Application Note 002
Version 002
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# Network Control of an Eaton PowerXL DG1 VFD

The concept of interacting with a VFD by using an Industrial Networking Protocol – such as Modbus or EtherNet/IP – is vastly superior to legacy methods that use discrete I/O wired to the terminal block. Why? Because there is so much more information available to the Control System when communicating directly with the VFD's microprocessor.

Network-available feedback tags include Speed (Hz), Power (HP, KW), Energy (MWH), Current (A), Voltage (V), Temperature ($^{o}$), and Fault Information. Furthermore, the network wiring is arguably simpler than discrete signal wiring – since it only relies upon a single twisted pair or Ethernet cable. On the other hand, extra know-how is required to collect and process the extra information. Therefore, in order to clarify and simplify the theory and practice of controlling and monitoring a VFD across a network, Navionics Research has developed a library of Application Notes, each designed to address networking techniques specific to a particular manufacturer. Notes are currently available for Allen Bradley (Modbus), ABB (Modbus), Eaton (Modbus), and Toshiba (Toshiba Protocol). Others may be forthcoming.

## Eaton PowerXL DG

This document was created to address the specifics of the Eaton PowerXL DG1 VFD using the Modbus protocol. This paper will specifically address Modbus/RTU over RS-485, although the notes also apply to Modbus/TCP when wired for Ethernet.

First, the following documents should be available for reference:

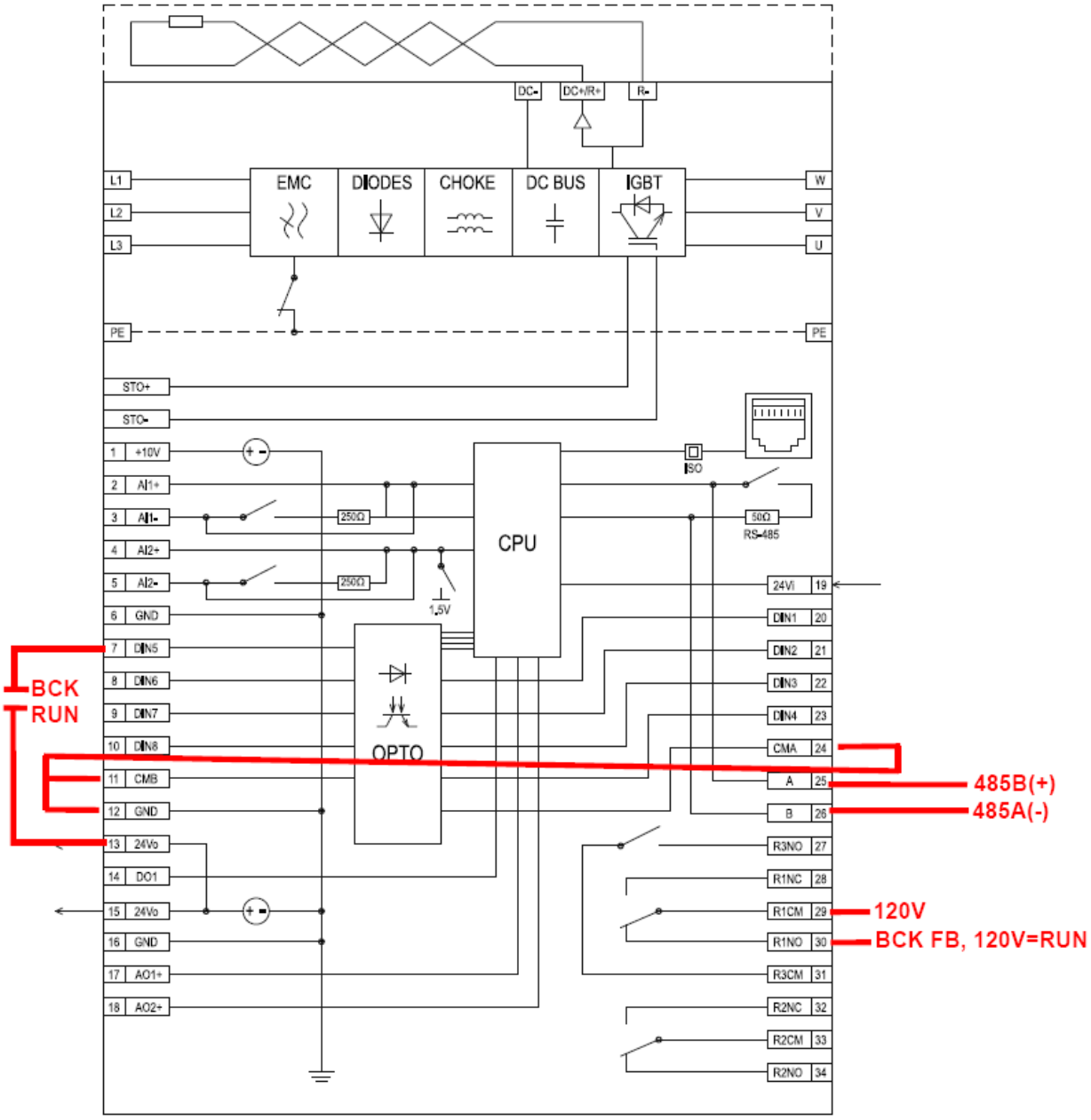
DG1 Installation Manual
DG1 Series Quick Start Guide
DG1 Communication Manual
DG1 Application Manual
DG1 Firmware Upgrade Procedures

## Signal Wiring

The VFD should be wired for Modbus/RTU Control/Monitoring. Note that the DG1's RS-485 terminals are labeled opposite to NRI's convention; so the terminal marked as 'A' should be connected to the RTU Terminal B(+), and the terminal marked as 'B' should be connected to the RTU Terminal A(-).

In addition to the Modbus/RS-485 terminals, wiring is provided for backup discrete controls in case of communication bus failure: A single dry contact is to provide a run signal, and a 120V feedback signal denotes that the drive is at-speed.

Figure 21. Basic Internal Control Wiring Diagram




## Keypad: Motor Nameplate Value Registration

The VFD should be configured using the Wizard Setup Screens with the Motor Nameplate Values.

**P1.1** Min Frequency
**P1.2** Max Frequency
**P1.3** Accel Time
**P1.4** Decel Time
**P1.5** Motor Nominal Nameplate Full Load Current
**P1.6** Motor Nominal Nameplate Base Speed
**P1.7** Motor Nominal Nameplate Full Load Power Factor
**P1.8** Motor Nominal Nameplate Base Voltage

## Keypad: Basic Configuration

The VFD should be configured for Modbus/RTU communications by setting the following parameters:

| | | | | |
|---|---|---|---|---|
| **P20.2.1** | RS485 Comm Set | 0 | Modbus/RTU | (default=0) |
| **P20.2.2** | Slave ID | [n] | [User-Defined] | (default=18) |
| **P20.2.3** | Baud Rate | 0 | 9600 bps | (default=2, 38400) |
| **P20.2.4** | Parity | 0 | None | (default=2, Even) |
| **P20.2.10** | Comm Timeout ms | 30000 | | (default=2000ms) |

(Note that the above Comm settings do not take effect until after a VFD reset or power cycle.)

| | | | | |
|---|---|---|---|---|
| **P1.10** | Local/Remote Sel | 0 | Hold Last | (default=0) |
| **P1.11** | Remote1 Ctrl Place | 1 | FieldBus | (default=0, I/O Terminal) |
| **P1.14** | Remote 1 Reference | 7 | FieldBus Ref | (default=6, Keypad) |
| **P1.15** | Reverse Enable | 0 | Disabled | (default=1, Enabled) |

## Keypad: Communication & Terminal Block Configuration

Once the VFD is set up with the desired comm port parameters and device address, much of the configuration may be performed by the connected Master PLC. The following comm port parameters should be initially configured:

| | | | |
|---|---|---|---|
| **P3.3** | Dig In 5 | 006 | Start Signal 2 |
| **P3.10** | Dig In 5 | 006 | Preset Speed B0 |
| **P3.23** | Dig In 5 | 006 | Remote 1/2 Select |
| **P5.2** | At Speed | 007 | RO1 Function |
| …or… | | | |
| **P5.2** | Run | 002 | RO1 Function |
| **P12.1** | 55.0 | | Preset Speed 1 – In Hz (Set this to owner preference!) |

## Keypad: Modbus Read-Register Aggregation

The VFD should be configured using the Wizard Setup Screens with the Motor Nameplate Values.
The DG1 has a nice register-aggregation feature in which a bank of 8 registers can be user-programmed to hold user-defined tags of interest that would otherwise be scattered throughout the Modbus Memory Map. This allows the user to perform a single, 22-byte block read – rather than a multitude of single-register reads– thereby speeding up communications between the RTU/Controller and the VFD.

The User-Selectable FieldBus Data Outputs may be chosen from the MONITOR registers, which are detailed in the Application Manual, Pages 198-200. The User-Selectable items are highlighted in yellow below, along with the NRI's preferred register contents:

| **Modbus Register** | | | | **Contents** | |
|---|---|---|---|---|---|
| 2100 | | | | Status Word | |
| 2101 | | | | Gen Status Word | |
| 2102 | | | | Actual Speed, 0-60.00 Hz | |
| 2103 | P20.1.1 | FB Data Output 1 Sel | 1 | Actual Speed, 0-100.00 % | (default=1) |
| 2104 | P20.1.2 | FB Data Output 2 Sel | 5 | Motor Power, 0-100.0% | (default=2) |
| 2105 | P20.1.3 | FB Data Output 3 Sel | 28 | Last Fault | (default=3) |
| 2106 | P20.1.4 | FB Data Output 4 Sel | 4 | Motor Torque, 0-100.0% | (default=4) |
| 2107 | P20.1.5 | FB Data Output 5 Sel | 5 | Motor Power, 0-100.0% | (default=5) |
| 2108 | P20.1.6 | FB Data Output 6 Sel | 6 | Motor Voltage, 0.0-Actual | (default=6) |
| 2109 | P20.1.7 | FB Data Output 7 Sel | 7 | DC Bus Voltage, 0-Actual | (default=7) |
| 2110 | P20.1.8 | FB Data Output 8 Sel | 8 | Unit Temp degC, 0.0-Actual | (default=359) |

## Modbus Registers for DG1 Monitoring:

**Master PLC <u>READS</u> These Words:**

## Drive Monitoring Using Modbus:

The registers detailed above, 2100-2110, contain the data to be collected by the Master PLC. Register 2100, which contains the STATUS_WORD, contains an array of bitflags per the following table:

2100 STATUS_WORD

| | |
|---|---|
| 0 | Ready (1=Ready, 0=Not Ready) |
| 1 | Run (1=Run, 0=Stop) |
| 2 | Rotation (0=Clockwise, 1=Counterclockwise) |
| 3 | Fault (1=Faulted) |
| 4 | Warning (1=Warning) |
| 5 | At Ref Speed (1=At Ref Speed) |
| 6 | Bypass (1=Bypass Activated) |
| 7 | Enable (1=Run Enable, 0=Run Disable) |
| 8 | [Not For Use] |
| 9 | [Not For Use] |
| 10 | [Not For Use] |
| 11 | [Not For Use] |
| 12 | [Not For Use] |
| 13 | [Not For Use] |
| 14 | [Not For Use] |
| 15 | [Not For Use] |

## Modbus Registers for DG1 Control:

**Master PLC <u>WRITES</u> These Words:**

2000 CONTROL_WORD

| | |
|---|---|
| 0 | Run (1=Run) |
| 1 | Direction (0=Fwd) |
| 2 | Fault Reset (1=Reset Fault) |
| 3 | [Not For Use] |
| 4 | [Not For Use] |
| 5 | [Not For Use] |
| 6 | [Not For Use] |
| 7 | BYS |
| 8 | VFD ON/OFF Controlled Via Network/Modbus |
| 9 | VFD Speed Reference Via Network/Modbus |
| 10 | [Not For Use] |
| 11 | [Not For Use] |
| 12 | [Not For Use] |
| 13 | [Not For Use] |
| 14 | [Not For Use] |
| 15 | [Not For Use] |

2002 SPEED REFERENCE (Unsigned Integer)
0-10,000 (0-100%) for Firmware Versions 20.0 and Later
0-6,000 (0-60.00Hz) For Firmware Versions 19.0 and Before

The CONTROL_WORD should be written as:

| | | | |
|---|---|---|---|
| 768 | (256+512) | 0b0000000110000000 | STOP DRIVE |
| 769 | (1+256+512) | 0b0000000110010001 | RUN DRIVE |
| 772 | (4+256+512) | 0b0000000110000100 | RESET FAULTS |

## Backup/Alternative VFD Control Via Terminal Block

How should the system be configured to handle a Modbus communication failure? First and foremost, the VFD should be configured to shut down if it stops receiving commands from the Master PLC. A 30 second timeout should be sufficient for this purpose. When the VFD stops due to comm loss, it will show a Fault Code 83.

