An Overview of SCADA and Heartbeat Functionality as it Relates to VVO

Distribution Protection and Control Track
Thursday, August 7, 2025
Day 4 – Session 2

SCADA OVERVIEW

- SCADA = Supervisory Control and Data Acquisition.
- SCADA is a generalized term meant to describe a monitoring and control system designed to cover large geographical areas.
- Early utility SCADA systems were proprietary and expensive with little interoperability between device manufacturers.
  - Examples:
    - 2179 (and MANY variation customized by individual vendors or utilities)
    - Conitel 2020
    - CDC 44-500
    - DNP1 and DNP2

SCADA OVERVIEW

- Modbus is an open protocol standard and was/is widely used in industrial applications as well as by some utilities. Some systems still use it today to gather configuration change information.
- Some systems still use it today to gather configuration change information. (Cooper Yukon, Siemens Crossbow, etc.)
- Beckwith uses Modbus in our communication software to talk with all our communicating products.

SCADA OVERVIEW

- As the need to communicate and control devices remotely grew, the need for advanced standards-based protocols resulted.
- Protocols such as UCA, IEC 60870-5-101, and DNP3 were developed and used by some utilities.
- DNP3 became the standard for most utilities in the US.
- IEC 60870-5-101 is widely used worldwide, particularly in Europe.
- UCA2.0 was the basis for the IEC 61850 protocol which is used in most of the world’s Power Utilities today.

SCADA DNP OVERVIEW

- DNP was originally developed by Westronic (GE) as a proprietary protocol in 1990.
- The DNP.org user group was created to make it an open protocol with the standard guided by both utilities and vendors. DNP3 was born in 1993.
- It is the primary protocol in use by Electric utilities in North America.

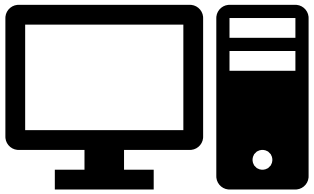
SCADA DNP OVERVIEW

- DNP is typically implemented in devices by the vendor purchasing a DNP3 certified library from a protocol vendor.
- Examples of protocol vendors include:
  - Triangle MicroWorks (used in Beckwith products)
  - ST Microelectronics
  - JP Embedded
- DNP points are programmed into a map and loaded into a device and master and those maps must match for the devices to communicate.

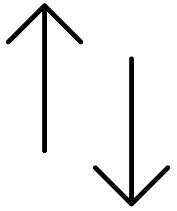
SCADA DNP OVERVIEW

Basic Architecture (Single Connection)

Master



Also aka as:
- Client
- SCADA
- DMS
- Control Center
- Source



Unicast Communication

Outstation

Also aka as:
- Slave
- Remote Unit
- IED
- Remote Terminal Unit
- Destination

SCADA DNP OVERVIEW

Architecture (Multiple Connection)

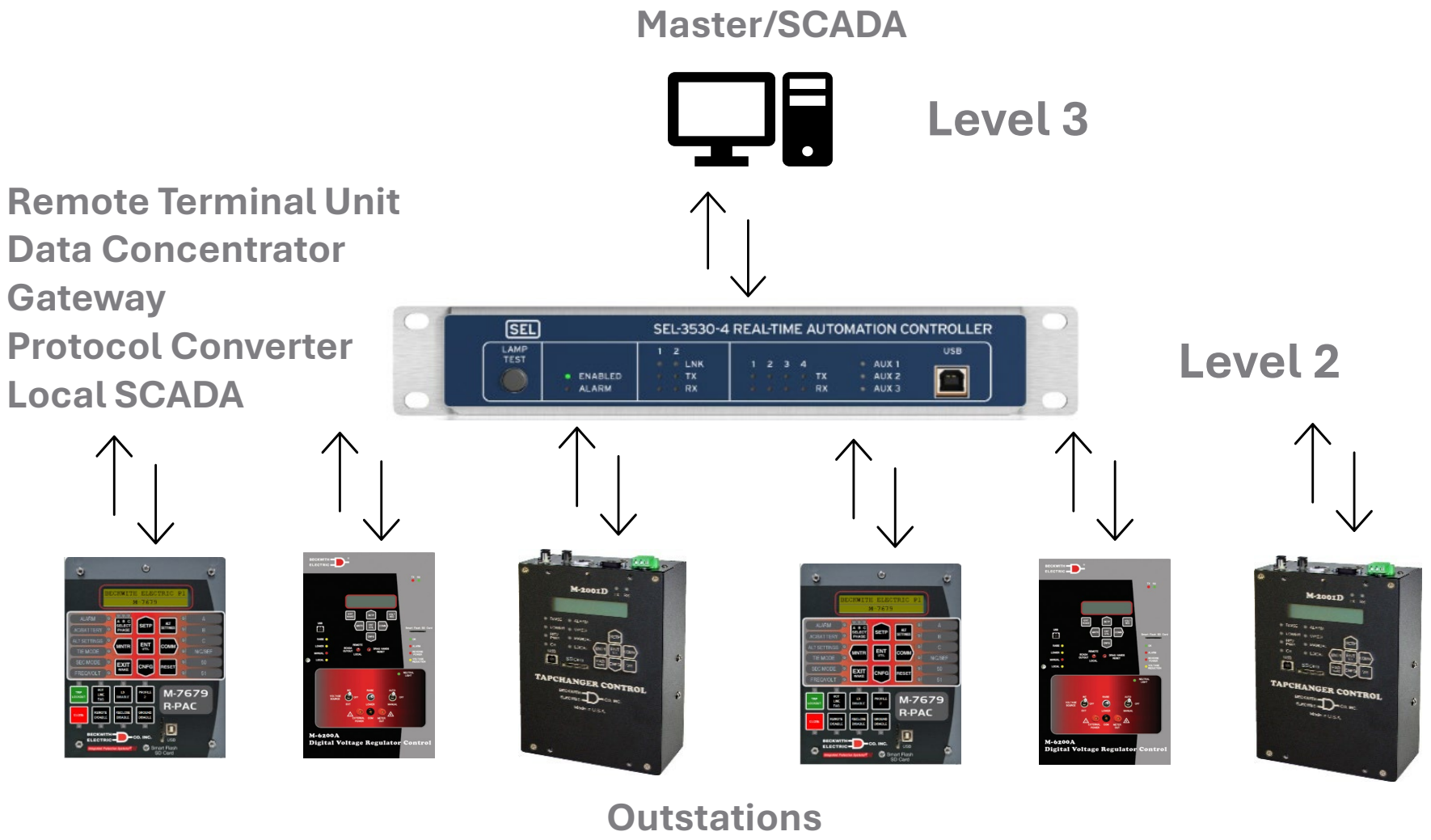
Master

Unicast Communication

Outstations

SCADA DNP OVERVIEW

Architecture (Multiple Connection with Data Concentrator / Gateway)



SCADA DNP OVERVIEW

Basic point structure

- DNP is structured into five data types:
  - Binary Inputs – These points are True/False data points typically used to communicate the state of a contact, feature, function, alarm, etc., for example:

Index	Name	Value	Mask
0	Raise Output Status	TRUE	CLASS_ONE
1	Lower Output Status	TRUE	CLASS_ONE
2	VR Contact Input 1	TRUE	CLASS_ONE
3	VR Contact Input 2	TRUE	CLASS_ONE

SCADA DNP OVERVIEW

Basic point structure

- DNP is structured into five data types:
    - Analog Inputs – These points are typically values the device is measuring or calculating, for example:

Index	Name	DeadBand	Mask
0	Load Voltage (Secondary)	50	CLASS_TWO
1	Source Voltage (Secondary)	100	CLASS_TWO
2	Load Current Secondary	50	CLASS_TWO
3	Circ Current	50	CLASS_TWO

SCADA DNP OVERVIEW

Basic point structure

- DNP is structured into five data types:
  - Counter Inputs - These points are typically values the device is incrementing, for example:

Index	Name	DeadBand	Mask
0	Operation Counters	10	CLASS_THREE
1	Resettable Operation Count...	10	CLASS_THREE
2	CBEMA Event1 Counter	10	CLASS_THREE

SCADA DNP OVERVIEW

Basic point structure

- DNP is structured into five data types:
  - Binary (Control) Outputs - These points are used to send commands to operate the device, reset alarm, etc., for example:

Index	Name	Crob	Mask	Inverse
0	Manual Raise 1 Tap	LATCH_ONOFF	CLASS_ZERO	FALSE
1	Manual Lower 1 Tap	PAIRED_TRIPCLOSE	CLASS_ZERO	FALSE
2	Block Automatic Control via Comm	LATCH_ONOFF_TC	CLASS_ZERO	FALSE
3	Voltage Reduction Step 1	PULSE_ONOFF_TC	CLASS_ZERO	FALSE

SCADA DNP OVERVIEW

Basic point structure

- DNP is structured into five data types:
  - Analog Outputs - These points are typically settings in the device which can be read and written to. This allows remote changing of parameters in the device.
  - Examples include:

Index	Name	Mask
0	Bandcenter (Forward)	CLASS_ZERO
1	Bandwidth (Forward)	CLASS_ZERO
2	Time Delay (Forward)	CLASS_ZERO
3	Intertap Delay	CLASS_ZERO

SCADA DNP OVERVIEW

Static vs. Event data

- DNP defines data as either static or event data.
- Static Data
  - Static data is the actual value read at the time it is queried.
  - It does not contain date/time information in the data.

SCADA DNP OVERVIEW

Static vs. Event data

- DNP defines data as either static or event data.
- Event Data
  - Event data is the value stored at the time it is triggered.
  - It does contain date/time information in the data.
  - Binary Input points will trigger on change of state.
    - For example, an LTC raise output status point will trigger each time the raise output status changes state from 0 to 1 and from 1 to 0.
  - Analog Input and Analog Output points have a deadband which must be exceeded since the last successful retrieval of the event data.
    - For example, LTC Load Voltage with a deadband of 2 will only trigger an event when the voltage has changed by 2 volts since the last event.

SCADA DNP OVERVIEW

Classes

- DNP allows the user to assign points into classes.
- The classes are as follows:
  - Class None
    - This class was created to allow points to be mapped in a device, but they will not respond to any other class poll.
    - These points can be individually polled by the SCADA master.
    - This class could be used to map Analog Outputs in the device that the user may want to be able to remotely change, but they do not want those points to be in Class0, 1, 2, or 3 data to minimize data usage.

SCADA DNP OVERVIEW

Classes

- DNP allows the user to assign points into classes.
- The classes are as follows:
  - Class None
  - Class 0
    - This class is used to read the static values of all the points mapped in a device.
    - Often this is referred to as an integrity poll.
    - Typically, SCADA systems will send an integrity poll periodically to verify the communications path to the unit is still viable.
    - Ensures the SCADA system is synched with the controller for status.

SCADA DNP OVERVIEW

Classes

- DNP allows the user to assign points into classes.
- The classes are as follows:
  - Class None
  - Class 0
  - Class 1, 2, and 3
    - All Binary Input, Analog Input, Analog Output, and Counters can be assigned one of these classes and polling can be set to retrieve event data at different intervals.
    - DNP3 does not assign significance to the three event classes.
    - One strategy is to assign the highest priority events classes 1 and lowest priority to class 3.
    - The device will have a buffer of events that will overwrite the oldest if it is exceeded before a class poll occurs. For example, the M-6283A can store 100 Class events.

SCADA DNP OVERVIEW

DNP uses several methods to collect data from devices

- Polling (also called report by exception)
  - The master initiates a request for event data
    - Integrity poll
    - Class poll (class 1, 2, 3)
  - For example, a system may be set up to do an integrity poll every 5 minutes and class 1,2,3 poll every 1 minute.
    - The device will tell it if it has data in any of the three classes. Then the Master can poll for the data in each class that had events to send.

SCADA DNP OVERVIEW

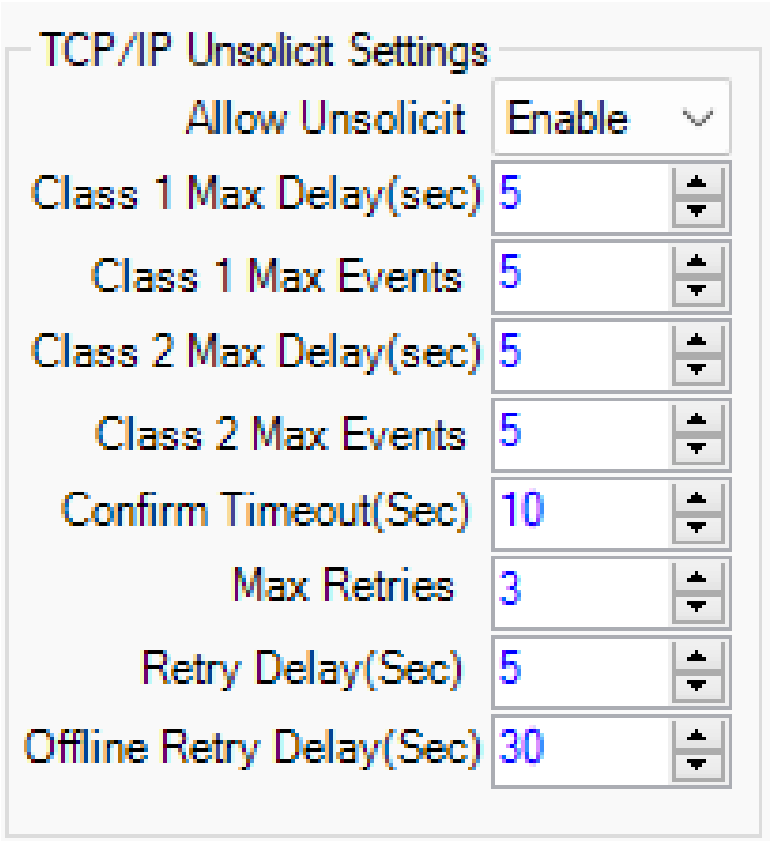
DNP uses several methods to collect data from devices

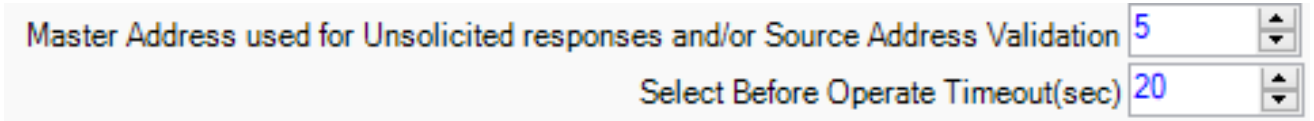
- Polling
- Unsolicited
  - This method when enabled allows the units to send data to a master without the master requesting it when class triggers have occurred.
  - This method must be “turned on” in units to enable it and typically does not stay on if the device is power cycled.
  - This method can be used with polling or polling can be disabled.
  - Unsolicited and Report by Exception are commonly mistaken for each other in conversations about DNP
  - Most of our customers use polling (Report by Exception) vs. Unsolicited.

