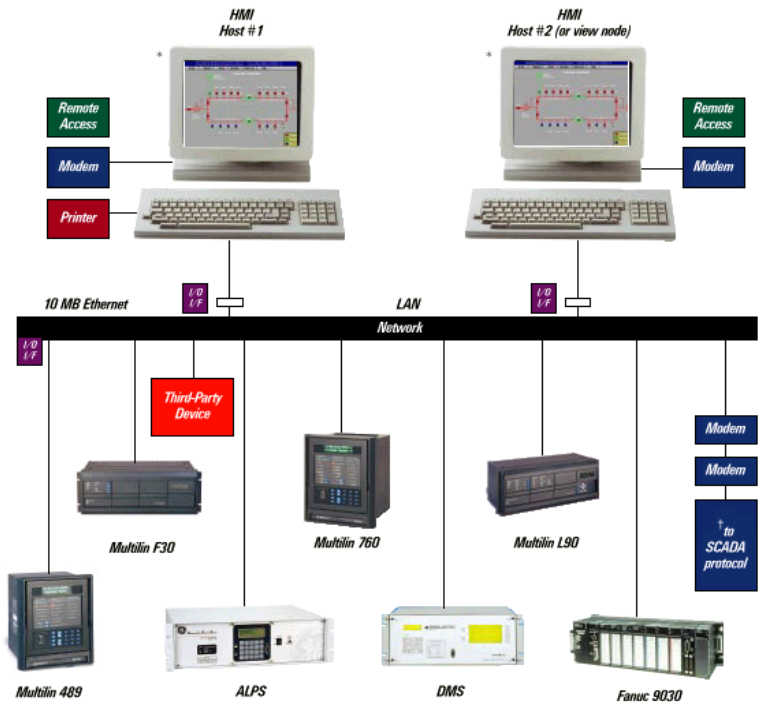
"On-Line Information": Your key competitive advantage

GESA 2000 The competitive solution

- Sub-second response for Ethernet connected devices
- Dual master redundancy with automatic system control transfer
- Automatic interleaving of events and metering values
- Ethernet substation UCA 2.0 LAN Peer to peer communications
- Remote view nodes and web browser compatible HMI Interface
- Automatic oscillography upload
- Object oriented system tools for reliable, low cost reconfiguration
- Real-time system status and control execution

