

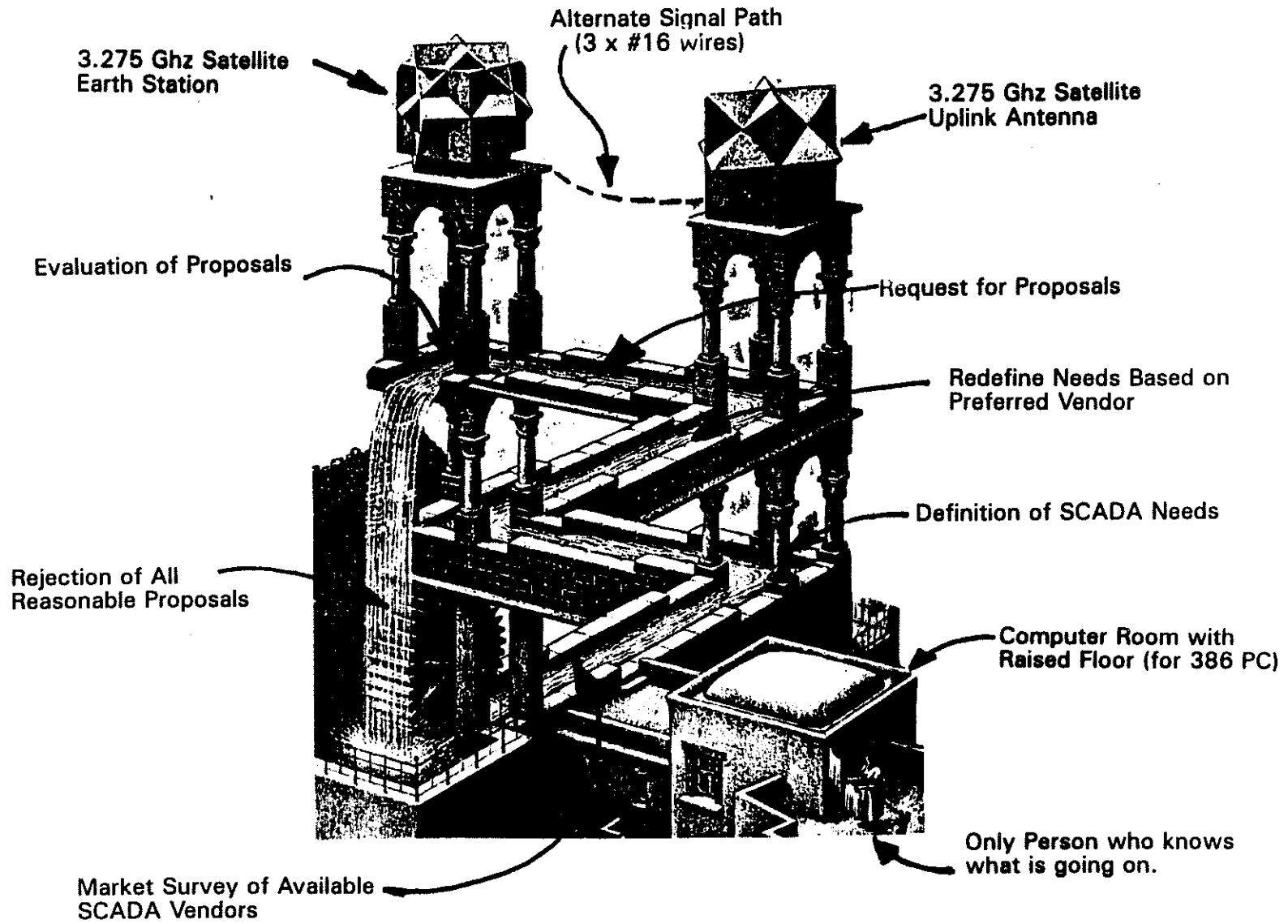


**TEST**

A Weatherford Enterra Company

# **SCADA Systems Seminar**

Contact Arthur Zatarain, PE  
via [www.artzat.com](http://www.artzat.com)  
For information on this document



**TYPICAL SCADA PROJECT  
FLOW DIAGRAM  
(by AMZ)**

Note: Not all projects flow this smoothly.  
Some are confusing and complicated.

## **TEST Inc. - Corporate Data**

- **Headquarters in Harvey (New Orleans), La.**
- **Domestic Offices - Lafayette, Houston, Ventura, Anchorage**
- **International Offices - Lagos, Bahrain, Singapore**
- **Approximately 350 employees, \$US 30 Million annual sales**
- **Independent Corporation - Part of Weatherford-Enterra Corp. \$US 900 Million company**
- **TEST offers - Instrument and electrical engineering, fabrication, installation, training, CAD services**
- **Particular expertise in automation, safety systems, DCS, PLC, and SCADA systems**
- **Also does turn-key projects for packaged equipment (DCS, Generators, Quarters)**



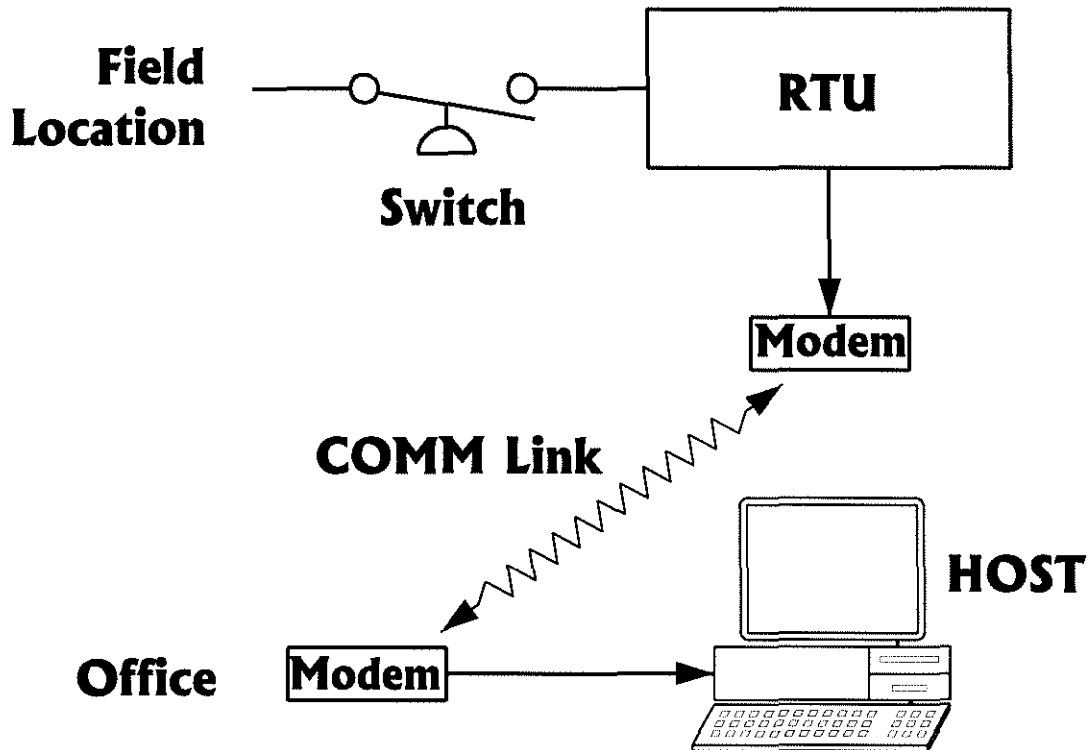
## **TEST Inc. - SCADA**

- **Worked with other vendor's RTU's since 1980:  
HP, TI, Analog Devices, Motorola, Valmet**
- **Purchased DATARAN Corp. In 1987 for SCADA and  
electrical engineering expertise**
- **First PC based SCADA installed in 1987**
- **First TEST Inc. Small RTU (T2000) in 1989**
- **SCADA is major segment of business**
- **TEST does all aspects of SCADA project:  
Specification, Design, Hardware, Software,  
Programming, System Integration, Installation,  
Startup, Training**
- **Existing TEST Inc. SCADA applications:  
Satellite well to main platform,  
Main platform monitoring  
Main platform to land based office  
Gas/Oil production measurement  
Gas lift optimization - Choke control  
Storage ship loading/balancing**






# SCADA Installation

- **Offshore - Gulf of Mexico - Independents**  
Small and large platforms  
Gas and Oil measurement / checking
- **Onshore - Well sites and production facilities**  
Pipeline leak detection
- **Mid East - Dubai Petroleum - Gas lift control**  
Storage tanker loading / balance
- **China - Various SCADA/DCS systems**
- **North Africa - Algeria - Steam powered generator**
- **West Africa - Well control to tank battery**
- **Trinidad - Satellite well to main platform**






# "The Big Picture"



# SCADA - Overall Functions

-  **Monitor input signals**
-  **Determine Out-of Tolerance conditions for alarms**
-  **Communicate with “HOST” system**
-  **Display information**
-  **Generate status and production reports**

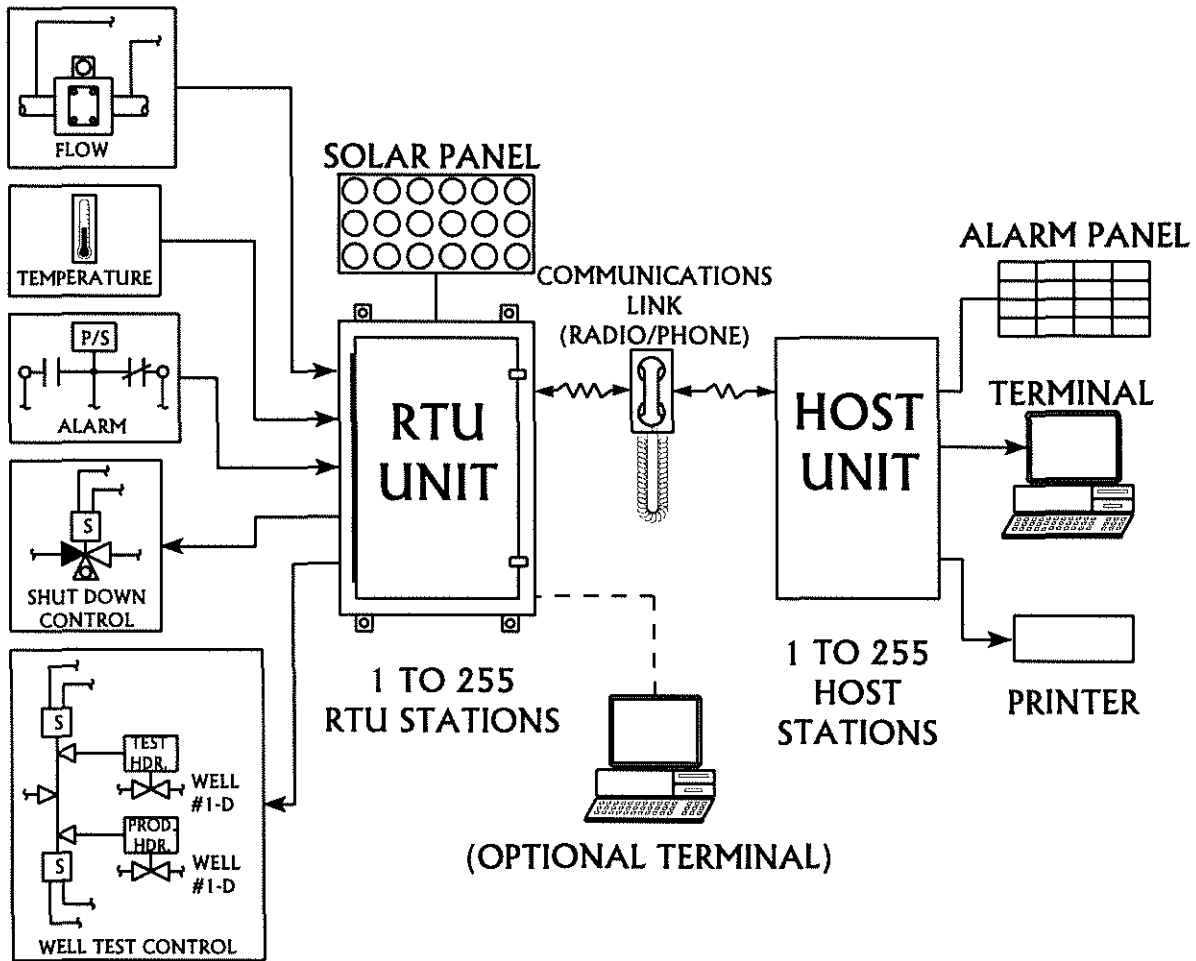
# SCADA Terminology

-  **SCADA**      **Supervisory Control and Data Acquisition**
  
-  **RTU**      **Remote Terminal Unit**  
**Remote Telemetry Unit**
  
-  **HOST**      **Central computer that receives RTU information**
  
-  **CHANNEL**      **One data point or value within the system**
  
-  **LINK**      **A communication path between two units**






# Software Terminology

- **DOS - Disk Operating System**
- **Application programs run under DOS**
- **HOST Software - Runs "Main" computer**
- **RTU Software - Runs "Remote" computer**
- **SCADAWARE™ - TEST's own program for both HOST and RTU**
- **SCADAWARE™ Lite - Smaller version for RTU and simple HOST applications**
- **Real-time - Fast enough to be transparent to the process monitored/controlled**
- **Multi-Tasking - Concurrent operation of more than one function**






# End to End



# Equipment Types

-  **Dumb RTU**      **Basic signal conversion and communications**
-  **Smart RTU**      **Adds local intelligence in the field**
-  **RTU/HOST**      **Local and remote points**
-  **PC**      **IBM personal computer compatible equipment**
-  **P.L.C.**      **Programmable Logic Controller**







# TEST RTU Systems

-  **Type 1000**      **Large scale “Smart” SCADA**  
**Uses Metrabus I/O**  
**Works with Scadaware™ + OA**
  
-  **Type 1200**      **Medium scale “Smart” SCADA**  
**Uses Generic I/O**  
**Works with Scadaware™ + OA**
  
-  **Type 2000**      **Small-Medium “Dumb” SCADA**  
 **Type 2200**      **Works with Scadaware™**  
**Type 2250**      **or MODBUS**
  
-  **Type 100**      **Small scale Voice RTU**  
**Provides status I/O only**  
**Works with touch tone codes**




# Primary vs. Secondary Control

- **Primary Control - On-site, reliable, “Fool Proof”**
- **Secondary Control - Optimize production, improve safety, reduce operating costs**
- **Combination of Primary and Secondary systems can reduce the effectiveness of both**
- **Oilfield - Primary controls are usually pneumatic**
- **Secondary Controls - SCADA added to existing Pneumatic Safety and Control Systems**
- **SCADA functions can also be added to Electrical or Electronic (PLC) Systems**







# RTU Concepts

-  **Very similar to PLC hardware**
-  **Difference is application**
-  **Less local processing**
-  **More communications tricks**
-  **Can use PLC as RTU**
-  **Normally reports to “HOST”**








# SCADA I/O Types

-  **Status**
  - **Simple Off/On sensing and control**
  - **Also called Digital I/O**
  - **Lowest complexity and cost**
  
-  **Analog**
  - **Value sensing in engineering units**
  - **Highest cost and complexity**
  
-  **Counter**
  - **Event (Pulse) counting**
  - **Also called Accumulator**
  - **Mostly for liquid meters**








# Offshore Applications

-  **Satellite to main platform**
-  **Main platform to office**
-  **Reduce production downtime**
-  **Extend production of marginal locations**
-  **Reduce transportation costs**
-  **Reduce unsafe trips**

# **Oilfield / Offshore Requirements**

-  **Cost sensitivity related to available production**
-  **Unreliable radio / phone communications**
-  **Loosely defined requirements that are guaranteed to change**
-  **Limited availability of electrical power**
-  **Difficult operating environment**
-  **Installation and training logistics**
-  **Limited maintenance support**

# Offshore Problems

-  **Unreliable communications**
-  **Difficult environment**
-  **Technical support**
-  **Varying requirements**
-  **Operator training**
-  **Operational testing**
-  **Maintenance**

# Scadaware™

 **Totally written by TEST, Inc.**













 **DOS Based - 3 versions**

**Lite - RTU**  
**Medium DPMI - Large RTU**  
**Full DPMI - HOST**

 **Self contained SCADA functions**

**Multi-Tasker**  
**RTU Polling**  
- Radio, phone, fiber, wire, network  
**Operator Display and Report**  
**System Status & Diagnostics**  
**TSP Programming Language**  
**Graphics and Database**  
**Open Architecture Links**  
- MODBUS, AB, Daniels, etc.









# Scadaware™ Components

-  **Multi-Tasker**
-  **Text Editor**
-  **Data Table Configuration**
-  **Data Table Scanner**
-  **One Second Operations**
-  **Comm Link Sub-system**
-  **Daily Agenda Processor**
-  **System Status Displays**
-  **Local I/O Driver**
-  **Graphics and Database Sub-systems**
-  **Network Support**
-  **Fax Report and Sound Output Options**

# System Management

- **Designation of HOST and RTU names**
- **Logical RTU setup - I/O groups**
- **Menu system preparation and testing**
- **Channel configuration screens**
- **Data transfer procedures**
- **Diagnostic Screens - I/O, Tasks, COMM, etc.**
- **Password levels - Rarely used**







# **SCADAWARE - Options**

-  **Not required for any critical function**
-  **Graphical displays - Backdrops and animated realtime objects (Bars, Text, Dots, Squares, etc.)**
-  **Graphical menus - Text objects with mouse actions**
-  **Database storage - Sliding file structure with auto time/data stamping**
-  **Voice alert with low cost PC based sound cards**
-  **Custom report formats**
-  **Fax data reports via phone**
-  **DOS program interface via ASCII text files**






# Logical RTU

- **Each “RTU” is a sub-group of channels in overall System Data Table**
- **Each RTU is independent of all others**
- **Default remote or local status for all RTU points**
- **Data is time stamped for each RTU**
- **Individual Config files - text version of config data**
- **Only one RTU is “Current”**

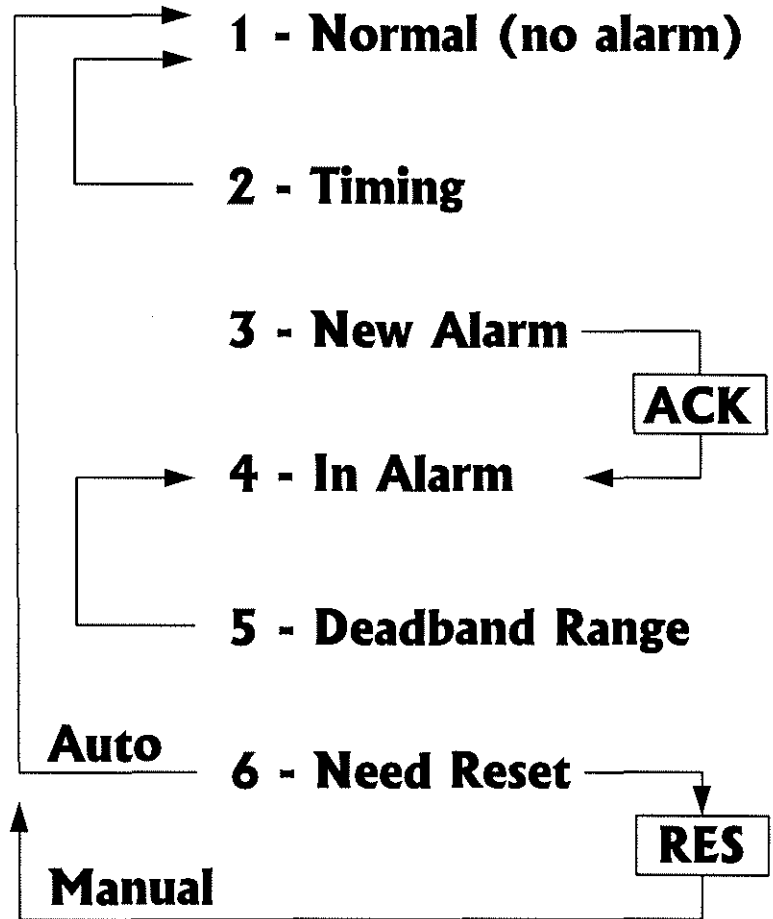
# Logical RTU Setup

-  **RTU ID (8 Characters)**
-  **Number of channels**
-  **Remote/Local status**
-  **Default Comm link**
-  **Optional menu files**
-  **Optional custom display**

# Text Editor

-  **Allows on-line editing of RTU files and libraries**
-  **Can edit any ASCII DOS file**
-  **Has search, replace, block, copy and move type functions**
-  **Pop-up directory display**
-  **On-line help system (1991) in RTUEEDIT.HLP**

# Alarm States



# Function Keys






## Quick access to frequent commands

- F1** - Silence local horn
- F2** - ACK new alarms on display
- F3** - RESET old alarms on display
- F4** - Print report for RTU
- F5** - Poll current RTU
- F7** - Display RTU data
- Shift + F7** - Display First Out alarm
- F9** - Start pop-up menu
- F10** - RTU select menu







## Programmed Keys

- Shift + F1** - Watch ON
- Shift + F2** - Watch Off
- F6** - Main Display

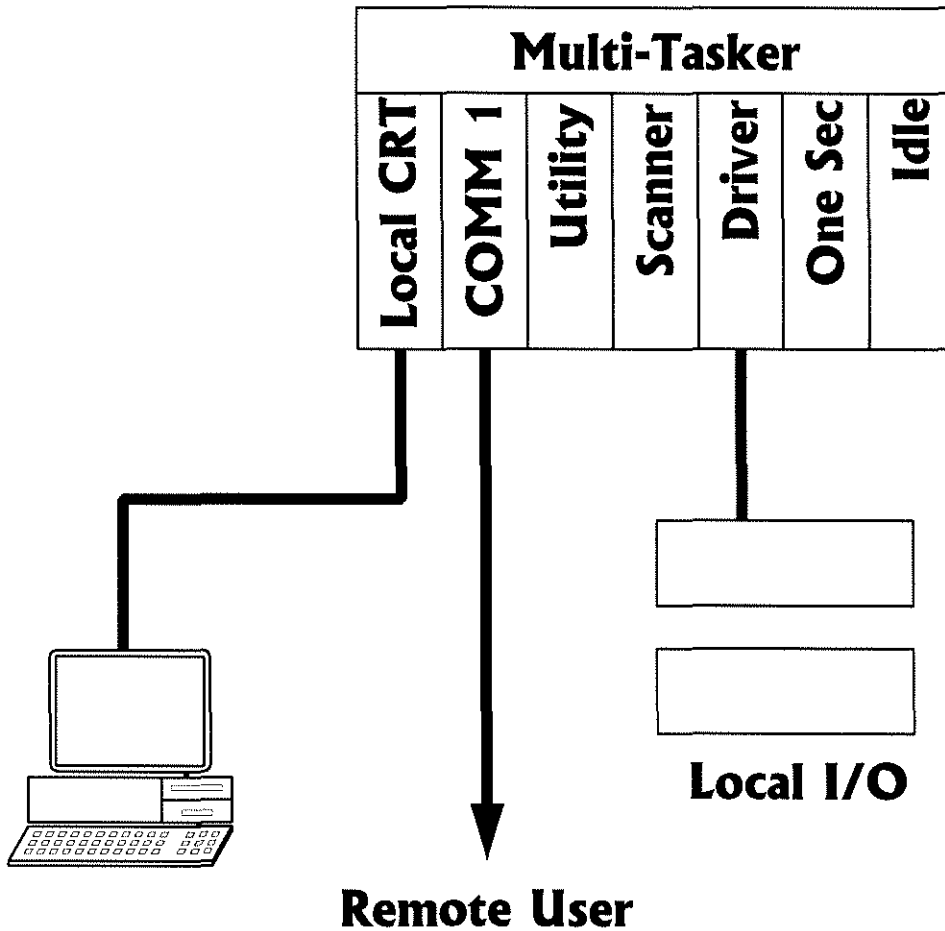
# Data Displays

-  **Shows current RTU data**
-  **Indicates alarm status**
-  **Easily flip among channel types and various RTU locations**
-  **Easily started with F7 or Shift + F7**
-  **Remote systems indicate the last update time and date**