SCADA DNP OVERVIEW

DNP uses several methods to collect data from devices

- Example of Unsolicited settings



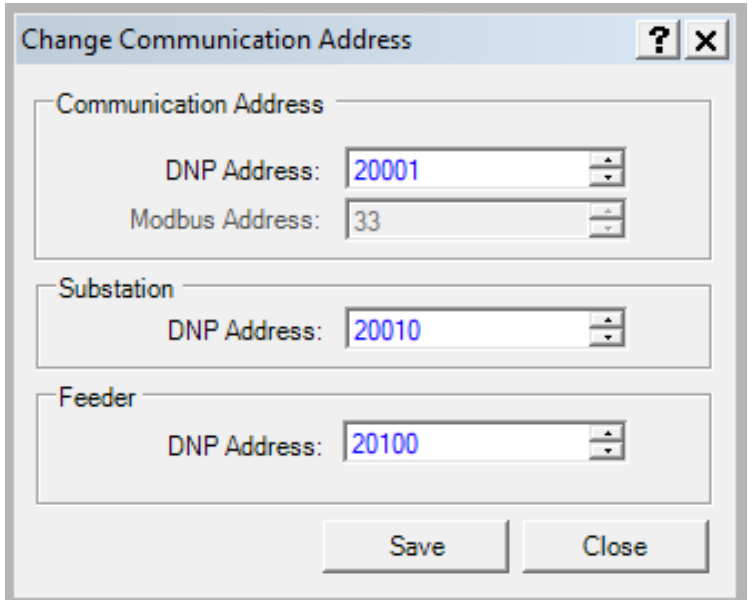


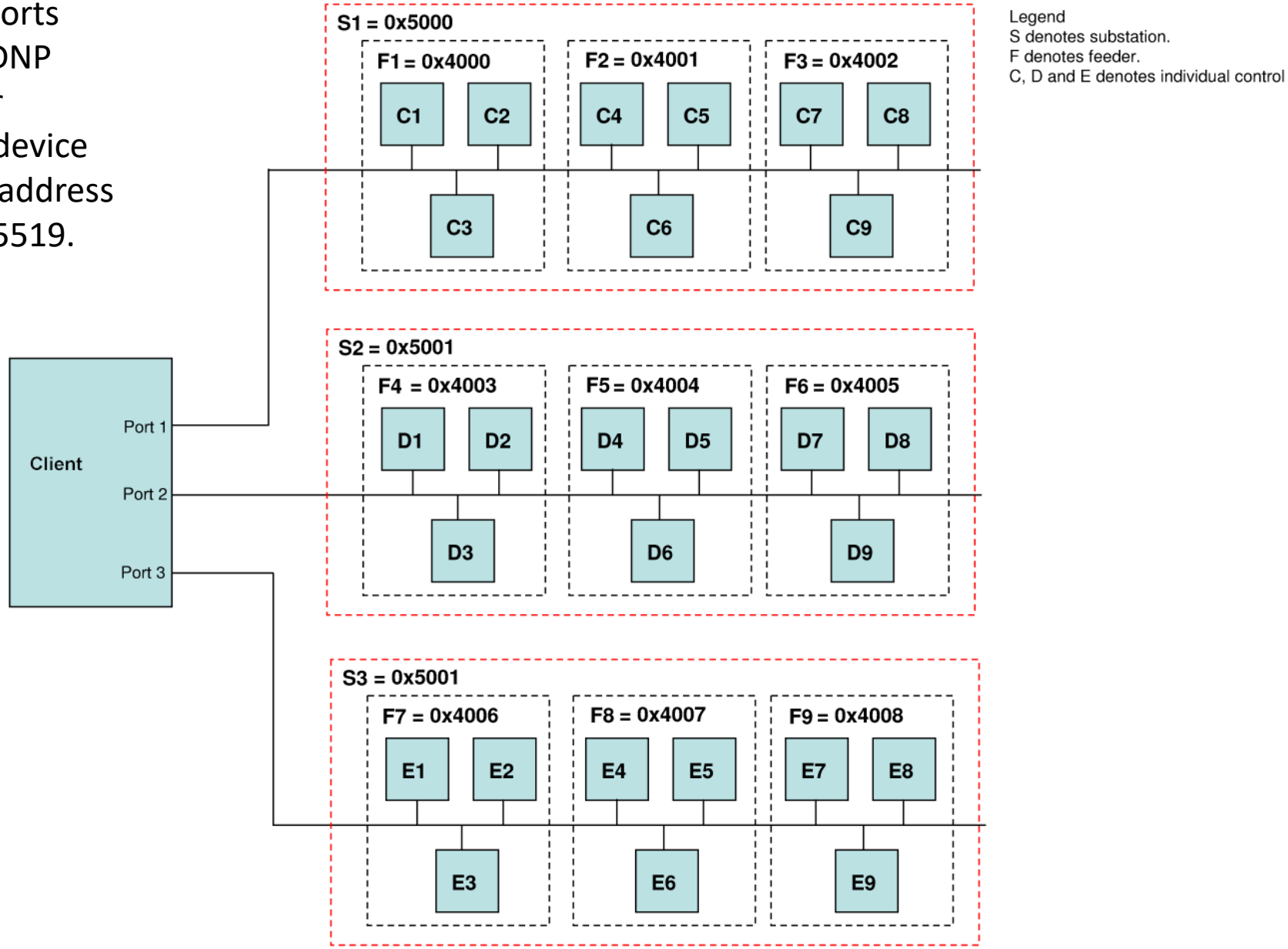
SCADA DNP OVERVIEW

Remote operation of devices by a SCADA Master

- Typically, SCADA can remotely operate any function mapped in a device.
- For example, if the user wants to cause an LTC to issue a Raise command to increase its tap position by one count it will first send a command to place the unit in Remote Manual and then send a Raise command.
- Commands can be sent either to an individual device by addressing that device, or can be broadcast to a selection of devices using a DNP broadcast address.
- In Beckwith devices, we allow the user to program up to 3 addresses in a device to facilitate grouping units.

Beckwith DNP implementation supports multiple addresses (up to 3) (serial DNP only). Each capacitor, transformer or regulator control can be assigned a device address, feeder address, substation address or zone address ranging from 1 to 65519.





SCADA DNP OVERVIEW

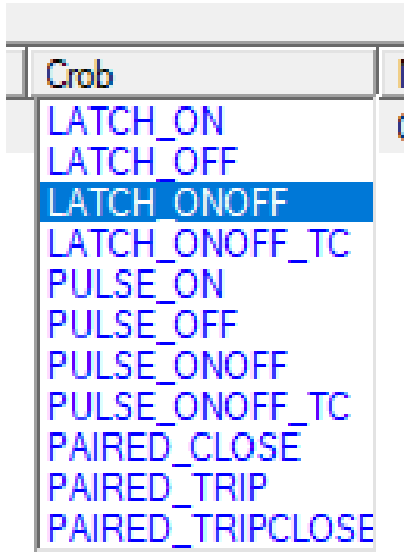
Common issues Utilities face with DNP

- Unfortunately, being DNP compliant does not mean you have to fully support all features and functions within the DNP standard.
- Mismatch between DNP map in a unit vs. the Master.
- Utility wanting to use unsolicited but not turning it on after power up or not refreshing it during integrity polls in units.
- A common issue is that a SCADA master can only write Analog Outputs but cannot read them. The DNP standard allows both Write (object 41) and read (object 40) but many SCADA masters do not support Object 40. To accommodate this, vendors must map Analog Outputs also to Analog Inputs so the Master can see the results of their writes to a device.

SCADA DNP OVERVIEW

Common issues Utilities face with DNP

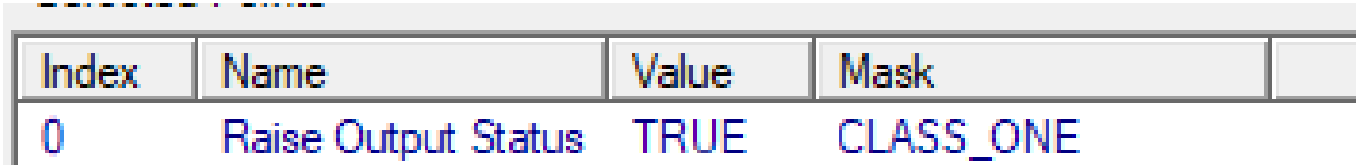
- A mismatch in control command types between the Master and devices will result in commands not being received properly.
  - This is an example of all the types supported in our controls:



SCADA DNP OVERVIEW

Common issues Utilities face with DNP

- The SCADA cutout switch in the device is in Local preventing SCADA from writing to the unit.
- Deadband settings are too high resulting in not getting event data or too low resulting in getting flooded with data.
- Binary statuses are opposite expected. DNP Binary Input points are either 0 or 1, and generally the 0 is the standard state and the 1 is the exception or abnormal state. Vendors can define this differently. Some vendors like Beckwith allow points to be inverted to match existing convention at that utility. (Value column in the example below)



Index	Name	Value	Mask
0	Raise Output Status	TRUE	CLASS_ONE

SCADA DNP OVERVIEW

Common issues Utilities face with DNP

- Mismatch between supported variations between point types
  - DNP3 offers options for encoding format for many of the data types. This choice is known as variations. Every group has an independent set of variations.

Some vendors allow the choice of variation by point

1—a 32-bit integer value with flag
2—a 16-bit integer value with flag
3—a 32-bit integer value
4—a 16-bit integer value
5—a 32-bit floating-point value with flag
6—a 64-bit floating-point value with flag

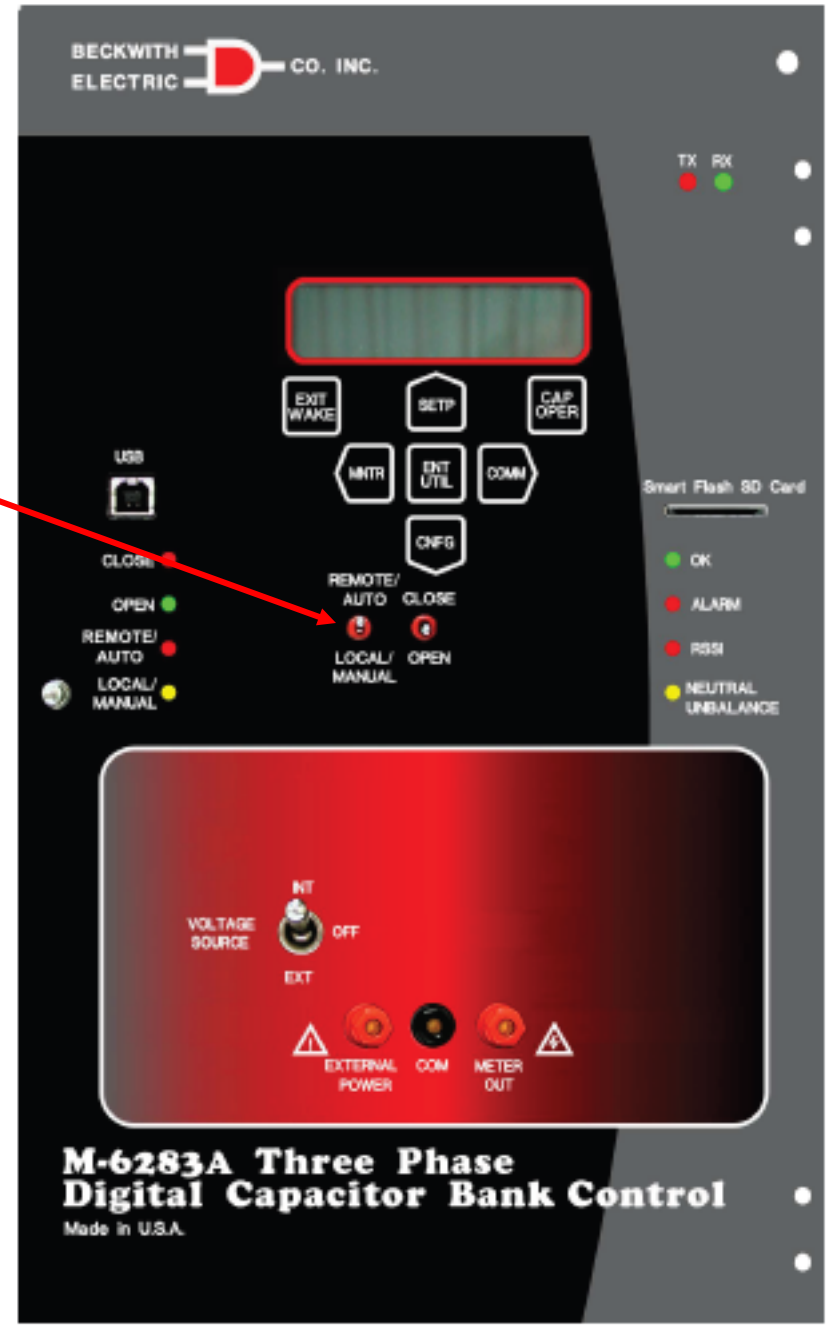
Example of choice data type (variation) to object 30

Control Modes – Local Mode

The control can be in one of four operating modes and only one at a time.