After a Modbus communication fault is detected, NRI's standard backup control method consists of parallel, discrete (ON/OFF) control circuitry. The activation of this circuitry requires the operator to perform the following steps:

1. CLEAR THE VFD FAULT AT THE KEYPAD
2. ACTIVATE MASTER PLC SETPOINT: DISCRETE_VFD_CONTROL = YES/TRUE

The parallel, discrete control circuitry consists of two pairs of low-voltage wires: One for control of the drive, and one for feedback/monitoring. Through pair 1, a single dry contact will provide the run signal to the drive to run at the user-defined "PRESET 0" speed. Through pair 2, a single contact output will provide RUN feedback to the Master PLC: When the DG1 is "At Desired Frequency", a 120VAC or 24VDC signal will be transmitted. Until the Modbus communication link is re-established/repaired, this method allows for the VFD to run in ON/OFF mode at a preset speed with controlled ramp-up and ramp-down times. Note that the VFD's will run only at a pre-determined speed – No speed throttling will occur in this mode.

## Detailed VFD Monitoring

Now that network communication to the DG1 has been achieved, the PLC programmer now has READ access to valuable VFD internal information.

Available **DISCRETE** tags for reading include (not a complete list):

VFD_READY
VFD_ACTIVE (RUNNING)
VFD_ROTATION_DIRECTION
VFD_WARNING
VFD_FAULTED
VFD_AT_REFERENCE_SPEED

Available **ANALOG** tags for reading include (not a complete list):

VFD_OUTPUT_SPEED
VFD_OUTPUT_AMPS
VFD_OUTPUT_VOLTS
VFD_DC_BUS_VOLTS
VFD_OUTPUT_POWER_KW
VFD_ENERGY_MWH
VFD_TEMPERATURE
VFD_ACTIVE_FAULT_CODE

## Feedback Control Strategies

In a Water Utility, the VFD will typically be installed to control the speed of a pump motor. Available telemetry data may include pump discharge pressure, pump suction pressure, pump rate-of-flow, in addition to the data available from the drive itself. This extra data, when combined with the VFD control algorithm, may be used to implement closed-loop feedback control strategies. For example, an upper limit may be placed on the pump discharge pressure – or a lower limit on the pump suction pressure – or both. Other possibilities are to implement an upper limit on the rate-of-flow, or an upper limit on the power consumption. In any of these cases, the speed of the VFD will be throttled up or down in order to maintain the pressures and/or flow and/or power consumption within the desired envelope.

## Cavitation Traps

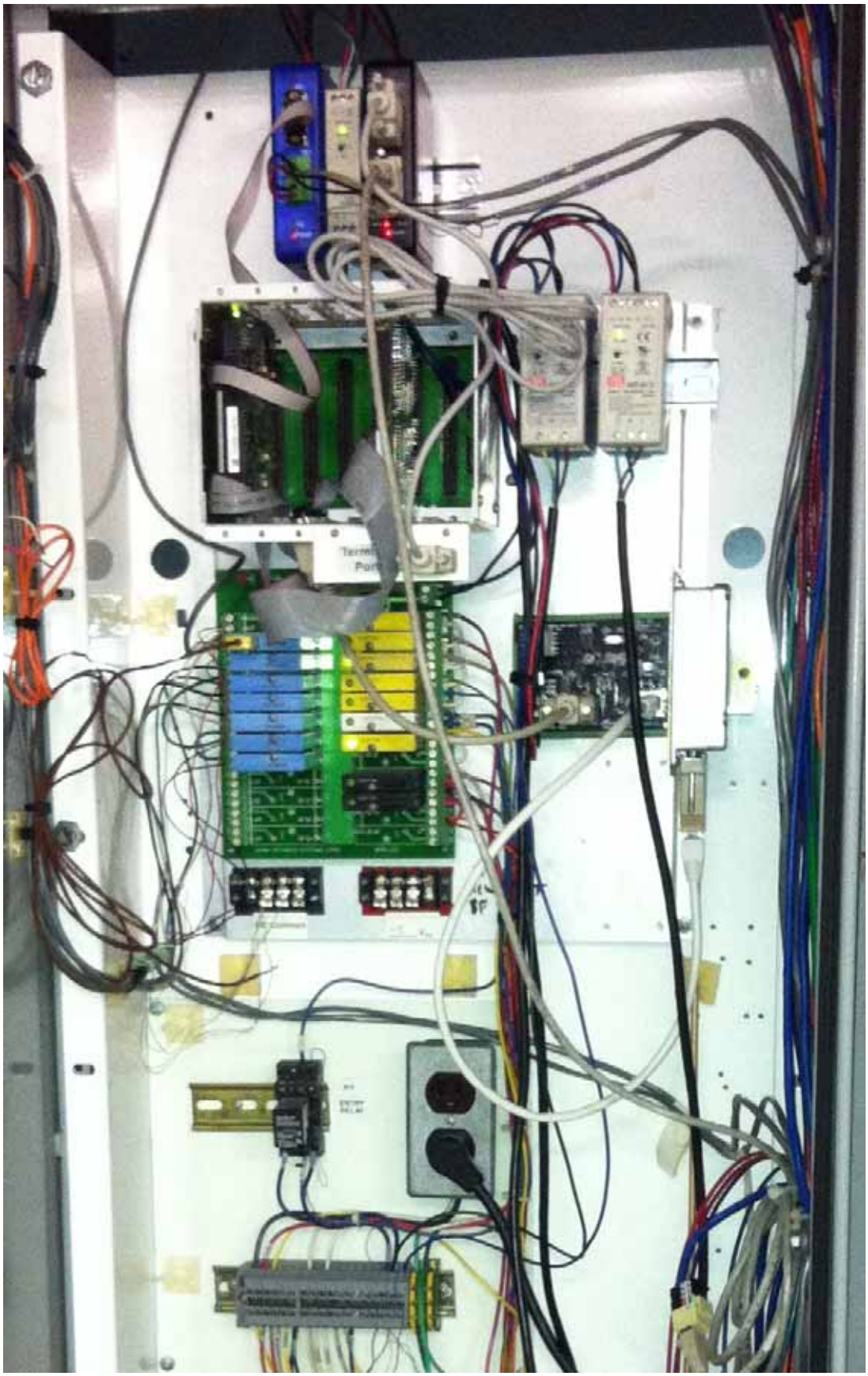
Ideally, pump “no flow” conditions are detected by monitoring a flow meter. In situations where a flow meter is not available, and because the DG1 provides realtime power consumption of the pump motor to the Master PLC, it is possible that the PLC can detect and/or alarm cavitation conditions – situations where the pump is not moving water as evidenced by the power consumption of the motor falling below the normal range.

## Feedback Control

In a Water Utility, the VFD will typically be installed to control the speed of a pump motor. Available telemetry data may include pump discharge pressure, pump suction pressure, and pump rate-of-flow. This extra data, when combined with the VFD, may be used to implement closed-loop feedback control

## VFD Reset Via Modbus

Because the DG1 provides actual VFD fault information to the Master PLC, this information can be alarmed and the operator notified of the problem. The information is transmitted as a decimal fault code, and the Operator may refer to this document (or the Eaton DG1 User Manual) to decode the fault. After decoding the fault, the Operator may reset the fault remotely using a provided “one-shot” pushbutton setting within the Telemetry System.