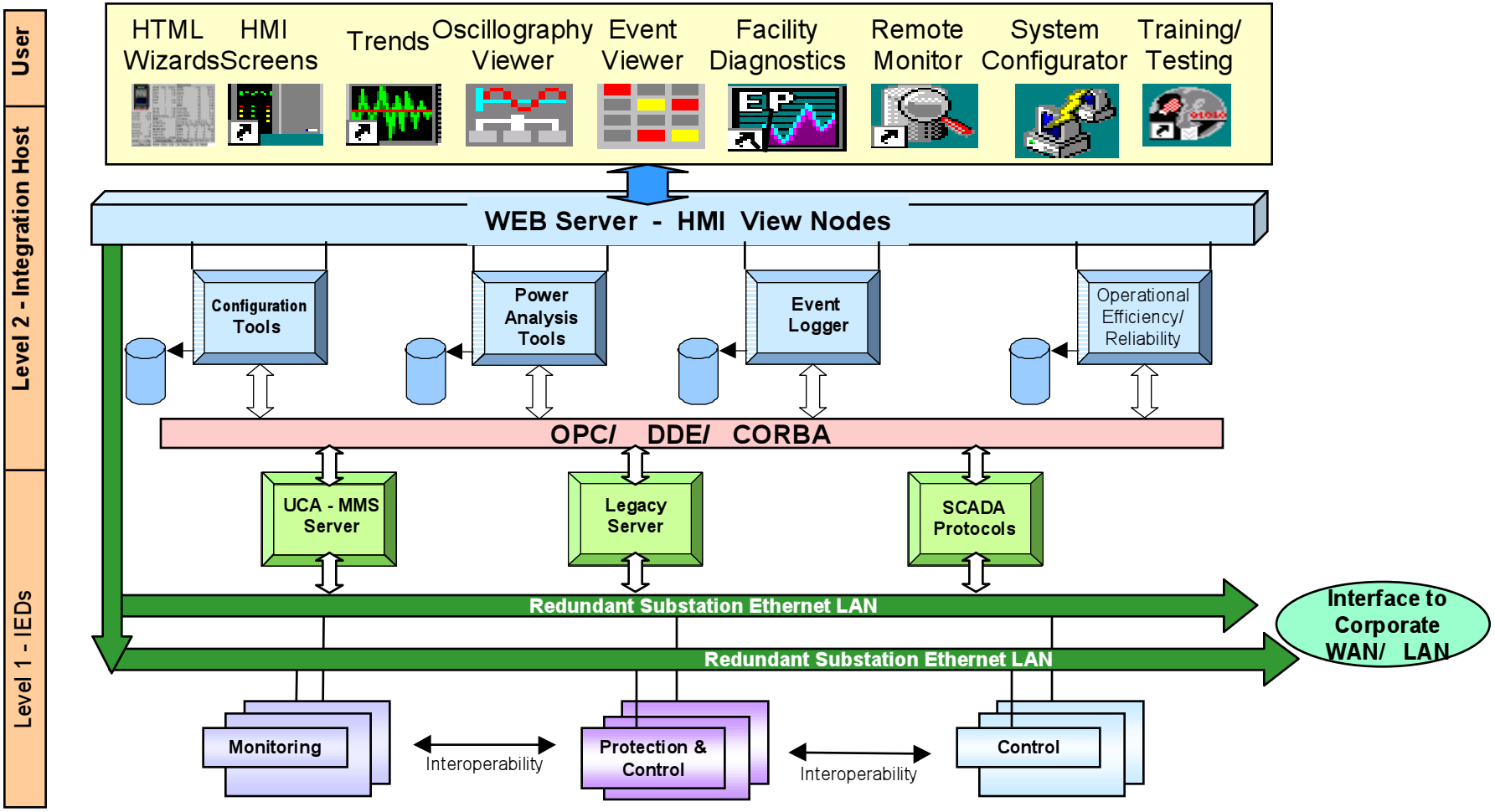
Maximize your Competitive Edge

Three powerful dimensions to a complete Substation Automation Solution:



- Proven, “off the shelf” components that integrate today’s IEDs
- Ethernet for data transport in the substation and to remote sites
- Pre-engineered software, application tools and device interfaces