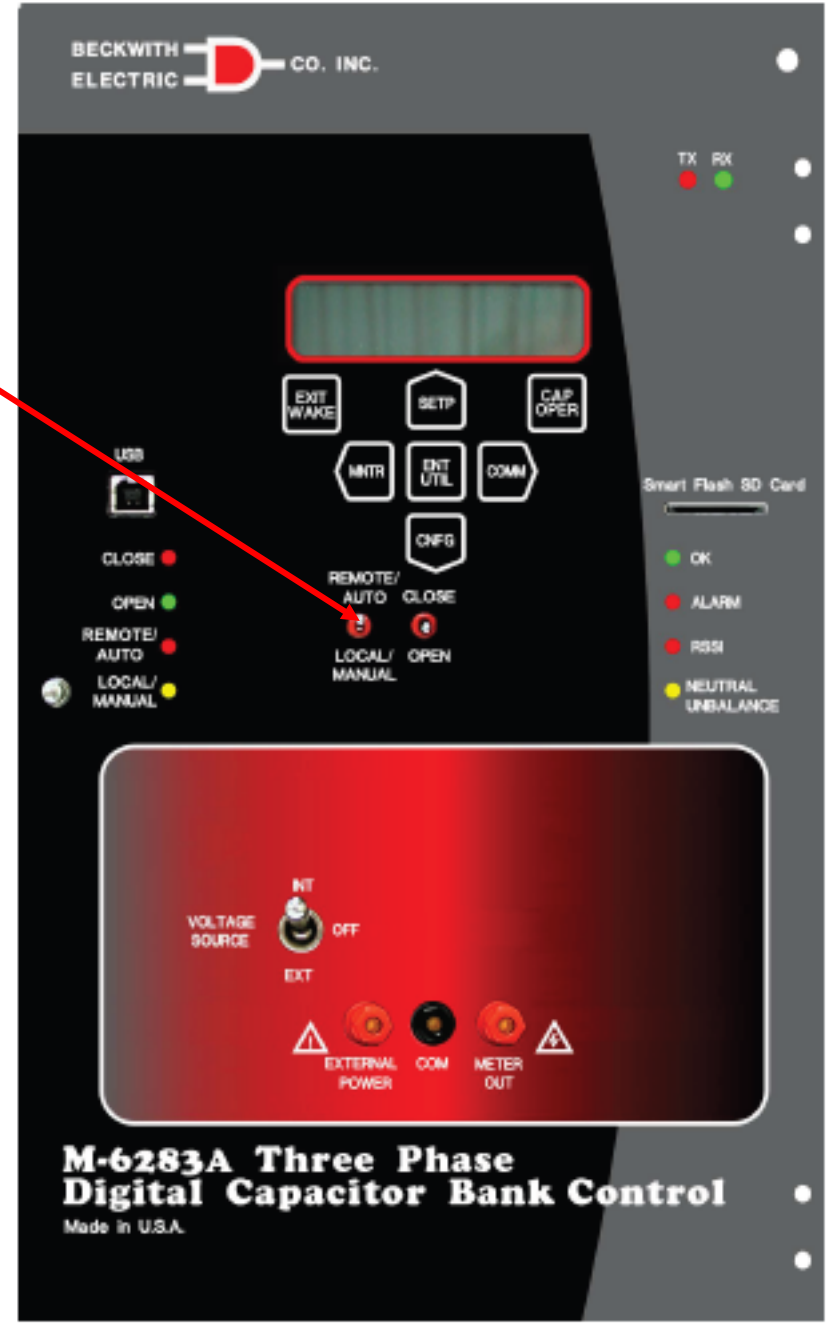
In the Local/Manual Position the control will only issue controls through the Close/Open Switch locally.

1. Automatic function and SCADA will not be able to perform controls as switch power is removed from the controller.
2. In the Local/Remote position, all SCADA write functionality is blocked including changing settings.



Control Modes – Automatic Mode

1. Automatic Mode. This mode is entered by:
   a. The switch must be in the Remote/Auto position.
   b. SCADA has not issued a Remote Comm Block and Heartbeat is not active.
2. In this mode, local and remote operations are disabled and the controller is using the setpoints of the active profile (normal, not Heartbeat) in order to determine control commands.
3. SCADA can still change setpoints.



Control Modes – Remote Automatic Mode

1. Remote Automatic Mode. For LTC/reg controls the Auto/Manual switch must be in auto, heartbeat enabled, and timing and the Remote Comm Block not asserted.
2. In this mode local and Remote operations are blocked and the control is in automatic but using the heartbeat setpoints instead of the local settings. If the heartbeat is lost the control will remain in automatic operation but switch back the local setpoints.
3. SCADA can change setpoints in this mode and may change profiles,
4. This mode requires the Heartbeat to be enabled.

Control Modes – Remote Manual Mode

1. Remote Manual Mode. For LTC/Reg controls it is in this mode when the Auto/Manual switch is in Auto and the SCADA Comm block is active.
2. In this mode local and automatic operations are blocked and the control is in manual only taking action when commanded from SCADA (open/close or raise/lower). It will remain in this mode unless SCADA removes the Comm block, the heartbeat is enabled and expires or the control loss of power (only if the Save Block Auto at Power Off is disabled for controls that support this setting).
3. This mode requires use of the Remote Manual Timer.

SCADA Heartbeat

- Heartbeat is one of the simplest concepts to understand in Centralized IVVC/CVR strategies, but actual implementation varies and can be complex.

- The Heartbeat is a feature designed to allow a controller to fall back into a safe mode of operation in the event communications is lost with a controlling algorithm.

- Heartbeat methods have been designed and implemented in various ways by all manufacturers of LTC, Voltage Regulator, and Capacitor controls.

- Heartbeat offers verification that:
  - Field devices are communicating with the SCADA/DMS.
  - Possible verification that the CVR/VVO software is running on the SCADA/DMS.
  - Typically has to be enabled in the control via a setting or SCADA Command.

Remote Control of Field Devices

Two Methods

1. Basic - Place the devices in remote manual and dispatch open/close commands as needed (Remote Manual Mode):
    a. Have local Auto/Manual in Auto.
    b. Have local SCADA Cutout in Remote.
    c. Send a Remote Comm Block Command from SCADA (placing control in remote manual). The Control will stay in Remote Manual even after loss of Communications.
    d. Setting the Remote Manual Timer to a non-zero value. The control will come out of Remote Manual once the Remote Manual Timer Reaches 0. Writing a non-zero value automatically places control in Remote Manual.
    e. Send Close and Open Commands.

Remote Control of Field Devices

2. Advanced - Leave local devices in automatic mode but bias the action by remotely changing operating setpoints such as Open/Close voltage setpoints (Remote Auto Mode). SCADA can also have a different Setting Profile active for heartbeat and then it reverts back to the normal setting profile on loss of heartbeat.

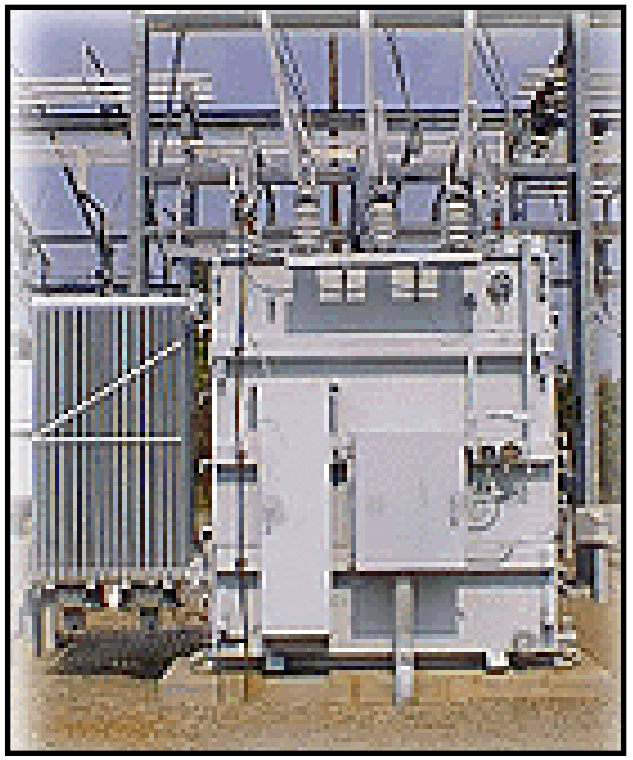
a. A SCADA Heartbeat must be enabled. The control then uses the Heartbeat parameters (HB Bandcenter, HB Bandwidth) instead of the programmed settings.
b. If the Heartbeat times out control reverts back to using the programmed setpoints.
c. Can also change profiles and the control will return to the default profile on loss of heartbeat.

Approaches commonly used in VVO/CVR

- Decentralized, no communications
- Decentralized with communications
- Centralized with one-way communications and “dumb” controllers
- Centralized with two-way communications and “smart controllers”
- Substation level Centralization with two-way communications and “smart controllers”

The Starting Line Up

- Regulates the Load –side voltage.
- Has 33 taps:
  - 16 Raise (load voltage will be higher than rated voltage).
  - 16 Lower (load voltage will be lower than rated voltage).
- Transformer With LTC:
  - Neutral Tap – Load voltage is rated voltage.
  - Each tap changes secondary voltage by approximately 0.75 volts.
  - Controlled by microprocessor-based control with communication capabilities.
  - Typically run in automatic mode.

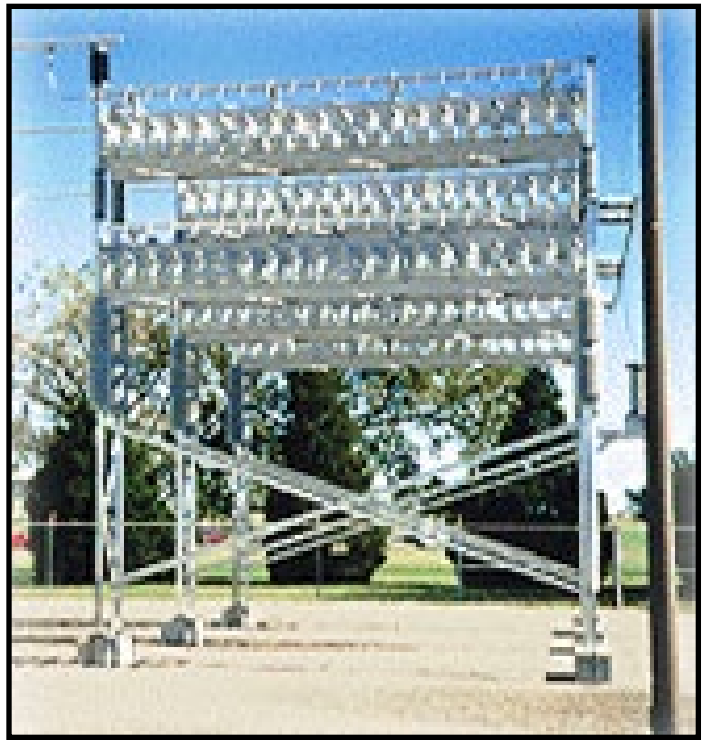


The Starting Line Up

- Single Phase Regulators (Bus or Feeder).
- Regulates the Load–side voltage.
- Has 33 taps:
  - 16 Raise (load voltage will be higher than rated voltage).
  - 16 Lower (load voltage will be lower than rated voltage).
  - Neutral Tap – load voltage is rated voltage.
  - Each tap changes secondary voltage by approximately 0.75 volts.
  - Controlled by microprocessor-based control with communication capabilities.
  - Typically run in automatic mode.

The Starting Line Up

- Substation Capacitor Bank:
  - Typically large and added or removed in stages.
  - Provides power factor correction at the substation.
  - Provides Voltage support to the transmission system through the transformer.
  - Typically controlled remotely via SCADA.
  - Adds operations to LTCs and regulators.
  - Does not eliminate the line losses.
  - The sledge hammer approach.



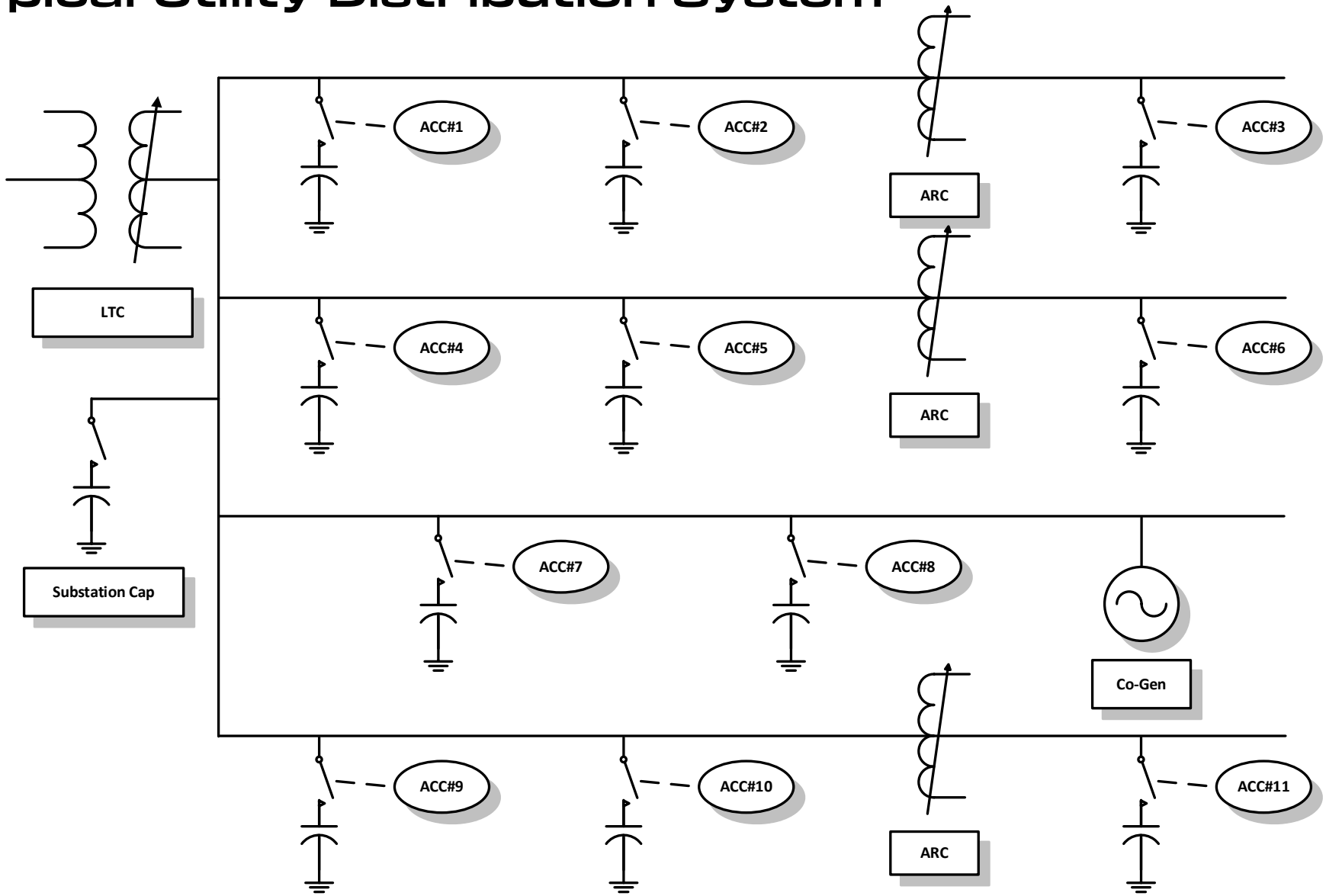
The Starting Line Up

- Switched Pole-top Capacitor Banks:
  - Addition of a switch and a control.
  - Control can monitor:
    - Time of Day.
    - Temperature.
    - Voltage.
    - VARs.
    - Power factor.
    - Current.