tiostar


E·T·N


EATON


EMC
M3V
Not for customer
EMC

```
$NCH - NEW FILTER PLANT: IOZ.02, ADDR=2, SERNO=1000
  10     # Number of Discrete Setpoints
  21     # Number of Analog   Setpoints
   8     # Number of Integer  Setpoints
   7     # Number of Discrete Input Modules
   7     # Number of Analog   Input Modules
   2     # Number of Integer  Input Modules
  26     # Number of Discrete Flag States
  18     # Number of Analog   Flag States
   7     # Number of Integer  Flag States
   3     # Number of Relay    Output Modules
   4     # Number of Analog   Output Modules
# Remote Setup Information ... (No Blank Lines Allowed...)
   2     # Number of Dependent Sites (Dependent Sites Follow)
   001      # Softening Plant / Elev Tank
   003      # Well Field
# Variable Name Definitions ... (Blank Lines Allowed...)

#
# DISPLAY OPTIONS:
# ================
# D1  // ON=GREEN          , OFF=BLANK
# D2  // ON=RED/BLINKING   , OFF=BLANK
# D3  // ON=GREEN          , OFF=RED/BLINKING
# D4  // ON=GREEN/BLINKING , OFF=BLANK
#
# $BLANK - SKIP LINE
# $PAGE  - SKIP TO NEXT PAGE
#
# 'S' PREFIX - SERIAL DISPLAY
#

ALIAS     POWER_OK_MODULE                    LDM    0
ALIAS     P1_FEEDBACK_MODULE                 LDM    1
ALIAS     P2_FEEDBACK_MODULE                 LDM    2
ALIAS     GEN_FEEDBACK_MODULE                LDM    3
ALIAS     GEN_LOW_FUEL_MODULE                LDM    4
ALIAS     ENTRY_MODULE                       LDM    5
ALIAS     FLOW_SWITCH_MODULE                 LDM    6

ALIAS     P1_PRESET_SSR                      LDR    0
ALIAS     P2_PRESET_SSR                      LDR    1
# (FUTURE)...
ALIAS     EXT_MODE_SSR                       LDR    2

# 200 PSI (OFFSET=+1.83)...
ALIAS     EFFLUENT_MODULE                    LAM    0

# 200 PSI (OFFSET=-2.00)...
ALIAS     INFLUENT_MODULE                    LAM    1

# 630 LB (OFFSET=0.00)...
ALIAS     CHLORINE_MODULE                    LAM    2

# 450 LB (OFFSET=0.00)...
ALIAS     FLUORIDE_MODULE                    LAM    3

# 34.6FT,15PSI SPAN(OFFSET=+1.00)...
ALIAS     EAST_DETENTION_MODULE              LAM    4
# 34.6FT,15PSI SPAN (OFFSET=+0.80)...
```

```
ALIAS     WEST_DETENTION_MODULE                LAM    5

# T-THERMO...
ALIAS     BLDG_TEMP_MODULE                     LAM    6

ALIAS     EFFLUENT_WORKING                     LAMV   0
ALIAS     INFLUENT_WORKING                     LAMV   1
ALIAS     EAST_DETENTION_WORKING               LAMV   4
ALIAS     WEST_DETENTION_WORKING               LAMV   5


ALIAS     ALTERNATE_PUMPS                      LDS    0
ALIAS     ALLOW_2_HI_SVC_PUMPS                 LDS    1
ALIAS     LEVEL_SMOOTHING                      LDS    2
ALIAS     VFD_HARDWIRE_CONTROL                 LDS    3
ALIAS     VFD1_RESET_1SHOT                     LDS    4
ALIAS     VFD2_RESET_1SHOT                     LDS    5
ALIAS     RESET_ON_REBOOT                      LDS    6
ALIAS     COOLOFF_10_MINUTES                   LDS    7
ALIAS     VFD1_ONLINE                          LDS    8
ALIAS     VFD2_ONLINE                          LDS    9


ALIAS     DETENTION_WELL_ON_FT                 LAS    0
ALIAS     DETENTION_WELL_OFF_FT                LAS    1
ALIAS     INFLOW_DETECT_GPM                    LAS    2
ALIAS     OUTFLOW_DETECT_GPM                   LAS    3
ALIAS     DISCHARGE_LIMIT_PSI                  LAS    4
ALIAS     VFD_GAIN                             LAS    5
ALIAS     VFD_MAXSTEP                          LAS    6

ALIAS     PRESSURE_MODE_RUNTIME_HRS            LAS    7
ALIAS     PRESSURE_MODE_LEAD_ON_PSI            LAS    8
ALIAS     TIMER_1_START_HOUR                   LAS    9
ALIAS     TIMER_1_STOP_HOUR                    LAS   10
ALIAS     TIMER_2_START_HOUR                   LAS   11
ALIAS     TIMER_2_STOP_HOUR                    LAS   12
ALIAS     TIMER_3_START_HOUR                   LAS   13
ALIAS     TIMER_3_STOP_HOUR                    LAS   14
ALIAS     LOW_DETENTION_CUTOUT_FT              LAS   15
ALIAS     LOW_DETENTION_RELEASE_FT             LAS   16
ALIAS     TRANSDUCER_FAIL_SPEED_%              LAS   17

ALIAS     VFD_MIN_SPEED_%                      LAS   18
ALIAS     VFD_MAX_SPEED_%                      LAS   19

ALIAS     FILTER_LOSS_FACTOR                   LAS   20


ALIAS     MODE{RADIO-PRESS-TIMER-EXT}          LIS    0
ALIAS     FAILOVER{PRESS-TIMER-EXT}            LIS    1
ALIAS     DETENTION_TANK{EAST-WEST-BOTH}       LIS    2
ALIAS     HI_SVC_PUMP_1{AUTO-ON-OFF}           LIS    3
ALIAS     HI_SVC_PUMP_2{AUTO-ON-OFF}           LIS    4
ALIAS     LEAD_HI_SVC_PUMP{P1-P2}              LIS    5
ALIAS     LAG_HI_SVC_PUMP{P1-P2}               LIS    6
ALIAS     CALL_WELL_CONTROL{AUTO-ON-OFF}       LIS    7

DISPL_D3  POWER                                LDF    0
DISPL_C   UP_TIME_MIN                          LIF    6
$BLANK
DISPL_D4  HI_SVC_PUMP_1                        LDF    1
DISPL_D4  HI_SVC_PUMP_2                        LDF    2
DISPL_C   CURRENT_LEAD_PUMP                    LIF    5
```

```
DISPL_A   VFD1_SPEED_%                      LAF    5
DISPL_A   VFD2_SPEED_%                      LAF    6
DISPL_A   VFD1_POWER_KW                     LAF   12
DISPL_A   VFD2_POWER_KW                     LAF   13
DISPL_A   VFD1_FAULT_CODE                   LAF   14
DISPL_A   VFD2_FAULT_CODE                   LAF   15
DISPL_A   GALLONAGE1_GPK                    LAF   16
DISPL_A   GALLONAGE2_GPK                    LAF   17
$BLANK
DISPL_C   HI_SVC_PUMP_1_RUNTIME_MIN         LIF    2
DISPL_C   HI_SVC_PUMP_2_RUNTIME_MIN         LIF    3
DISPL_D2  HI_SVC_PUMP_1_FAIL                LDF    6
DISPL_D2  HI_SVC_PUMP_2_FAIL                LDF    7
$BLANK

DISPL_A   FINISHED_FLOW_GPM                 LAF    1
DISPL_C   FINISHED_METER_GAL                LIF    1
DISPL_A   RAW_FLOW_GPM                      LAF    0
DISPL_C   RAW_METER_GAL                     LIF    0
$BLANK 2

DISPL_D4  CALL_WELL                         LDF    3
$BLANK
DISPL_A   EAST_DETENTION_LEVEL_FT           LAF    7
DISPL_A   WEST_DETENTION_LEVEL_FT           LAF    8
DISPL_D2  LOW_DETENTION_CUTOUT              LDF   14
DISPL_D2  EAST_DETENTION_XDUCER_FAIL        LDF   17
DISPL_D2  WEST_DETENTION_XDUCER_FAIL        LDF   18
$BLANK
DISPL_A   EFFLUENT_PSI                      LAF    3
DISPL_A   INFLUENT_PSI                      LAF    2
DISPL_A   FILTER_LOSS_PSI                   LAF    4
DISPL_D2  EFFLUENT_TRANSDUCER_FAIL          LDF   15
DISPL_D2  INFLUENT_TRANSDUCER_FAIL          LDF   16
$PAGE

ALIAS     COMM_FAIL_TO_WELL                 LDF    8
ALIAS     COMM_FAIL_TO_ELEVATED_TANK        LDF    9
DISPL_D1  RADIO_MODE                        LDF   10
DISPL_D2  PRESSURE_MODE                     LDF   11
DISPL_D2  TIMER_MODE                        LDF   12
ALIAS     EXT_MODE                          LDF   13
DISPL_D2  ENTRY_DETECT                      LDF   19
DISPL_D2  POSSIBLE_WELL_FAIL                LDF   20
DISPL_D2  POSSIBLE_FLOW_SWITCH_FAIL         LDF   21
DISPL_D2  VFD1_COMM_FAULT                   LDF   22
DISPL_D2  VFD2_COMM_FAULT                   LDF   23
DISPL_D2  FINISHED_METER_FAULT              LDF   24
DISPL_D2  RAW_METER_FAULT                   LDF   25
$BLANK

DISPL_A   BLDG_TEMP_DEGF                    LAF    9
$BLANK
DISPL_A   CHLORINE_LBS                      LAF   10
DISPL_A   FLUORIDE_LBS                      LAF   11
$BLANK
DISPL_D2  GENERATOR                         LDF    4
DISPL_D2  GENERATOR_LOW_FUEL                LDF    5
DISPL_C   GENERATOR_RUNTIME_MIN             LIF    4
$PAGE

DISPL_D3  COMM_TO_ELEVATED_TANK             VLD    0
$BLANK
DISPL_D3  ELEVATED_TANK_POWER               RDF    0   0
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DISPL_C   ELEVATED_TANK_UP_TIME_MIN          RIF    0  3
$BLANK
DISPL_D4  ELEVATED_TANK_CALL_LEAD            RDF    0  1
$BLANK
DISPL_A   ELEVATED_TANK_LEVEL_FT             RAF    0  0
DISPL_A   ELEVATED_TANK_LEVEL_KGAL           RAF    0  1
DISPL_A   ELEVATED_TANK_FLOW_RATE_GPM        RAF    0  2
DISPL_D2  ELEVATED_TANK_TRANSDUCER_FAIL      RDF    0  6
$BLANK
DISPL_A    BLDG_TEMP_DEGF                    RAF    0  3
$BLANK 7

DISPL_A    TOTAL_FLOW_GPM                    RAF    0  4
DISPL_C    TOTAL_METER_GAL                   RIF    0  0
$BLANK

DISPL_A    SOFTENED_FLOW_GPM                 RAF    0  5
DISPL_C    SOFTENED_METER_GAL                RIF    0  1
$BLANK

DISPL_A    UNSOFTENED_FLOW_GPM               RAF    0  6
DISPL_C    UNSOFTENED_METER_GAL              RIF    0  2
$BLANK

DISPL_A    SOFTENED_MIXTURE_%                RAF    0  7

$PAGE

DISPL_D3  COMM_TO_WELL                       VLD    1
DISPL_C   WELL_UPTIME_MIN                    RIF    1  2
$BLANK
DISPL_D3  POWER_WELL_3                       RDF    1  1
DISPL_D3  POWER_WELL_4                       RDF    1  2
$BLANK
DISPL_D4  WELL_3                             RDF    1  3
DISPL_C   WELL_3_RUNTIME_MIN                 RIF    1  0
DISPL_D2  WELL_3_FAIL                        RDF    1  9
DISPL_D2  WELL_3_VFD_FAIL                    RDF    1 11
DISPL_D2  WELL_3_ENTRY                       RDF    1 13
$BLANK

DISPL_D4  WELL_4                             RDF    1  4
DISPL_C   WELL_4_RUNTIME_MIN                 RIF    1  1
DISPL_D2  WELL_4_FAIL                        RDF    1 10
DISPL_D2  WELL_4_VFD_FAIL                    RDF    1 12
DISPL_D2  WELL_4_ENTRY                       RDF    1 14
$BLANK


# MODBUS TAGS...

ALIAS     VFD1_CTRL_WORD_MBO                 M_SOU  1  2000
ALIAS     VFD1_SPEED_REF_MBO                 M_SOU  1  2002

ALIAS     VFD2_CTRL_WORD_MBO                 M_SOU  2  2000
ALIAS     VFD2_SPEED_REF_MBO                 M_SOU  2  2002

ALIAS     POWER_OK_TIMER                     TMR    0
ALIAS     P1_FAIL_TIMER                      TMR    1
ALIAS     P2_FAIL_TIMER                      TMR    2
ALIAS     PRESSURE_LEAD_ON_TIMER             TMR    3
ALIAS     PRESSURE_LEAD_OFF_TIMER            TMR    4
ALIAS     P1_DELAY_TIMER                     TMR    5
ALIAS     P2_DELAY_TIMER                     TMR    6