# Multi-Tasker

-  **Allows many simultaneous program activities**
-  **Local CRT, remote interfaces and other background tasks**
-  **Configured for each RTU**
-  **Allows optimum setup for each hardware combination**
-  **Monitored with STAT T command**
-  **Task switch on PC timer, DOS, Simulated**





# Typical Setup







# RTU Tasks

-  **Provide command processing for RTU related functions**
-  **Interfaces to Humans as well as other RTU systems**
-  **Receives input from People, files other tasks, and Comm ports**
-  **May operate without console (utility)**
-  **Same code for all instances**
-  **Local CRT has special tricks**

# Point Scanner

-  **Looks for changes in alarm status for all channels**
-  **Provides calculation for AGA meter channels**
-  **Adjusted for RTU or HOST**
-  **Overhead based on number of channels needing service**







# One Second Task

-  **Scheduled once per second**
-  **Processes timers, totals, and other time related data**
-  **Catches up if running late**
-  **Must be on all Scadaware™ systems, HOST and RTU**

# I/O Hardware Driver

- **Reads physical I/O points attached to RTU**
- **Must be defined for each configuration**
- **Slightly different for each type of I/O hardware**
- **Each driver operated by its own task**

# Pop-Up Menu

-  **Allow 1 button automation**
-  **Easily configured in field**
-  **Unlimited number of menus**
-  **Menu “Gosub” supported**
-  **Mouse selection supported**
-  **DOS files or Library Proc**







# TSP Commands

- **TSP is both Language and Protocol**
- **Simple text command driven system**
- **Direct keyboard entry**
- **Message from remote unit**
- **Message from other task or event**
- **Message from text command file**







# Agenda System

- **Processes RTU commands at specified time of day**
- **Can send command to any task**
- **Can be dynamically changed**
- **Normally starts CMD file**
- **Used for daily Logoffs**








# RTU Diagnostics

-  **Check basic RTU operations**
-  **Verify input operation**
-  **Verify local values for inputs**
-  **RTU processes raw and converted values**
-  **Check basic Comm link**
-  **Monitor data at various points**

# Typical RTU Tasks

-  **Retrieve status and analog data**
-  **Alarm on error conditions**
-  **Accumulate production info**
-  **Remote operation of outputs**
-  **Default control on communication loss**
-  **May be on-line or dial-up**

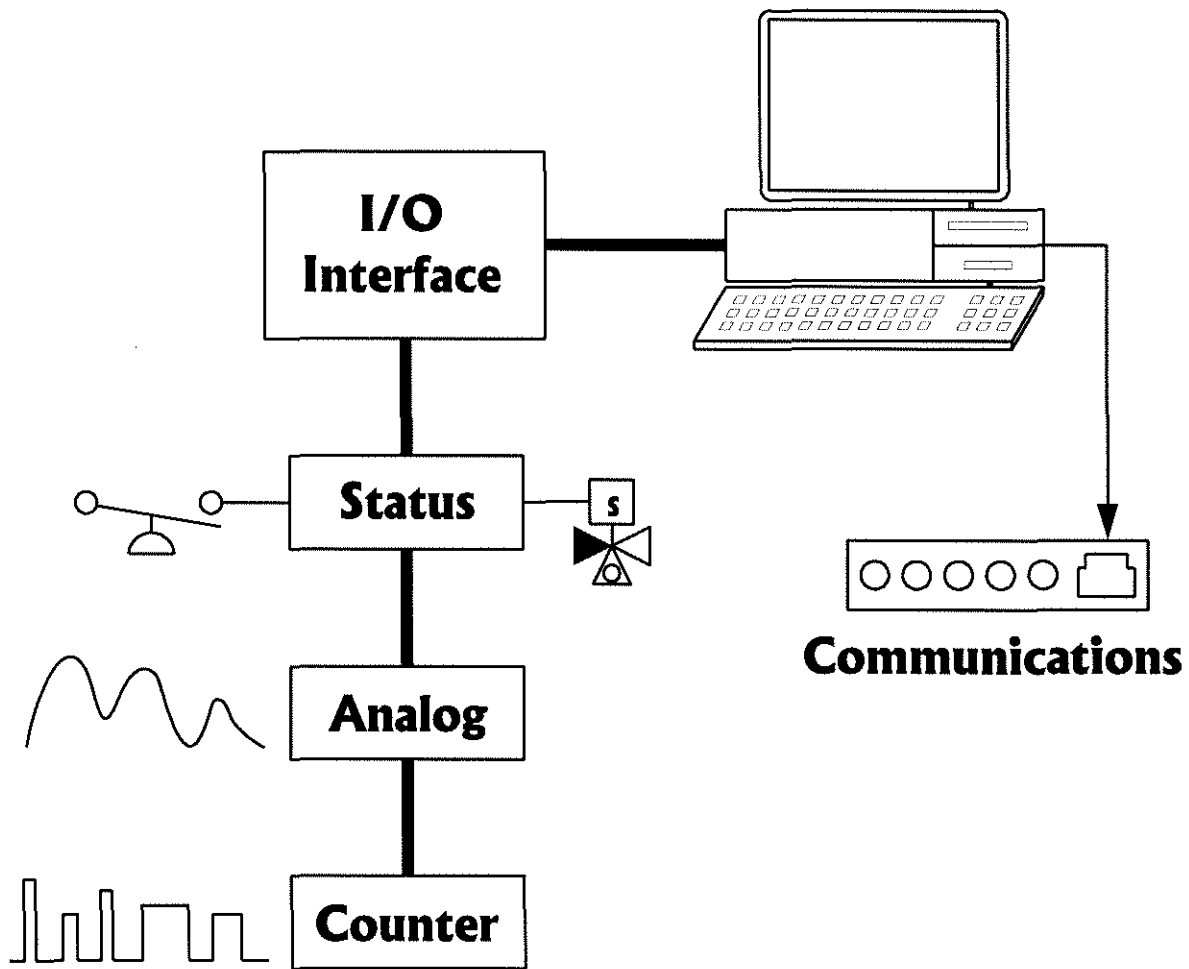
# Diagnosics

-  **Built-in to RTU and HOST**
-  **See problems inside system**
-  **Task monitoring**
-  **Communications status**
-  **Message monitoring**
-  **Data transfer “watch”**
-  **Manual simulations**







# 1200 Smart RTU - History

- **Early RTU's were low capacity units linked to mainframes (IBM, Sperry Univac, Burroughs)**
- **Later RTU's connected to Mini-Computers (DEC, HP, Data General)**
- **1980's - IBM PC changes the rules for Host Links**
- **Mid 80's - PC used for RTU functions**
- **1987 - First "Official" TEST PC based RTU. Later named 'Type 1000 Metabus'**
- **1990 - Industrial PC hardware continues to improve - Provides standard hardware base**
- **Type 1200 based on generic I/O devices**





# TEST RTU Design



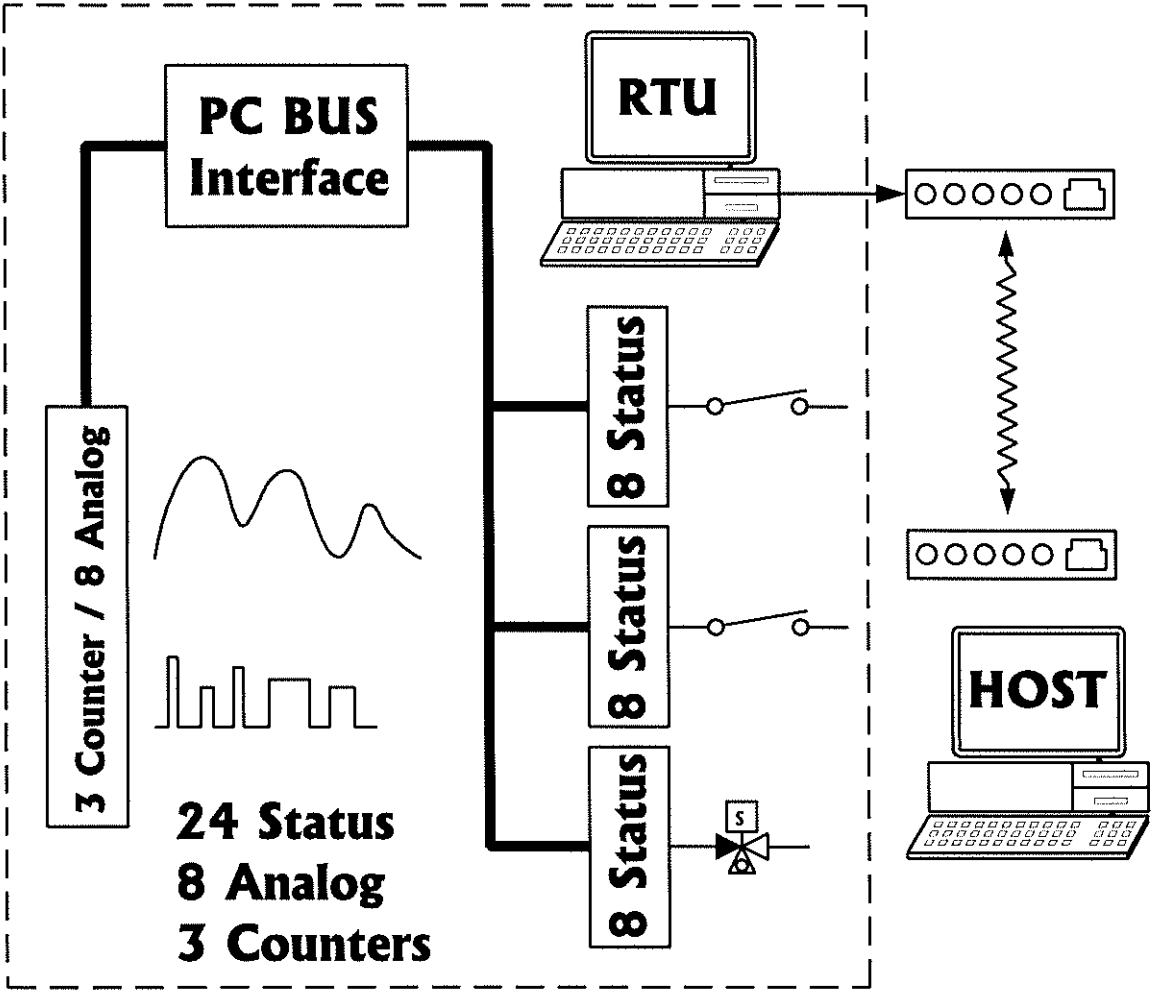
# PC Based RTU Advantages

-  **Very high computing power at relatively low cost**
-  **Non-proprietary designs**
-  **Continuous development of industry standard eliminates obsolescence**
-  **Wide variety of components**
-  **Common components across systems**
-  **Ease of understanding and maintenance**

# PC Based RTU Disadvantages

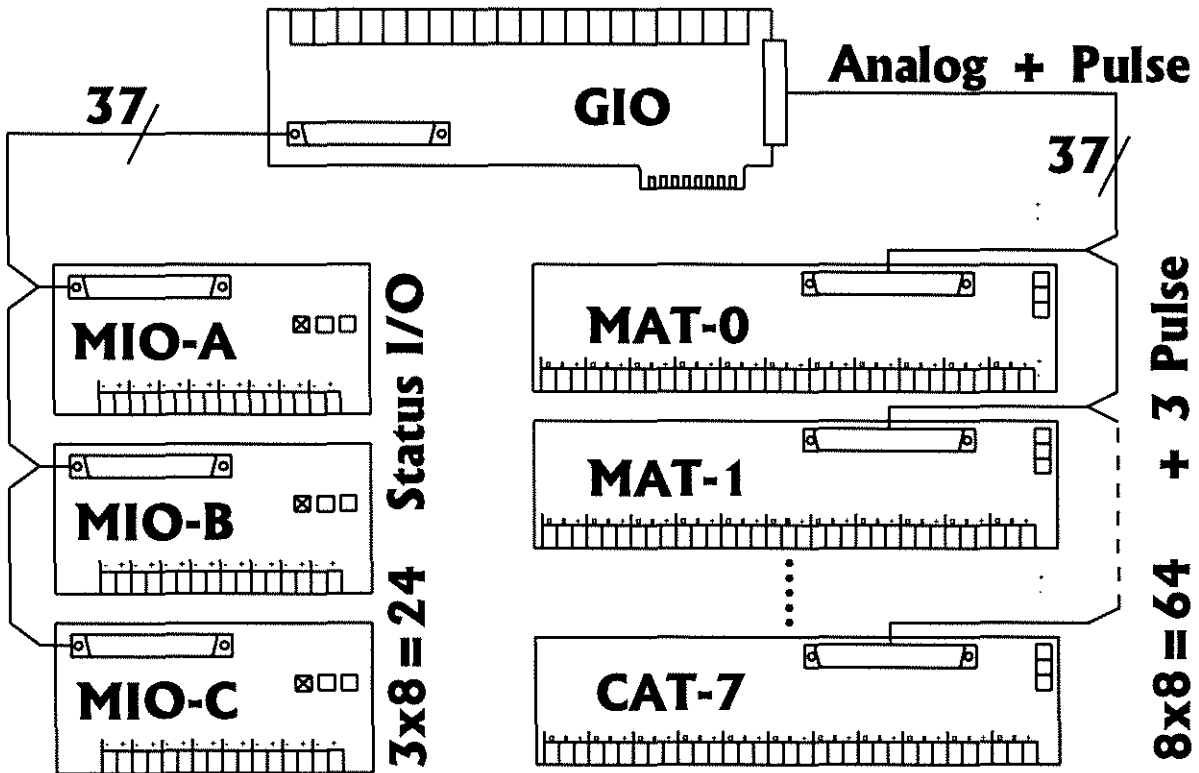
-  **Very small systems have high cost**
-  **Typical applications reduce reliability in Real-Time control**
-  **More complex on-board software than dedicated RTU or PLC**
-  **Inadequate hardware and software less obvious to untrained user**

# Type 1200 RTU








# Generic I/O

- **PC based standard input/output**
- **Multi-vendor support**
- **TEST, Inc. manufacturers termination boards**
- **24 Status, 64 Analog, 3 Pulse per board**



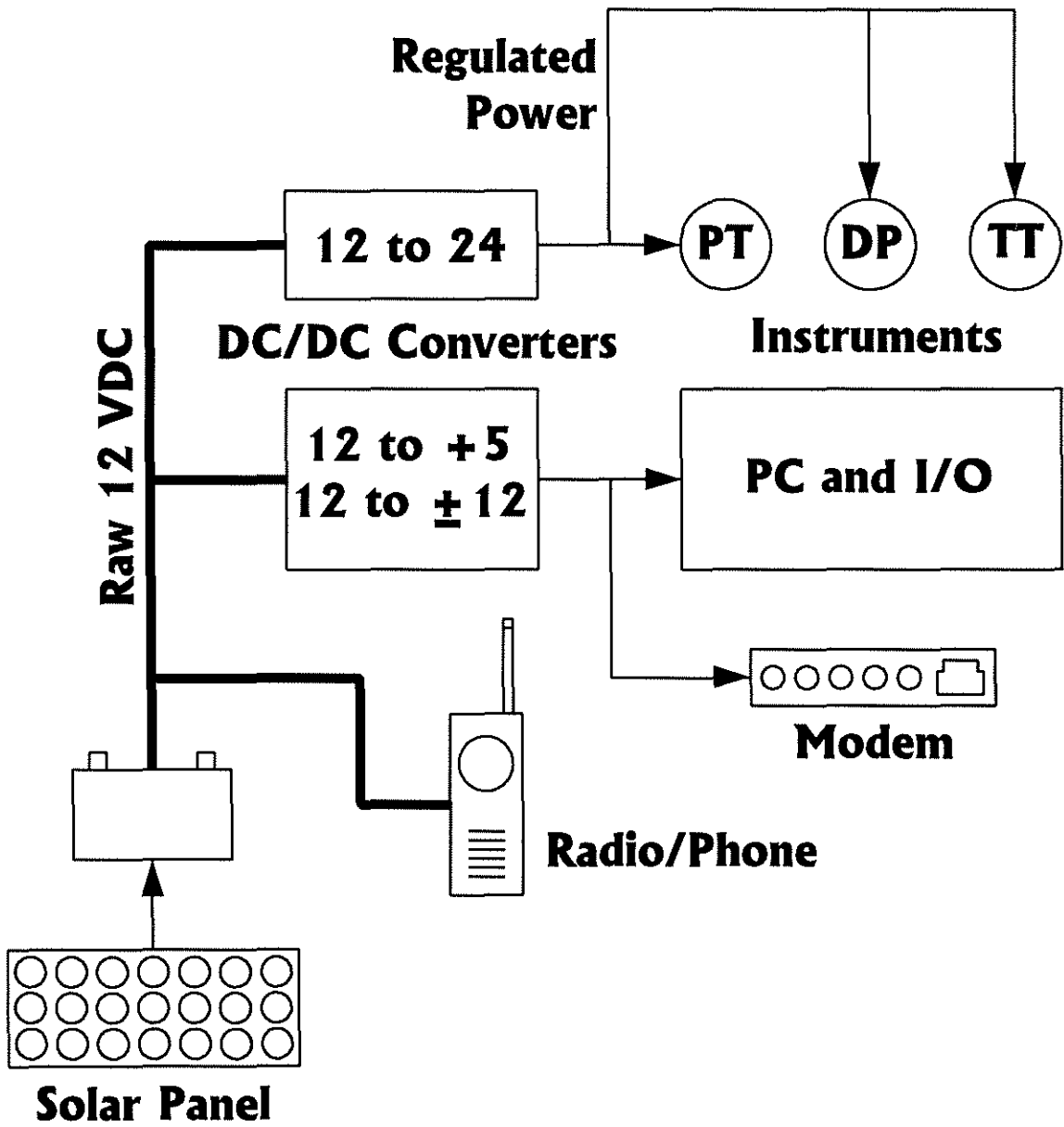
## Field Terminations

# GIO Configuration






- 
**Stored in RTUNAME.GIO**
- 
**Edit with any text editor**
- 
**Defines I/O system to Scadaware™**
  - Base address of GIO ports
  - Number of I/O points by type
  - Map into Scadaware™ data table
  - Offset for multiple boards
- 
**May contain optional modifiers - Fast**
- 
**Sample GIO file:**

	<u>Port</u>	<u>Qty</u>	<u>Address Size</u>	<u>RTU Point</u>	<u>Offset</u>
Status	\$328	16	8	1	0
Output	\$328	8	8	1	2
Analog In	\$320	15	16	1	
Counter	\$324	2	16	1	

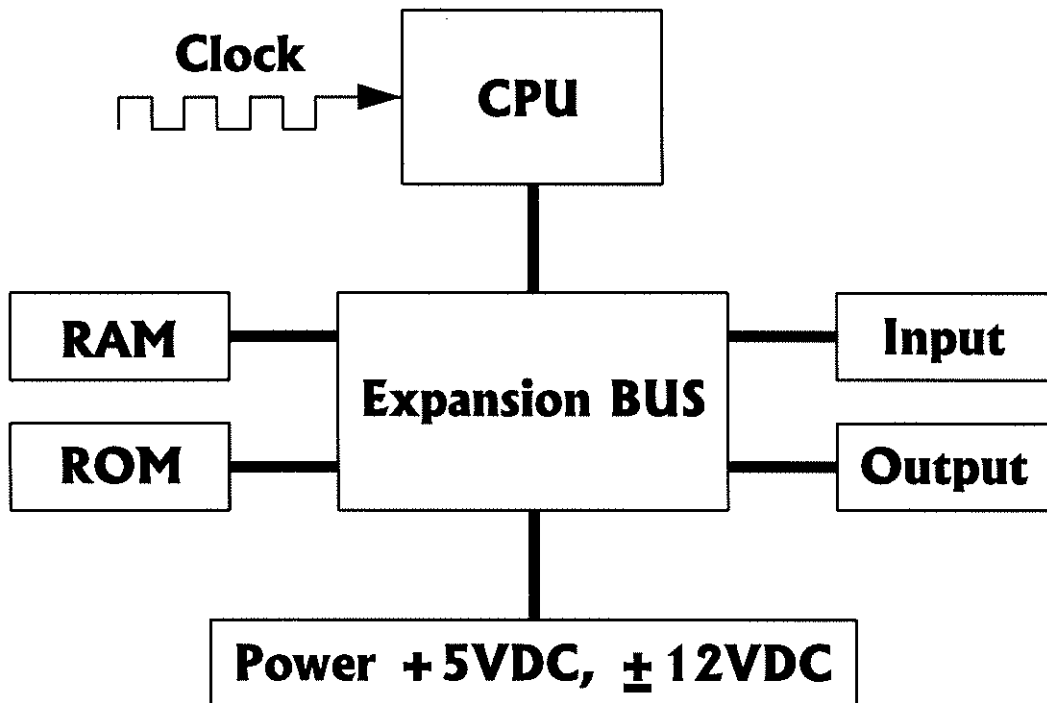
# RTU Power System








# RTU CPU Module

-  **PC compatible hardware (8088 → Pentium)**
-  **Low power industrial unit**
-  **Supports RAM disks**
-  **No keyboard or display required for operation**
-  **PC expansion bus**

# Micro Components











# Comparing Micros

-  **Processor data size (4 bit → 32 bit)**
-  **Processor clock speed (5 MHz → 200 MHz)**
-  **Instruction cycle time**
-  **Memory space (32 KB → 16 GB)**
-  **On-board peripherals (ports, video, memory)**






# RTU Disk Drives

- **Store RTU programs, setup files, and data logs**
- **At least one required**
- **DOS compatible formats**
- **Any floppy disk type**
- **Any hard disk type**
- **Solid state (RAM) disks have no moving parts**
- **Can mix types to meet individual requirements**