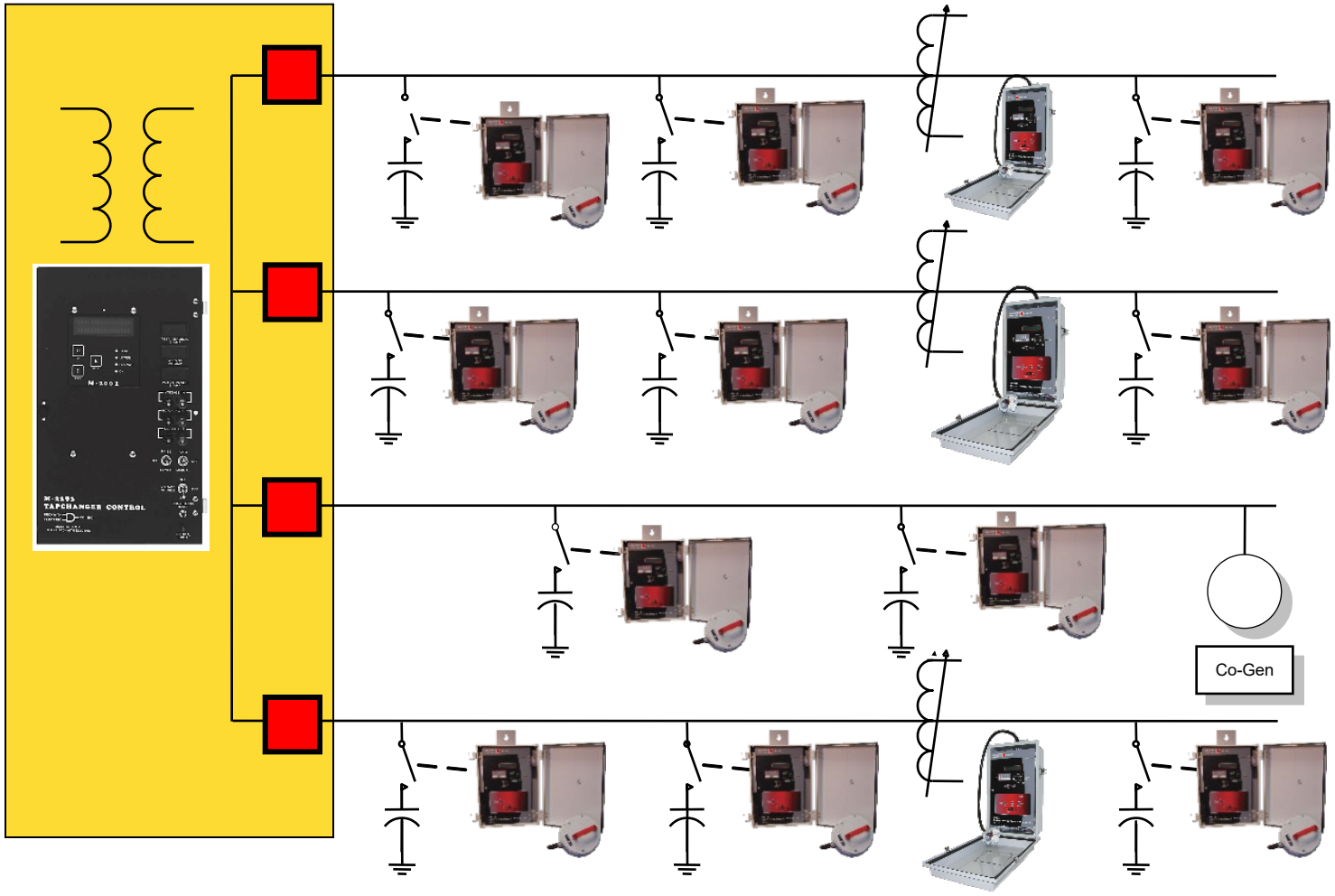
The Starting Line Up

- Line Regulators:
  - Smaller size and less expensive than feeder or bus regulators.
  - Typically found on longer distribution circuits where line losses are greater.

Typical Utility Distribution System



Decentralized Approach Without Communications



Decentralized Approach Without Communications

What is a Decentralized Approach:

1. Voltage Controlled Switched Capacitor Banks.
2. Line Regulators only when needed.
3. Typically more switched banks of smaller size (600 kVar).
4. Let the capacitor banks be the primary regulating device and the LTC, substation regulator and line regulators be the backup for voltage support.
5. Attempt to reduce operations on LTCs and regulators.

Decentralized Approach Without Communications

How Does It Work?

1. Coordination made easier as all controls (LTC, regulator and switched capacitor) use voltage as the sense.
2. Downstream regulators coordinate with upstream via longer time delays to reduce total system operations.
3. Capacitor Banks coordinated with upstream regulators via time delay.
4. Upstream regulator and LTC controls use Negative X in the LDC settings to supervise capacitor banks.
5. LTC and regulator controls can also dynamically via band center using VAr data to coordinate with capacitor banks.

Decentralized Approach Without Communications

Advantages:

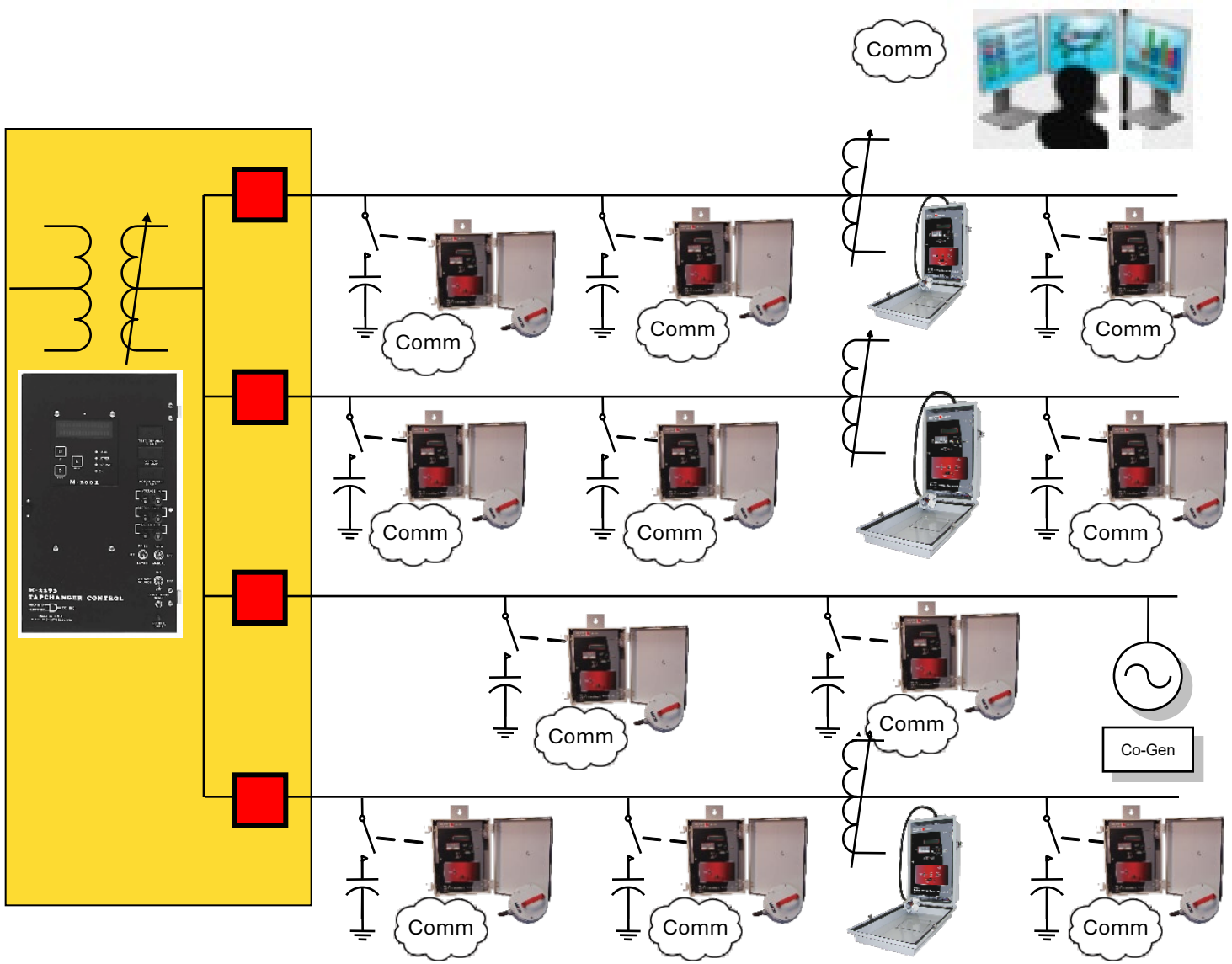
1. Does not require large communication infrastructure to implement.
2. Use of voltage controls on capacitor banks provide the following benefits:
   a. Less expensive controls.
   b. No need for line post sensors or phase CTs.
   c. Less equipment on the pole.
   d. Easier to place capacitor banks as they do not need to be on the main circuit.
3. No added burden on the SCADA system:
   a. No additional Front End Processors required.
   b. No additional database requirements.
4. No field engineering required.
5. No programming of the control required.
6. Control can provide historical data locally:
   a. Metering information.
   b. Harmonic information.
   c. Waveform capture.
   d. Operational data.

Decentralized Approach Without Communications

Disadvantages:

1. Does not permit remote alarming of bank failures.
2. Requires larger number of smaller capacitor banks to run optimally.
3. No indication of control failures.
4. Slightly more expensive controls versus straight on/off controls.
5. Data has to be collected by dispatching field personnel.
6. No immediate way to determine excessive operations on regulators or capacitor banks.

Decentralized With Communications



Decentralized With Communications

What is Decentralized with Communications?

1. Neutral Overcurrent added:
   a. Positive Indication of switch status.
   b. Alarming of Bank problems.
2. Two-way communications added.
3. Additional metering.
4. Additional Power Quality alarming.
5. System still run in automatic locally.
6. Ability to temporary override part or all of the system remotely.

Decentralized With Communications

Advantages:

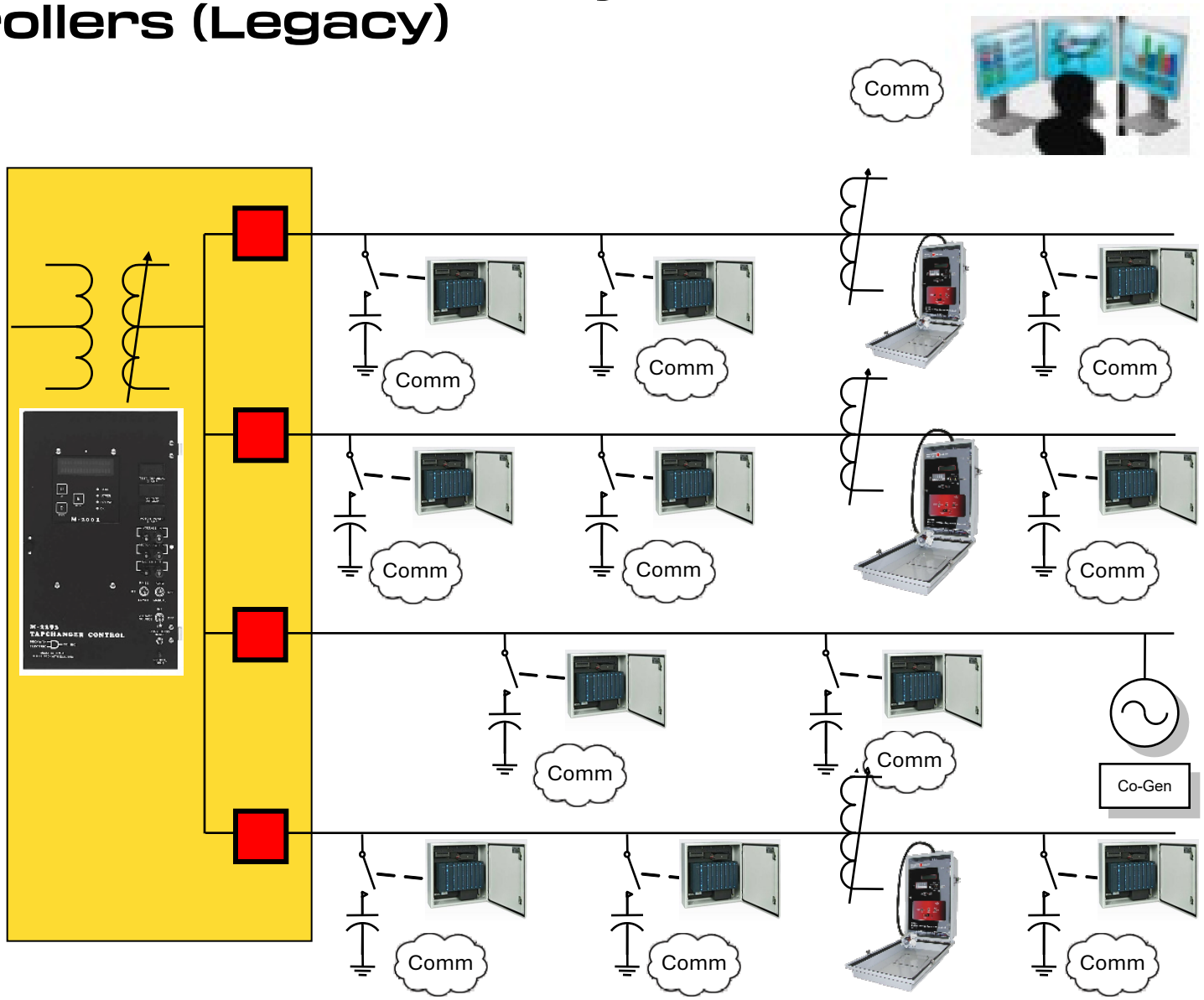
1. This architecture provides remote monitoring of:
   a. The health of the switch.
   b. The health of the fuses and capacitors.
   c. The health of the control.
2. Allows the control to trip off a bank that has problems.
3. Allows the control to retry if the switch did not fully operate.
4. Allows for real-time data to see if the design is working correctly.
5. Can be lower bandwidth for communications compared to centralized schemes
6. Allows for power quality alarms to be remotely transmitted:
   a. Sags and Swells.
   b. Harmonic Violations.
   c. CBEMA Violations.