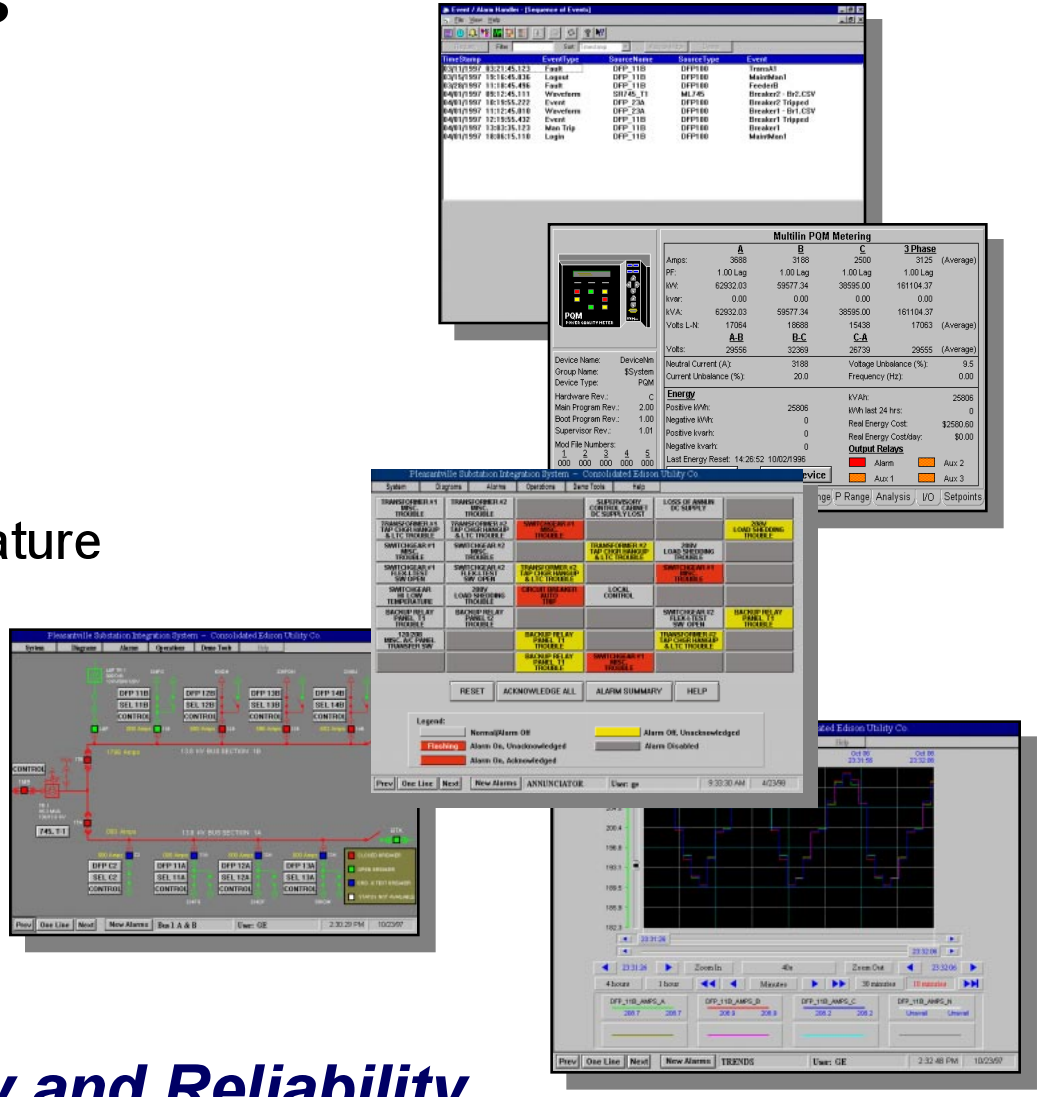
Built Upon a New Generation Substation Architecture



Open System Solution -- Relays, Software, Communications, Networking

Smart Screen "Wizards"

- One Line Diagrams
- Event Logger
- IED Faceplate
- IED Tabular Values
- Annunciator Panel
- Alarm List with Sorting Feature
- Trending



Integration Productivity and Reliability

Monitors and records all system event characteristics

Event / Alarm Handler - [Sequence of Events]