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ALIAS     VFD1_SHUTD_TIMER                  TMR    7
ALIAS     VFD2_SHUTD_TIMER                  TMR    8
ALIAS     LOW_DETENTION_TIMER               TMR    9
ALIAS     LOW_DETENTION_RELEASE_TIMER       TMR   10
ALIAS     WELL_ON_TIMER                     TMR   11
ALIAS     WELL_OFF_TIMER                    TMR   12
ALIAS     WELL_FAIL_TIMER                   TMR   13
ALIAS     SWITCH_FAIL_TIMER                 TMR   14
ALIAS     WATER_HAMMER_TIMER                TMR   15

ALIAS     P1_RUNTIME_SECS                   USR    0
ALIAS     P2_RUNTIME_SECS                   USR    1
ALIAS     LEAD_PUMP_DEF                     USR    2
ALIAS     LAG_PUMP_DEF                      USR    3
ALIAS     LASTCALL_TIME                     USR    4
ALIAS     DELTA_TIME                        USR    5
ALIAS     TOWER_LEAD                        USR    6
ALIAS     TOWER_LAG                         USR    7
ALIAS     PRESSURE_LEAD                     USR    8
ALIAS     PRESSURE_LAG                      USR    9
ALIAS     TIMER_LEAD                        USR   10
ALIAS     NEW_LEAD_STATE                    USR   11
ALIAS     LEAD_TURNING_ON                   USR   12
ALIAS     LEAD_TURNING_OFF                  USR   13
ALIAS     LEAD_STATE                        USR   14
ALIAS     LAG_STATE                         USR   15
ALIAS     LOCAL_P1                          USR   17
ALIAS     LOCAL_P2                          USR   18
ALIAS     TOWER_CONTROL_FAIL                USR   19
ALIAS     TOWER_LOW_VERIFIED                USR   20
ALIAS     TOWER_HIGH_VERIFIED               USR   21
ALIAS     LEAD_TIMER                        USR   22
ALIAS     SEQUENCE_POINTER_1                USR   23
ALIAS     SEQUENCE_POINTER_2                USR   24

ALIAS     TRY_1_FAIL                        USR   25
ALIAS     TRY_2_FAIL                        USR   26

ALIAS     AOK                               USR   27

ALIAS     TOWER_CALL_LEAD                   USR   28
ALIAS     TOWER_CALL_LAG                    USR   29

ALIAS     P1_FINAL                          USR   30
ALIAS     P2_FINAL                          USR   31

ALIAS     GEN_RUNTIME_SECS                  USR   32

ALIAS     FLOWING_IN_USR                    USR   33
ALIAS     FLOWING_OUT_USR                   USR   34
ALIAS     DETENTION_USR                     USR   35

ALIAS     PUMP_FAIL_NOW_USR                 USR   36
ALIAS     DETENTION_WORKING_USR             USR   37

# EATON VFD CONSTANTS...
ALIAS     NET_CTRL_USR                      USR   38
ALIAS     NET_REF_USR                       USR   39
ALIAS     NET_RESET_USR                     USR   40
ALIAS     NET_RUN_USR                       USR   41

ALIAS     VFD_TARGET_SPEED_%                USR   42
ALIAS     P1_VIRTUAL_SSR                    USR   43
ALIAS     P2_VIRTUAL_SSR                    USR   44
```

```
ALIAS     WATER_HAMMER_OK_USR                USR   45
ALIAS     PUMP_RUNNING_USR                   USR   46

ALIAS     VFD1_TARGET_SPEED_%                USR   47
ALIAS     VFD2_TARGET_SPEED_%                USR   48

ALIAS     VFD1_FAULT_USR                     USR   49
ALIAS     VFD1_ALARM_USR                     USR   50
ALIAS     VFD2_FAULT_USR                     USR   51
ALIAS     VFD2_ALARM_USR                     USR   52

ALIAS     VFD1_STATUS_WORD_MBI               USR   53
ALIAS     VFD1_SPEED_FB_MBI                  USR   54
ALIAS     VFD1_PWR%_MBI                      USR   55
ALIAS     VFD1_FAULT_CODE_MBI                USR   56

ALIAS     VFD2_STATUS_WORD_MBI               USR   57
ALIAS     VFD2_SPEED_FB_MBI                  USR   58
ALIAS     VFD2_PWR%_MBI                      USR   59
ALIAS     VFD2_FAULT_CODE_MBI                USR   60

ALIAS     FILTER_CORRECT_USR                 USR   61
ALIAS     PUMP_WAS_ON_USR                    USR   62
ALIAS     PUMP_IS_ON_USR                     USR   63
ALIAS     OFF_DETECT_USR                     USR   64


$NCL


# NCL Program
#
# Station : Water Filtration and Pumping Plant
# Author  : Jim Mimlitz, Navionics Research Inc.
# Date    : 23 Sep 2003
# Mods    : 29 Nov 2007
#           Low-Speed Pulse Detection Added
#           03 Sep 2014
#           Major Repairs After Direct Lightning Strike,
#           Incl. EtherMeter-Based Meter Readings.

# TRANSFER MODULE INPUTS TO FLAG INPUTS ...

      LBL      MAIN


# IF FIRSTRUN, INITIALIZE VARIABLES AND TIMERS ...

      FIRSTRUN?
      IF_FALSE
      GOTO     10

      SYSTIME
      STORE    LASTCALL_TIME
      POP

      LOAD     0.0
      STORE    PUMP_FAIL_NOW_USR
      STORE    TRY_1_FAIL
      STORE    TRY_2_FAIL
      STORE    HI_SVC_PUMP_1_FAIL
      STORE    HI_SVC_PUMP_2_FAIL
      STORE    P1_FAIL_TIMER
```

```
STORE    P2_FAIL_TIMER
STORE    P1_DELAY_TIMER
STORE    P2_DELAY_TIMER
STORE    PRESSURE_LEAD_ON_TIMER
STORE    PUMP_IS_ON_USR
STORE    PUMP_WAS_ON_USR
POP

LOAD     1.0
STORE    VFD1_SHUTD_TIMER
STORE    VFD2_SHUTD_TIMER
STORE    WELL_OFF_TIMER
STORE    LOW_DETENTION_RELEASE_TIMER
STORE    POWER_OK_TIMER
STORE    WATER_HAMMER_TIMER
POP

LOAD     120.00
SDELAY   LOW_DETENTION_TIMER
SDELAY   LOW_DETENTION_RELEASE_TIMER
POP

LOAD     30.0
SDELAY   WELL_ON_TIMER
SDELAY   WELL_OFF_TIMER
POP

LOAD     20.0
SDELAY   VFD1_SHUTD_TIMER
SDELAY   VFD2_SHUTD_TIMER
POP

LOAD     15.0
SDELAY   P1_DELAY_TIMER
SDELAY   P2_DELAY_TIMER
POP

LOAD     600.0
SDELAY   WATER_HAMMER_TIMER
POP

LOAD     600.0
SDELAY   POWER_OK_TIMER
POP

LOAD     900.0
SDELAY   WELL_FAIL_TIMER
SDELAY   P1_FAIL_TIMER
SDELAY   P2_FAIL_TIMER
SDELAY   SWITCH_FAIL_TIMER
POP

LOAD     900.0
SDELAY   PRESSURE_LEAD_ON_TIMER
POP

LOAD     CHLORINE_MODULE
PSTORE   CHLORINE_LBS

LOAD     FLUORIDE_MODULE
PSTORE   FLUORIDE_LBS

LOAD     INFLUENT_MODULE
PSTORE   INFLUENT_PSI
```

```
      LOAD     EFFLUENT_MODULE
      PSTORE   EFFLUENT_PSI

      LOAD     EAST_DETENTION_MODULE
      PSTORE   EAST_DETENTION_LEVEL_FT

      LOAD     WEST_DETENTION_MODULE
      PSTORE   WEST_DETENTION_LEVEL_FT

      LOAD     BLDG_TEMP_MODULE
      PSTORE   BLDG_TEMP_DEGF

# DEFINE EATON VFD BIT CONSTANTS...

      LOAD     1
      PSTORE   NET_RUN_USR

      LOAD     4
      PSTORE   NET_RESET_USR

      LOAD     256
      PSTORE   NET_CTRL_USR

      LOAD     512
      PSTORE   NET_REF_USR

10    POP


# RESET BOTH VFD'S RIGHT AFTER BOOT UP...

      FIRSTRUN?
      LOAD     RESET_ON_REBOOT
      &
      IF_FALSE
      GOTO     11

      LOAD     NET_REF_USR
      LOAD     NET_CTRL_USR
      LOAD     NET_RESET_USR
      +
      STORE    VFD1_CTRL_WORD_MBO
      STORE    VFD2_CTRL_WORD_MBO
      LOAD     NET_RESET_USR
      -
      STORE    VFD1_CTRL_WORD_MBO
      STORE    VFD2_CTRL_WORD_MBO
      POP

      LOAD     0
      STORE    P1_VIRTUAL_SSR
      STORE    P2_VIRTUAL_SSR
      STORE    VFD_TARGET_SPEED_%
      POP

11    POP


# IF NEW-SETPOINTS OR FIRSTRUN, SANITY CHECK THE SETPOINTS ...

      NEW_SETPOINTS?
      FIRSTRUN?
      |
```

```
      IF_FALSE
      GOTO     20
      LOAD     PRESSURE_MODE_RUNTIME_HRS
      LOAD     3600.0
      *
      PSDELAY  PRESSURE_LEAD_OFF_TIMER

      GOSUB    SANITY_CHECKS
      GOSUB    MY_PUMP_SEQUENCE_SETUP

      LOAD     LEAD_PUMP_DEF
      PSTORE   CURRENT_LEAD_PUMP

20    POP


# TIME CALCULATOR ...

      SYSTIME
      LOAD     LASTCALL_TIME
      -
      PSTORE   DELTA_TIME
      SYSTIME
      PSTORE   LASTCALL_TIME


# SYSTEM UPTIME CALCULATOR ...

      UPTIME
      LOAD     60.0
      /
      PSTORE   UP_TIME_MIN


      LOAD        VFD1_ONLINE
      IF_FALSE
      GOTO        201

# VFD COMMS...

# MODBUS BLOCK TRANSFERS...
# LOADM <DEVICE ID> <INDEX-40001> <N_REGISTERS_TO_READ>
# NOTE! - THE FLOW SHOULD BE LONG, NOT ULONG! (FIXED HERE)...

      LOADM       1  2100  10

      CAST_UINT   0
      PSTORE      VFD1_STATUS_WORD_MBI

      CAST_UINT   3
      PSTORE      VFD1_SPEED_FB_MBI

      CAST_UINT   4
      PSTORE      VFD1_PWR%_MBI

      CAST_UINT   5
      PSTORE      VFD1_FAULT_CODE_MBI

      MA_VLD
      !
      PSTORE      VFD1_COMM_FAULT

###
```

```
      LOAD     P1_VIRTUAL_SSR
      LOAD     NET_REF_USR
      +
      LOAD     NET_CTRL_USR
      +
      PSTORE   VFD1_CTRL_WORD_MBO

###

      LOAD     VFD_TARGET_SPEED_%
      LOAD     P1_VIRTUAL_SSR
      *
      STORE    VFD1_TARGET_SPEED_%
      LOAD     100
      *
      PSTORE   VFD1_SPEED_REF_MBO

# SPEED FEEDBACK IS ALWAYS IN HZx100, RATHER THAN %...
      LOAD     VFD1_SPEED_FB_MBI
      LOAD     60
      /
      PSTORE   VFD1_SPEED_%

# FAULT? ALARM?...

      LOAD     VFD1_STATUS_WORD_MBI
      BITMASK  3
      PSTORE   VFD1_FAULT_USR

      LOAD     VFD1_STATUS_WORD_MBI
      BITMASK  4
      PSTORE   VFD1_ALARM_USR

# POWER TRANSMITTED AS "%x10" ...
# 60 HP, x0.7457 KW/HP = 44.742 KW
      LOAD     VFD1_PWR%_MBI
      LOAD     0.044742
      *
      PSTORE   VFD1_POWER_KW

201   POP



      LOAD        VFD2_ONLINE
      IF_FALSE
      GOTO        202

      LOADM       2  2100  10

      CAST_UINT   0
      PSTORE      VFD2_STATUS_WORD_MBI

      CAST_UINT   3
      PSTORE      VFD2_SPEED_FB_MBI

      CAST_UINT   4
      PSTORE      VFD2_PWR%_MBI

      CAST_UINT   5
      PSTORE      VFD2_FAULT_CODE_MBI

      MA_VLD
      !
```

```
      PSTORE      VFD2_COMM_FAULT

###

      LOAD     P2_VIRTUAL_SSR
      LOAD     NET_REF_USR
      +
      LOAD     NET_CTRL_USR
      +
      PSTORE   VFD2_CTRL_WORD_MBO

###

      LOAD     VFD_TARGET_SPEED_%
      LOAD     P2_VIRTUAL_SSR
      *
      STORE    VFD2_TARGET_SPEED_%
      LOAD     100
      *
      PSTORE   VFD2_SPEED_REF_MBO

# SPEED FEEDBACK IS ALWAYS IN HZx100, RATHER THAN %...
      LOAD     VFD2_SPEED_FB_MBI
      LOAD     60
      /
      PSTORE   VFD2_SPEED_%

# FAULT? ALARM?...

      LOAD     VFD2_STATUS_WORD_MBI
      BITMASK  3
      PSTORE   VFD2_FAULT_USR

      LOAD     VFD2_STATUS_WORD_MBI
      BITMASK  4
      PSTORE   VFD2_ALARM_USR

# POWER TRANSMITTED AS "%x10" ...
# 60 HP, x0.7457 KW/HP = 44.742 KW
      LOAD     VFD2_PWR%_MBI
      LOAD     0.044742