Decentralized With Communications

Disadvantages:

1. Additional cost for the control.
2. Additional cost for neutral current sensing.
3. Additional cost of communications equipment.
4. May require field technicians/engineers for settings and communication commissioning.
5. Requires interface to SCADA system.

Centralized With One-Way Communications And “Dumb” Controllers (Legacy)



Centralized With One-Way Communications And “Dumb” Controllers (Legacy)

What is Centralized With One-Way Communications And “Dumb” Controllers ?

1. Dumb Control on switched capacitor banks.
2. One way communication to send open and close commands.
3. Algorithm at SCADA Master determines when and how to operate capacitor banks.
4. Regulators and LTCs are typically not part of the algorithm.

Centralized With One-Way Communications And “Dumb” Controllers (Legacy)

Advantages:

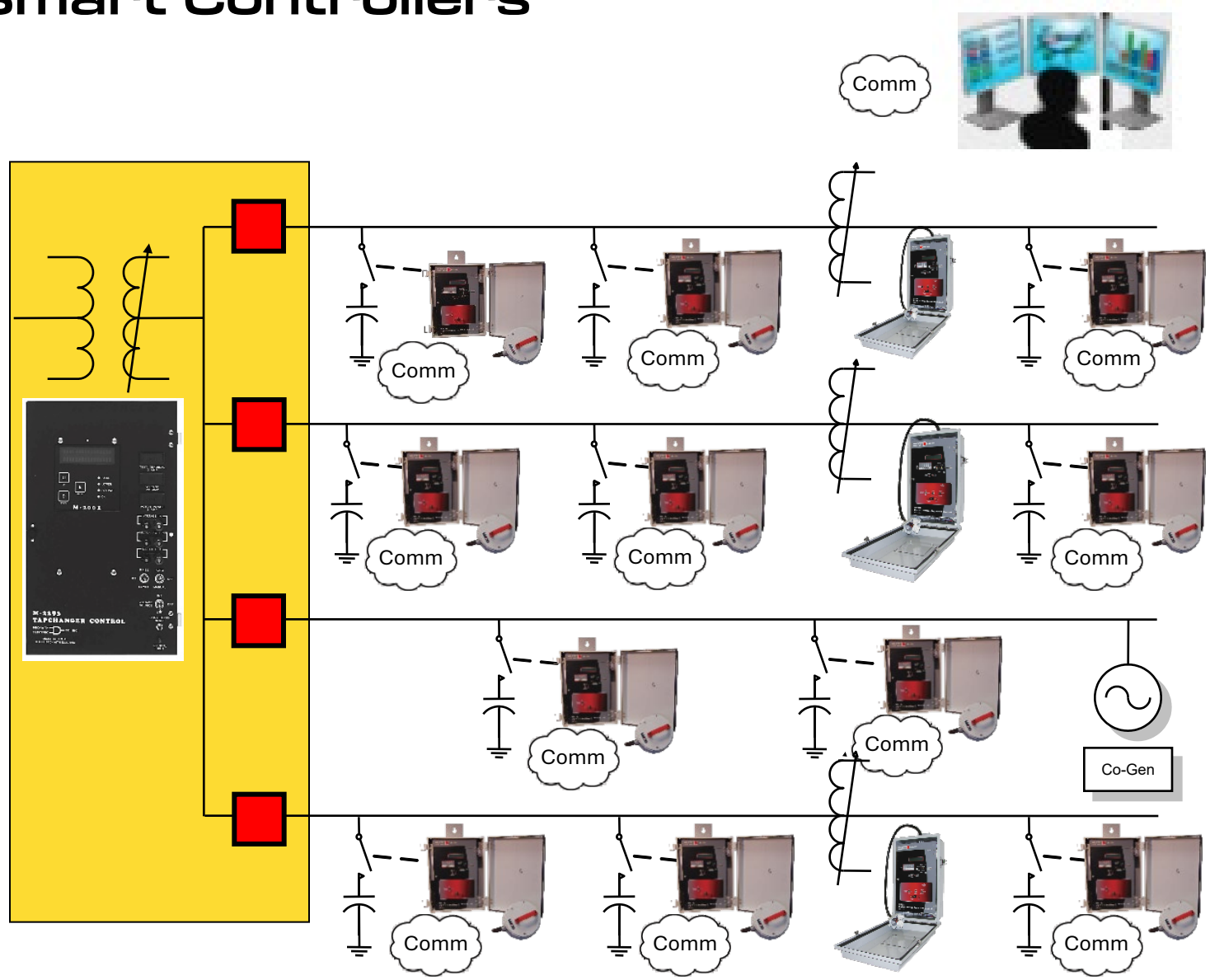
1. Cost at each switched capacitor bank is reduced:
    a. Less expensive control.
    b. No neutral overcurrent CT.
    c. No Line post sensor.
    d. One way paging is a cheap communications medium.
2. No settings at each control.

Centralized With One-Way Communications And "Dumb" Controllers (Legacy)

Disadvantages:

1. No feedback from the control:
    a. Some schemes will use feeder metering to aid in the determination of switch operation.
    b. No alarming on neutral overcurrent or system violations or harmonics.
2. Centralized Algorithm complex or prone to failure:
    a. What if bank is out-of-service?
    b. What if control in manual?
    c. What if circuits are tied differently?
3. If communication is lost, the switched bank becomes a fixed bank.

Centralized With Two-Way Communications And “Smart Controllers”



Centralized With Two-Way Communications And “Smart Controllers”

What is Centralized With Two-Way Communications And “Smart Controllers” ?

1. One-way communication replaced with two-way communication.
2. Dumb control replaced with a Smart control.
3. Smart control is run in remote manual but will switch to local automatic if comm is lost.
4. Smart control can disobey SCADA Master commands.

Centralized With Two-Way Communications And “Smart Controllers”

Advantages:

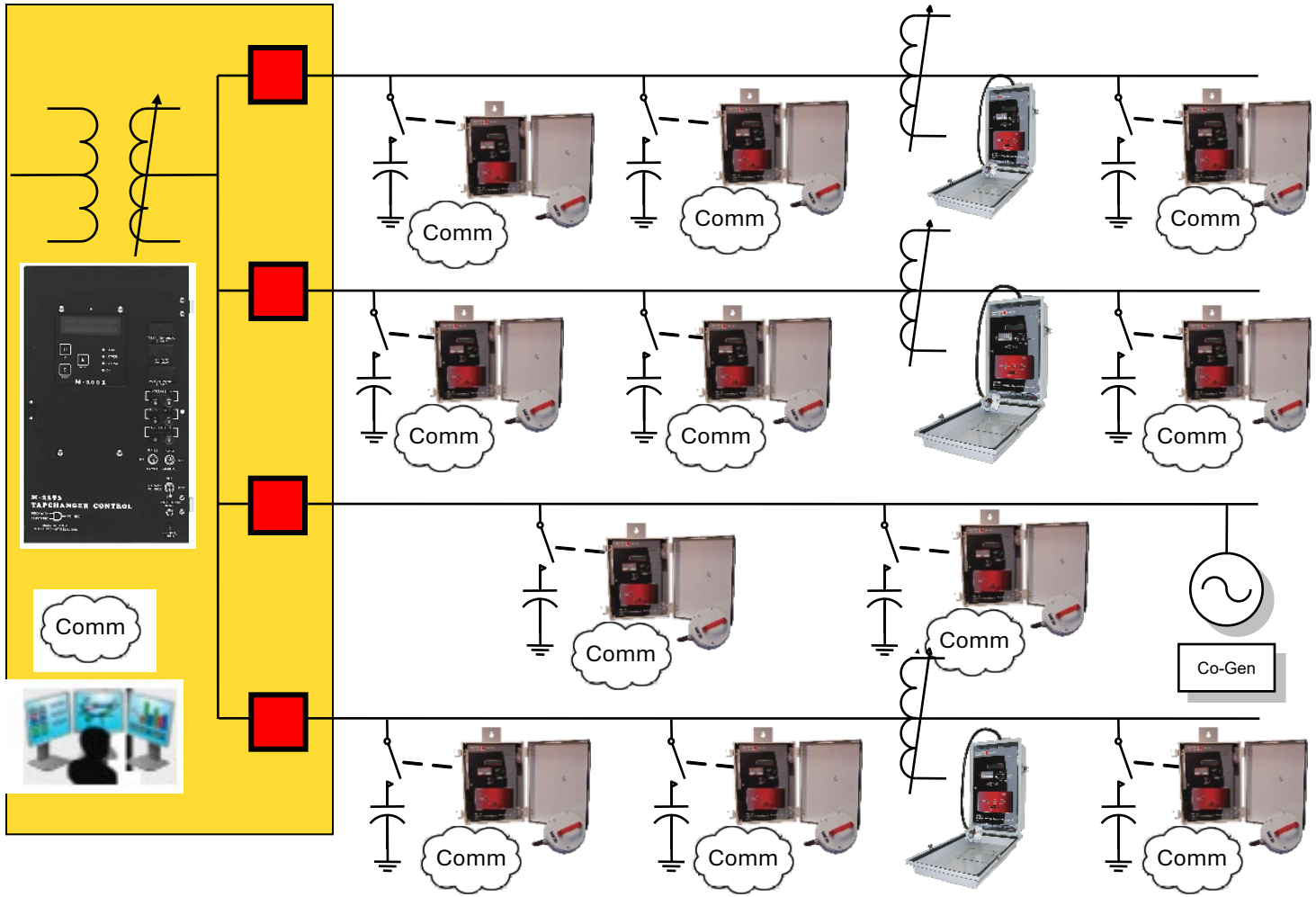
1. There is a backup if communications is lost.
2. Control has error checking in case remote algorithm is not operating correctly.
3. More intelligent control provides more data to aid the algorithm.

Centralized With Two-Way Communications And “Smart Controllers”

Disadvantages:

1. This is the most expensive approach.
2. Complex.
3. Must implement a large portion of system before any benefit is seen.

Substation Level Centralization With Two-Way Communications And “Smart Controllers”



Substation Level Centralization With Two-Way Communications And “Smart Controllers”

What is Substation Level Centralization With Two-Way Communications And “Smart Controllers”?

1. Substation Automation system becomes distributed centralized master.
2. Controls still have the ability to fall back into automatic operation.
3. Controls still have the ability to disregard master commands.
4. Substation Automation system acts as a filter to the SCADA system.
5. Centralized SCADA may have ability to override local substation automation system.

Substation Level Centralization With Two-Way Communications And "Smart Controllers"

Advantages:

1. Reduces length of communication circuits allowing for different types of communication.
2. Reduces burden on centralized SCADA master:
    a. Centralized master polls no additional devices.
    b. Centralized master may not require a volt/VAr algorithm.
3. Allows for staged implementations.

Substation Level Centralization With Two-Way Communications And “Smart Controllers”

Disadvantages:

1. Multiple databases to be maintained.
2. Switching circuits between substations can affect the complexity of the local algorithm.
3. Problems in the algorithm become more difficult to upgrade.

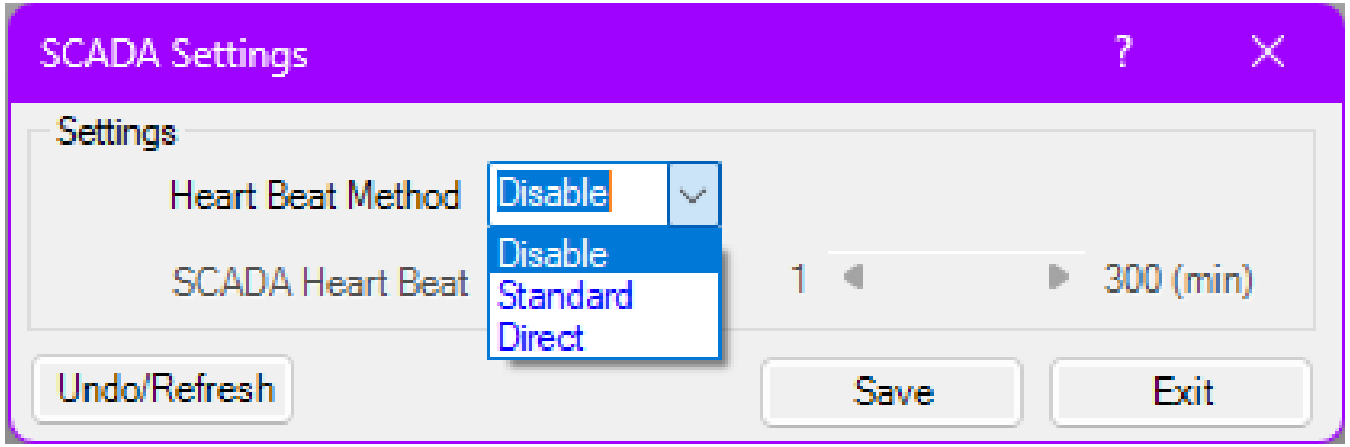
Centralization algorithm types

Most centralized methods use one of the following approaches to operating distribution devices:

- Meter-centric method.
  - Uses data directly from end points (revenue meters) to calculate what devices should operate.
  - Best method in that it is most responsive to keeping end customers within PUC limits.
  - Example of vendors that use this method include : DVI, OATI,
- Real time load flow method
  - Measured values from devices in the system are fed into a system model to determine which devices to operate.
  - Most common method in use with IOU's.
  - Efficiency of this method is directly dependent on amount of data being provided and accuracy of that data.
  - Example of vendors that use this method include GE, ABB, Hitachi
- Historical data comparison method
  - Uses both environmental and operational historical data compared to current data to decide what to operate and when.
  - Example of vendors that use this method include Utilidata.

Heartbeat implementation example – Cap Controllers

Cap Control Heartbeat DNP Option - Disable



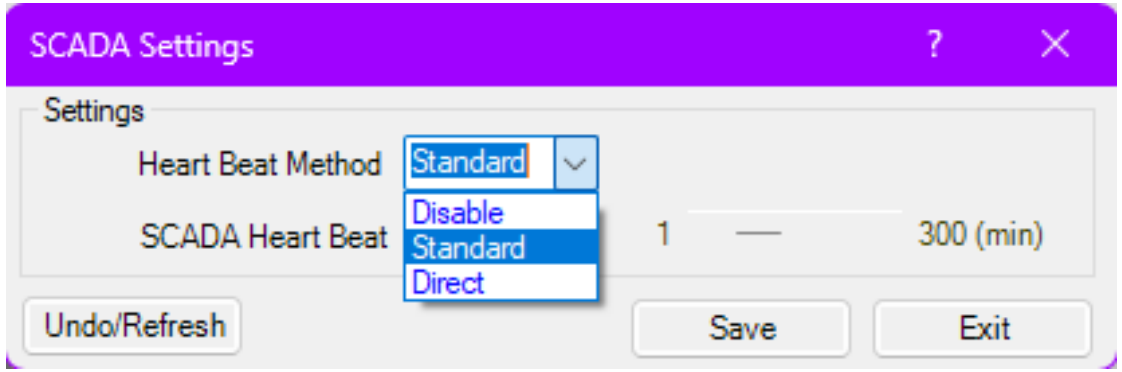
When Disable is selected, no heartbeat mode will be supported.