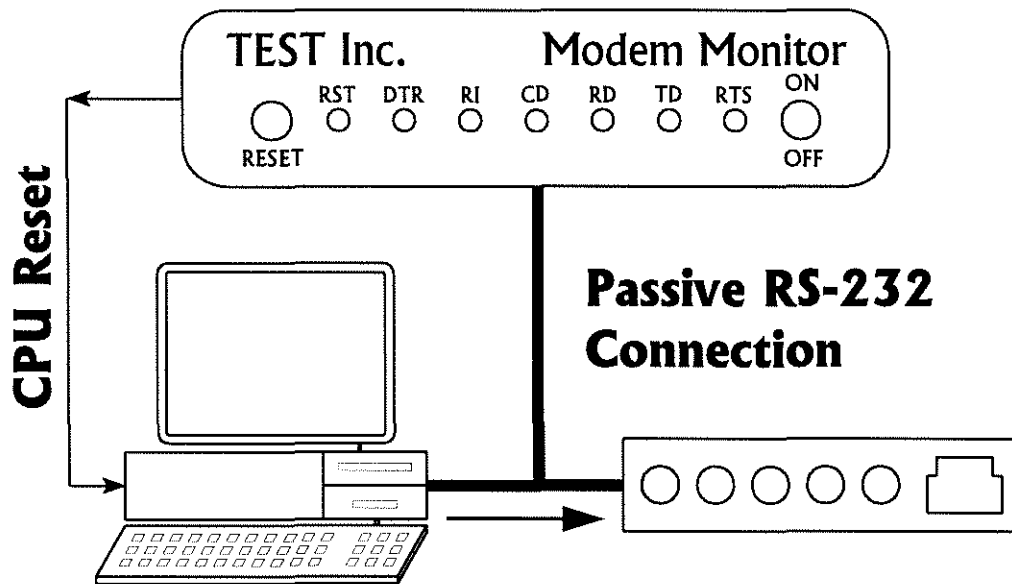
# Displays and Keyboards


-  **Any PC display supported**
-  **CRT normally provided**
-  **Portable unit available**
-  **Color or Mono up to 50 lines**
-  **Separate ANSI terminal**
-  **Standard PC keyboard**
-  **Sealed units available**
-  **Keyboard NOT required**

# RTU COMM Ports

-  **PC compatible devices**
-  **Normally RS-232 standard**
-  **Up to 4 ports per RTU**
-  **Used for Remote Comm, Remote I/O, and extra CRT displays**
-  **Connect to modems and packet radio controllers**

# Modem Monitor



-  **Detects computer failure**  
**Counts Modem rings**  
**Allows remote reset**  
**Phone, radio, LB-100 versions**

 **Design/Built by TEST**

## **AFD INTERFACE ANALOG FOR DIGITAL**

**Permits multiplexed analog inputs to be used as status (off/on) inputs**

**"Borrows" unused analog inputs which are mapped into TSP status point table**










**Optical isolation via board mounted chips rather than larger Opto-22 type modules**

**Each board interfaces like two MAT Multiplexed Analog Termination boards for a total of 16 points per board. Point density is thereby doubled.**

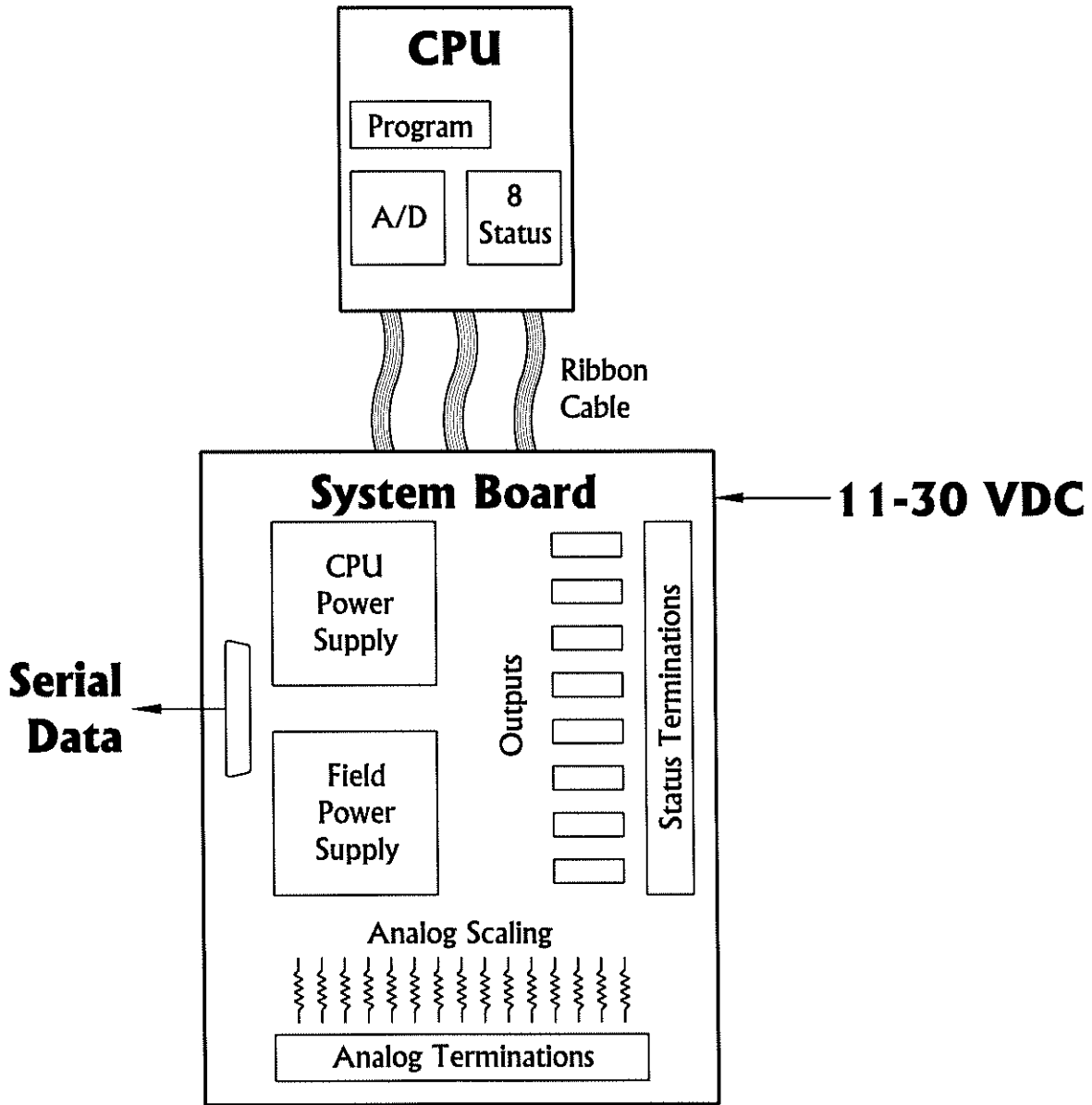
**GIO Analog driver must be set to scan total of analog and AFD points**

**Driver automatically reduces number of true analogs by deleting AFD points.**

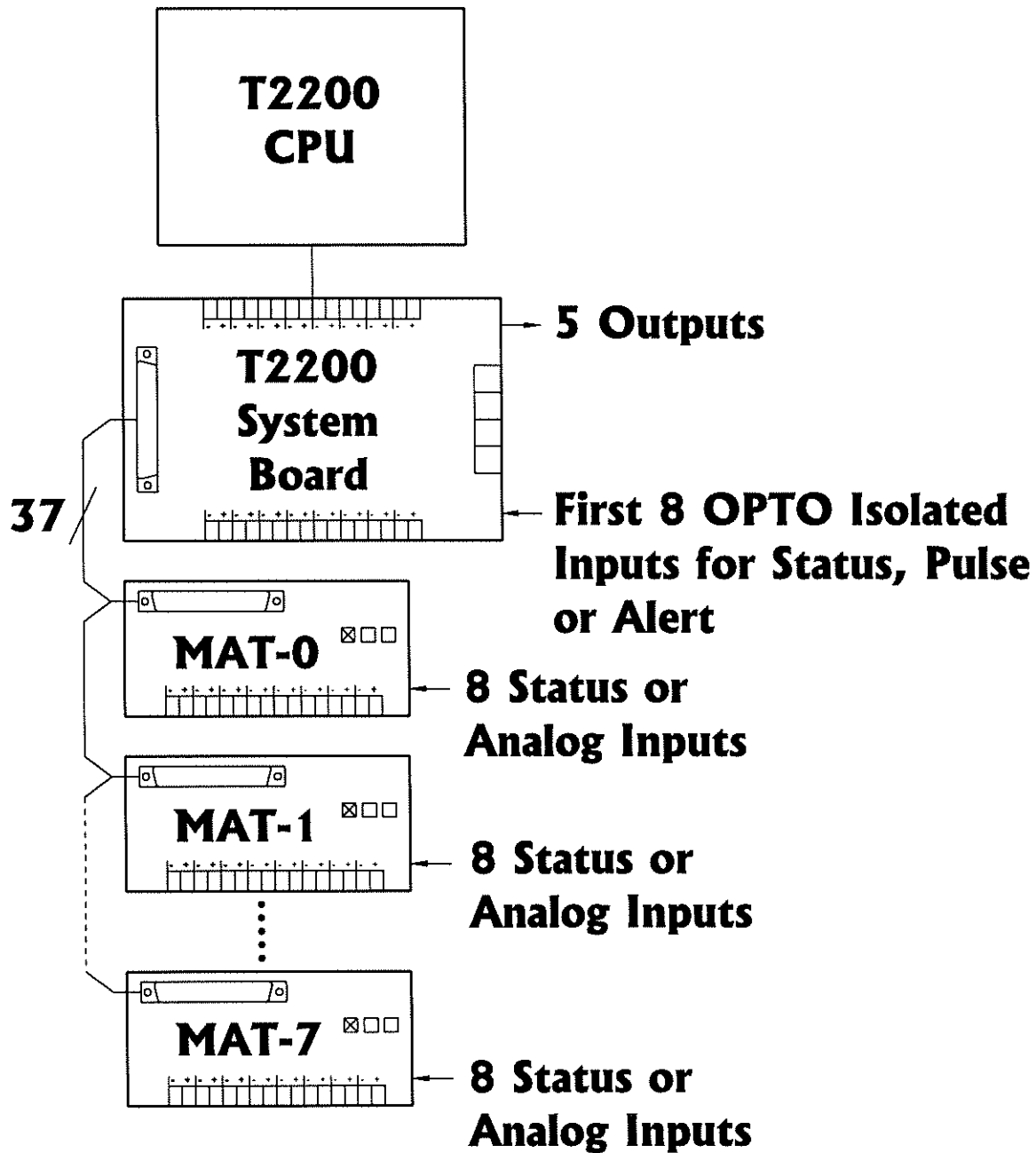
# **Type 2200 SCADA Node RTU**

-  **Low power, low point-count application**
-  **8 Opto-Isolated status inputs - outputs**
-  **8 Analog inputs - 2 Analog outputs**
-  **Talks TSP or MODBUS RTU**
-  **Any serial communications type**
-  **Call-On-Exception callout capability**
-  **Multiple units can share COMM modems**
-  **Slave I/O device for larger TEST RTU**
-  **Expandable as Type 2250 to 64 I/O**

# T2200 Overview



# T2250 Overview



# **SCADA System Planning Guide**

## **1. Introduction**

### **1.1 SCADA Application Philosophy**

## **2. System Justification**

### **2.1 Reduce Production Downtime**

### **2.2 Reduce Transportation Costs**

### **2.3 Improve Operations Safety**

### **2.4 Better Use of Existing Manpower**

### **2.5 Extend Marginal Production**

### **2.6 Improve Production Information**

# **SCADA System Planning Guide**

## **3. Necessary Technical Information**

- 3.1 List of monitored and controlled points**
- 3.2 Detailed point list with ranges -  
Sort by type (analog, status, value)**
- 3.3 Communications availability**
- 3.4 Local processing and/or display  
requirements**
- 3.5 Realistic system requirements**
- 3.6 Provide system design goals to vendor**
- 3.7 List system's optional requirements**
- 3.8 General screen display and report  
formats**
- 3.9 Operator interface requirements**
- 3.10 Physical installation plans and  
information**
- 3.11 MMS compliance responsibility**

# **SCADA System Planning Guide**

## **4. Procurement and Installation**

**4.1 Vendor selection**

**4.2 SCADA vendor qualifications**

**SCADA system hardware and software**

**Oilfield operations**

**Instrumentation and safety systems**

**Production measurement**

**MMS regulations compliance**

**Field service of ALL system components**

**Industrial training**

**4.3 Installation logistics**

**4.4 Operator training**

**4.5 Documentation**

# **RTU Channel Types**

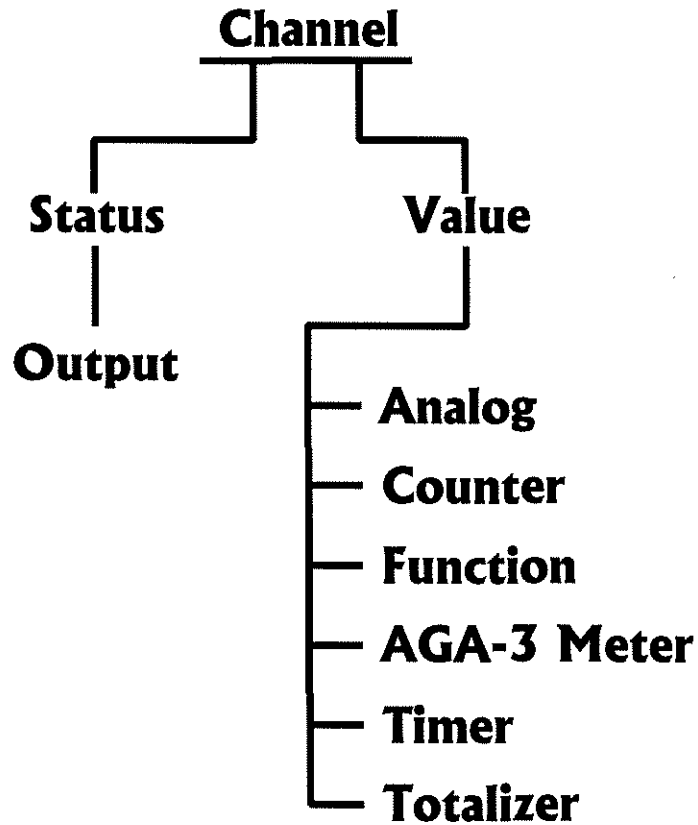
## **Real Channels**

**Status Inputs**  
**Status Outputs**  
**Analog Inputs/Outputs**  
**Counter Inputs**

## **Logical Channels**

**Values**  
**AGA-3 Meters**  
**Totalizers**  
**Timers**  
**Function (rate, average, difference)**







# RTU Channels



# Channel Setups

- **Describe points to system**
- **Normally done on RTU itself**
- **Setup screen for each different channel type**
- **Easy RTU duplication**
- **Setups stored in DOS ASCII Text file**
- **HOST can read RTU setups from diskette**

# Config Command

-  **Setup for Channels and Links**
-  **Separate screen for each Channel type**
-  **Easily move among all Channels of same type for each RTU**
-  **Screen cursor stays on same field after move**
-  **Setups only in memory until SAVE command**
-  **Access from Display Screen with right mouse click**






# Channel References

- **Point ID: A5, Q3, O2**
- **TAG PSL110, TOTAL, NAVBAT**
- **Single or Group reference**
- **Current RTU is default**
- **RTU can be specified with RtuName.CH1:CH2**
- **S6:S12 Ambiguous**
- **VR25.S6:S12 Unambiguous**

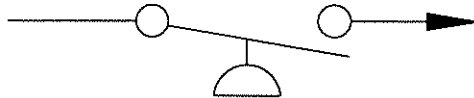
# Channel Basics





**Channel Name**  
**TAG Name**  
**Alarm Delay (Seconds)**  
**Alarm Type?**  
**Blow Horn or Alarm?**  
**Reset after ACK?**  
**Call on Abnormal?**  
**Call on Reset?**  
**Log Abnormals?**  
**Execute RTU File?**  
**Skip Reports?**  
**Play Sound?**  
**Callout Group?**

# Channel Runtime Options

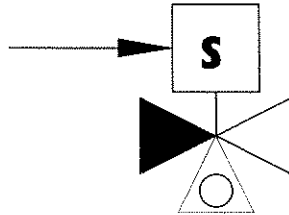
-  **Used to modify system's view of a data channel**
-  **Hold - Freeze Channel Value and suspend low level data conversion**
-  **Local / Remote - Controls low level calculation and alarm response**
-  **Enable / Disable - Controls alarm response**
-  **Direct "Calc" - Manual setting of values**




# Status Input



-  **Inherits Channel Basics**
-  **Normal State Text**  
**“Platform Running”**
-  **Abnormal State Text**  
**“Platform Shut-In”**
-  **Normal State is ON?**








# Status Output



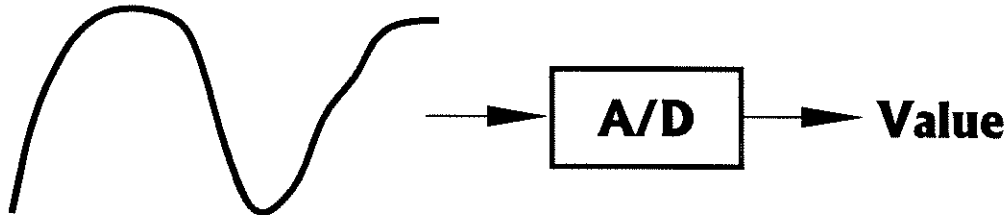
-  **Inherits Channel Basics**  
**Inherits Status Basics**
-  **Normally Energized?**
-  **May be tied to Timer**

# Value Channels

1234.567


-  **Inherits channel basics**
-  **Units (Volts, PSI, Deg-F)**
-  **Input Control Channel**
-  **Low Alarm Value**
-  **High Alarm Value**
-  **Dead Band (Hi and Lo)**
-  **Decimal Places**

# Analog Inputs



-  **Inherits Channel Basics**  
**Inherits Value Basics**

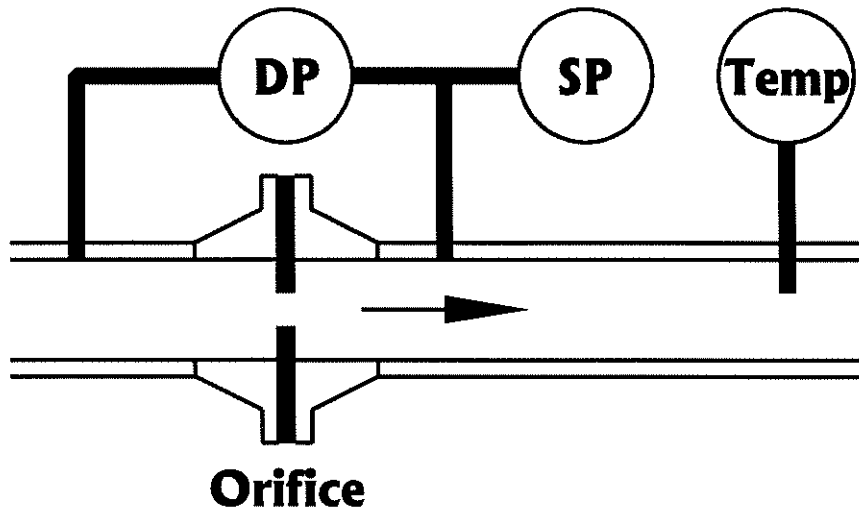
**Offset Channel?**

-  **Value at 0%**  
**Value at 100%**  
**Allow Negative?**

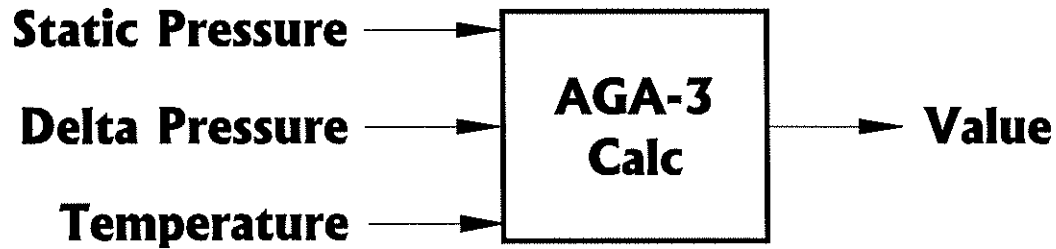
-  **Used for Pressure, Temperature, Level, Etc.**






# Gas Flow Measurement

- **AGA-3 Gas flow calculation**
- **Uses Delta-P, Static-P and Temp variables**
- **Has many setup parameters**








# AGA-3 Gas Meters



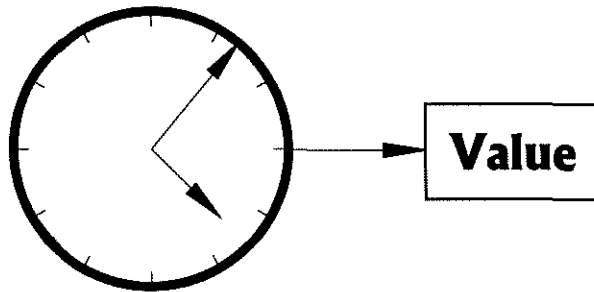
-  **Inherits Basic and Value Channels**
-  **Pressure, Delta-P, Temperature, Plate, MCO2, MN2 from any channel**
-  **Deg-C or F, Up-Down Stream, Pile or Flange, Stainless or Monel, Height, Latitude**
-  **Contract Temperature and Pressure**
-  **Adjustable Recalc Frequency**







# Totalizers

$$\text{Total} = \text{Total} + \frac{\text{Sample}}{\text{Factor}}$$

-  **Inherits Basics + Values**
-  **Samples each second**
-  **Factor divided into Sample**
-  **Minimum acceptable input**
-  **Used for Total Gas Volume**

# Timers



-  **Inherits Basics Channel**  
**Inherits Value Channel**
-  **Can count Up or Down**
-  **Alarm at Time or Zero**
-  **Hours, Minutes or Seconds**
-  **Any channel can start/control**
-  **Can directly control output**

# Counter Inputs



- **Inherits Channel Basics**  
**Inherits Value Basics**
- **Threshold Count**  
**How many ticks = 1 unit**
- **Counter Factor**  
**Multiply each unit for value**
- **Filter Ticks**  
**Eliminate stray counts**
- **Used for meters**

# Function Channel

- **Samples other channels over fixed time period**
- **Does math with time and units factor**
- **Averaging - AGA-3 Meters, Pressures**
- **Rate - Change Counts into Flow/Time**
- **Difference - Meter failures**
- **Procedure - Execute periodic TSP Procedure**
- **Allows alarms, etc., like any other channel**

# RTU Commands

- **Processed by RTU, Utility, and Net tasks only**
- **Consist of Command and some number of keywords or parameters**
- **Humans use plain text format**
- **Computers use special error correcting format**
- **Local CRT has special commands**

# Command Files

- **Store prepared command scripts**
- **DOS files for single procedure**
- **Library for multiple procedures**
- **DOS files execute from disk**
- **Library procedures execute from memory**
- **Parameters for multiple use of single file**
- **Started by hand, timer, agenda, or abnormal**
- **Execution controlled by COMM LINK status**
- **Allow program operator input and custom displays**

# Typical CMD File



**Select SMI7**

**Dial**

**Wait connect 45**

**Set Online On**

**MSG RTU \$R is Online**


**Gosub Pulse\_timer**

**Msg Shut In command sent**

**Sleep 45**

**Block READ DOWNLOAD**

# TSP Command Types

 **Data and System Configuration:**  
Config, Change, Hold, SetLow

 **Data Calculation, Display, Reporting:**  
AGA3, Calc Display, Menu, Report

 **Communications Control:**  
Dial, Hangup, Bye, Link, Hayes, PRC

 **Alarm Control:**  
ACK, Reset, Disable, Horn

 **Data Transfer:**  
Scan, Data, Block

 **Command File Control:**  
Read, If, Endif, Gosub, Sleep, Wait

 **Diagnostics:**  
Dump, Stat, Version

 **System Access:**  
Logon, Password, \*Terminal

 **DOS File Commands:**  
Dir, Edit, Exec, Copy

# CALC Command

- **Set channel values**
- **Uses expression evaluator**
- **Channel reference by TAG or point ID or variable**
- **Assumes current RTU**
- **Functions like Sin, Cos, < >**
- **Command line parameters can be used in files**