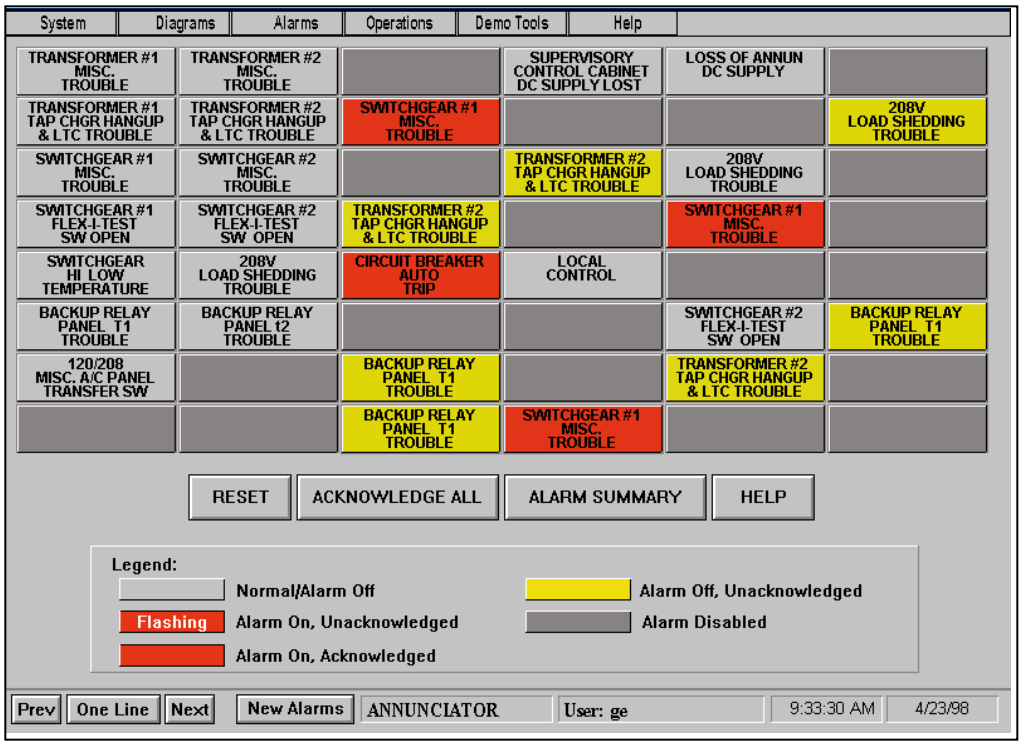
File View Help

Requery | Filter | Sort Timestamp | Acknowledge | Delete

TimeStamp	EventType	SourceName	SourceType	Event
03/11/1997 03:21:45.123	Fault	DFP_11B	DFP100	TransA1
03/15/1997 19:16:45.836	Logout	DFP_11B	DFP100	MaintMan1
03/28/1997 11:18:45.496	Fault	DFP_11B	DFP100	FeederB
04/01/1997 09:12:45.111	Waveform	SR745_T1	ML745	Breaker2 - Br2.CSV
04/01/1997 10:19:55.222	Event	DFP_23A	DFP100	Breaker2 Tripped
04/01/1997 11:12:45.010	Waveform	DFP_23A	DFP100	Breaker1 - Br1.CSV
04/01/1997 12:19:55.432	Event	DFP_11B	DFP100	Breaker1 Tripped
04/01/1997 13:03:35.123	Man Trip	DFP_11B	DFP100	Breaker1
04/01/1997 18:06:15.110	Login	DFP_11B	DFP100	MaintMan1

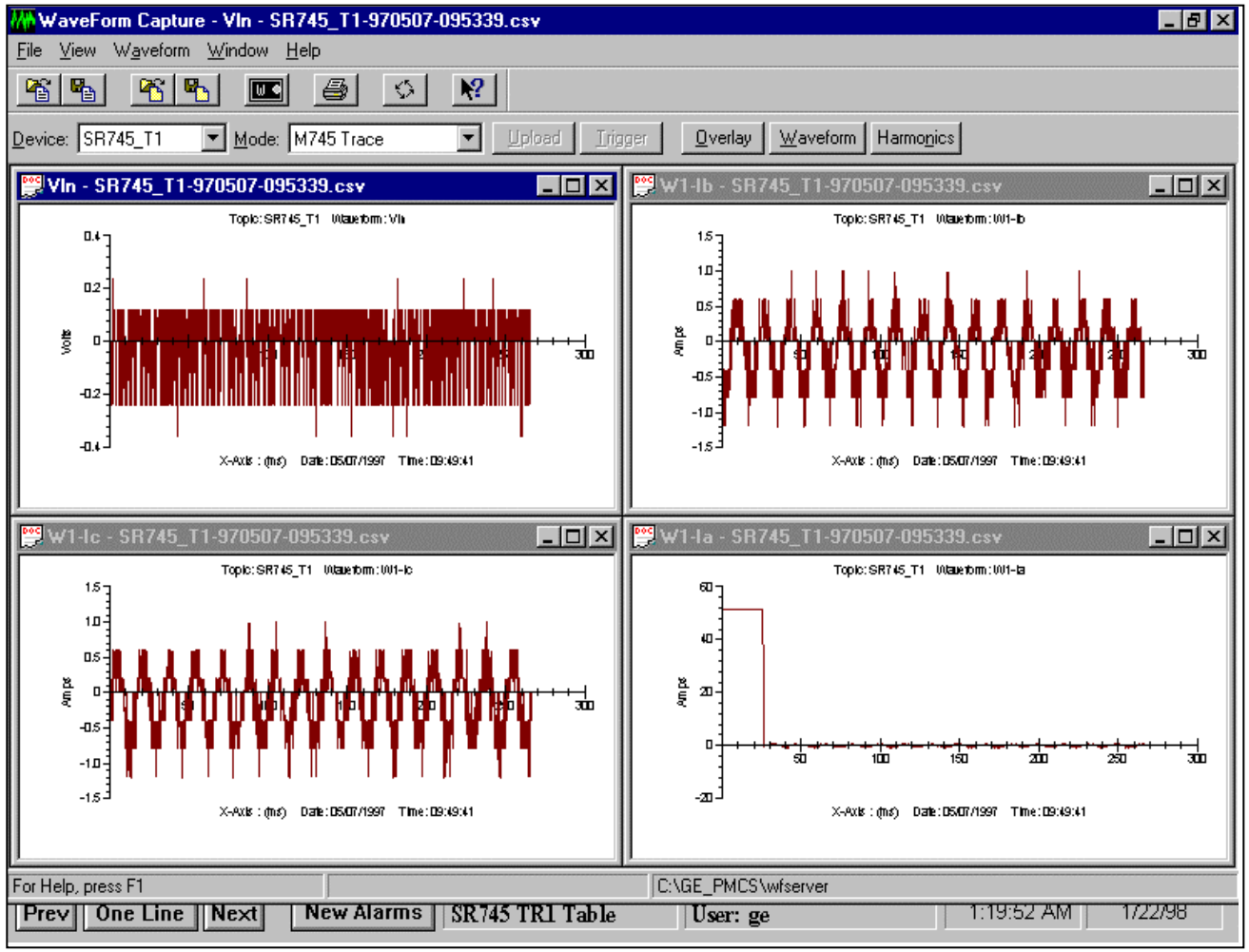
- Time stamped to nearest milli-second
- Synchronizable to GPS via IRIG-B
- Automatic retrieval from IED to Host
- Storage on host disk
- Automatically forward to operations PC
- Data sort capability included:
  - Standard filters
    - Time
    - Device Type
    - Alarm Condition
  - Custom filters per your needs