Cap Control Heartbeat Modes – Standard

There are two types of heartbeat, Direct and Standard:

Standard –

- Any DNP Read or Write to the controller will initiate heartbeat mode.
- Uses DNP Analog Input point named Scada Heartbeat Timeout as the timer value to start decrementing from since the last read or write.
- Unit will be in Remote Manual and SCADA or an IVVC/CVR algorithm can send Open or Close commands.
- If the Timer reaches 0 with no read or write, the unit will revert back to automatic operation using the settings it was programmed to use for operation.



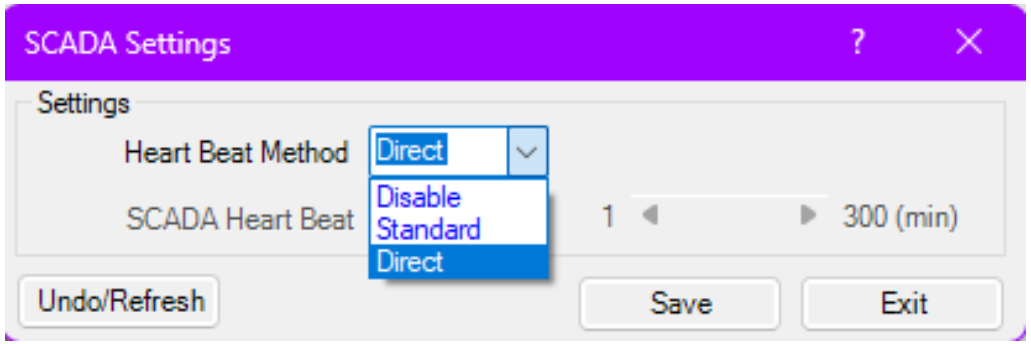
Cap Control Heartbeat Modes – Direct

Direct –

- A value is written into this timer - Direct Heartbeat. The control decrements the timer every second. If the timer Direct Heartbeat reaches zero before being re-initialized to a new value the control returns to automatic mode

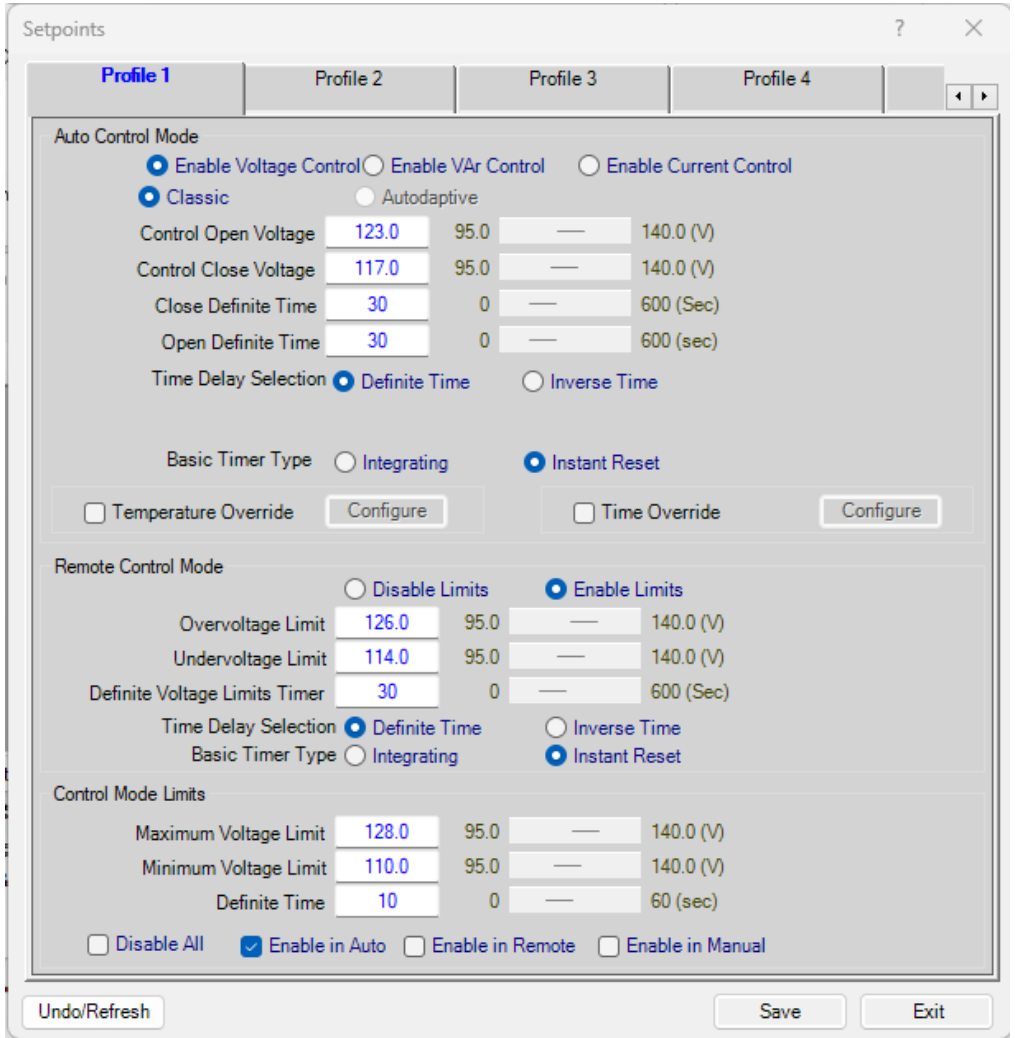
- The timer is reinitialized every time the control receives a valid DNP write to the Direct Heartbeat setting from the SCADA Master to its programmed address.

- This method is preferred when both SCADA and a controlling algorithm are both communicating to the unit as it allows the Algorithm to control when the unit is in Remote Manual.



Cap Control Heartbeat DNP Option – Switch Profile

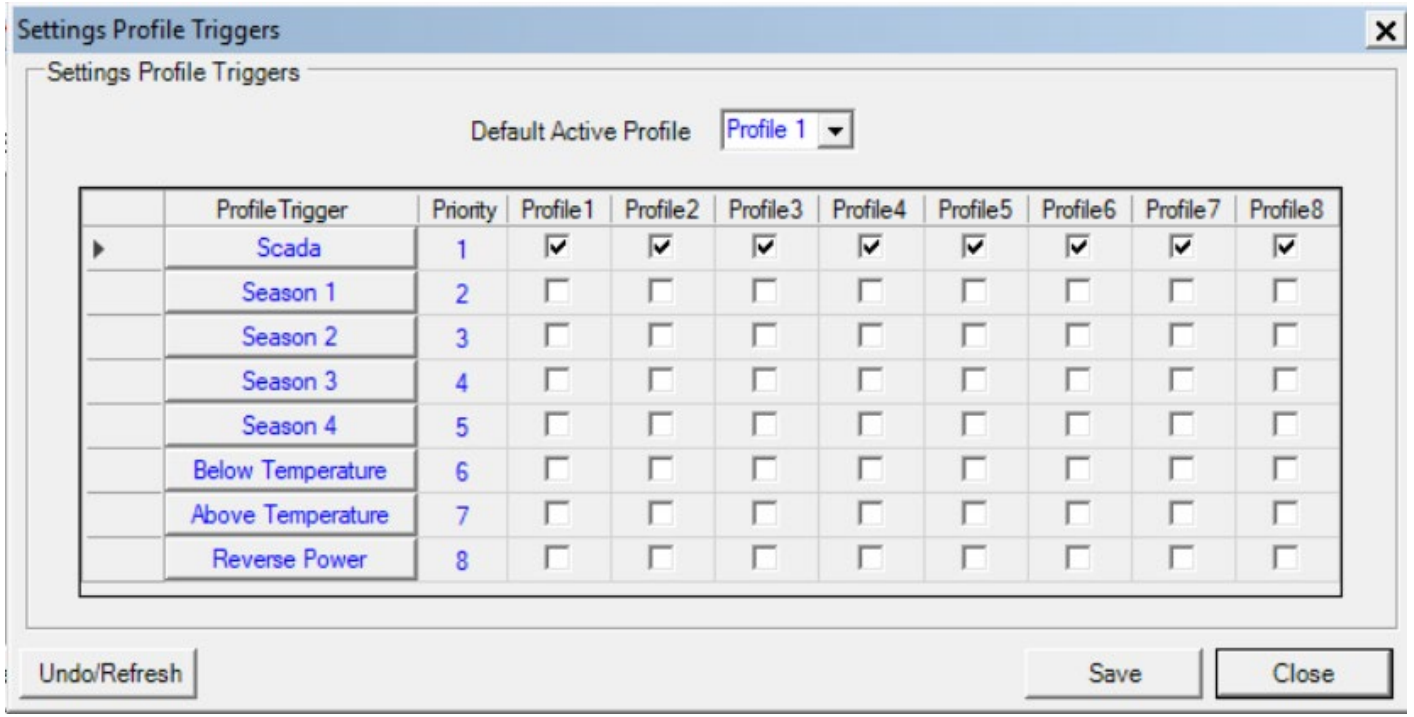
- The heartbeat can switch profiles from the default to any other profile. Here is an example of a setpoints screen



Cap Control Heartbeat DNP Option – Switch Profile

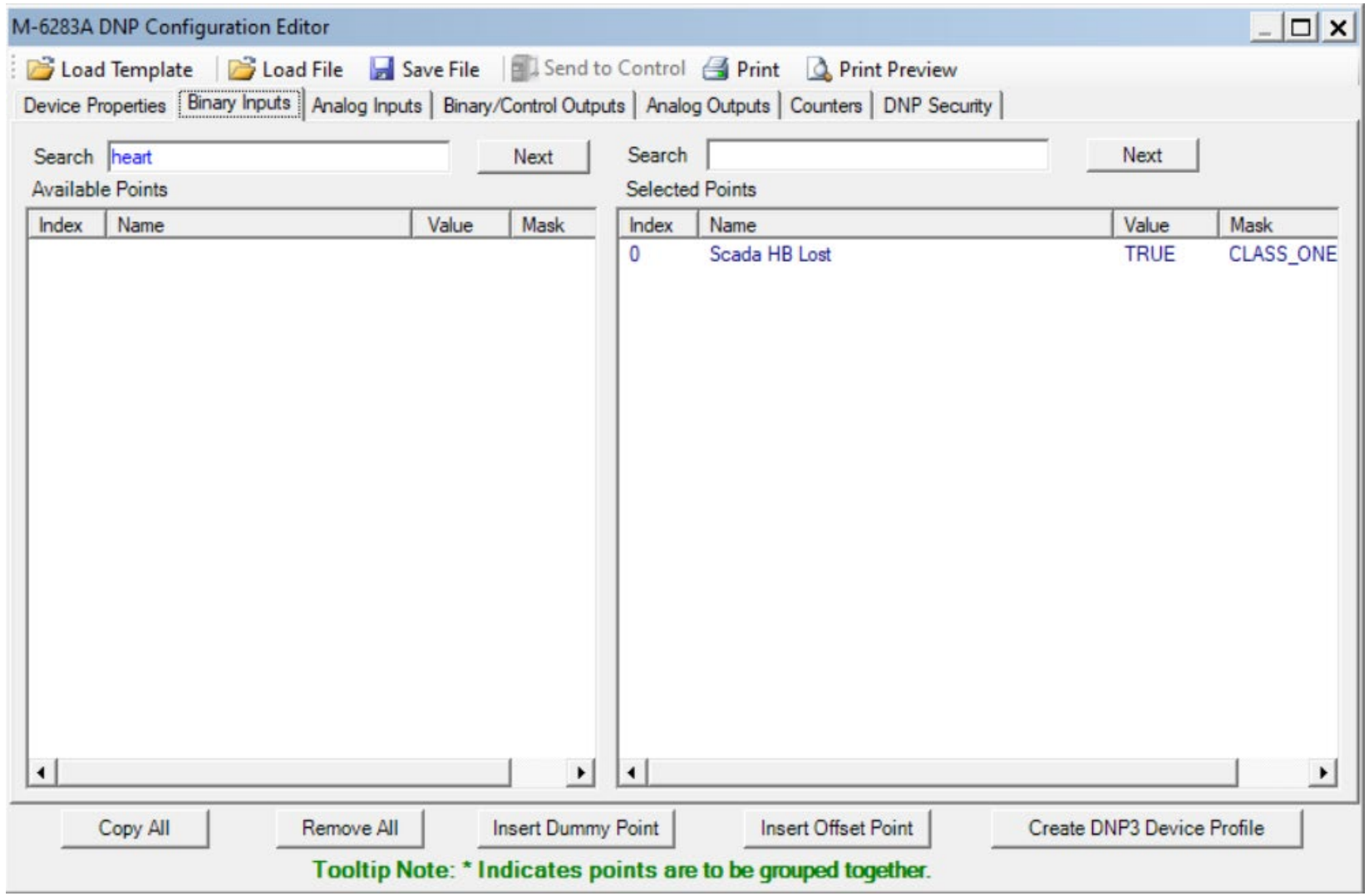
- This mode utilizes a DNP AO point named “ScadaHB Profile Switch”.
- You write the profile and time you want the heartbeat timer to be using this point.
  - For example, to switch to profile 2 and use a 5-minute timer, you would write 8197 (You create this number by multiplying the profile number by 4096 and then adding the timer value: (2x4096)+5 = 8197)
- If the timer reaches 0 without the point being refreshed, the unit will revert back to profile 1.