**Calc o1 = On**

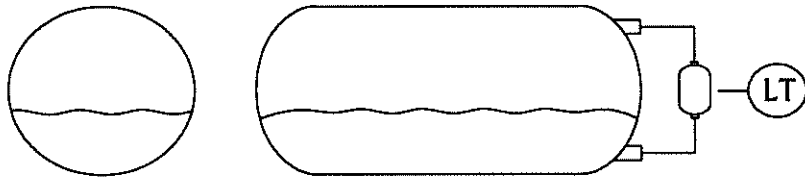
**Calc o1:o4 = Off**

**Calc TOTAL = tot1 + tot2**

**Calc DAYTOT = C1 + DAYTOT**

# Table Look-ups

- Establish X-Y relationships between lists of numbers
- Useful for non-linear relationships (Tank Strapping)
- Example:      **Cylindrical Tank**



**X = Volume**

0%  
10%  
20%  
30%  
40%  
50%  
:  
100%

**Y-Signal (Level)**

4.0 ma  
6 ma  
8 ma  
10.0 ma  
10.5 ma  
11.0 ma  
:  
20.0 ma

- Table load reads in definition file

Size 10  
X1, Y1  
X2, Y2  
:  
X10, Y10

● Closest Match -      **@TABX, @TABY**






● Interpolated -      **@INTX, @INTY**

# Block Command

- **Sends commands and data to other unit**
- **Verifies that line received property**
- **Automatic retry if fail**
- **Verification may be reply from other unit to save transmission time**
- **Typical user is to pulse output timer at RTU**

**BLOCK Calc T1 = 15**

# Data Transfer Options

-  **Field adjustable for each RTU and COMM link**
-  **Optimized for phone or radio**
-  **Either HOST or RTU can control transfers**
-  **DOWNLOAD file normally used**
-  **Default action based on HOST or RTU status**

# RTU Download File

## PROC Download

**Set online ON**

**SCAN a1:a8 E m1:m2 E**

**SCAN s1:s16 R o1:o8 R**








**SCAN c1:c4 E q1:q2 E**

**SCAN v1:v8 E@**

**Set online OFF**

**BYE**

# Scan/Data Options

-  **E - Engineering units**
-  **R - Raw units**
-  **T - Channel time and date**
-  **@Ends - Update time and date**
-  **AGA3 error numbers**
-  **Multiple SCANS per line**
-  **Automatic time stamp with @**

# Report Command

- **Produces Standard report for current or any RTU**
- **FOR option specifies RTU**
- **TO option specifies destination file or PRN**
- **Printer must be enabled to get a printout**
- **Destination may be file**

**Report**  
**Report for VR256E**  
**Report for SM17 to SM17.rep**

# Custom Screen

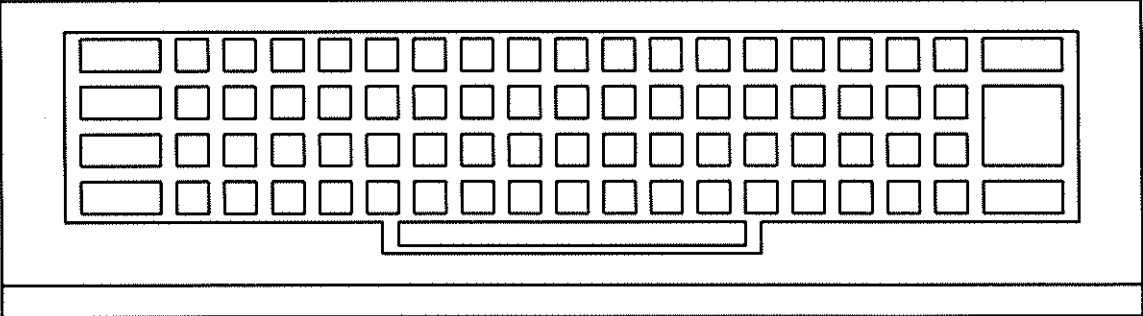
Wacker GA343A Daily Production Report  
Report Printed On 11/30/90

Previous Day Production







Sales Meter Number 1	0.00 MMCF
Sales Meter Number 2	0.00 MMCF
Sales Meter Total	0.00 MMCF
Pipeline Pressure	0.00 PSIG

Data was transmitted from GA343 at 19:04:15 11/30/90









Hit any key to continue....



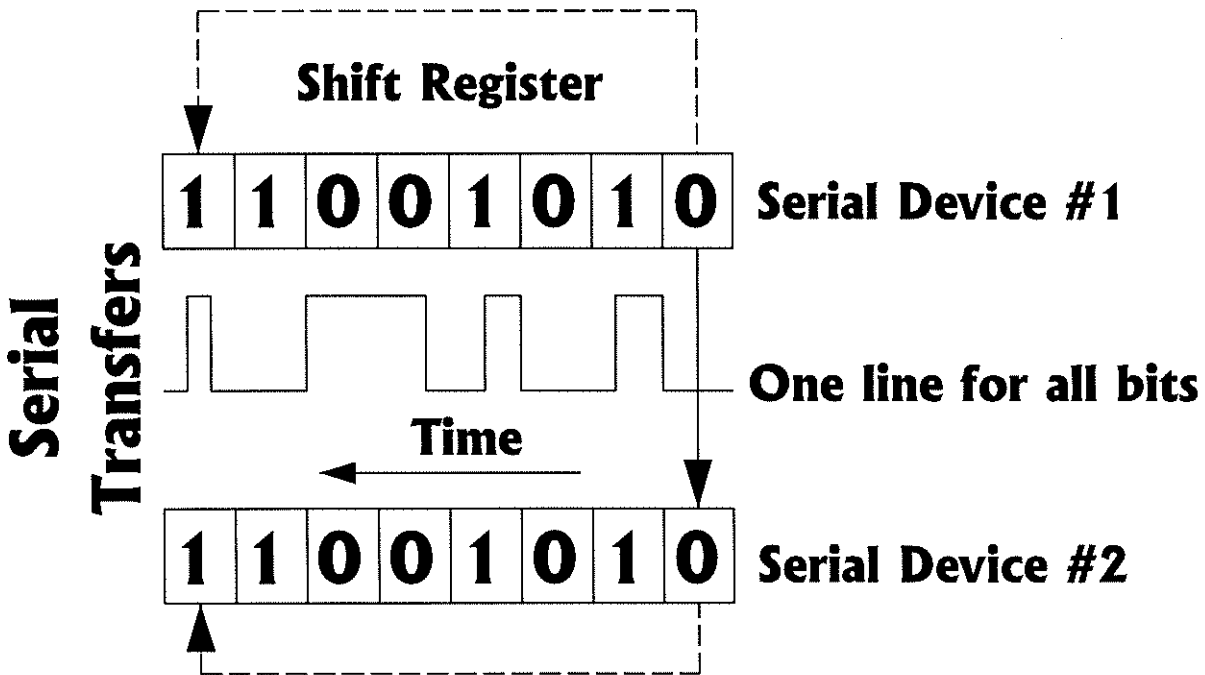
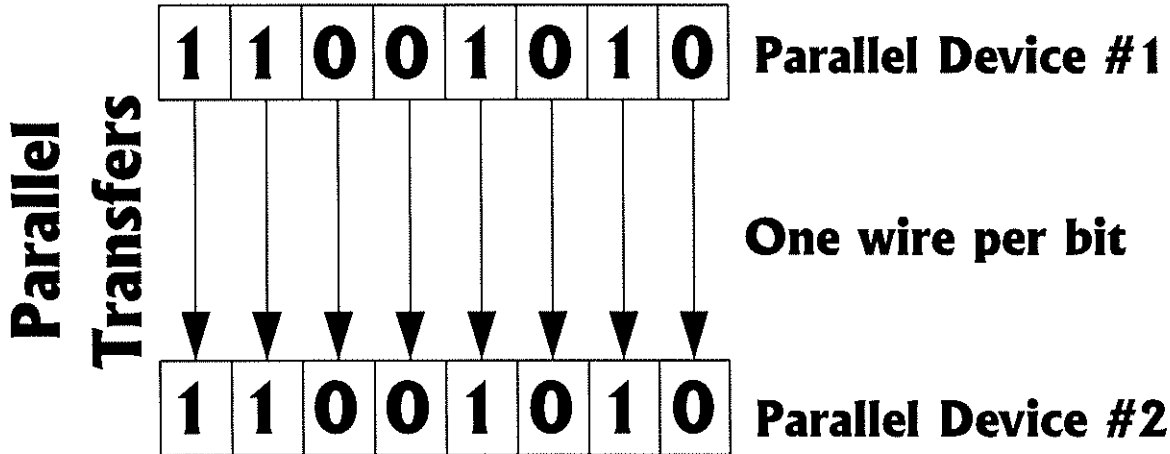
# Communications

-  **RTU to HOST connections**
-  **Serial data transmission of digital information**
-  **Hard wire electrical**
-  **Audio tone via telephone or radio links**
-  **On-line or Dial-up link**
-  **Error prone technology**

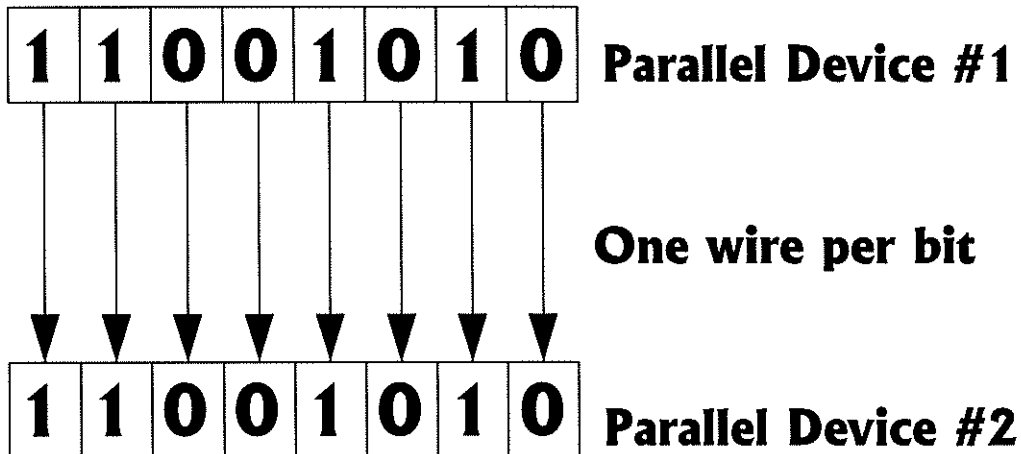
# Communication Terms





-  **Simplex - Duplex**
-  **Half - Full Duplex**
-  **Originate - Answer**
-  **Baud Rate**
-  **Start and Stop Bits**
-  **Parity - Odd, Even, None, Mark**
-  **Echo**
-  **2 Wire - 4 Wire**

# Data Transfers

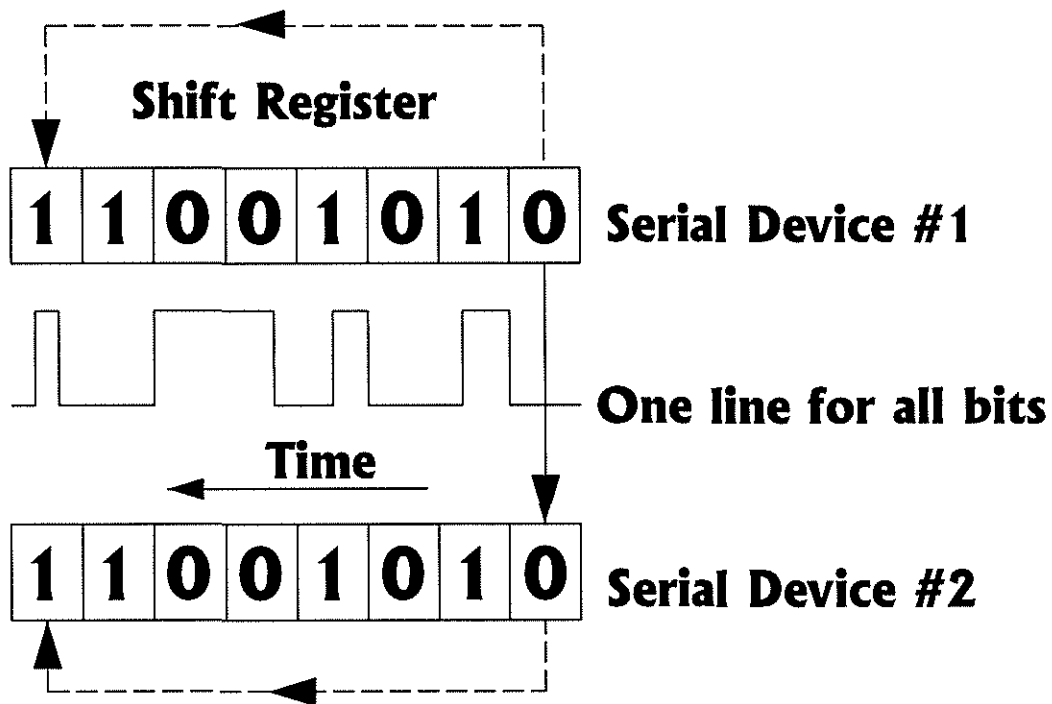






# Parallel Data



-  **One Comm path per bit**
-  **Data valid at any time**
-  **Very high speed transfers**
-  **Short lengths only**

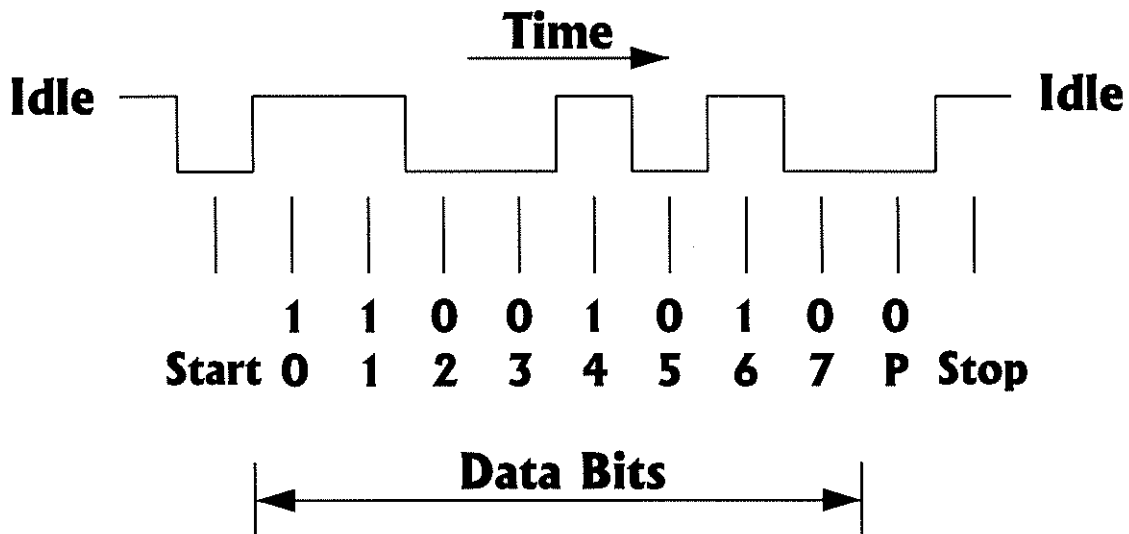
# Serial Data



-  **Data not valid during transfer**
-  **Only one Comm path required for all bits**
-  **Slower than parallel**
-  **Any distance possible**

# Serial Comm

- Synchronous or Async
- Normally 8 data bits
- Start and Stop bits (1 or 2)
- Parity bits - odd, even, mark, spare, none
- Baud rate (Bits/sec.)



# EIA Standards

 **RS-232**

**± 3 to 15 volts**  
**Up to 9600 Baud (officially)**  
**Single drop (officially)**  
**50' max.**





 **RS-422**

**Multiple receivers/Single transmit**  
**1000' length**

 **RS-485**

**Multiple receive/transmit**  
**1000' length**  
**Higher speeds**

# RS-232 Standard

-  **Recommended Standard**
-  **Defines pins and levels only**
-  **DTE and DCE varieties**
-  **Not related to data content**







Protective Ground	1	14	
Transmit Data	2	15	
Receive Data	3	16	
Request to Send	4	17	
Clear to Send	5	18	
Data Set Ready	6	19	
Signal Ground	7	20	Data Terminal Ready
Carrier Detect	8	21	
	9	22	Ring Indicator
	10	23	
	11	24	
High Speed	12	25	
	13		

**DCE-MODEM**  
**DB-25**

# Data Modems

- **MOdulator + DEModulator = MODEM**
- **Changes 1/0 into tones**
- **Changes tones back to 1/0**
- **Many industry standards - Bell, CITT**
- **Both ends must match exactly**
- **Getting complicated (FAX, error detect/correct)**

# Packet Radio Controller

-  **Acts as very smart modem for radio systems**
-  **Each has unique “call sign”**
-  **Sends tones to radio via microphone input**
-  **Receives tones from radio via speaker output**
-  **Keys radio and waits for transmitter**
-  **Provides routing, error checks, FCC timeouts, other tricks**

# Dial-Up vs. Direct

- **Many systems require direct connection by design**
- **Direct is easy and fast but least flexible**
- **Dial-Up requires sophisticated Comm technology**
- **In dial-up, most transfer time is spent making the connection**
- **Dial-Up is usually cheaper**
- **Dial-Up uses less power than continuous transmit**

# Multi-Drop Communications

- **Multiple units share common communications path**
- **Typical in radio and hard-wire systems**
- **Only one unit “talks” at any time**
- **Each station has unique ID address**
- **Single Master, Multi-Slave**
- **Multi-Master, Multi-Slave**
- **Best in low traffic, high communications cost applications**

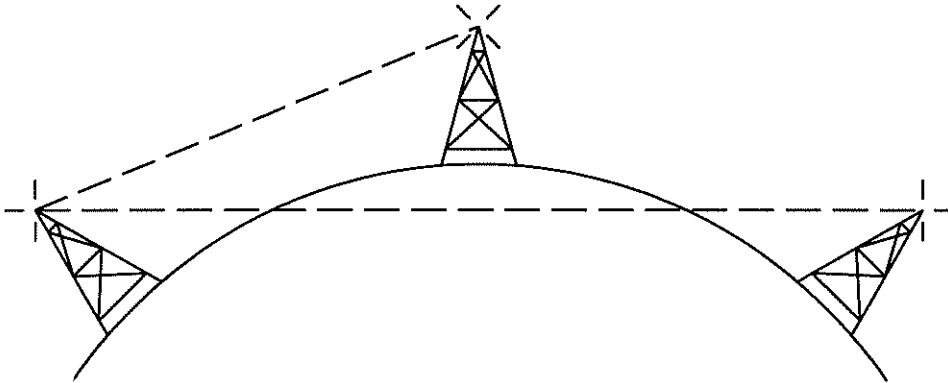
# Phone Systems

- **Various technologies trying to be compatible**
- **Wireline, Cellular, Radio**
- **Signal can vary from one call to another**
- **Phone carries audio modem signals for 1 and 0**
- **System usually maintained by others**

# Radios

- **Electromagnetic radiation**
- **Microvolt levels at receiver**
- **Limited reliability due to interference**
- **Each band has characteristics -  
HF, UHF, VHF, 900, Microwave**
- **Radio carries modem tones in simple systems**
- **Digital signal techniques in complex systems**
- **Normally half duplex - One side at a time**

# Radio Ranges



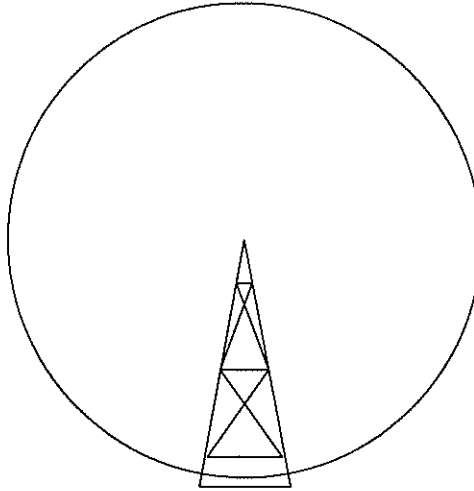
- **Antenna height gives range**
- **Distance (miles) =  $1.22 \sqrt{\text{Height (feet)}}$**
- **Lower frequency follows curve (50 - 150 Mhz)**
- **Higher frequency is "line of sight" (> 150 mi.)**
- **Open water is good and bad**

# Antennas

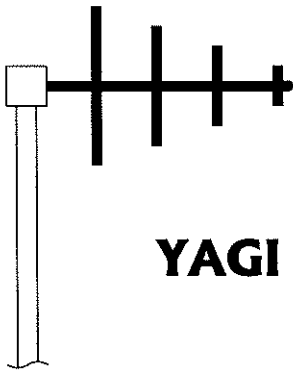
## Omni-directional



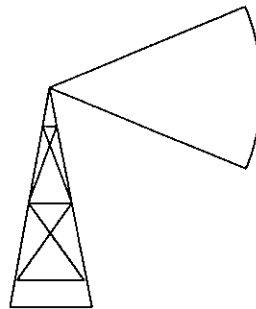
**WHIP**



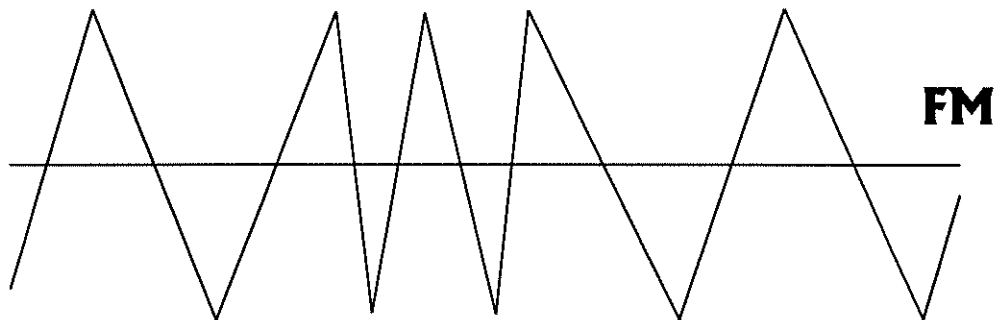
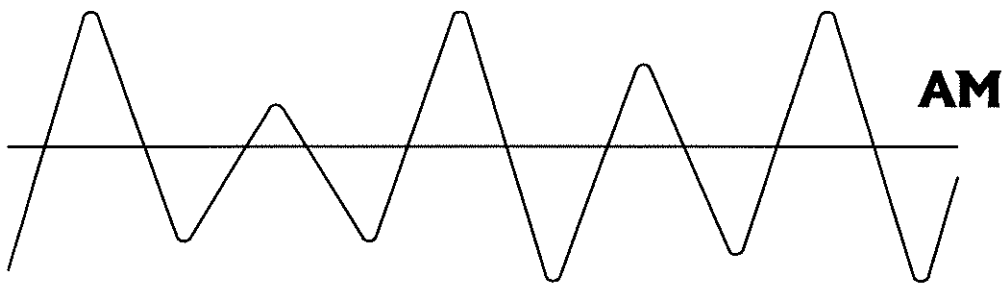
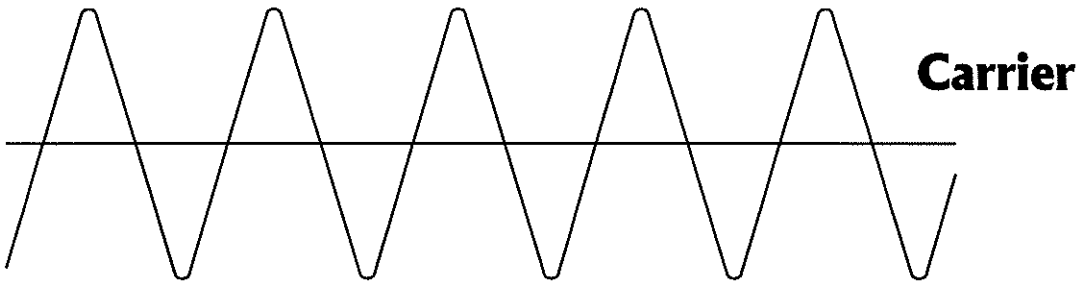
## Uni-directional