Alarm Annunciator Panel



- Configurable alarm conditions
  - Any present value can drive an alarm
  - Set range of operation
- Failure Alarms
  - Equipment generated
  - System generated
  - Grouped per IED
- Remote Communication of Critical Alarms

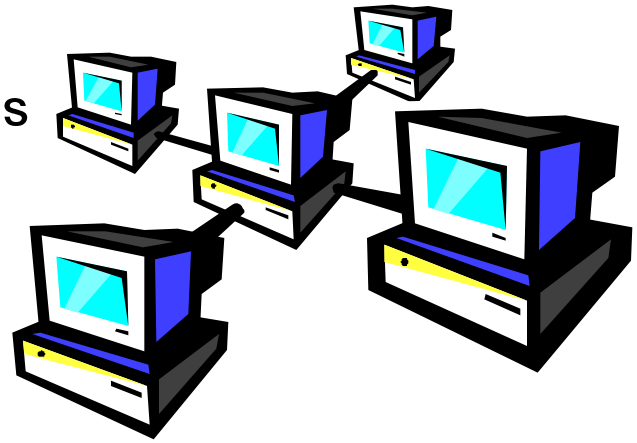
Oscillography/Fault Reporting



- Automatic upload from IEDs via your Wide Area Network
- Comtrade format for file storage
- Remote file access
- Full feature viewer with analysis tools

Integrated Solutions to help you succeed

- Interoperability
- Peer to peer communications
- Reliability of software objects and modules
- Modularity of hardware modules and components
- Dynamic reconfiguration
- Real-time state analysis and operation



SUBSTATION AUTOMATION INSTALATIONS AROUND THE WORLD

North America

ConEd
PSE&G
PECO
Salt River

Europe & Africa

ERZ

South America

Electroperu
Inepar
Electronorte
EDENOR
Rio Light
Furnas

Asia Pacific

Aliu Zhou
Zhe Zhang
Guang Xi

What our Customers Require: That GE is Committed to Deliver

- Access to system application experts -- before, during and after a sale
- Open architecture solutions, built on industry standards - future upgrade path
- Thorough specification of the system to be delivered - fully understood by the user
- Deliver and commission on schedule; within budget - supplier and customer
- Effective operator training - establishing basic user competency
- Return on investment - work together to obtain the expected benefits

Customer Focused

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