Example of what to write		
Profile	Timer	Value written
1	5	4101
2	5	8197
3	5	12293
4	5	16389
5	5	20485
6	5	24581
7	5	28677
8	5	32773



Cap Control Heartbeat DNP Points

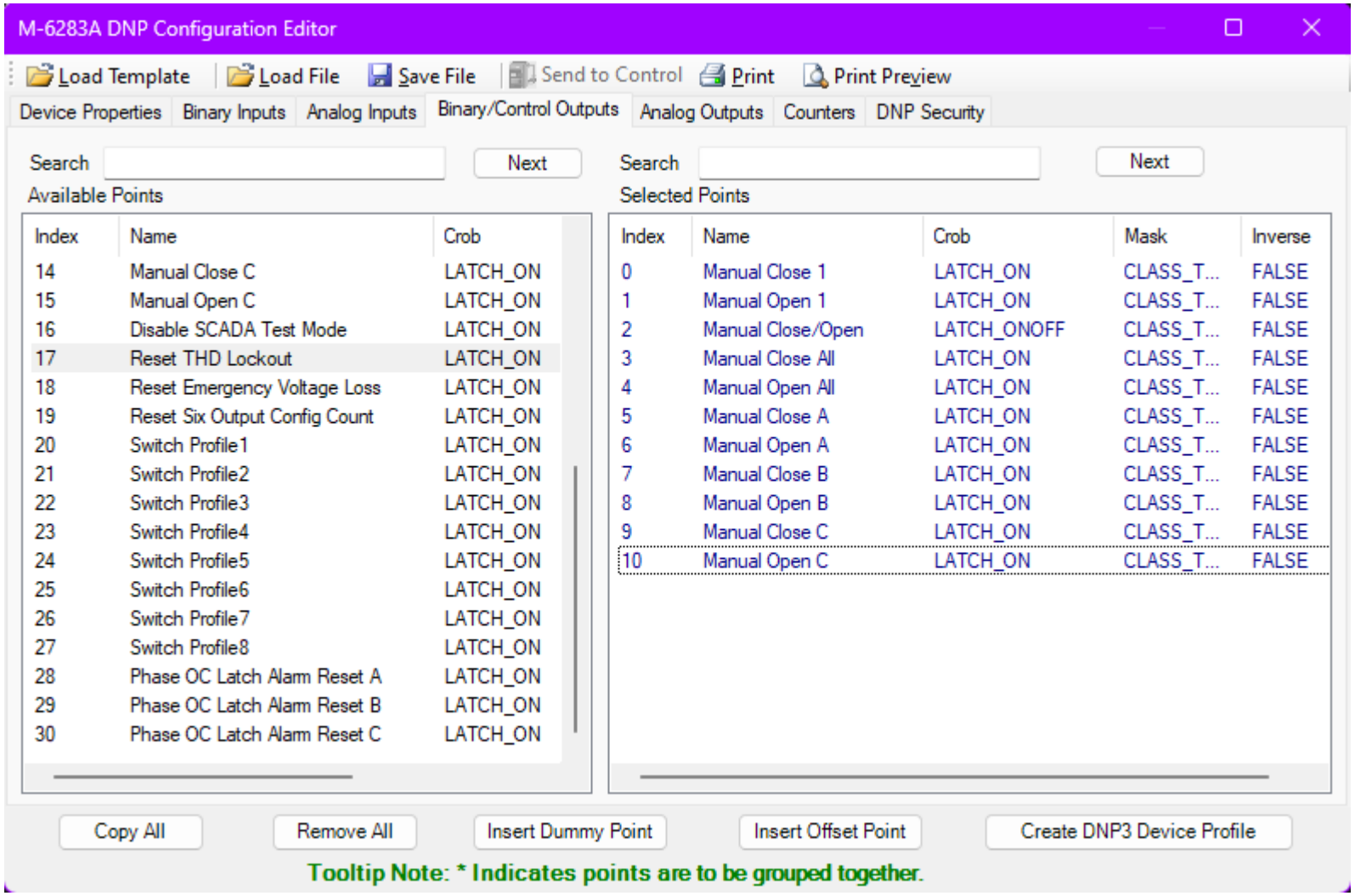
Binary Inputs Associated with Heartbeat



This point works when Heartbeat is enabled.
It will trigger when Heartbeat has timed out.

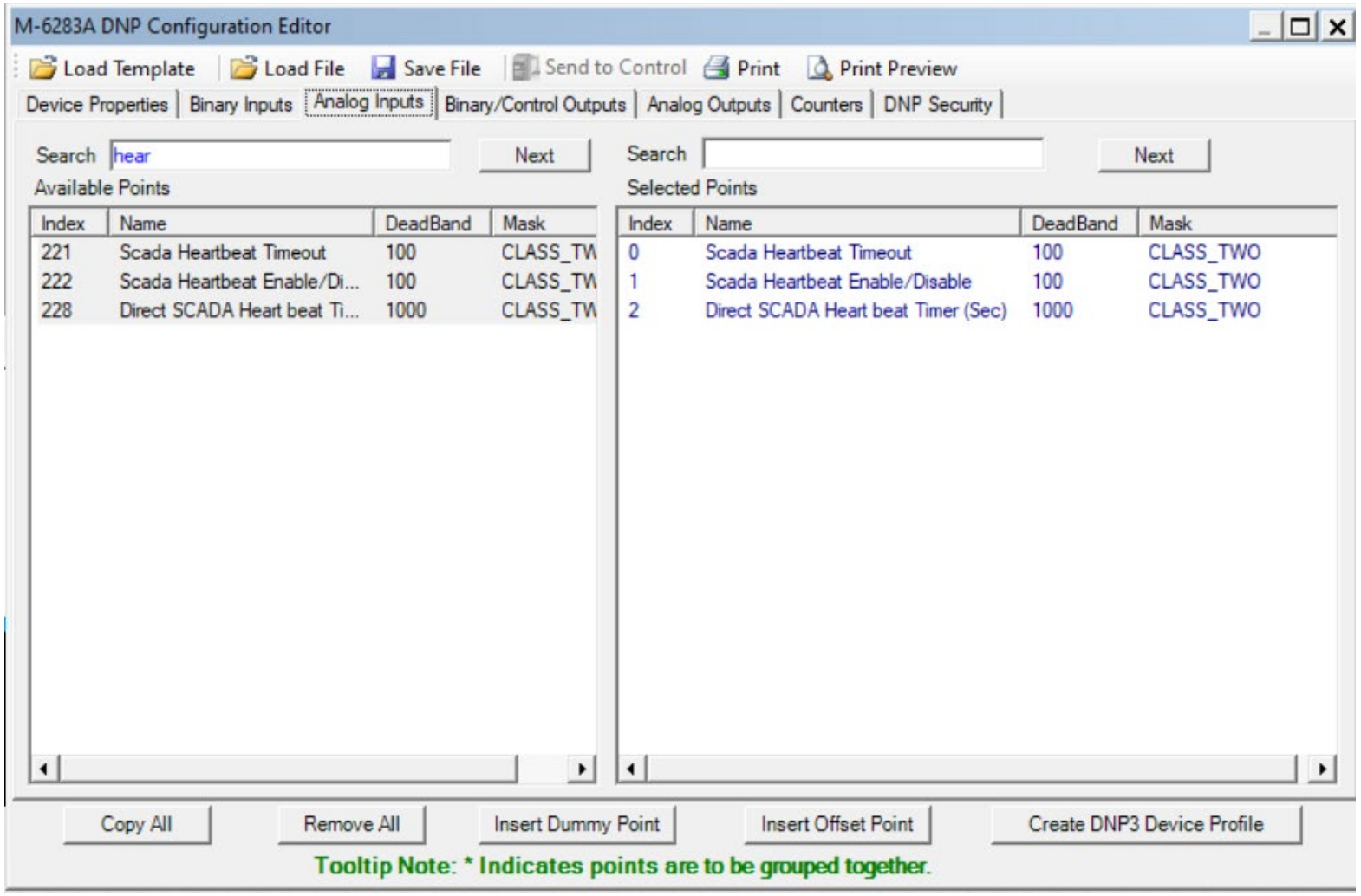
Cap Control Heartbeat DNP Points

Binary Outputs Associated with Heartbeat



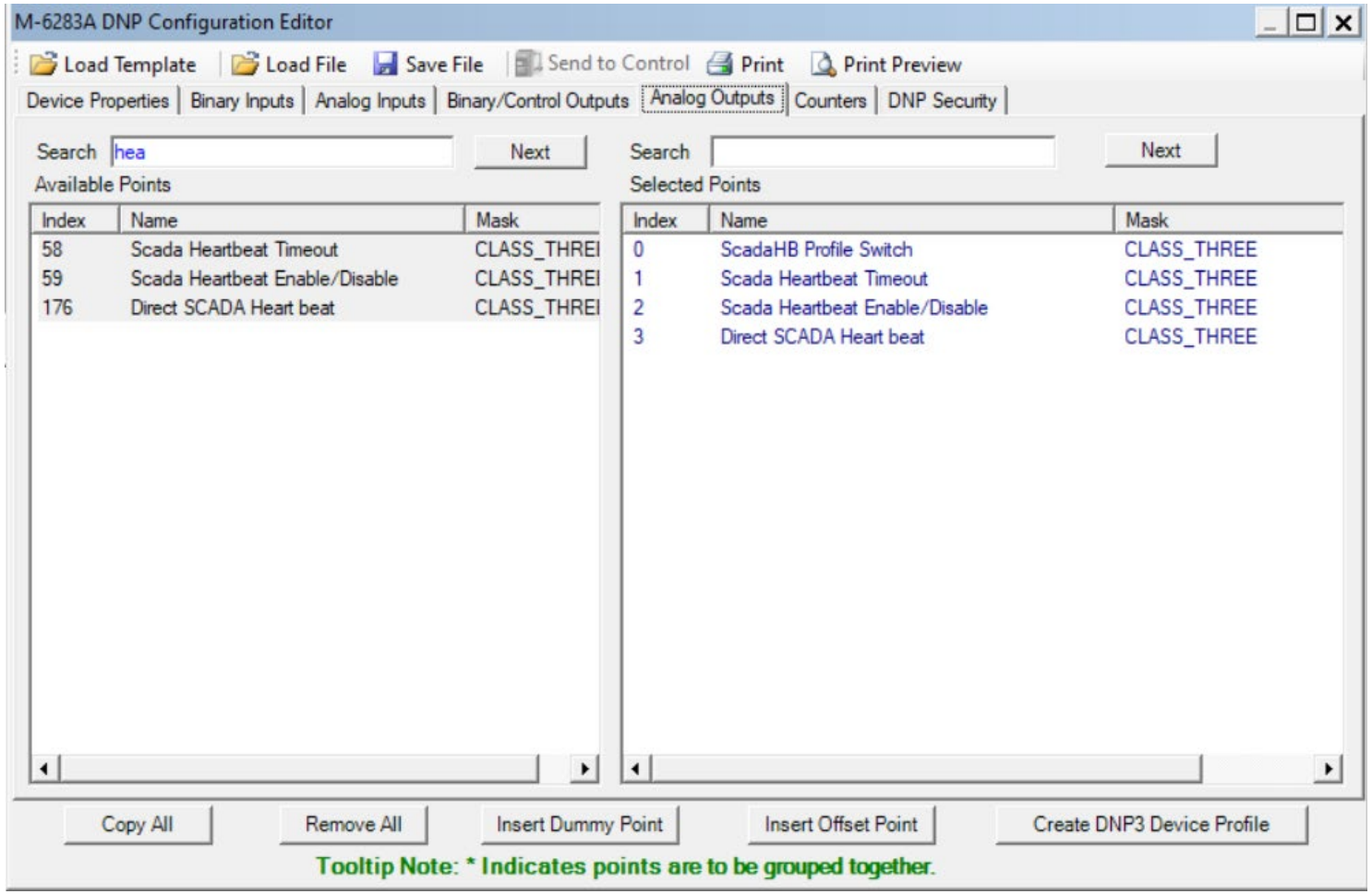
Cap Control Heartbeat DNP Points

Analog Inputs Associated with Heartbeat
(mimics the Analog Output points for systems that cannot read AO's.)



Cap Control Heartbeat DNP Points

Analog Outputs Associated with Heartbeat

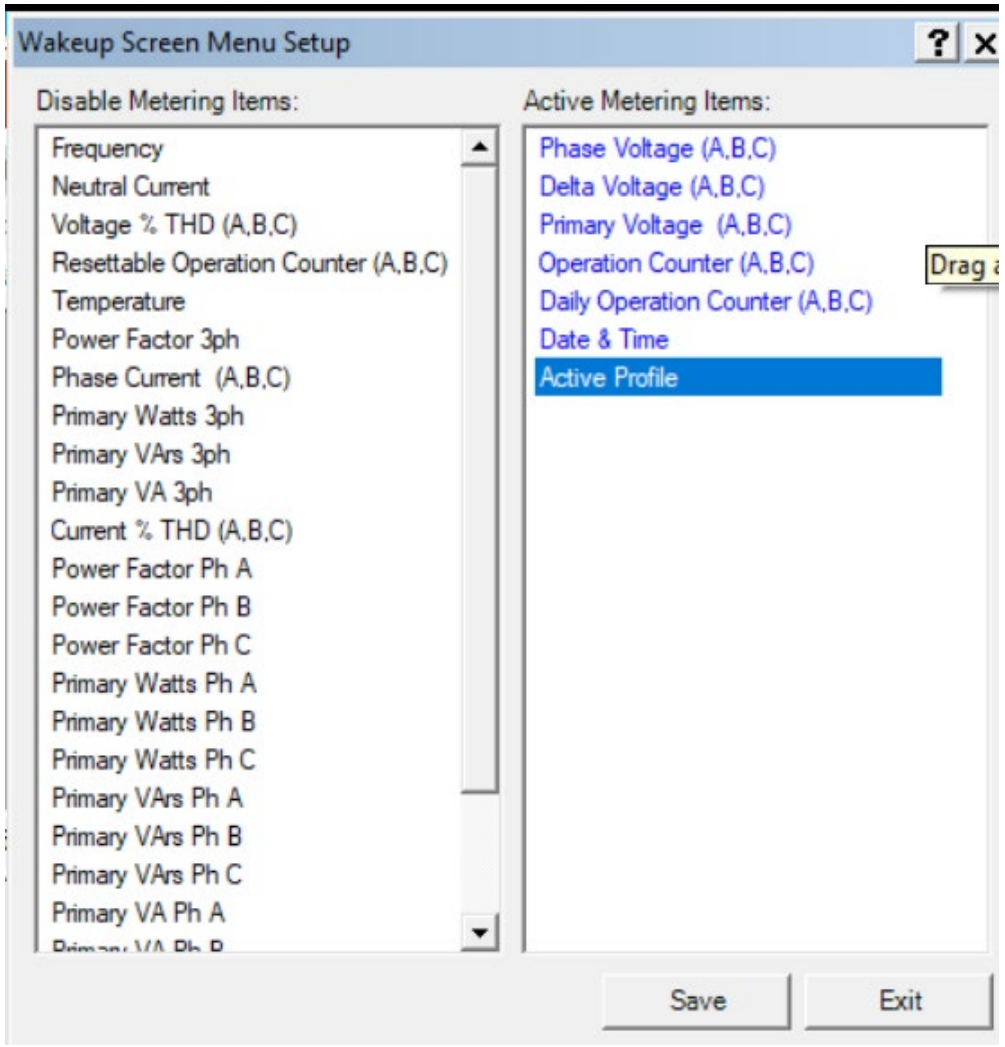


There are Three Heartbeat Timers that can be used.