**YAGI**



# AM-FM Transmission



# Frequency Coordination

-  **Government regulated via CFR Part 90 and Coordination Committee**
-  **Distribute frequencies among various “services”**
-  **Petroleum radio service**
-  **Share channels with groups not normally close**
-  **Various license types**






# Microwave Systems

- **“Microwave” covers frequencies > 1,000 MHZ**
- **Strictly line-of-sight transmission with towers required every 10-20 miles (16-32 Km)**
- **Signal affected by atmospheric conditions**
- **Typical systems cost effective only in high capacity applications**
- **External, modular interfaces for audio, phone, and digital circuits**
- **Each circuit has combined sub-circuits (channels) with a specific signal bandwidth. Adjacent channels can be combined for high-demand applications such as real-time video.**







# Fiber Optic Communications

- **Another form of serial communications**
- **Uses laser “light” pulses to carry information over a very thin glass/plastic “rod”**
- **Each fiber optic carries one data stream in one direction (half duplex)**
- **Very high band width - lots of data capability (giga-baud)**
- **High reliability and noise immunity**
- **Often used to multi-plex lots of separate data streams in one mixed signal**
- **Limited distance (10 Km) between repeaters**

# Communications Problems

-  **Total equipment failure - rare**
-  **Continuous interference - easy to locate**
-  **Periodic interference - hard to locate**
-  **Equipment changes - maintained by others**
-  **Maintenance - usually non-existent**

# Comm Security

-  **Detect transmission errors**
-  **Required for industrial systems**
-  **Difficult in dial-up systems**
-  **Normally uses "Checksum" for error detect**
-  **System reactions vary - poor to excellent**
-  **Automatic retry and timeout is typical**

# Protocols

- **Language of communications**
- **Formed by industry (Modicon, Allen-Bradley)**
- **Formal and Informal (MODBUS, MAP)**
- **Not tied to hardware vendor**
- **Constantly evolving**
- **XMODEM, MAP, MODBUS, TIWAY, TSP**










# ASCII Data

- **American Standard Code for Information Interchange (ASCII)**
- **Binary codes for text - 01000110 = F**
- **Also control codes - 0000 1101 = Return**
- **Worldwide standard**
- **7 bits - 128 characters**
- **8 bits - 256 characters (US ASCII)**


# SCADA Protocols

- **Means to transmit and exchange data in an organized and efficient manner**
- **Normally related to serial data communications**
- **Efficiency used to favor the computer: Now it favors the user**
- **Many variations and sub-variations exist. All are incompatible with each other, and sometimes with themselves**
- **TSP - TEST SCADA Protocol**
- **MODBUS is de-facto standard due to age, but is very low level protocol**
- **TEST systems can also use MODBUS as master or slave**

# TEST SCADA Protocol

-  **TSP developed for oilfield SCADA, useful for any SCADA**
-  **Simple, reliable, text based design**
-  **SCADA data types - Status, analog, timer, counter, meter, etc.**
-  **Full error checking, sequencing, routing, and ACK for every message**
-  **Optimized communications with multiple data types per scan**
-  **Protocol is also TSP programming language**
-  **Very flexible communications**
-  **Published formal specification by TEST**
-  **SCADAWARE provides “Map” into other PLC and RTU protocols (MODBUS, Allen-Bradley)**

## Other TSP Features

-  **Data is time stamped when transmitted, even from HOST to HOST.**

Valid at 12:34:09      06/12/96

-  **Data related to RTU and Type, not physical location in I/O table:**

WC240.A1:A5

-  **Data reference by ID or Tag name:**







WC240.A1 or WC240.WELLPRES

-  **Handles data and commands**

# TSP SCADA Links

- **Combination of elements needed to connect units and perform useful function**
- **Used to upload/download/control RTU and Host**
- **Each link can have associated TSP file**
- **Link activation caused by events:**
  - Alarm / Abnormal condition**
  - Keypress - Menu selection**
  - Daily agenda**
  - Failure of other links**
  - TSP command sequence**
- **Configuration:**
  - Link description**
  - Task processing the link**
  - Host or RTU status during link**
  - Max tries per callout cycle**
  - “Quick” retry timeout and count**
  - Max total callouts till reset**
  - Alternate link activation on failure**

# Comm Link States

- |   |                |                                      |
|---|----------------|--------------------------------------|
|    | <b>IDLE</b>    | <b>Link is dormant</b>               |
|    | <b>ACTIVE</b>  | <b>Link needs servicing</b>          |
|    | <b>PENDING</b> | <b>Link waiting for attention</b>    |
|  | <b>POLLING</b> | <b>Link currently being serviced</b> |
|  | <b>FAILED</b>  | <b>Retry count exceeded</b>          |
|  | <b>BLOCKED</b> | <b>Link offline (auto or manual)</b> |





# TSP Data TAP

- **Multi-drop “eavesdrop” capability**
- **Radio, Wire and PC-Net systems**
- **Simultaneous update of all interested Scadaware™ computers**
- **Limited to DATA and TIME commands**
- **Each computer must be configured to TAP**
- **DAT file determines size of TAP list**
- **TAP statement adds RTU ID's to TAP list**





# Open Architecture

- **Concept of linking multi-vendor units to share internal data values**
- **Allows distribution of capability among otherwise incompatible equipment**
- **No formal definition or specification**
- **MODBUS RTU is common protocol**
- **FIELDBUS is future standard for instrument grade communication**
- **MODBUS provides transportation only**
- **Different systems “Map” into MODBUS**
- **Registers hold low level binary data**

# Open Architecture Benefits

-  **Good solution for well designed sub-systems and software**
-  **Reduces overall system complexity by isolating specialized systems to what they do best**
-  **Reduces system costs by widening choices for each sub-system**
-  **Allows future growth without unnecessary initial expense**









# Open Architecture Realities

-  **Everything is not compatible**
-  **Open Architecture is only a tool**
-  **Each vendor has different restrictions, features and interpretations**
-  **Required interfaces can and should be kept small, typically less than 5% of I/O**








# MODBUS RTU Protocol

- **Commonly used for “Open Architecture”**
- **Roots in direct connect (wired) PLC technology**
- **Minimal formal technical specification**
- **Binary data transfer only - Bits, Bytes, words**
- **No RTU or SCADA level components**
- **Single Smart Master to multiple RTU’s**
- **Multi-drop wire or radio only**
- **No call on exception support**
- **Many variants from miscellaneous vendors**






# Network Terms

-  **Server**      **Main PC which stores data**
-  **Client**      **PC obtaining data from server**
-  **NetWare**      **Novell network software**
-  **Netbios**      **PC-LAN compatible messaging**
-  **Viewnode**      **Scadaware™ client**
-  **Ethernet**      **Physical network connection**
-  **10 base-T**      **Twisted pair Ethernet**
-  **10 Base-2**      **Thin coax Ethernet**

# Network Communications

-  **PC-LAN Netbios facility is required**
-  **Network port emulates standard PC serial port in Scadaware™**
-  **Netbios messages simulate Multi-drop Comm link**
-  **Each node has same Net address, unique Multi-drop ID**
-  **HOST can broadcast to all Scadaware™ nodes for simultaneous update**
-  **Nodes can also do point-to-point links**
-  **Net task configured for all network changes**

# Network Requirements

-  **Netbios support - PC-LAN compatible system**
-  **Novell requires optional Netbios**
-  **DOS Share required for file access**
-  **Files can be used in DOS, server, or client modes**
-  **Messages can be point-to-point or broadcast**

# Network Links

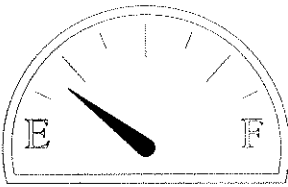
- **RTU can have link set to "Net"**
- **Net links request update at Host PC**
- **Procedure NETPOLL controls activity of network link update**
- **Typical NETPOLL procedure for Viewnode**
  - Dial HOST**
  - Block Poll Now \$1**
  - Bye**
- **After HOST completes remote link to RTU it will update Viewnode over network**

# Analog Systems

 **Analog forms basis of analogy**








**35MPH**  
**Relates Transmission RPM**  
**to Over-ground Speed**

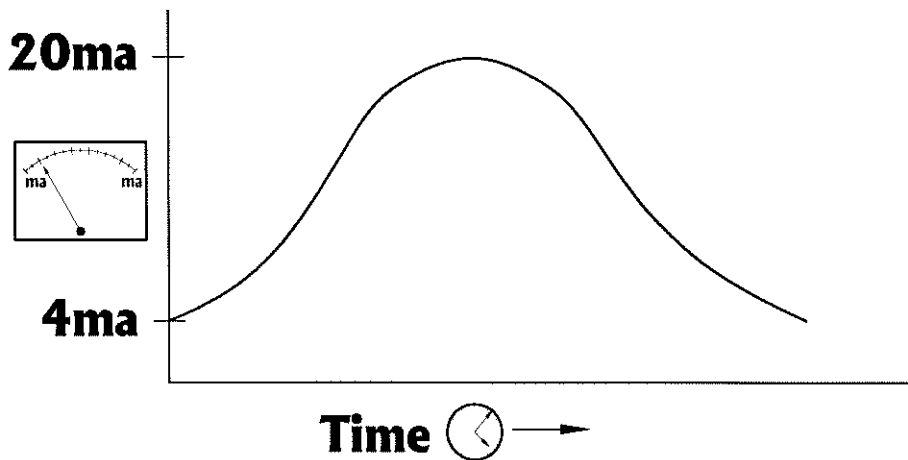


**Relates Tank Float position**  
**to Fuel Remaining**

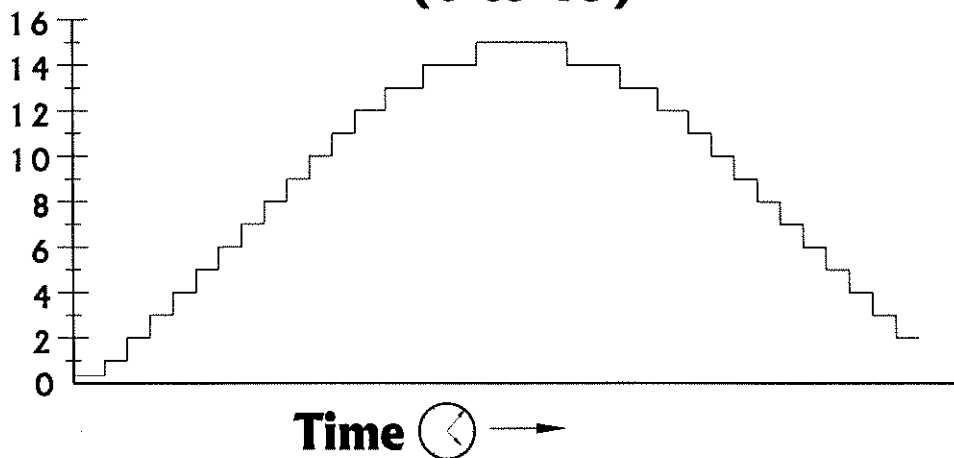
# Analog Signals

-  **Signal varies directly with process**
-  **Often has 20% signal offset from process zero**
-  **Instrumentation signals are linear**
-  **Pneumatic - 3-15 PSI**
-  **Electronic - 4-20 ma, 1-5 VDC**

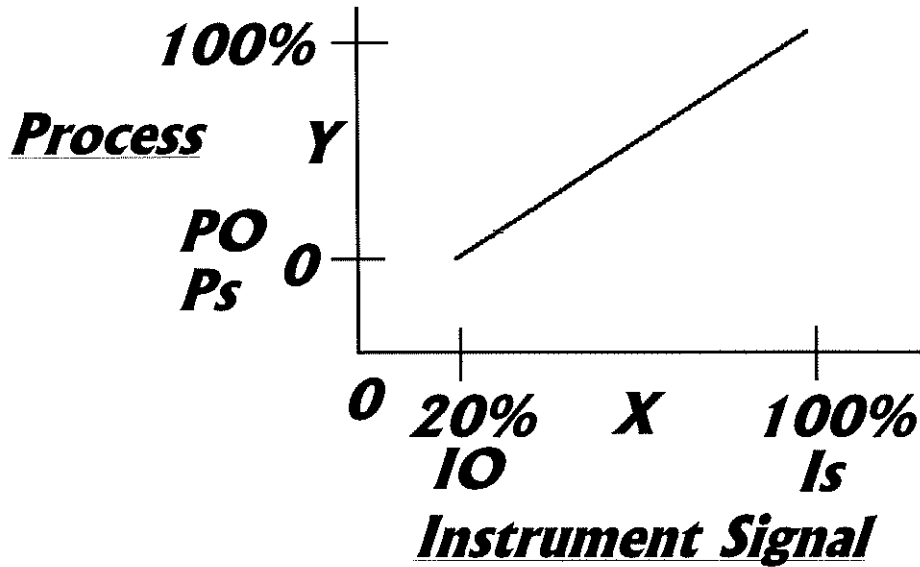
# Analog Systems



## 4 BIT Binary (0 to 15)

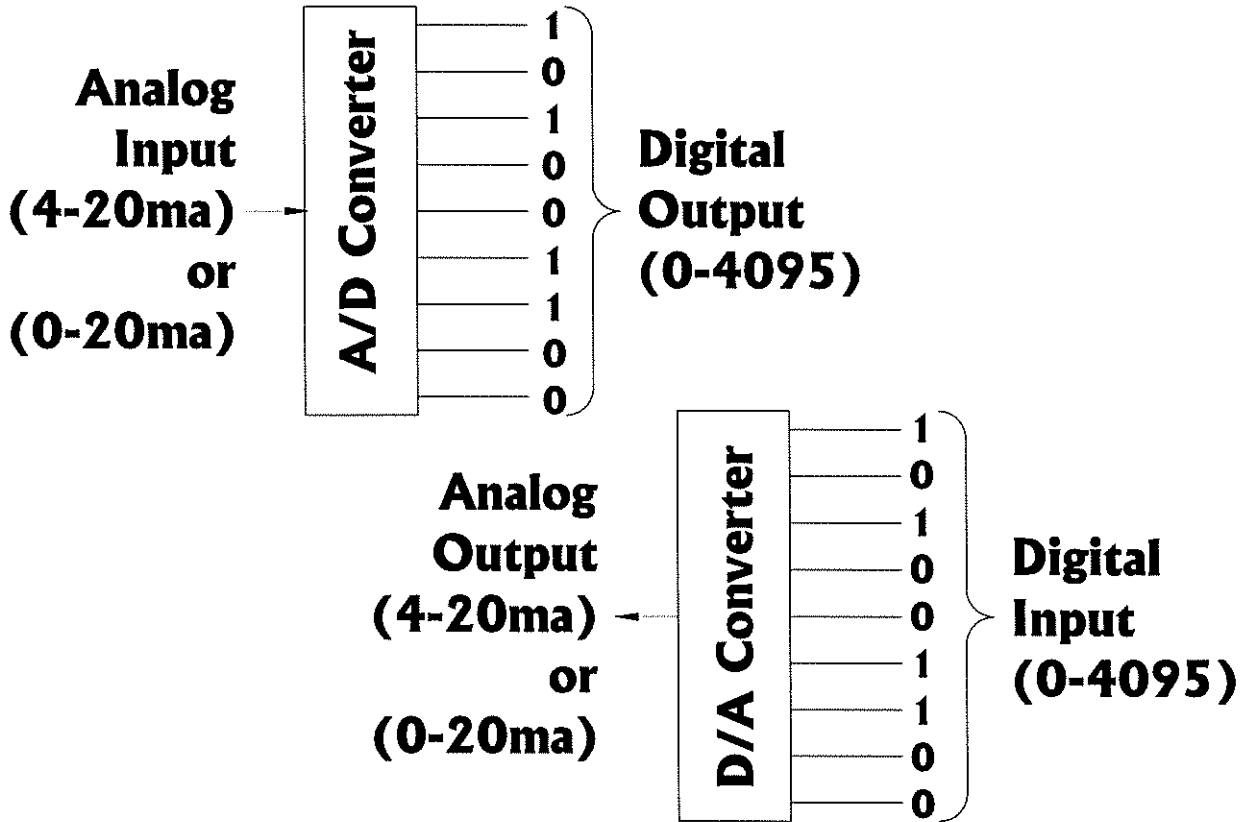





# Voltage Measurements



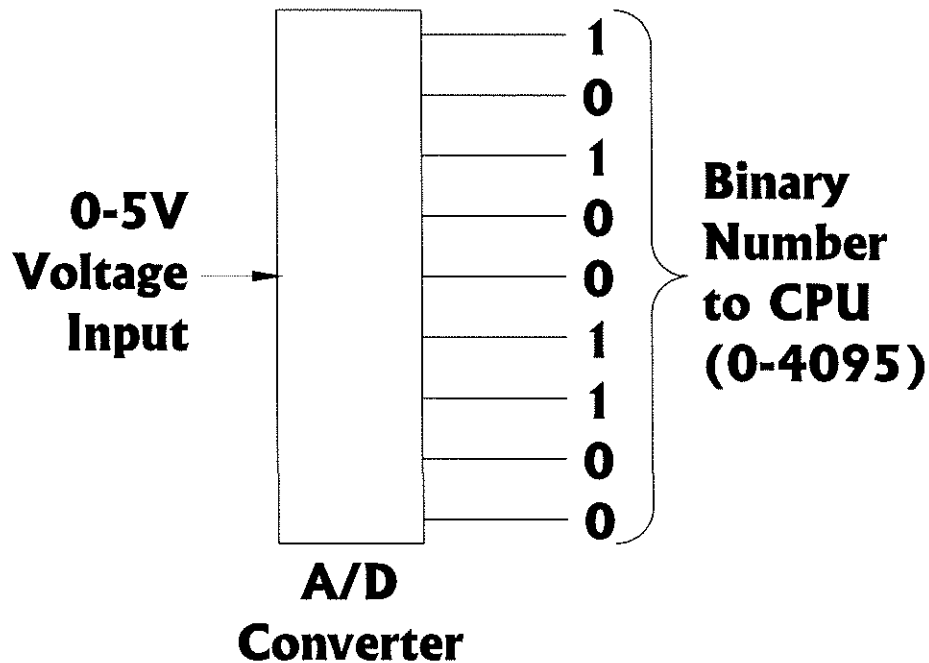
$$\frac{X-IO}{Is-IO} = \frac{Y-PO}{Ps-PO}$$




# Analog I/O



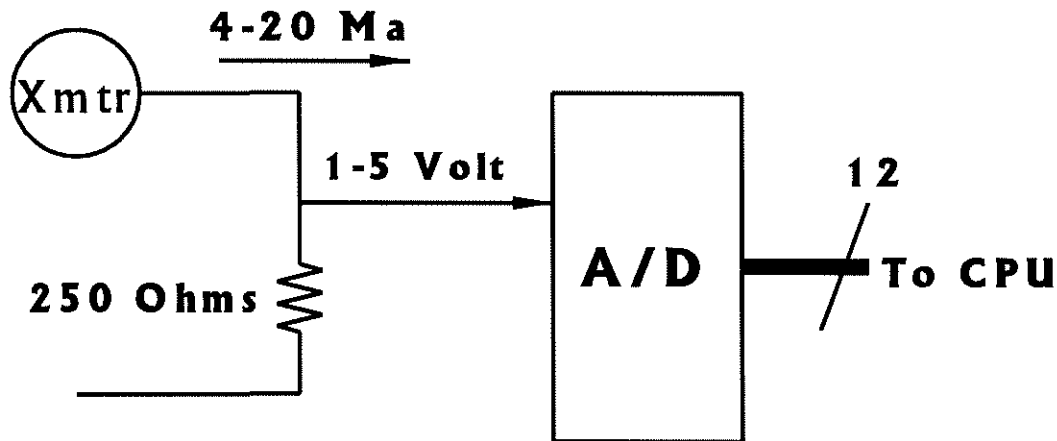
- 
**Analog to Digital (A/D) conversion**
- 
**Digital to Analog (D/A) conversion**
- 
**Converter size determines accuracy**

# RTU Analog Inputs



-  **A/D Converter mates voltage to CPU**
-  **Binary Number is 0-100% of Full Voltage Scale**
-  **RTU software must convert Binary Units to Engineering Units**

# 4-20Ma Transmitters

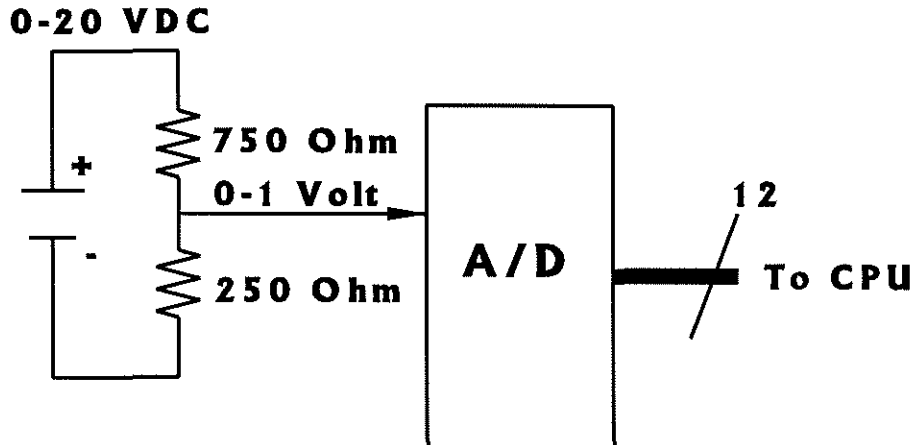




- 250 Ohm resistor gives 5 Volts at 20Ma full scale

$$5 = .020 \times 250$$

- RTU software converts A/D result to engineering units
- 20% offset may be hardware or software