      *
      PSTORE   VFD2_POWER_KW

202   POP



# NRI VFD & ENERGY ANALYTICS...

      LOAD     FINISHED_FLOW_GPM
      LOAD     60.0
      *
      LOAD     HI_SVC_PUMP_1
      LOAD     HI_SVC_PUMP_2
      +
      LOAD     1
      MAX
      /
      LOAD     VFD1_POWER_KW
      LOAD     0.1
      MAX
      /
```

```
      LOAD     VFD1_POWER_KW
      !
      !
      *
      PSTORE   GALLONAGE1_GPK

      LOAD     FINISHED_FLOW_GPM
      LOAD     60.0
      *
      LOAD     HI_SVC_PUMP_1
      LOAD     HI_SVC_PUMP_2
      +
      LOAD     1
      MAX
      /
      LOAD     VFD2_POWER_KW
      LOAD     0.1
      MAX
      /
      LOAD     VFD2_POWER_KW
      !
      !
      *
      PSTORE   GALLONAGE2_GPK


# IF WARNING, MAKE CODE NEGATIVE.
# IF FAULT, MAKE CODE POSITIVE...

      LOAD     VFD1_FAULT_CODE_MBI
      LOAD     VFD1_FAULT_USR
      LOAD     VFD1_ALARM_USR
      CHS
      +
      *
      PSTORE   VFD1_FAULT_CODE

      LOAD     VFD2_FAULT_CODE_MBI
      LOAD     VFD2_FAULT_USR
      LOAD     VFD2_ALARM_USR
      CHS
      +
      *
      PSTORE   VFD2_FAULT_CODE


# PREVENT WATER HAMMER WITH 10 MIN SHUTDOWN AFTER PUMP SHUTDOWN...

      LOAD     HI_SVC_PUMP_1
      LOAD     HI_SVC_PUMP_2
      |
      PSTORE   PUMP_IS_ON_USR

      LOAD     PUMP_WAS_ON_USR
      LOAD     PUMP_IS_ON_USR
      STORE    PUMP_WAS_ON_USR
      !
      &
      PSTORE   OFF_DETECT_USR
      LOAD     OFF_DETECT_USR
      !
      PSTORE   WATER_HAMMER_TIMER
      LOAD     WATER_HAMMER_TIMER
      LOAD     COOLOFF_10_MINUTES
```

```
      !
      |
      PSTORE   WATER_HAMMER_OK_USR


# HARDWIRE CONTROL WHEN REQUESTED...

      LOAD     P1_VIRTUAL_SSR
      LOAD     VFD_HARDWIRE_CONTROL
      &
      LOAD     WATER_HAMMER_OK_USR
      &
      PSTORE   P1_PRESET_SSR

      LOAD     P2_VIRTUAL_SSR
      LOAD     VFD_HARDWIRE_CONTROL
      &
      LOAD     WATER_HAMMER_OK_USR
      &
      PSTORE   P2_PRESET_SSR


# TRANSFER MODULE STATES INTO FLAG STATES ...

      LOAD     POWER_OK_MODULE
      PSTORE   POWER_OK_TIMER
      LOAD     POWER_OK_TIMER
      PSTORE   POWER

      LOAD     COMM_TO_WELL
      !
      PSTORE   COMM_FAIL_TO_WELL

      LOAD     ENTRY_MODULE
      PSTORE   ENTRY_DETECT

      LOAD     P1_FEEDBACK_MODULE
      LOAD     VFD_HARDWIRE_CONTROL
      &
      LOAD     VFD1_SPEED_%
      LOAD     VFD_HARDWIRE_CONTROL
      !
      &
      |
      LOAD     FLOWING_OUT_USR
      &
      PSTORE   HI_SVC_PUMP_1

      LOAD     P2_FEEDBACK_MODULE
      LOAD     VFD_HARDWIRE_CONTROL
      &
      LOAD     VFD2_SPEED_%
      LOAD     VFD_HARDWIRE_CONTROL
      !
      &
      |
      LOAD     FLOWING_OUT_USR
      &
      PSTORE   HI_SVC_PUMP_2

      LOAD     GEN_FEEDBACK_MODULE
      PSTORE   GENERATOR

      LOAD     GEN_LOW_FUEL_MODULE
```

```
PSTORE   GENERATOR_LOW_FUEL

LOAD     FILTER_LOSS_FACTOR
LOAD     FINISHED_FLOW_GPM
LOAD     1000.0
MIN
LOAD     60.0
/
LOAD     3
Y^X
*
PSTORE   FILTER_CORRECT_USR

LOAD     INFLUENT_MODULE
LOAD     FILTER_CORRECT_USR
-
LOAD     INFLUENT_PSI
-
LOAD     1.0
MIN
LOAD     -1.0
MAX
LOAD     INFLUENT_PSI
+
PSTORE   INFLUENT_PSI

LOAD     EFFLUENT_MODULE
LOAD     EFFLUENT_PSI
-
LOAD     1.0
MIN
LOAD     -1.0
MAX
LOAD     EFFLUENT_PSI
+
PSTORE   EFFLUENT_PSI

LOAD     INFLUENT_PSI
LOAD     EFFLUENT_PSI
-
LOAD     0.0
MAX
PSTORE   FILTER_LOSS_PSI

LOAD     CHLORINE_MODULE
LOAD     CHLORINE_LBS
-
LOAD     10.0
MIN
LOAD     -1.0
MAX
LOAD     CHLORINE_LBS
+
PSTORE   CHLORINE_LBS

LOAD     FLUORIDE_MODULE
LOAD     FLUORIDE_LBS
-
LOAD     10.0
MIN
LOAD     -1.0
MAX
LOAD     FLUORIDE_LBS
+
```

```
PSTORE   FLUORIDE_LBS

LOAD     EAST_DETENTION_MODULE
LOAD     EAST_DETENTION_LEVEL_FT
-
LOAD     0.025
MIN
LOAD     -0.025
MAX
LOAD     EAST_DETENTION_LEVEL_FT
+
PSTORE   EAST_DETENTION_LEVEL_FT

LOAD     WEST_DETENTION_MODULE
LOAD     WEST_DETENTION_LEVEL_FT
-
LOAD     0.025
MIN
LOAD     -0.025
MAX
LOAD     WEST_DETENTION_LEVEL_FT
+
PSTORE   WEST_DETENTION_LEVEL_FT

LOAD     BLDG_TEMP_MODULE
LOAD     BLDG_TEMP_DEGF
-
LOAD     0.05
MIN
LOAD     -0.05
MAX
LOAD     BLDG_TEMP_DEGF
+
PSTORE   BLDG_TEMP_DEGF


LOAD     EAST_DETENTION_WORKING
LOAD     EAST_DETENTION_LEVEL_FT
LOAD     2.0
Y>X?
|
!
LOAD     DETENTION_TANK{EAST-WEST-BOTH}
LOAD     2
Y<>X?
&
PSTORE   EAST_DETENTION_XDUCER_FAIL

LOAD     WEST_DETENTION_WORKING
LOAD     WEST_DETENTION_LEVEL_FT
LOAD     2.0
Y>X?
|
!
LOAD     DETENTION_TANK{EAST-WEST-BOTH}
LOAD     1
Y<>X?
&
PSTORE   WEST_DETENTION_XDUCER_FAIL

LOAD     DETENTION_TANK{EAST-WEST-BOTH}
LOAD     3
X=Y?
LOAD     EAST_DETENTION_XDUCER_FAIL
```

```
        !
        LOAD     WEST_DETENTION_XDUCER_FAIL
        !
        &
        &
        LOAD     LEVEL_SMOOTHING
        |
        IF_FALSE
        GOTO     30
        LOAD     EAST_DETENTION_LEVEL_FT
        LOAD     WEST_DETENTION_LEVEL_FT
        MAX
        STORE    EAST_DETENTION_LEVEL_FT
        PSTORE   WEST_DETENTION_LEVEL_FT
30      POP

        LOAD     EFFLUENT_WORKING
        !
        PSTORE   EFFLUENT_TRANSDUCER_FAIL

        LOAD     INFLUENT_WORKING
        !
        PSTORE   INFLUENT_TRANSDUCER_FAIL


# DETENTION TANK FILL HANDLER ...

        LOAD     EAST_DETENTION_XDUCER_FAIL
        !
        LOAD     DETENTION_TANK{EAST-WEST-BOTH}
        LOAD     1
        X=Y?
        &

        LOAD     WEST_DETENTION_XDUCER_FAIL
        !
        LOAD     DETENTION_TANK{EAST-WEST-BOTH}
        LOAD     2
        X=Y?
        &

        LOAD     EAST_DETENTION_XDUCER_FAIL
        !
        LOAD     WEST_DETENTION_XDUCER_FAIL
        !
        |
        LOAD     DETENTION_TANK{EAST-WEST-BOTH}
        LOAD     3
        X=Y?
        &
        |
        |
        PSTORE   DETENTION_WORKING_USR

        LOAD     EAST_DETENTION_LEVEL_FT
        LOAD     DETENTION_TANK{EAST-WEST-BOTH}
        LOAD     1
        X=Y?
        *

        LOAD     WEST_DETENTION_LEVEL_FT
        LOAD     DETENTION_TANK{EAST-WEST-BOTH}
        LOAD     2
        X=Y?
```

```
      *

      LOAD     EAST_DETENTION_LEVEL_FT
      LOAD     EAST_DETENTION_XDUCER_FAIL
      !
      *
      LOAD     WEST_DETENTION_LEVEL_FT
      LOAD     WEST_DETENTION_XDUCER_FAIL
      !
      *
      +
      LOAD     EAST_DETENTION_XDUCER_FAIL
      !
      LOAD     WEST_DETENTION_XDUCER_FAIL
      !
      +
      LOAD     1
      MAX
      /
      LOAD     DETENTION_TANK{EAST-WEST-BOTH}
      LOAD     3
      X=Y?
      *

      +
      +
      PSTORE   DETENTION_USR

      LOADA    DETENTION_USR
      LOADA    DETENTION_WELL_ON_FT
      LOADA    DETENTION_WELL_OFF_FT
      LOADA    WELL_ON_TIMER
      LOADA    WELL_OFF_TIMER
      LOADA    CALL_WELL
      MACRO    HYSTERESIS_LO_W_TIMER
      LOAD     DETENTION_WORKING_USR
      &
      LOAD     CALL_WELL_CONTROL{AUTO-ON-OFF}
      LOAD     2
      Y=X?
      |
      LOAD     CALL_WELL_CONTROL{AUTO-ON-OFF}
      LOAD     3
      Y<>X?
      &
      PSTORE   CALL_WELL


# LOW DETENTION CUTOUT CALC ...
# NOTE: IF XDUCER(S) FAILED, LOW_DETENTION_CUTOUT WILL
#       BE ASSERTED (UNLESS LOW_DETENTION_CUTOUT_FT < 0 ).
#       THIS IS AN IMPORTANT SAFETY.  OPERATOR MUST RUN
#       HI SVC PUMPS USING PLANT'S MANUAL SWITCHES FOR SAFETY.

      LOADA    DETENTION_USR
      LOADA    LOW_DETENTION_CUTOUT_FT
      LOADA    LOW_DETENTION_RELEASE_FT
      LOADA    LOW_DETENTION_TIMER
      LOADA    LOW_DETENTION_RELEASE_TIMER
      LOADA    LOW_DETENTION_CUTOUT
      MACRO    HYSTERESIS_LO_W_TIMER
      PSTORE   LOW_DETENTION_CUTOUT
```

```
# WELL FAIL CALCULATION ...

      LOAD     CALL_WELL
      LOAD     FLOWING_IN_USR
      XOR
      LOAD     INFLOW_DETECT_GPM
      &
      PSTORE   WELL_FAIL_TIMER
      LOAD     WELL_FAIL_TIMER
      PSTORE   POSSIBLE_WELL_FAIL


# FLOW SWITCH FAIL CALCULATION ...

      LOAD     HI_SVC_PUMP_1
      LOAD     HI_SVC_PUMP_2
      |
      LOAD     FLOW_SWITCH_MODULE
      XOR
      PSTORE   SWITCH_FAIL_TIMER
      LOAD     SWITCH_FAIL_TIMER
      PSTORE   POSSIBLE_FLOW_SWITCH_FAIL


# SIEMENS MAG 8000 METERS, SENSUS PROTOCOL
# VIA ETHERMETERS (FINISHDED:3, AND RAW:4)
# MODBUS BLOCK TRANSFERS...
# LOADM <DEVICE ID> <INDEX-40001> <N_REGISTERS_TO_READ>
# NOTE! - THE FLOW SHOULD BE LONG, NOT ULONG!

      LOADM       3  0  20

      CAST_ULONG  0
      PSTORE      FINISHED_METER_GAL

      CAST_LONG   4
      LOAD        0.001
      *
      PSTORE      FINISHED_FLOW_GPM

      MA_VLD
      !
      CAST_UINT   14
      |
      PSTORE      FINISHED_METER_FAULT


      LOADM       4  0  20

      CAST_ULONG  0
      PSTORE      RAW_METER_GAL

      CAST_LONG   4
      LOAD        0.001
      *
      PSTORE      RAW_FLOW_GPM

      MA_VLD
      !
      CAST_UINT   14
      |
      PSTORE      RAW_METER_FAULT

# POST-PROCESSING RAW FLOW...
```

```
      LOAD     RAW_FLOW_GPM
      LOAD     INFLOW_DETECT_GPM
      Y>=X?
      PSTORE   FLOWING_IN_USR


# POST-PROCESSING FINISHED FLOW...

      LOAD     FINISHED_FLOW_GPM
      LOAD     OUTFLOW_DETECT_GPM
      Y>=X?
      PSTORE   FLOWING_OUT_USR


# VFD SPEED CALCULATION...
#
# Note that when the pumps are to be shut down
#  (p1_final=0 AND p2_final=0), the discharge pressure
#  limit is artificially set to zero.  This ensures that
#  the speed is tapered down to zero before pump shutdown.
#
# Note that the vfd's are configured for a min speed
#  of 20 Hz (33%).  Control logic reflects this, too.
#
      LOAD     VFD_TARGET_SPEED_%
      LOAD     VFD_GAIN
      LOAD     VFD_MAXSTEP
      LOAD     0.0
      LOAD     EFFLUENT_PSI
      LOAD     0.0
      LOAD     DISCHARGE_LIMIT_PSI
      LOAD     P1_FINAL
      LOAD     P2_FINAL
      |
      *
      MACRO    FEEDBACK_CONTROL
      LOAD     EFFLUENT_TRANSDUCER_FAIL
      !
      *
      LOAD     TRANSDUCER_FAIL_SPEED_%
      LOAD     EFFLUENT_TRANSDUCER_FAIL
      *
      +
      LOAD     VFD_MIN_SPEED_%
      MAX
      LOAD     VFD_MAX_SPEED_%
      MIN
      LOAD     P1_VIRTUAL_SSR
      LOAD     P2_VIRTUAL_SSR
      |
      *
      LOAD     WATER_HAMMER_OK_USR
      *
      PSTORE   VFD_TARGET_SPEED_%


# CHECK COMMUNICATION STATUS ...

      LOAD     COMM_TO_ELEVATED_TANK
      !
      LOAD     ELEVATED_TANK_TRANSDUCER_FAIL
      |
      LOAD     MODE{RADIO-PRESS-TIMER-EXT}
```

```
      PUSH     1.0
      X=Y?
      &
      PSTORE   TOWER_CONTROL_FAIL


# RADIO_MODE CALC ...

      LOAD     TOWER_CONTROL_FAIL
      !
      LOAD     MODE{RADIO-PRESS-TIMER-EXT}
      PUSH     1.0
      X=Y?
      &
      PSTORE   RADIO_MODE


# PRESSURE_MODE CALC ...

      LOAD     TOWER_CONTROL_FAIL
      LOAD     FAILOVER{PRESS-TIMER-EXT}
      PUSH     1.0
      X=Y?
      &
      LOAD     MODE{RADIO-PRESS-TIMER-EXT}
      PUSH     2.0
      X=Y?
      |
      PSTORE   PRESSURE_MODE


# TIMER_MODE CALC ...

      LOAD     TOWER_CONTROL_FAIL
      LOAD     FAILOVER{PRESS-TIMER-EXT}
      PUSH     2.0
      X=Y?
      &
      LOAD     MODE{RADIO-PRESS-TIMER-EXT}
      PUSH     3.0
      X=Y?
      |
      PSTORE   TIMER_MODE


# EXT_MODE CALC ...

      LOAD     TOWER_CONTROL_FAIL
      LOAD     FAILOVER{PRESS-TIMER-EXT}
      PUSH     3.0
      X=Y?
      &
      LOAD     MODE{RADIO-PRESS-TIMER-EXT}
      PUSH     4.0
      X=Y?
      |
      STORE    EXT_MODE
      !
      PSTORE   EXT_MODE_SSR


# TIMER HANDLER ...

      LOAD     TIMER_1_START_HOUR
```

```
      LOAD     TIMER_1_STOP_HOUR
      BETWEEN_HOURS

      LOAD     TIMER_2_START_HOUR
      LOAD     TIMER_2_STOP_HOUR
      BETWEEN_HOURS

      LOAD     TIMER_3_START_HOUR
      LOAD     TIMER_3_STOP_HOUR
      BETWEEN_HOURS

      |
      |
      LOAD     TIMER_MODE
      &
      PSTORE   TIMER_LEAD


# TOWER HANDLER ...

      LOAD     ELEVATED_TANK_CALL_LEAD
      LOAD     RADIO_MODE
      &
      PSTORE   TOWER_LEAD


# PRESSURE-LEAD HANDLER ...

      LOAD     EFFLUENT_PSI
      LOAD     PRESSURE_MODE_LEAD_ON_PSI
      Y<=X?
      PSTORE   PRESSURE_LEAD_ON_TIMER
      LOAD     PRESSURE_LEAD_ON_TIMER
      !
      PSTORE   PRESSURE_LEAD_OFF_TIMER
      LOAD     PRESSURE_LEAD_OFF_TIMER
      !
      LOAD     PRESSURE_LEAD
      &
      LOAD     PRESSURE_LEAD_ON_TIMER
      |
      LOAD     PRESSURE_MODE
      &
      PSTORE   PRESSURE_LEAD


# LEAD_STATE & LAG_STATE CALC ...

      LOAD     TOWER_LEAD
      LOAD     PRESSURE_LEAD
      LOAD     TIMER_LEAD
      |
      |
      LOAD     TOWER_HIGH_VERIFIED
      !
      &
      PSTORE   NEW_LEAD_STATE

      LOAD     NEW_LEAD_STATE
      LOAD     LEAD_STATE
      !
      &
      STORE    LEAD_TURNING_ON
```

```
      LOAD     NEW_LEAD_STATE
      !
      LOAD     LEAD_STATE
      &
      STORE    LEAD_TURNING_OFF

      |
      IF_FALSE
      GOTO     111
      PUSH     0
      PSTORE   LEAD_TIMER
111   POP

      LOAD     NEW_LEAD_STATE
      PSTORE   LEAD_STATE


# LOCAL_P1, LOCAL_P2 CALC ...

      LOAD     LEAD_STATE
      LOAD     LEAD_PUMP_DEF
      PUSH     1.0
      X=Y?
      &
      PSTORE   LOCAL_P1

      LOAD     LEAD_STATE
      LOAD     LEAD_PUMP_DEF
      PUSH     2.0
      X=Y?
      &
      PSTORE   LOCAL_P2


# AOK CALC ...

      LOAD     POWER
      LOAD     LOW_DETENTION_CUTOUT
      !
      &
      PSTORE   AOK


# CALC OFF/SHUTDOWN TIMERS...

      LOAD     VFD1_TARGET_SPEED_%
      LOAD     VFD_MIN_SPEED_%
      Y<=X?
      PSTORE   VFD1_SHUTD_TIMER

      LOAD     VFD2_TARGET_SPEED_%
      LOAD     VFD_MIN_SPEED_%
      Y<=X?
      PSTORE   VFD2_SHUTD_TIMER


# FINAL P1 CALC ...

      LOAD     LOCAL_P1
      LOAD     HI_SVC_PUMP_1{AUTO-ON-OFF}
      PUSH     2.0
      X=Y?
      |
      LOAD     AOK
```

```
      &
      LOAD     HI_SVC_PUMP_1{AUTO-ON-OFF}
      PUSH     3.0
      X=Y?
      !
      &
      PSTORE   P1_DELAY_TIMER
      LOAD     P1_DELAY_TIMER
      STORE    P1_FINAL
      LOAD     VFD1_SHUTD_TIMER
      !
      |
      LOAD     WATER_HAMMER_OK_USR
      &
      LOAD     P2_VIRTUAL_SSR
      LOAD     VFD2_SPEED_%
      LOAD     P2_FEEDBACK_MODULE
      |
      |
      !
      LOAD     ALLOW_2_HI_SVC_PUMPS
      |
      &
      PSTORE   P1_VIRTUAL_SSR

      LOAD     P1_VIRTUAL_SSR
      LOAD     HI_SVC_PUMP_1
      XOR
      PSTORE   P1_FAIL_TIMER
      LOAD     P1_FAIL_TIMER
      LOAD     VFD1_FAULT_CODE
      LOAD     0
      Y>X?
      |
      STORE    TRY_1_FAIL
      LOAD     HI_SVC_PUMP_1_FAIL
      LOAD     HI_SVC_PUMP_1
      !
      &
      |
      LOAD     VFD1_FAULT_CODE
      LOAD     0
      Y>X?
      |
      PSTORE   HI_SVC_PUMP_1_FAIL


# FINAL P2 CALC ...

      LOAD     LOCAL_P2
      LOAD     HI_SVC_PUMP_2{AUTO-ON-OFF}
      PUSH     2.0
      X=Y?
      |
      LOAD     AOK
      &
      LOAD     HI_SVC_PUMP_2{AUTO-ON-OFF}
      PUSH     3.0
      X=Y?
      !
      &
      PSTORE   P2_DELAY_TIMER
      LOAD     P2_DELAY_TIMER
      STORE    P2_FINAL
```

```
      LOAD     VFD2_SHUTD_TIMER
      !
      |
      LOAD     WATER_HAMMER_OK_USR
      &
      LOAD     P1_VIRTUAL_SSR
      LOAD     VFD1_SPEED_%
      LOAD     P1_FEEDBACK_MODULE
      |
      |
      !
      LOAD     ALLOW_2_HI_SVC_PUMPS
      |
      &
      PSTORE   P2_VIRTUAL_SSR


      LOAD     P2_VIRTUAL_SSR
      LOAD     HI_SVC_PUMP_2
      XOR
      PSTORE   P2_FAIL_TIMER
      LOAD     P2_FAIL_TIMER
      LOAD     VFD2_FAULT_CODE
      LOAD     0
      Y>X?
      |
      STORE    TRY_2_FAIL
      LOAD     HI_SVC_PUMP_2_FAIL
      LOAD     HI_SVC_PUMP_2
      !
      &
      |
      LOAD     VFD2_FAULT_CODE
      LOAD     0
      Y>X?
      |
      PSTORE   HI_SVC_PUMP_2_FAIL


# PUMP-1 RUNTIME ...

      LOAD     HI_SVC_PUMP_1
      LOAD     DELTA_TIME
      *
      LOAD     P1_RUNTIME_SECS
      +
      ABS
      STORE    P1_RUNTIME_SECS
      PUSH     60.0
      /
      PUSH     1000000000.0
      %
      PSTORE   HI_SVC_PUMP_1_RUNTIME_MIN


# PUMP-2 RUNTIME ...

      LOAD     HI_SVC_PUMP_2
      LOAD     DELTA_TIME
      *
      LOAD     P2_RUNTIME_SECS
      +
      ABS
      STORE    P2_RUNTIME_SECS
```

```
      PUSH     60.0
      /
      PUSH     1000000000.0
      %
      PSTORE   HI_SVC_PUMP_2_RUNTIME_MIN


# GENERATOR RUNTIME ...

      LOAD     GENERATOR
      LOAD     DELTA_TIME
      *
      LOAD     GEN_RUNTIME_SECS
      +
      ABS
      STORE    GEN_RUNTIME_SECS
      PUSH     60.0
      /
      PUSH     1000000000.0
      %
      PSTORE   GENERATOR_RUNTIME_MIN


# IF THE LEAD PUMP FAILS, THE LEAD HAS RUN FOR 24 HOURS,
# OR PUMP-A JUST TURNED OFF, INCREMENT ALTERNATOR ...

      LOAD     LEAD_TIMER
      PUSH     24
      Y>X?
      LOAD     LEAD_PUMP_DEF
      PUSH     1
      X=Y?
      LOAD     TRY_1_FAIL
      &
      LOAD     LEAD_PUMP_DEF
      PUSH     2
      X=Y?
      LOAD     TRY_2_FAIL
      &
      |
      LOAD     LEAD_STATE
      &
      LOAD     LEAD_TURNING_OFF
      |
      |
      LOAD     ALTERNATE_PUMPS
      &
      IF_FALSE
      GOTO     110
      LOAD     SEQUENCE_POINTER_1
      PUSH     2.0
      %
      ++
      PSTORE   SEQUENCE_POINTER_1
      PUSH     0.0
      PSTORE   LEAD_TIMER
      GOSUB    MY_PUMP_SEQUENCE_SETUP

      LOAD     LEAD_PUMP_DEF
      PSTORE   CURRENT_LEAD_PUMP

110   POP

# INCREMENT LEAD TIMER
```

```
      LOAD     LEAD_STATE
      IF_FALSE
      GOTO     555
      LOAD     LEAD_TIMER
      LOAD     DELTA_TIME
      PUSH     3600
      /
      +
      PSTORE   LEAD_TIMER
555   POP


# RESET THE VFD ONE-SHOTS...

      NEW_SETPOINTS?
      LOAD     VFD1_RESET_1SHOT
      &
      IF_FALSE
      GOTO     998

      LOAD     NET_REF_USR
      LOAD     NET_CTRL_USR
      LOAD     NET_RESET_USR
      +
      STORE    VFD1_CTRL_WORD_MBO
      LOAD     NET_RESET_USR
      -
      STORE    VFD1_CTRL_WORD_MBO
      LOAD     NET_RUN_USR
      +
      STORE    VFD1_CTRL_WORD_MBO
      LOAD     NET_RUN_USR
      -
      STORE    VFD1_CTRL_WORD_MBO
      POP

998   POP

      NEW_SETPOINTS?
      LOAD     VFD2_RESET_1SHOT
      &
      IF_FALSE
      GOTO     999

      LOAD     NET_REF_USR
      LOAD     NET_CTRL_USR
      LOAD     NET_RESET_USR
      +
      STORE    VFD2_CTRL_WORD_MBO
      LOAD     NET_RESET_USR
      -
      STORE    VFD2_CTRL_WORD_MBO
      LOAD     NET_RESET_USR
      -
      STORE    VFD2_CTRL_WORD_MBO
      LOAD     NET_RUN_USR
      +
      STORE    VFD2_CTRL_WORD_MBO
      LOAD     NET_RUN_USR
      -
      STORE    VFD2_CTRL_WORD_MBO
      POP
```

```
999   POP

      LOAD     0
      STORE    VFD1_RESET_1SHOT
      STORE    VFD2_RESET_1SHOT
      POP


      END


# ========================================
#
# ADDITIONAL SUBROUTINES...
#
# ========================================

      LBL      SANITY_CHECKS

      LOAD     2.0
      LOAD     1.0
      LOAD     SEQUENCE_POINTER_1
      MAX
      MIN
      PSTORE   SEQUENCE_POINTER_1

      LOAD     2.0
      LOAD     1.0
      LOAD     LEAD_HI_SVC_PUMP{P1-P2}
      MAX
      MIN
      PSTORE   LEAD_HI_SVC_PUMP{P1-P2}

      LOAD     2.0
      LOAD     1.0
      LOAD     LAG_HI_SVC_PUMP{P1-P2}
      MAX
      MIN
      PSTORE   LAG_HI_SVC_PUMP{P1-P2}

      LOAD     3.0
      LOAD     1.0
      LOAD     HI_SVC_PUMP_1{AUTO-ON-OFF}
      MAX
      MIN
      PSTORE   HI_SVC_PUMP_1{AUTO-ON-OFF}

      LOAD     3.0
      LOAD     1.0
      LOAD     HI_SVC_PUMP_2{AUTO-ON-OFF}
      MAX
      MIN
      PSTORE   HI_SVC_PUMP_2{AUTO-ON-OFF}

      LOAD     4.0
      LOAD     1.0
      LOAD     MODE{RADIO-PRESS-TIMER-EXT}
      MAX
      MIN
      PSTORE   MODE{RADIO-PRESS-TIMER-EXT}

      LOAD     3.0
      LOAD     1.0
      LOAD     FAILOVER{PRESS-TIMER-EXT}
```

```
      MAX
      MIN
      PSTORE   FAILOVER{PRESS-TIMER-EXT}

      LOAD     3.0
      LOAD     1.0
      LOAD     CALL_WELL_CONTROL{AUTO-ON-OFF}
      MAX
      MIN
      PSTORE   CALL_WELL_CONTROL{AUTO-ON-OFF}

      RTN

# ========================================

      LBL      MY_PUMP_SEQUENCE_SETUP

      LOADA    ALTERNATE_PUMPS
      LOADA    SEQUENCE_POINTER_1
      LOADA    LEAD_HI_SVC_PUMP{P1-P2}
      LOADA    LAG_HI_SVC_PUMP{P1-P2}
      LOADA    LEAD_PUMP_DEF
      LOADA    LAG_PUMP_DEF
      MACRO    PUMP_SEQUENCE_SETUP2
      RTN

# ========================================
```