# Voltage Measurements



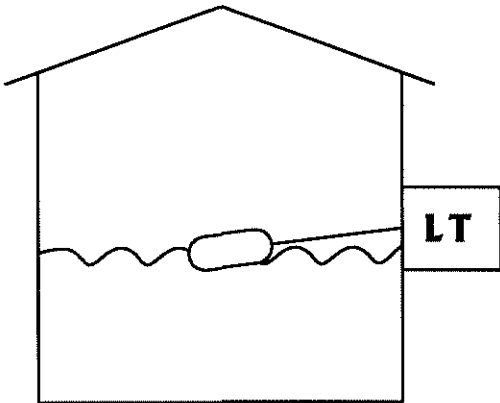
-  **Voltage divider gives 5 Volts when battery is at 20VDC**
-  **RTU software converts A/D result to engineering units**

# Analog Transmitters

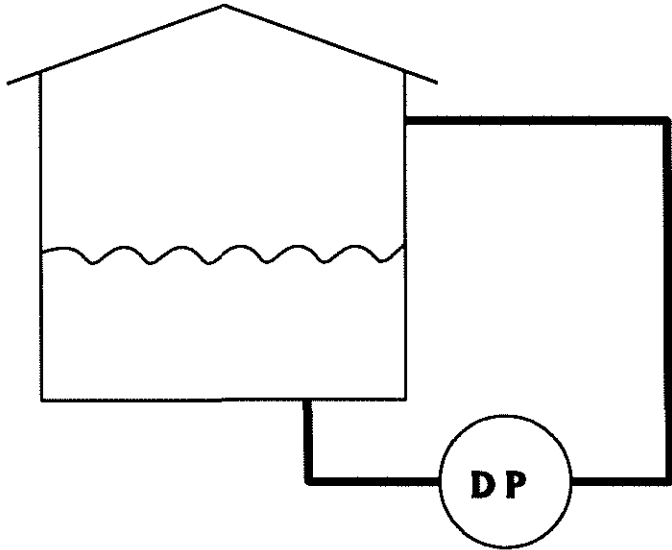


-  **Transducer at Process**
-  **Transmitter receives non-linear signal from Transducer electronics**
-  **Output is Standard linear signal**
-  **4-20ma, 1-5V - most common**
-  **Zero and Span adjustments in transmitter**

# Level Sensing



**Displacer  
Measurement**



**Head  
Measurement**

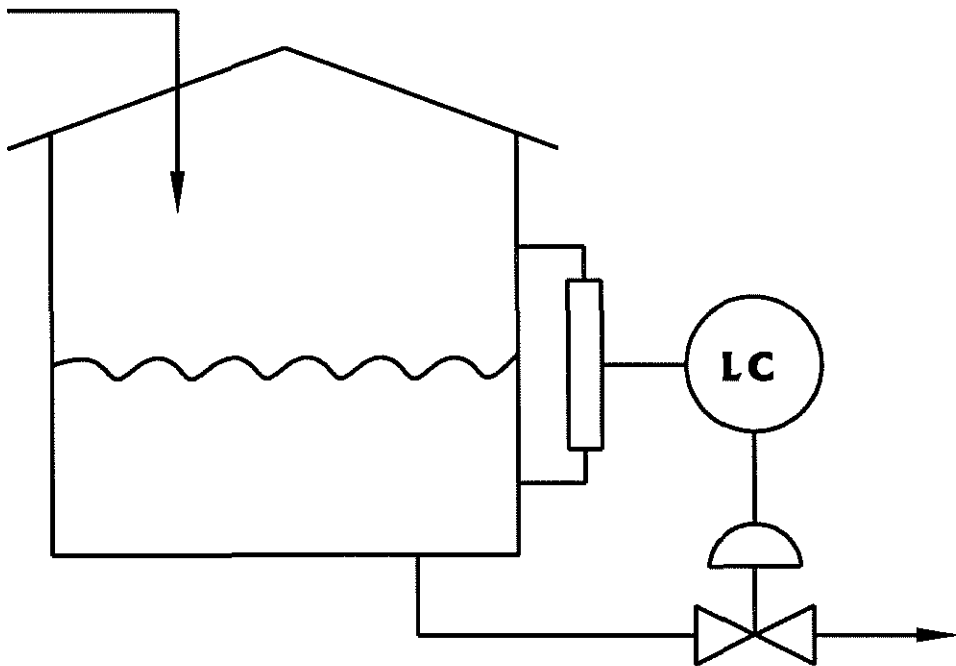
# Control Loops

- **Controlled variable is adjusted by manipulating controlled parameter**
- **Throttle is controlled parameter**
- **Speed is controlled variable**
- **Open and Closed types**

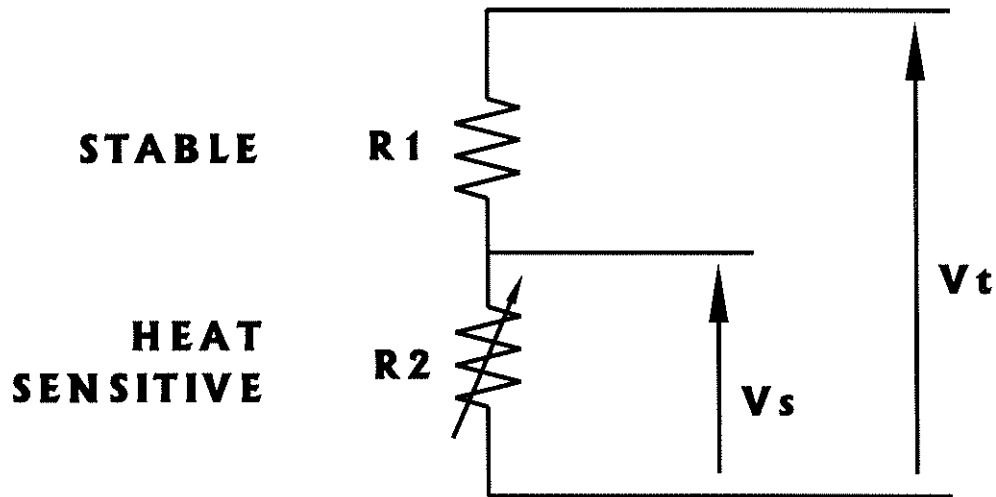
# Control Modes P-I-D

- **Proportional - Size of Error**
- **Integral Reset - Time away from Setpoint**
- **Derivative Rate - How fast signal changes**

# Level Control



# Combustible Gas Detector



$$V_s = V_t \frac{R_2}{R_1 + R_2}$$

# Flame, Heat & Smoke Detectors

 **Flame Detectors**

- Ultraviolet (UV)      **Fire Detection**
- Infrared (IR)        **Burner Control**

 **Heat Detectors**

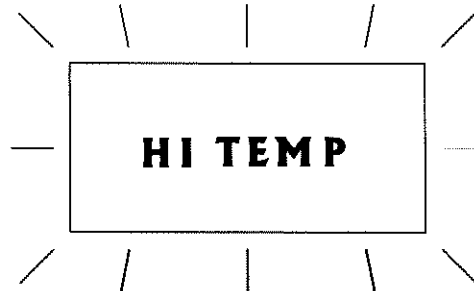
- Simple set point
- Rate of Rise

 **Smoke Detectors**

- Ionization            **Products of Combustion**
- Photo-electric      **Particles of Combustion**

# Annunciators

 **Engraved Window**



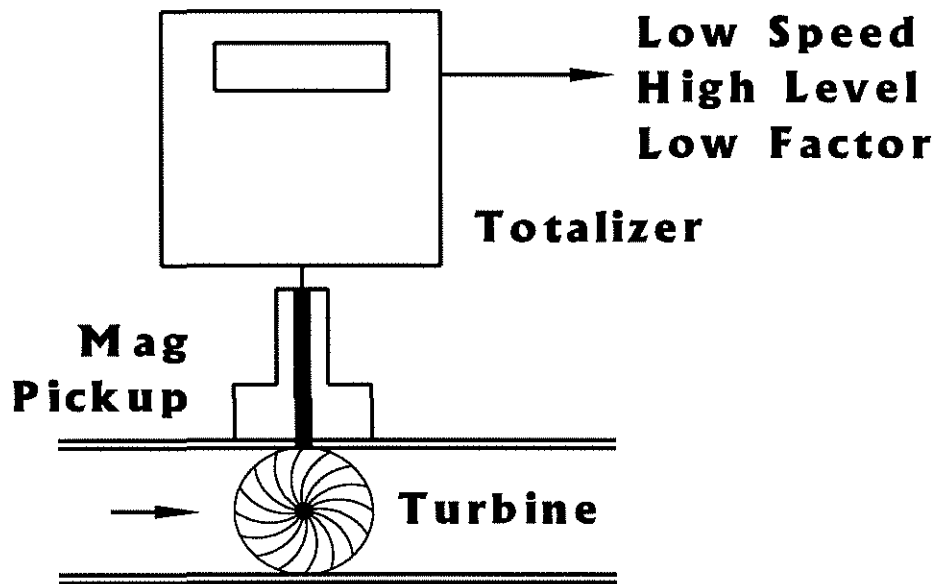
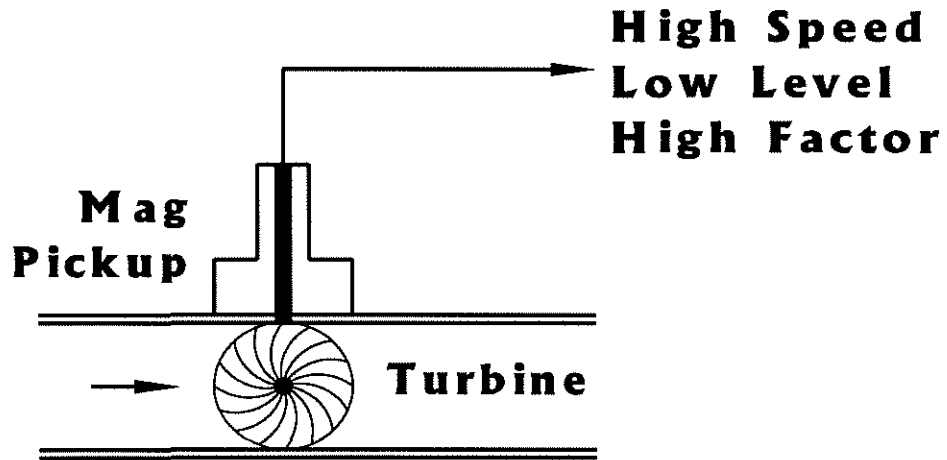
 **Bullet Lamp**



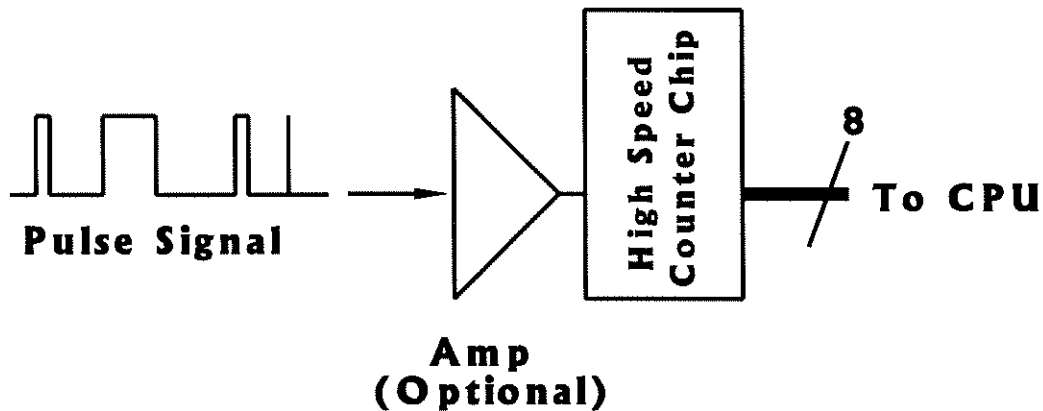
 **Modes of Operation**





- **First Out**
- **Auto Reset**
- **Manual Reset**
- **Audible Alarms**

# Pulse Sources










# Pulse Inputs











-  **Pulses represent events or meter flow**
-  **Counter chip catches quick pulses**
-  **Size of pulse not important to valve**
-  **RTU software calculates total**

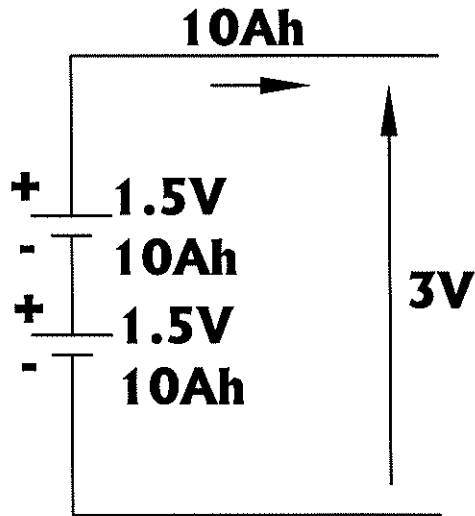
# Battery Basics

-  **Electricity from chemicals**
-  **Direct current only**
-  **Primary cell - One time**
-  **Secondary cell - Recharges**
-  **Series connection for increased voltage**
-  **Parallel connection for increased current**
-  **Cell type determines voltage**

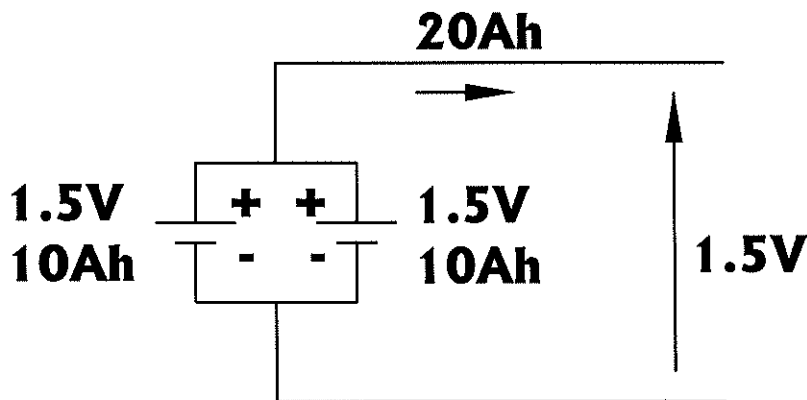
# Cell Types

 <b>Lead Acid</b>	<b>2.2V / Secondary</b>
 <b>Lead Calcium</b>	<b>2.2V / Secondary</b>
 <b>Lead Antimony</b>	<b>2.3V / Secondary</b>
 <b>Nickel Cadmium</b>	<b>1.2V / Secondary</b>
 <b>Gelatin</b>	<b>2.06V / Secondary</b>
 <b>Alkaline</b>	<b>1.5V / Primary</b>
 <b>Carbon Zinc</b>	<b>1.5V / Primary</b>
 <b>Lithium</b>	<b>3.0V / Primary</b>

# Connections



**Series for  
More Volts,  
Same Current**









**Parallel for  
More Current,  
Same Volts**







# Charging

- **Secondary cells only**
- **Rate depends on cell type**
- **Trickle - Slow charge**
- **Equalize - Fast charge**
- **Most cell types can be “Floated”**
- **Some cell types can be “Overcharged”**
- **Charge state difficult to determine**







# Boxes and Racks

-  **Allow proper ventilation**
-  **Protect electrical connections**
-  **Acid resistant materials**
-  **Vibration isolation**
-  **Level and secure**
-  **Locate away from people**








# Battery Maintenance

-  **Electrolyte levels**
-  **Periodic cycling**
-  **Measure volts under load**
-  **Remove bad cells and batteries**
-  **Re-make electrical connections**
-  **Read manufacturer's material**

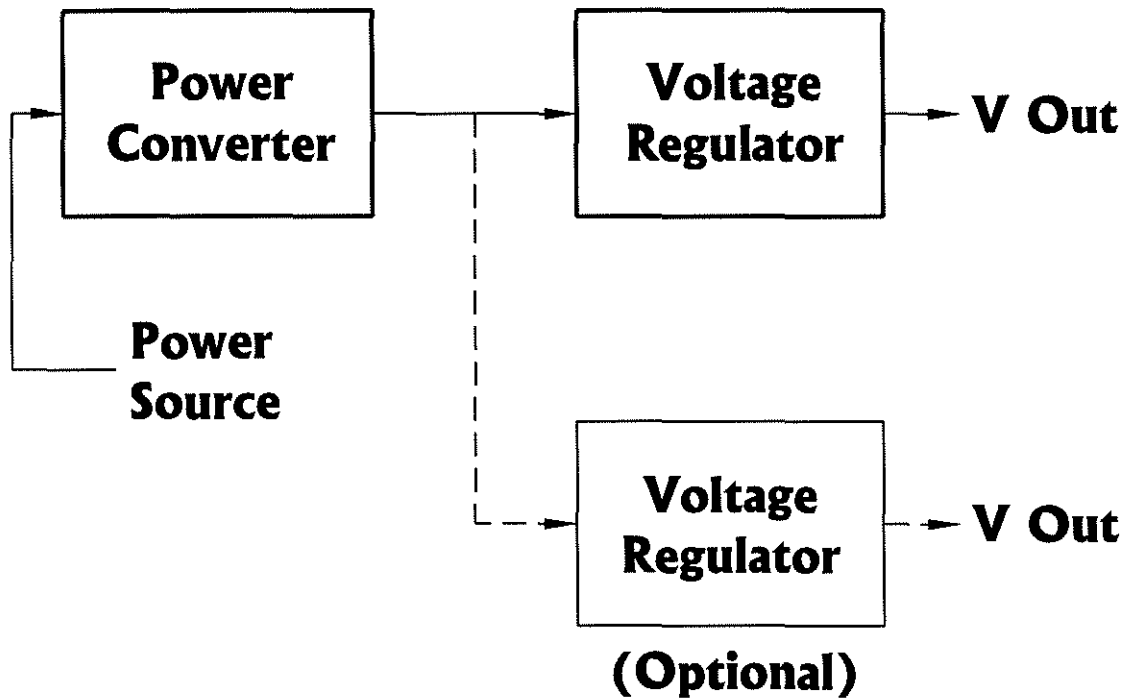
# Battery Safety

-  **Dangerous gases must be vented**
-  **Dangerous liquids must be trapped**
-  **Corrosive materials must be used**
-  **High current capability during short circuit**
-  **Handle with care even when discharged**
-  **Dispose of properly**

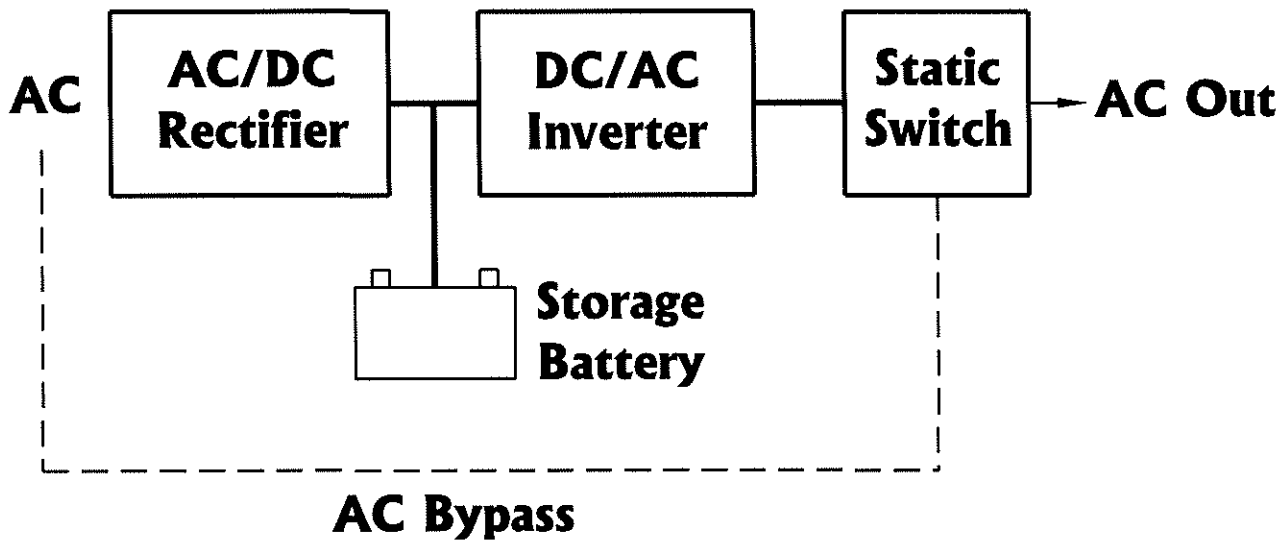
# Power Supplies




-  **Convert primary power**
-  **Provide regulated voltage**
-  **Over-current protection**
-  **Over-voltage protection**
-  **Remote voltage sensing**
-  **Power-Good logic signal**
-  **Built-in backup supply**