# DG1 FAULT CODES

| Fault code | Fault Name | Fault type | Default | Possible Cause | Remedy |
|---|---|---|---|---|---|
| 1 | Over Current | Fault | | AC drive has detected too high a current<br>(>4*IH) in the motor cable:<br>• Sudden heavy load increase<br>• Short circuit in motor cables<br>• Unsuitable motor | • Check loading<br>• Check motor<br>• Check cables and connections<br>• Make identification run<br>• Check ramp times |
| 2 | Over Voltage | Fault | | The DC-link voltage has exceeded the<br>limits defined:<br>• Too short a deceleration time<br>• Brake chopper is disabled<br>• High overvoltage spikes in supply<br>• Start/Stop sequence too fast | • Make deceleration time longer<br>• Use brake chopper or brake resistor (available as options)<br>• Activate overvoltage controller<br>• Check input voltage |
| 3 | Earth Fault | Configurable | Fault | Current measurement has detected that<br>the sum of motor phase current is not zero:<br>• Insulation failure in cables or motor | Check motor cables and motor |
| 5 | Charging Switch | Fault | | The charging switch is open, when the<br>START command has been given:<br>• Faulty operation<br>• Component failure | • Reset the fault and restart<br>• Should the fault re-occur, contact the distributor near to you |
| 6 | Emergency Stop | Fault | | • STO terminal open in control board<br>• Emergency signal from DI is activated | • Closed STO terminal<br>• Remove signal from DI |
| 7 | Saturation Trip | Fault | | • Short circuit in motor cables<br>• IGBT module is damaged | Check cables and connections<br>Reset the fault and restart<br>verify that EMC screw is installed<br>Should the fault re-occur, contact the distributor near to you |
| 9 | UnderVoltage | Configurable | Fault | DC link voltage is under the voltage limits<br>defined:<br>• Most probable cause: Too low a supply voltage<br>• AC drive internal fault<br>• Defect input fuse<br>• External charge switch not closed<br>Note: This fault is activated only if the drive is in Run state. | In case of temporary supply voltage break reset the fault and restart the AC drive<br>Check the supply voltage. If it is adequate, an internal failure has occurred. Contact the distributor near you |
| 10 | Input Phase Spv | Configurable | Fault | Input line phase is missing | Check supply voltage, fuses and cable |
| 11 | Output Phase Spv | Configurable | Fault | Current measurement has detected that there is no current in one motor phase | Check motor cable and motor |
| 12 | BrakeChopperSpv | Fault | | • No brake resistor installed<br>• Brake resistor is broken<br>• Brake chopper failure | Check brake resistor and cabling. If these are OK, the chopper is |
| 13 | Drive UnderTemp | Configurable | Warning | Too low temperature measured in power | |