# Basic Supply

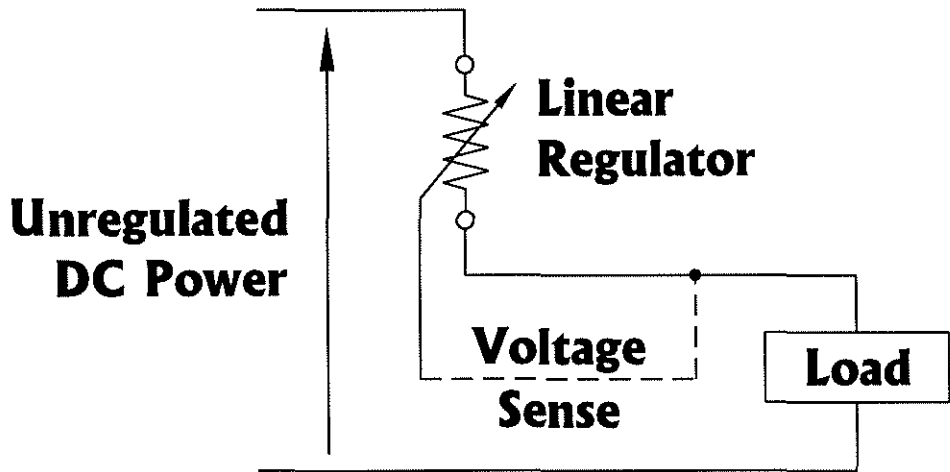


# U.P.S.

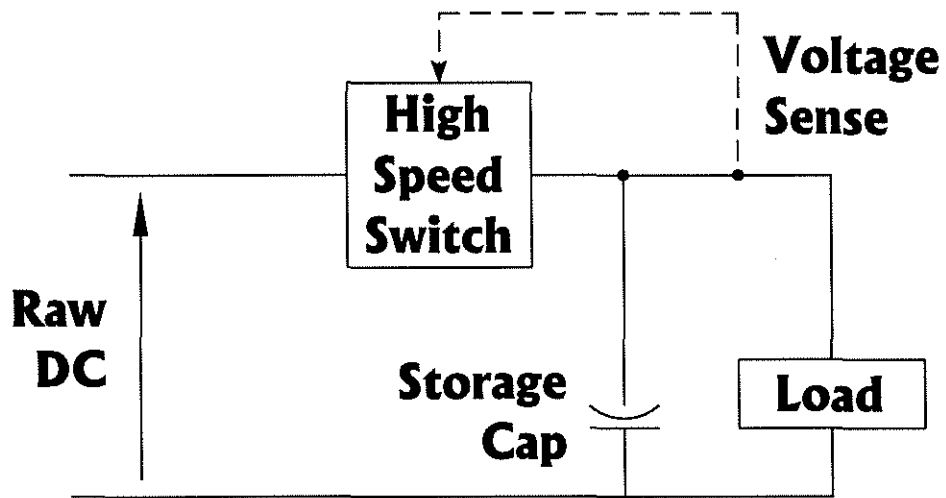


-  **Provides backup AC**
-  **Continuous or Standby**
-  **Battery sets time**

# Voltage Regulator

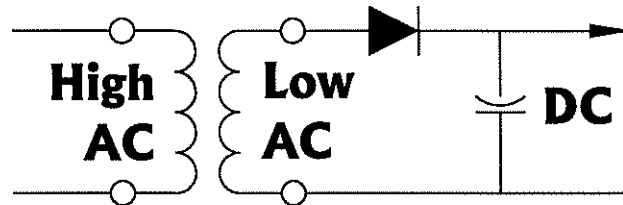


## Linear

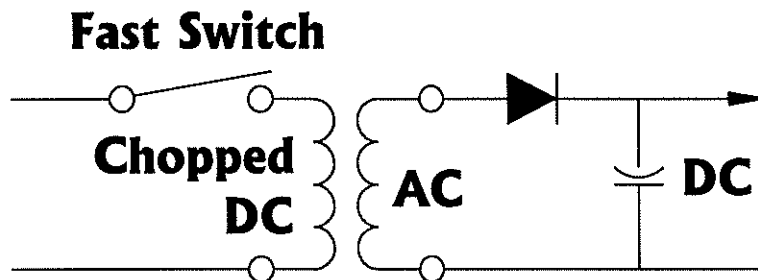


## Switcher

# Power Converter










## Unregulated AC/DC

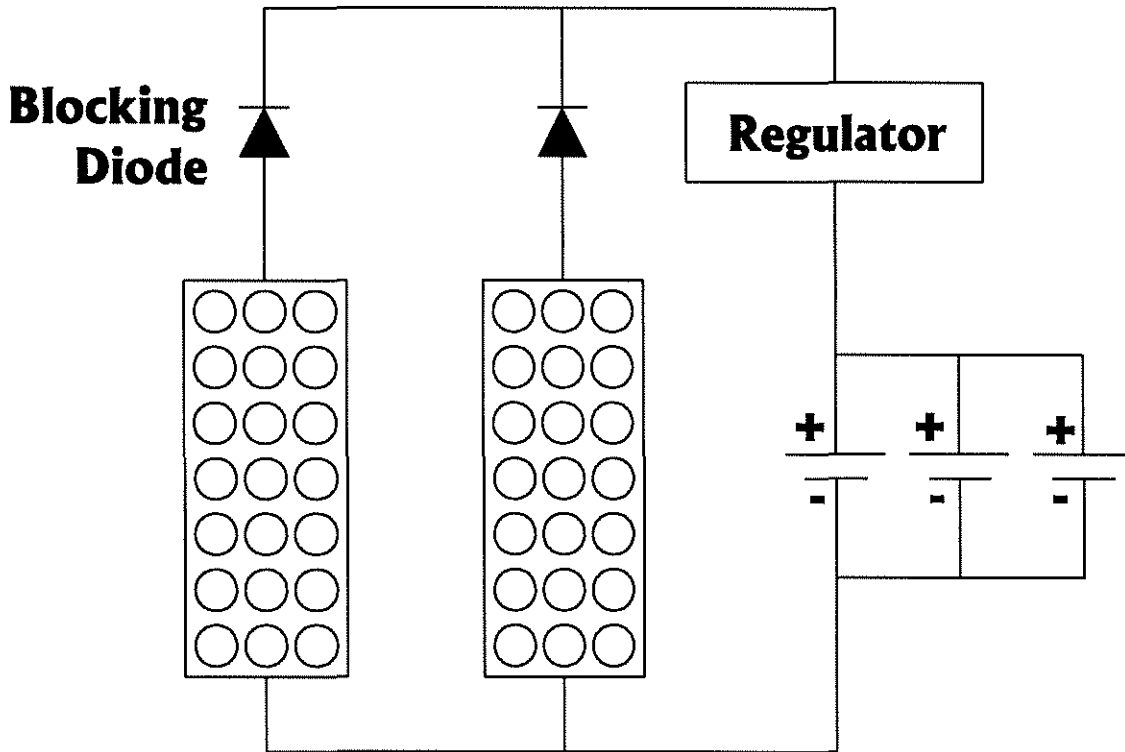


## Unregulated DC/DC

# Solar Power

-  **Low cost due to NASA**
-  **Generate low total power**
-  **Must be sized for extended periods of darkness**
-  **Diodes isolate cells**
-  **Require large battery reserve**
-  **Optimum at latitude + 15 deg**
-  **Must be kept clean**

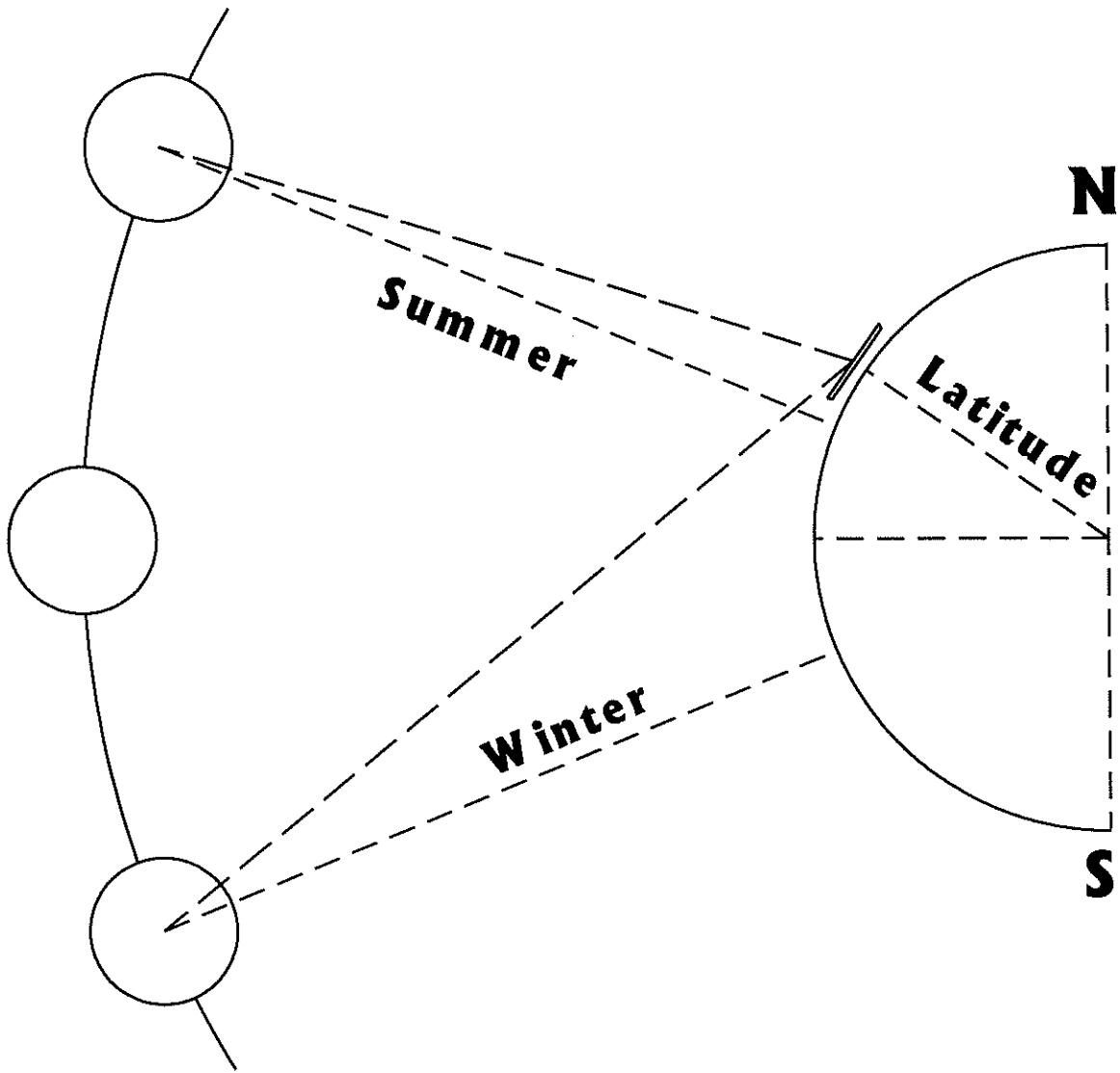
# Solar Hook-Up



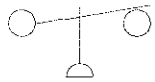
- **Diodes may be built-in**
- **Regulator may be eliminated**

# Solar Angle

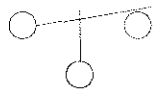
 **Mount at Latitude plus 15 degrees**



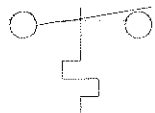
# Process Switches






**Pressure**



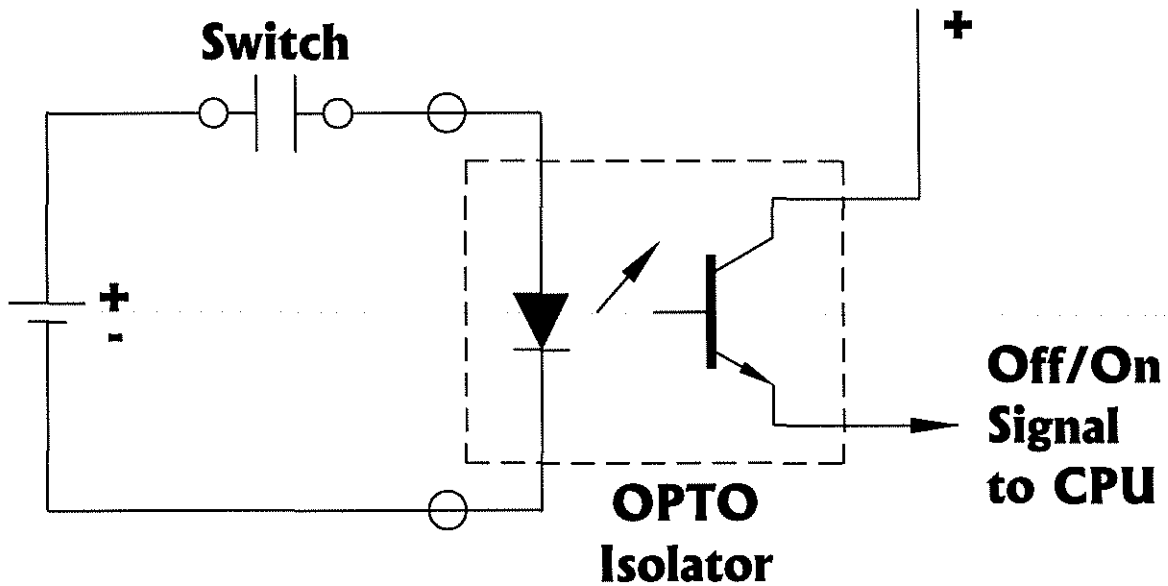
**Level**



**Temperature**

-  **Fixed or adjustable trip**
-  **Fixed or adjustable deadband**
-  **Various contact configurations**

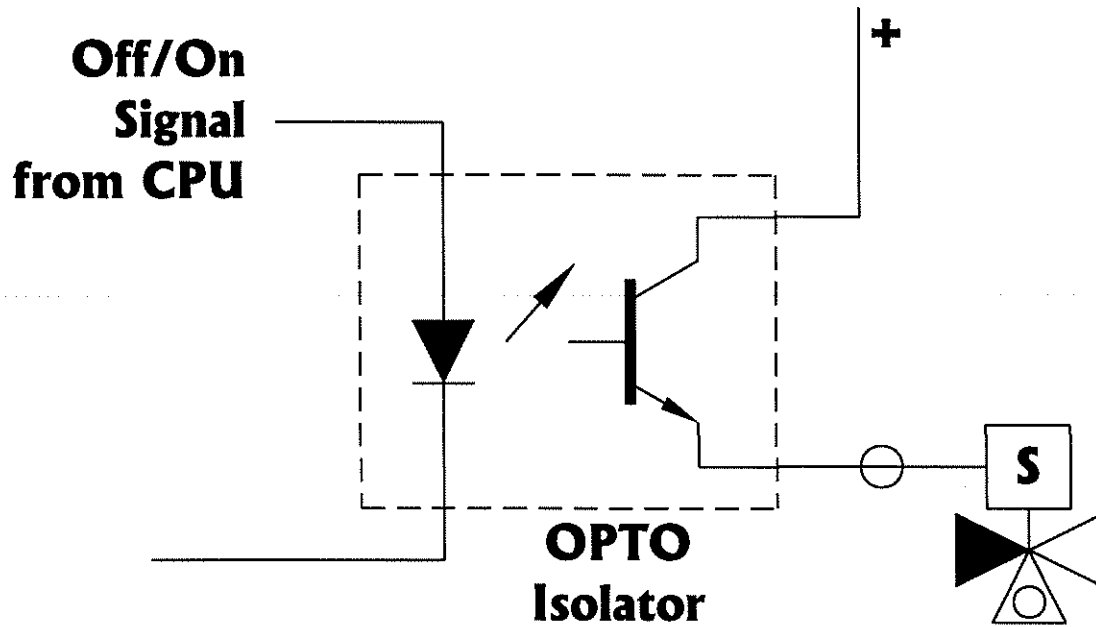
# RTU Status Inputs



 **Off/On status only**

 **OPTO provides isolation**

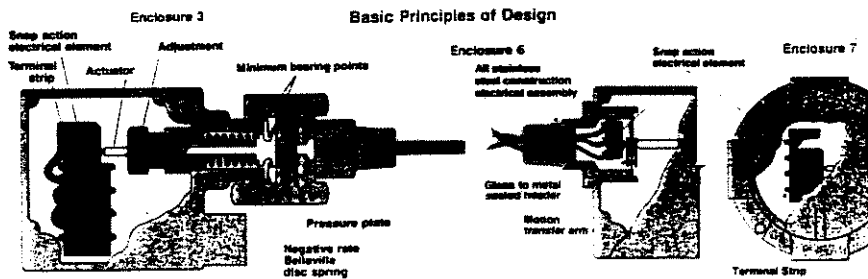
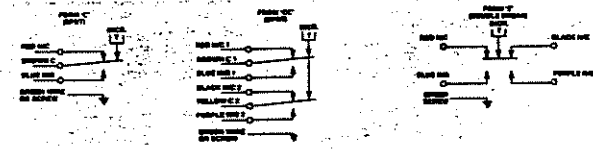
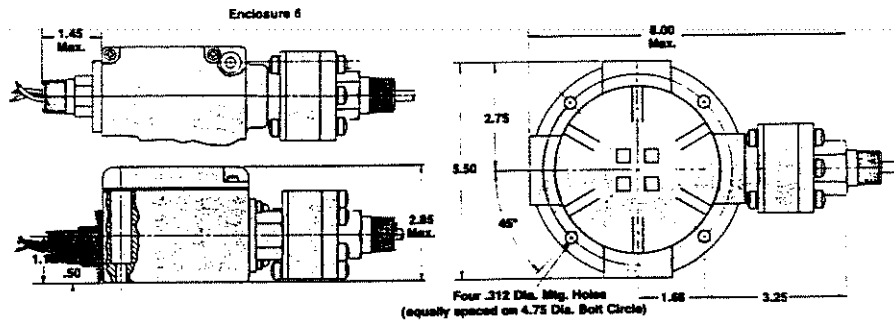
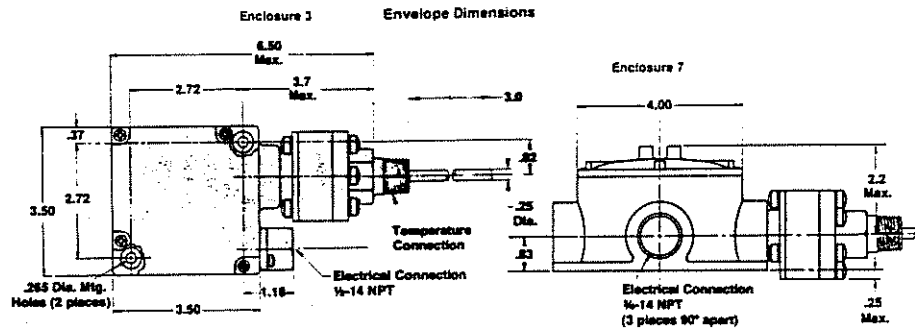
# RTU Status Outputs



 **Off/On control only**

 **OPTO provides isolation**

# TEMPERATURE SWITCH

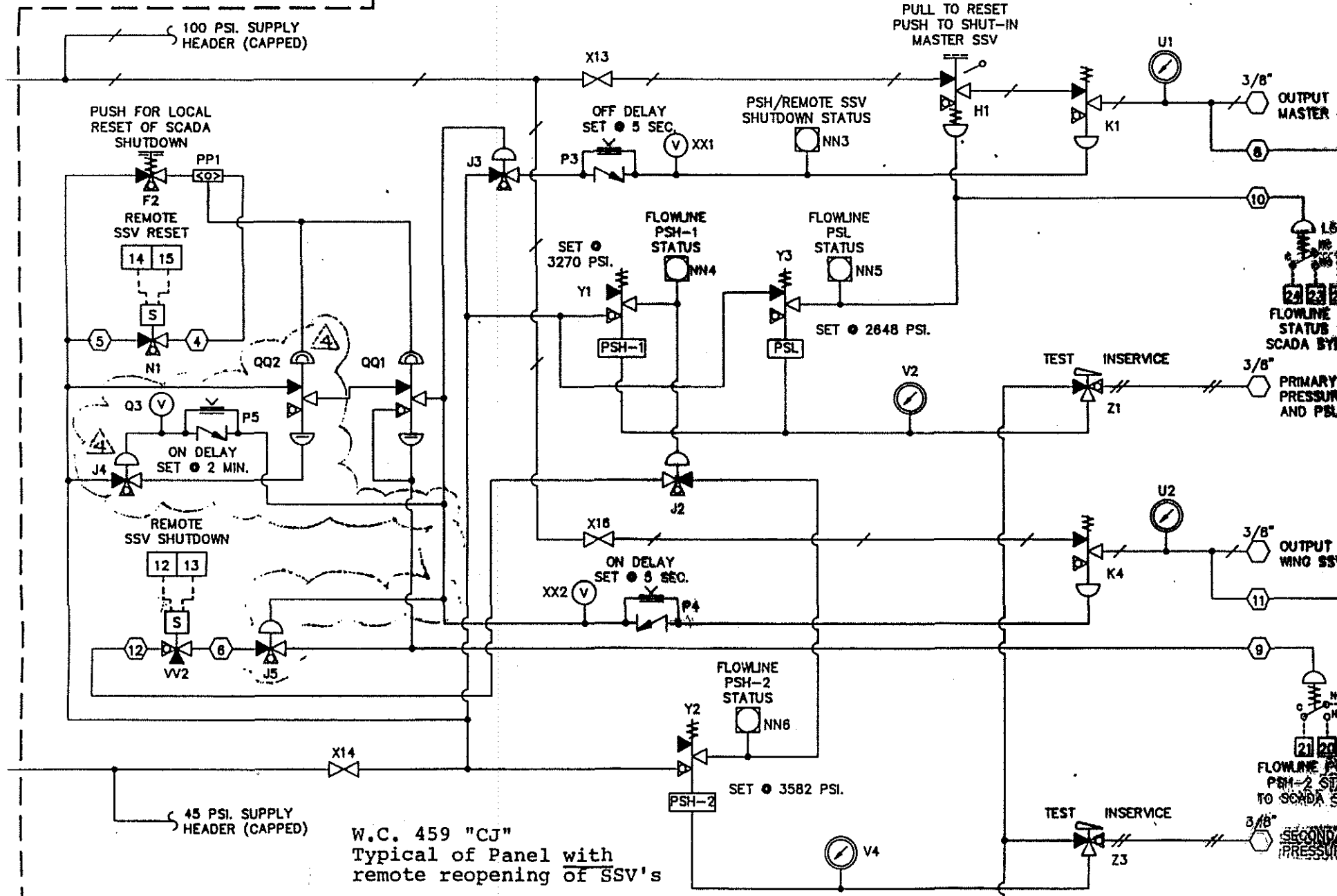
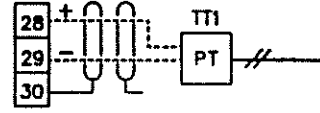




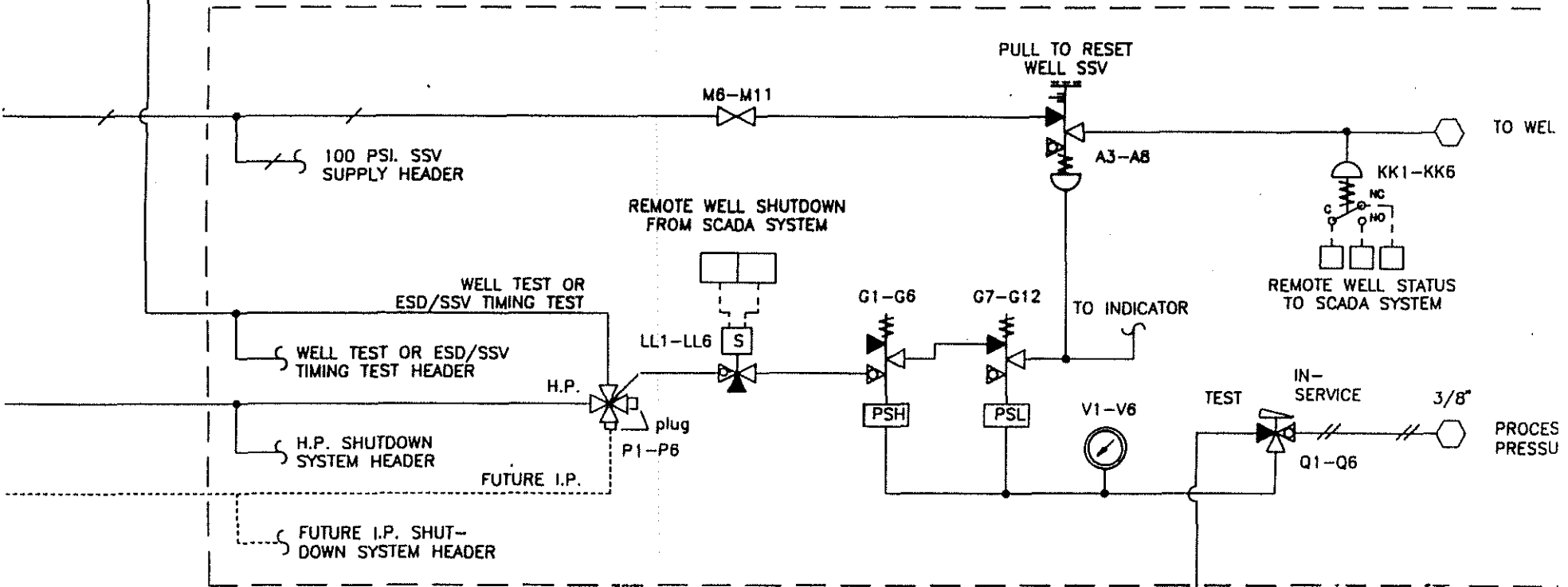
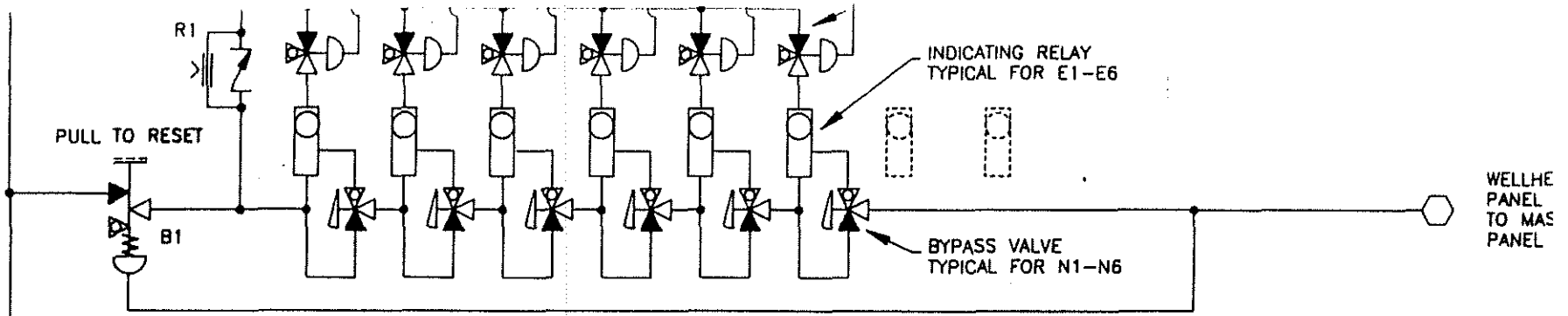