| | | | | | |
|---|---|---|---|---|---|
| | | | | Unit's heat sink or board. Heat sink temperature is under –10°C | |
| 14 | Drive OverTemp | Fault | | Too high temperature measured in power<br><br>Unit's heat sink or board. Heat sink temperature is over 90°C | • Check the correct amount and flow of cooling air<br>• Check the heat sink for dust<br>• Check the ambient temperature<br>• Make sure that the switching frequency is not too high in relation to ambient temperature and motor load |
| 15 | Motor Stalled | Configurable | No Action | Motor is stalled | Check motor and load |
| 16 | Motor OverTemp | Configurable | No Action | Motor is too hot, based on either the drive's estimate or on temperature feedback | Decrease motor load. If no motor overload exists, check the temperature model parameters |
| 17 | Motor UnderLoad | Configurable | No Action | Condition defined by parameter P1.9.15~P1.9.17 have been valid longer than the time defined by P1.9.18 | Check load |
| 18 | IP Address Conflict | Configurable | Warning | IP setting issue. | Check settings for IP address, verify no duplicates are on the network. |
| 19 | Power board EEPROM Fault | Fault | | Power board eeprom fault, memory lost in eeprom. | Cyle power to drive. Try updating software, if issue continues contact Distributor near you. |
| 20 | FRAM Fault | Fault | | FRAM data error in FRAM memory. | Cycle power to drive. Try updating software, if issue contines contact a Distributor near you. |
| 21 | Serial Flash Fault | warning | | Serial flash error, serial flash memory failed. | Cycle power to drive. Try updating software, if issue contines contact a Distributor near you. |
| 25 | MCU WatchDog Fault | Fault | | Watchdog register overflows in MCU | Cycle power to drive. Try updating software, if issue contines contact a Distributor near you. |
| 26 | Start-up Prevent | Fault | | The time when Interlock signal activates is over setting time. | Stop drive and resend start command. |
| 29 | Thermistor Fault | Configurable | Fault | Option board or control board thermistor resistor lager than 4.7K | Thermistor open or short, over temperature |
| 32 | Fan Cooling | Fault | | Fan is damaged or stalled. | Check fan and fan connected wires, verify 24Vdc is supplied to fan. |
| 36 | Compatibility Fault | Fault | | The control board isn't match with the power board. | Cycle power to drive. Try updating software, if issue contines contact a Distributor near you. |
| 37 | Device Change | Warning | | Power board or option card change. | Alarm will reset |
| 38 | Device Added | Warning | | Power board or option board added. | Device is ready for use |

| | | | | | |
|---|---|---|---|---|---|
| | | | | | Old parameter settings will be used |
| 39 | Device Removed | Fault | | Optional board removed from slot, or power board removed from control board. | Device no longer available in drive. |
| 40 | Device Unknown | Fault | | Unknown device connected (power board/option board) | Check eeprom connection.<br>Check board connection on slot A/B<br>Power cycle to drive. |
| 41 | IGBT Temperature | Fault | | IGBT temperature is too high. | • Check output loading<br>• Check motor size<br>• Decrease switching frequency |
| 43 | Encoder Fault | Fault | | • Encoder 1 channel A is missing<br>• Encoder 1 channel B is missing<br>• Both encoder 1 channels are missing<br>• Encoder reversed<br>• Encoder board missing | • Check encoder connections<br>• Check encoder and encoder cable<br>• Check encoder board<br>• Check encoder frequency in open loop |
| 50 | AIN<4mA(4to20mA) | Configurable | No Action | Loss in analog input signal, dropped below 4mA. | Verify analog input current reference value on either AI1 or AI2, check cabling. |
| 51 | External Fault | Configurable | Fault | Digital input is activated for external fault input. | check digital input settings and verify input level, could be an extrnal device causing fault. |
| 52 | Keypad Communication Fault | Configurable | Fault | The connection between the control keypad and frequency converter is broken, and The local reference is keypad reference or the local control place is keypad, and The keypad communication fault protection is not “NO action” | Check keypad connection and possible keypad cable. |
| 54 | OPT Card Fault | Configurable | Fault | Defective option card or option card slot | Check right option card and optoin card slot connections.<br>Check Board Status on Keypad for exact cause of fault.<br>Contact distributor nearest you. |
| 55 | Real time clock fault | Configurable | Warning | • Communication between MCU and RTC chip isn’t normal<br>• The power of RTC chip isn’t normal<br>• The real time isn’t normal | Check the RTC chip, power cycle to drive. If issue contines contact distributor near you. |
| 56 | PT100 Fault | Configurable | Fault | Temperature is beyond the limit of sensing capacity of PT100 | Pt100 short, open or over temperature, check PT100 temperature probe. |
| 57 | Motor ID fault | Fault | | The Motor parameters Identification running was not completed successfully | Check motor size<br>Verify the input and output wiring is connected properly. |

| | | | | |
|---|---|---|---|---|
| 58 | Current Measure Fault | Fault | Current measurement is out of range | Restart the drive again. Should the fault re-occur, contact the distributor near to you |
| 59 | Possible power wiring error de | Fault | power wiring connected to output of drive. | Verify power input wiring is connected to L1, L2 and L3 terminals and they are properly torqued. |
| 60 | Control Board OverTemp | Fault | Control board is over +85 degrees or under –30 degrees | Check NTC resistor<br>Check control board temperature |
| 61 | Internal-ctrl Supply | Fault | +24V port voltage is over 27V or under 17V | Check voltage range of +24V on terminals 12 to 13. If voltage is out of range contact distributor near you. |
| 62 | Too Many Speed Search Restarts | Fault | Speed searching failed when peforming flying start. | Check motor parameters' setting and motor connections. |
| 63 | Current Unbalance | Fault | Output current unballanced. | Check motor wiring and voltage output of drive. If issue continues contact distributor near you. |
| 64 | Replace Battery | Configurable Warning | RTC Battery voltage is too low. | Check the RTC battery voltage, contact distributor near you for replacement battery. |
| 65 | Replace Fan | Configurable Warning | Fan life is less than 2 months | Check the fan, clean out any contamination, contact distributor near you for replacement fan. |
| 66 | Safety Torque Off | Fault | STO Triggered, STO input is open. | Reset STO Trigger and verify wiring. Reset fault after input is enabled. |
| 67 | current limit control | Warning | The output current has reached the current limit value | Check the load<br>Set the acceleration time longer |
| 68 | over voltage control | Warning | The DC link voltage has reached its voltage limit value | Check the input voltage<br>Set the acceleration/deceleration time longer |
| 69 | System Fault | Fault | thermistor spi communication error. | check thermistor chip. |
| 70 | System Fault | Fault | MCU send wrong parameters to DSP | Restart the drive again. Should the fault re-occur, contact the distributor near to you. |
| 71 | System Fault | Fault | MCU and DSP communication error. | Restart the drive again. Should the fault re-occur, contact the distributor near to you. |
| 72 | Power Board EEPROM Fault | Fault | Power board eeprom fault, memory lost in eeprom when initial drive. | Cyle power to drive. Try updating software, if issue continues contact Distributor near you. |

| | | | | |
|---|---|---|---|---|
| 73 | FRAM Fault | Fault | fram chip is broken. | contact Distributor near you. |
| 74 | FRAM Fault | Fault | crc check fault when acess fram data | Try recovery factory default setting if issue continues contact Distributor near you. |
| 75 | Power Board EEPROM Fault | Fault | eeprom chipor I2c circuit is broken | contact Distributor near you. |
| 76 | Power Board EEPROM Fault | Fault | crc check fault when acess eeprom data. | Try recovery factory default setting if issue continues contact Distributor near you. |
| 77 | Serial Flash Fault | warning | external serial flash chip is broken. | contact Distributor near you. |
| 82 | BypassOverLoad | Fault | Over load when motor is in bypass mode | Check motor connection situation |
| 83 | FieldBus Fault | Configurable Fault | Loss of communication with Modbus RTU, and The fieldbus reference is the remote reference or The fieldbus control place is the remote control place ,and the fault protection is not “NO action” | Check RS485 communication wiring. Verify drive parameter are set correctly. Check master programming to verify proper addressing. |
| 84 | FieldBus Fault | Configurable Fault | Loss of communication with Modbus TCP ,and The fieldbus reference is the remote reference or The fieldbus control place is the remote control place ,and The fault protection is not “NO action” | Check Ethernet communication wiring. Verify drive parameter are set correctly. Check master programming to verify proper addressing. |
| 85 | FieldBus Fault | Configurable Fault | Loss of communication with BACnet, and The fieldbus reference is the remote reference OR The fieldbus control place is the remote control place ,and The fault protection is not “NO action” | Check RS485 communication wiring. Verify drive parameter are set correctly. Check BACnet master configuration programming to verify proper addressing. |
| 86 | FieldBus Fault | Configurable Fault | Loss of communication with Ethernet IP, and The fieldbus reference is the remote reference OR The fieldbus control place is the remote control place ,and The fault protection is not “NO action” | Check Ethernet communication wiring. Verify drive parameter are set correctly. Check EIP master configuration programming to verify proper addressing. |
| 87 | FieldBus Fault | Configurable Fault | Loss of communication with Profibus master on Slot A, and The fieldbus reference is the remote reference OR The fieldbus control place is the remote control place ,and The fault protection is not “NO action” | Check Profibus/CANOpen/DeviceNet communication wiring. Verify drive parameter are set correctly. Check Profibus/CANOpen/DeviceNet master configuration programming to verify proper addressing. |

| | | | | |
|---|---|---|---|---|
| 88 | FieldBus Fault | Configurable Fault | Loss of communication with Profibus master on Slot B, and The fieldbus reference is the remote reference OR The fieldbus control place is the remote control place ,and The fault protection is not “NO action” | Check Profibus/CANOpen/DeviceNet communication wiring. Verify drive parameter are set correctly. Check Profibus/CANOpen/DeviceNet master configuration programming to verify proper addressing. |
| 89 | Under Voltage | Fault | The DC link voltage has reached the Drive under voltage stop limit value. | Check the input voltage. |
| 90 | Drive UnderTemp | Warning/Fault | • Cold weather mode is not enabled, and unit temperature is less than -10 degree.<br>• Cold weather mode is enabled and Under Temp Fault Override is not set, unit temperature is less than -30 degree.<br>• Cold weather mode is enabled and Under Temp Fault Override is not set, unit temperature is -20~ -30 degree. The temp <-20 degree when cold weather start time out. | If unit temp -20 ~ -10 degree, start motor in cold weather mode.<br>If unit temp <-20 degree, Warm up unit above -20deg C for proper operation using cold weather mode.If still < -20 degree when cold weather mode time out, try higher output voltage in cold weather mode. |
| 91 | Option Card Fault | Fault | External supply on the DeviceNet communication connector is not present. | Check voltage and wiring of power supply of the DeviceNet communication. |