WELL SSV CIRCUIT  
 TYPICAL FOR ONE (1) WITH  
 SPACE FOR ONE (1) FUTURE

"SCADA" SYSTEM

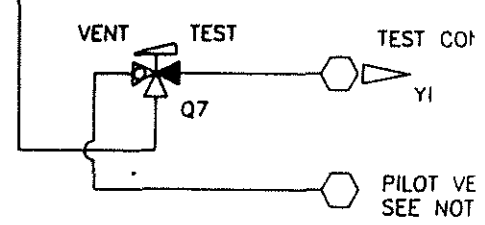


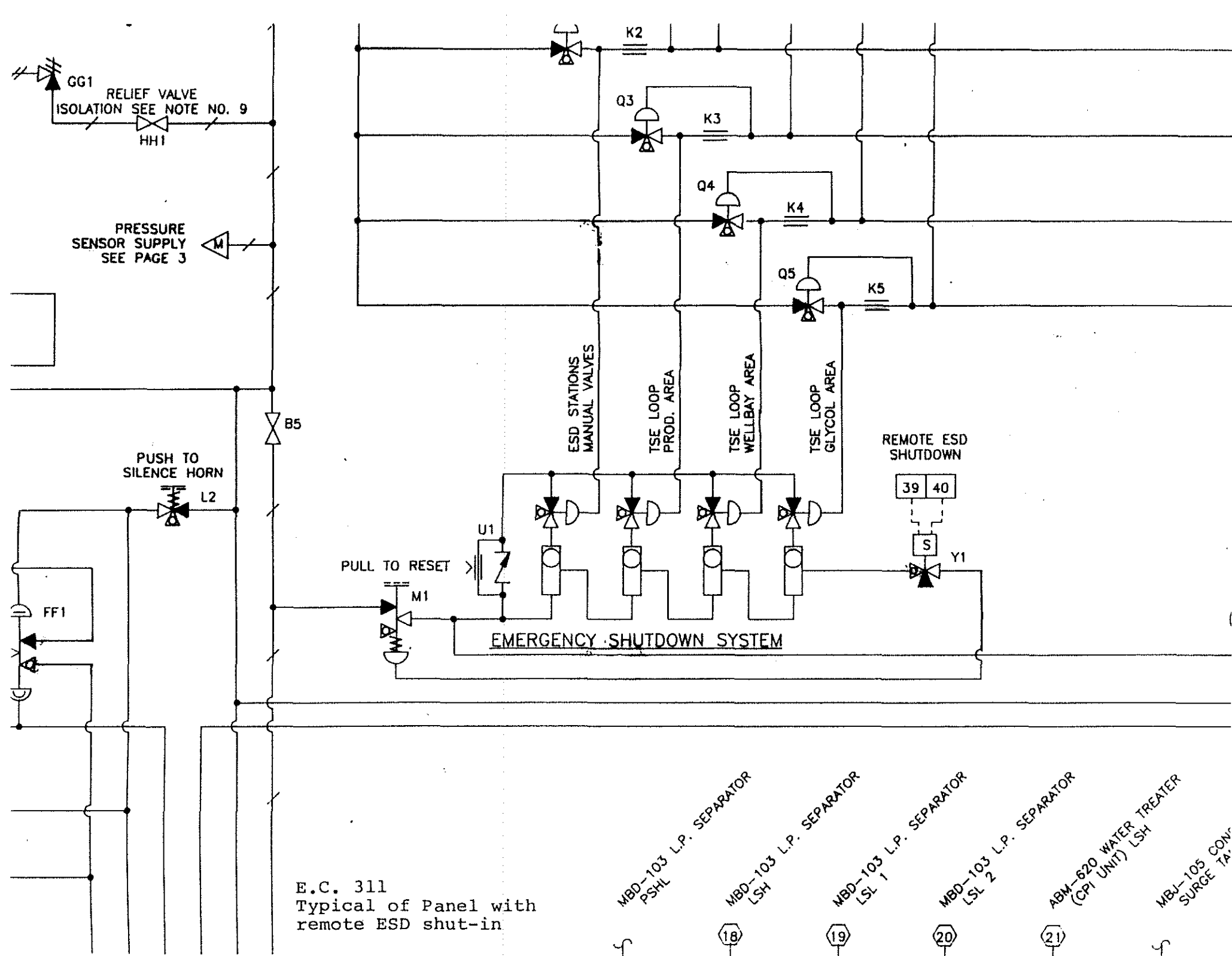
W.C. 459 "CJ"  
 Typical of Panel with  
 remote reopening of SSV's



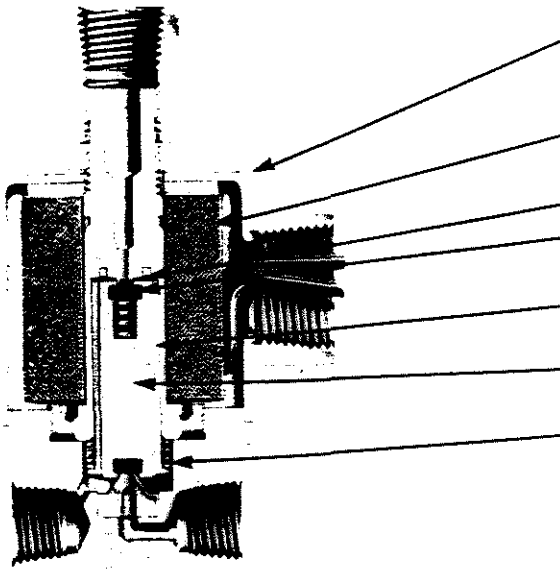
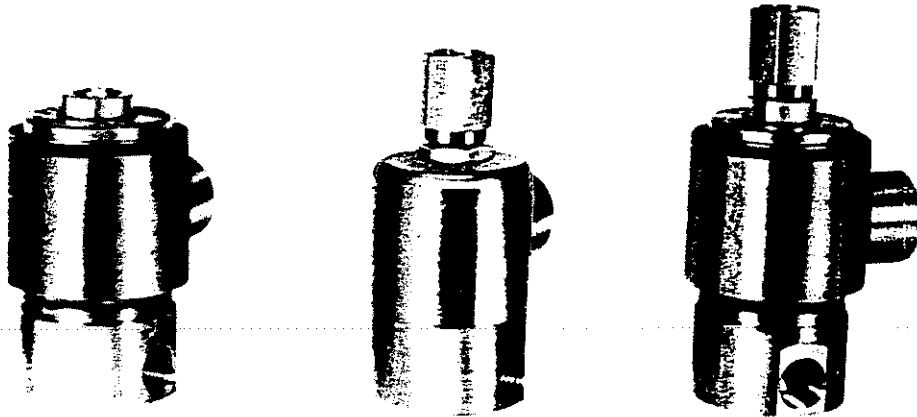
WELL SSV CIRCUIT  
TYPICAL FOR SIX (6)  
WITH SPACE FOR ONE (1)  
FUTURE WELL

E.C. 311  
 Typical of Panel with Remote  
 SSV Shut-in only





# SOLENOID VALVE



**Coil housing, zinc and chromate coated** — can be rotated 360°. 1/2" NPT conduit shown, wide selection of other types available.

**Coils for most voltages and frequencies** — wide choice with low wattage consumption.

**Copper shading ring** — used in AC voltage valves only.

**Orifice does not cut insert** — highly finished well-rounded surface provides long insert life.

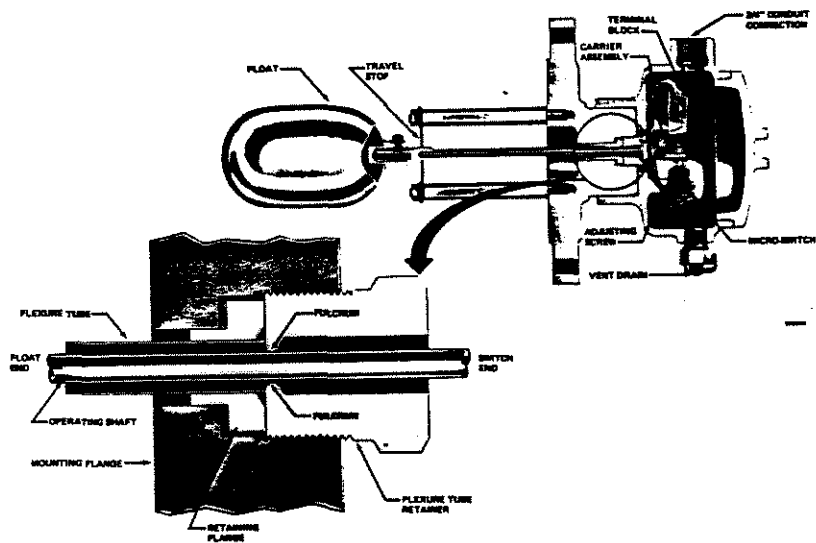
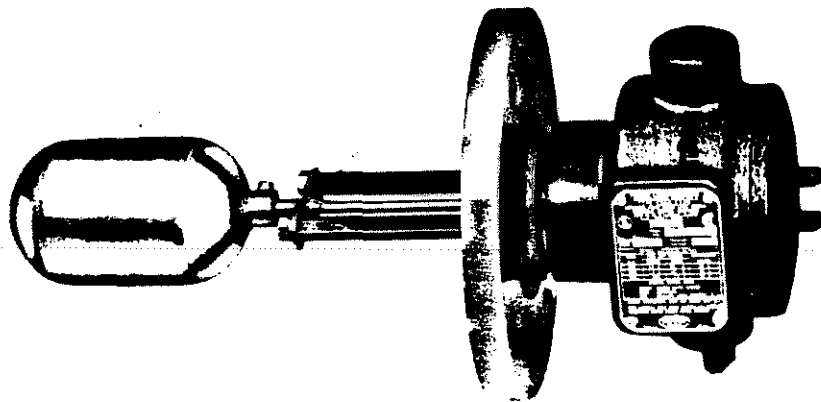
**Stainless steel sleeve prevents corrosion** — precision welded.

**Plunger is stainless steel** — has molded soft synthetic Buna-N insert for bubbletight sealing, other materials are available.

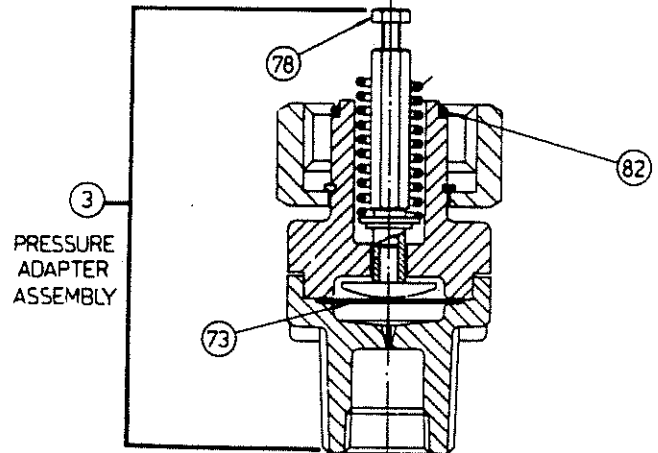
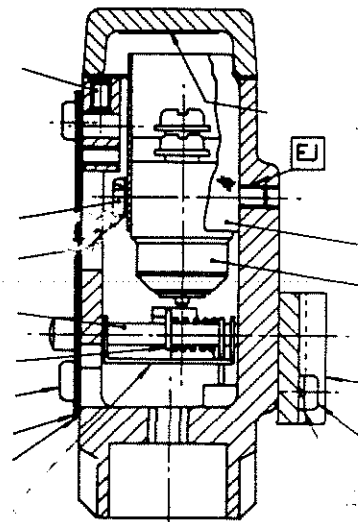
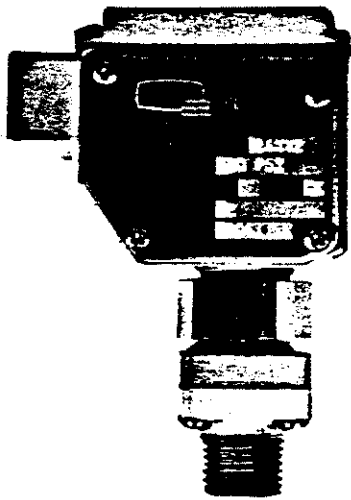
**Spring provides positive plunger return** — made of stainless steel, permits valve to be mounted in any position.








# LEVEL SWITCH



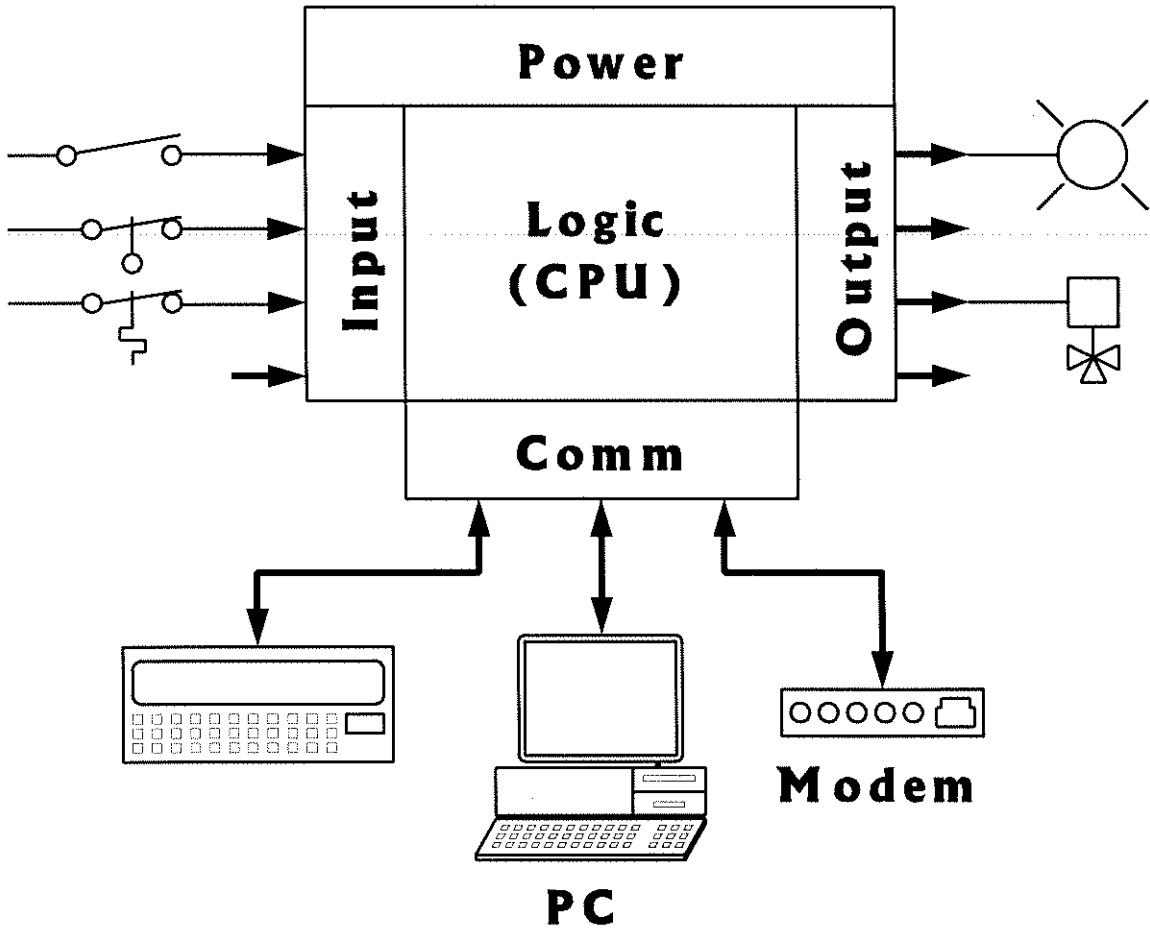
# PRESSURE SWITCH



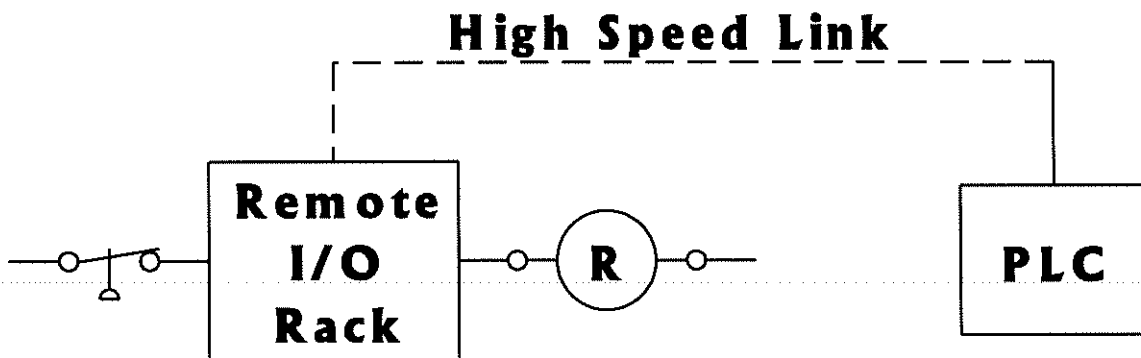
# P.L.C.

-  **Programmable Logic Controller**
-  **Ladder Logic via computer**
-  **Primarily for digital control**
-  **Many have analog capability**
-  **May be used as RTU**

# PLC Basics



# PLC Remote I/O

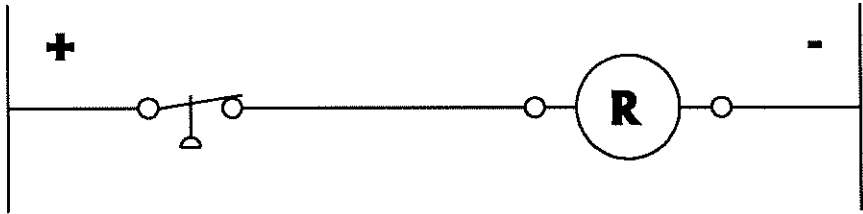


- **Remote rack concentrates I/O**
- **All logic still at PLC**
- **Reduces wiring costs**
- **Some performance penalty**

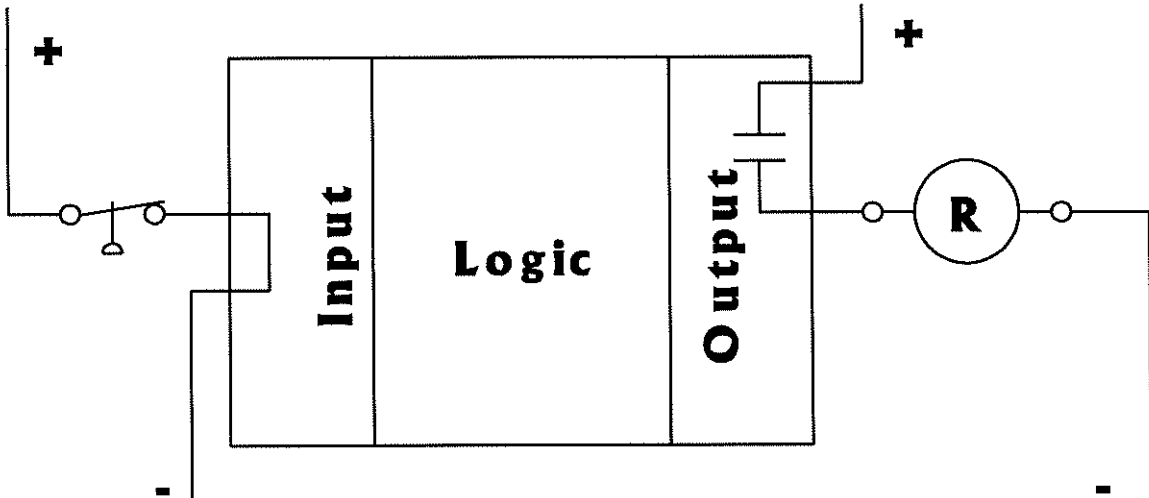
# PLC Programming

- **Basically similar to relays**
- **Requires programming device**
- **Uses ladder diagrams**
- **Less physical restrictions**
- **Many advanced features**

# PLC Ladders









**Relay Logic**










**PLC Logic**

# PLC Analogs

-  **Accept standard signals**
-  **Convert signal to number**
-  **Off-On at set point**
-  **PID control in some units**
-  **Costly in many units**
-  **May have separate CPU**







# Operator Interface

-  **Switches and Lamps**
-  **Thumbwheel Switches**
-  **Potentiometer Input**
-  **Digital Numeric Display**
-  **Alpha-Numeric Display**
-  **CRT Console or PC**
-  **Voice Synthesizer**








# Flow Computers

- **Special purpose device for gas or liquid measurement**
- **Daniels, GH-Flow Automation, Omni, Applied Automation, many others**
- **Small - Simple Pulse/DP Accumulators**
- **Large - Complete flow calculations**
- **Versatile Measurement Specifications  
AGA 3, 5, 6, 7, 8. NX-19**
- **Complex audit trail features**
- **Limited local programming and communications functions**
- **High cost for non-flow applications**

# Flow Computer Application

-  **Gas and liquid measurement where high accuracy is required**
-  **Production, purchasing, sales, well testing, fuel, and flare**
-  **Local measurement - No telemetry**
-  **Remote measurement - SCADA**
-  **Local control - Batch processing, valve positioning, very simple control**
-  **Can serve as input to other control system or telemetry system**

# Flow Computer Components

-  **Proprietary hardware design**
-  **Analog inputs - Flow sensing**
-  **Digital inputs - Flow status**
-  **Analog outputs - Valve positioning and local device interface**
-  **Digital outputs - Valve off/on, alarms**
-  **Local operator display / keyboard**
-  **Communications interface for programming and remote access**