- The SCADAHB Profile Switch point works as described earlier.
- If the Heartbeat mode is standard, the SCADA Heartbeat Timeout point is used to set the timer value and any read or write will trigger heartbeat mode.
- The Direct SCADA Heartbeat must be written to with a value of 0-999 and refreshed before it reaches 0.

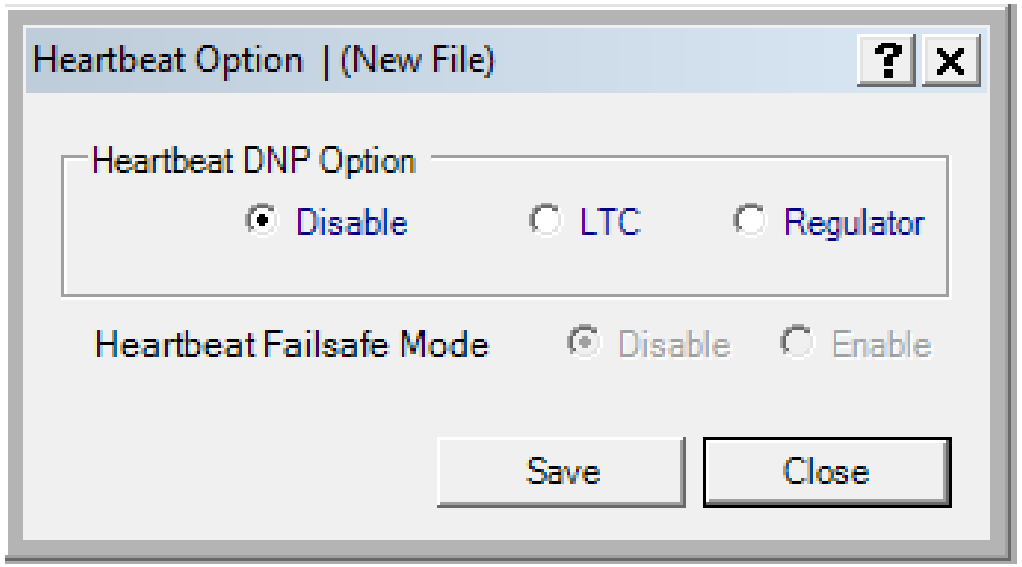
Cap Control Heartbeat DNP Option – Wake Up Screen

For local personnel to be able to determine the settings currently being used by the control (Heartbeat or programmed), the Active profile will show which profile the control is currently operating in.



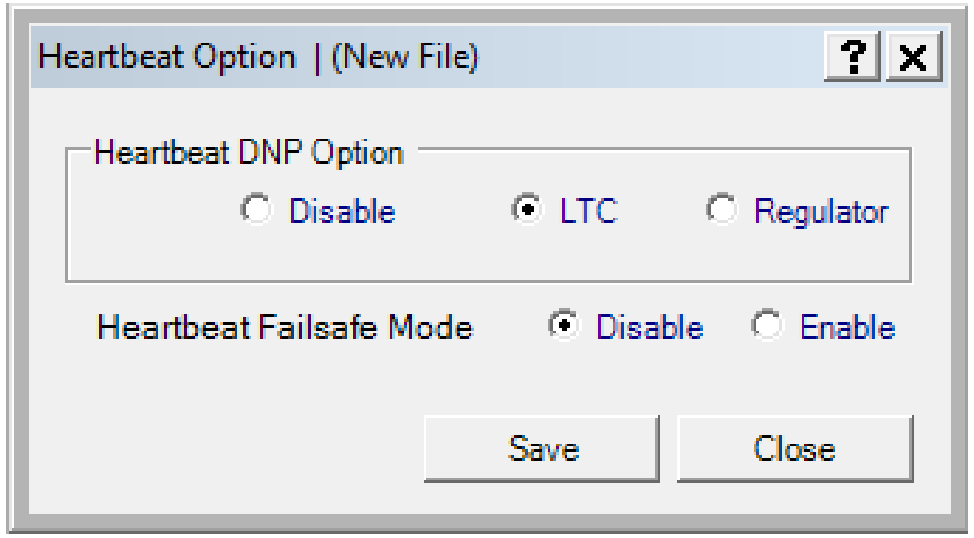
Reg/LTC Control Heartbeat DNP Modes

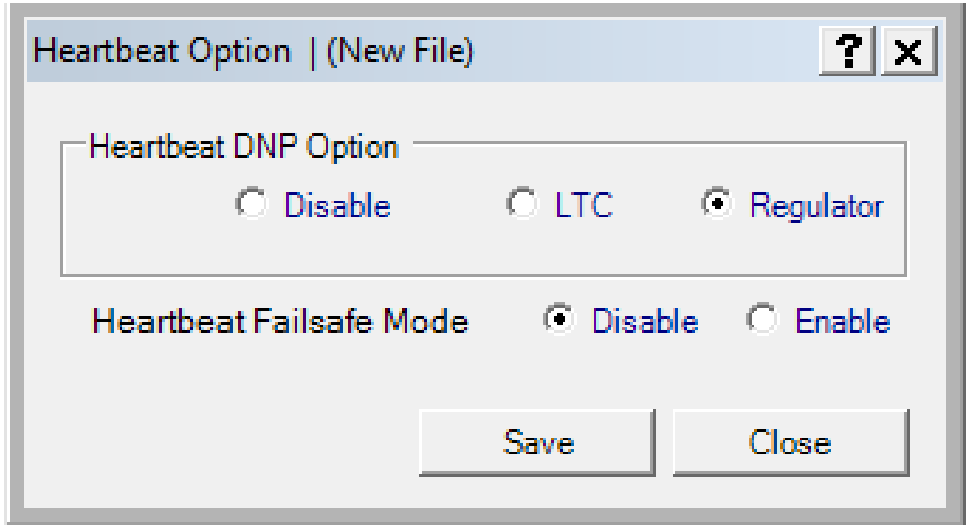
- The LTC and Regulator controls have different methods of heartbeat as discussed earlier.
- Disable as expected disables the heartbeat methods.



Reg/LTC Control Heartbeat DNP Modes

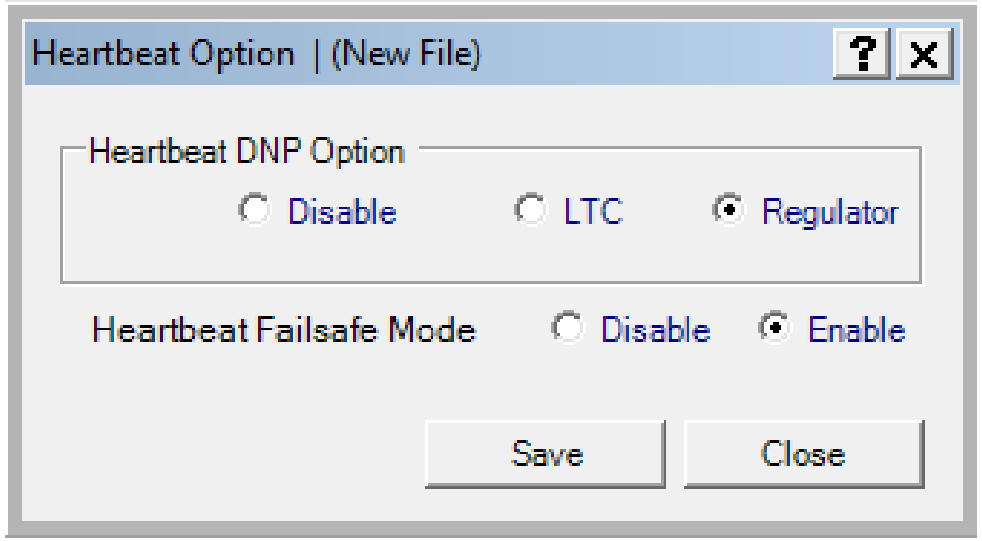
- LTC and Regulator are identical in heartbeat operation except that LTC uses a nonsequential input as the counter and Reg uses the standard counter input.
- These modes began life as a control Mod in the M-2001B's for JEA.
- Most customers today use REG regardless of actual LTC or reg application of the controller.





Reg/LTC Control Heartbeat DNP Modes

- Failsafe Mode was designed to make the controllers work like the ICMI heartbeat implementation. (Made for Duke energy when ICMI went out of business.)
- This mode should ONLY be enabled if you are replacing ICMI controllers with Beckwith and want the same DNP point functionality.



Reg/LTC Control Heartbeat DNP Modes

- Note the LTC and Reg controls do not have the equivalent of the standard mode in Cap controllers.
- Because the LTC and Reg controls have existed since the early 1990's and heartbeat has been around for a long time, they support several different methods.
  - One method uses a two DNP Analog Output points called "Write Heartbeat" and "Heartbeat Timer". When the "Heartbeat Timer" point is not 0, the unit is in heartbeat mode and will allow use of a selection of DNP points designated Heartbeat points to be written to and control operation of the device.
    - This mode works great when you want the algorithm to do a calculation and write to the controller proving the algorithm is "running"

Reg/LTC Control Heartbeat DNP Modes

- Here is a screenshot of some of those points

Index	Name	Mask
0	Write HeartBeat	CLASS_ZERO
1	HeartBeat Timer	CLASS_ZERO
2	HeartBeat Bandcenter (Forward)	CLASS_ZERO
3	HeartBeat Bandwidth (Forward)	CLASS_ZERO
4	HeartBeat Time Delay (Forward)	CLASS_ZERO
5	HeartBeat Intertap Delay	CLASS_ZERO
6	HeartBeat LDC Resistance (Forward)	CLASS_ZERO
7	HeartBeat LDC Reactance (Forward)	CLASS_ZERO
8	HeartBeat Inverse Time Delay (Forward)	CLASS_ZERO
9	HeartBeat Voltage Reduction Step 1	CLASS_ZERO
10	HeartBeat Voltage Reduction Step 2	CLASS_ZERO
11	HeartBeat Voltage Reduction Step 3	CLASS_ZERO
12	HeartBeat Block Lower (Voltage)	CLASS_ZERO
13	HeartBeat Block Raise (Voltage)	CLASS_ZERO

- The controller expects the SCADA system to write to the “Write Heartbeat” point and increment it by 10 each time for the control to recognize the command as a valid heartbeat refresh and keep the unit in Remote Automatic.

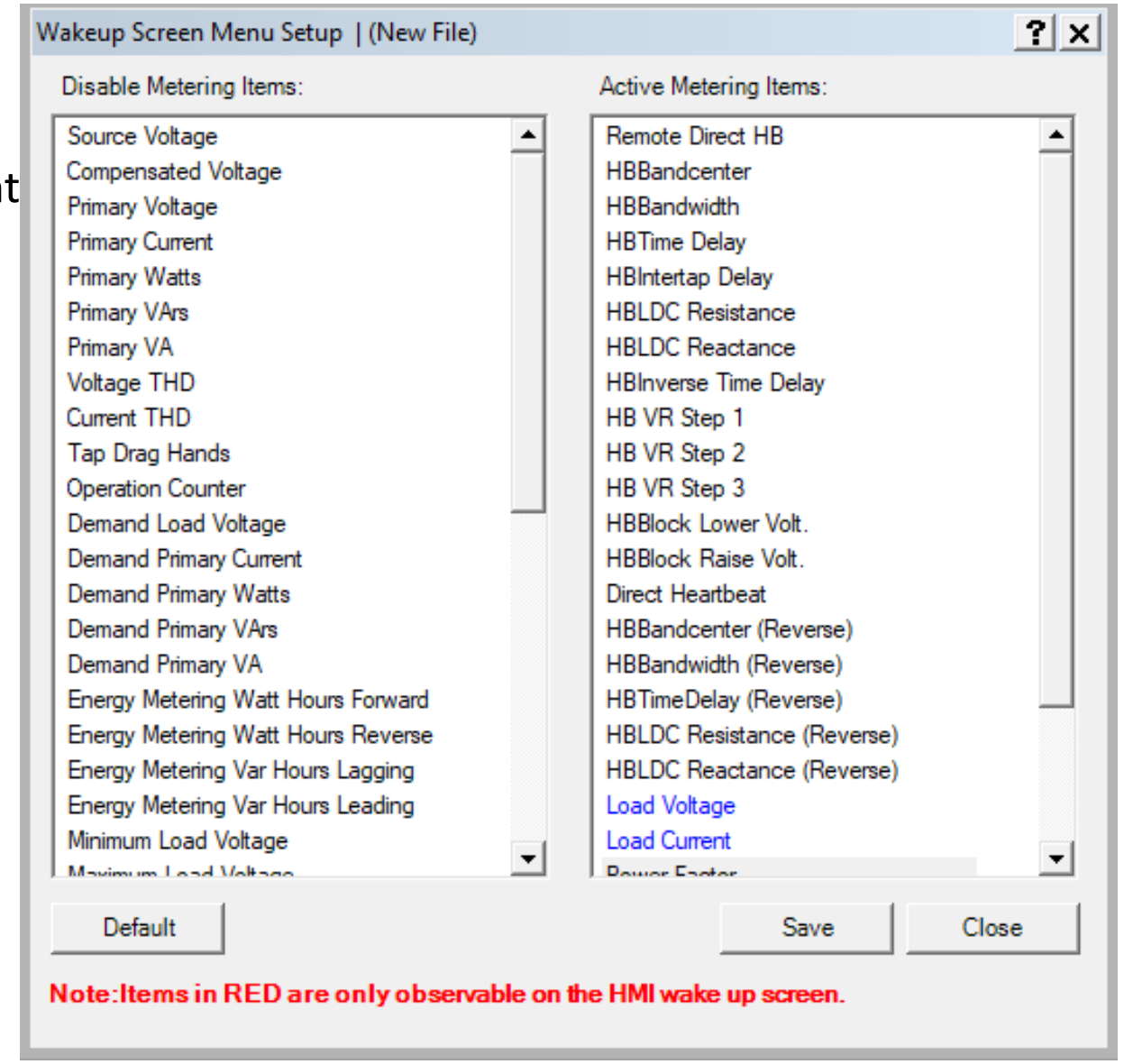
Reg/LTC Control Heartbeat DNP Modes

- Another method is like the Direct mode in Cap controllers.
  - This method uses a Direct Heartbeat Analog Output point and when that point is not 0 you are in Remote Automatic.
  - The same DNP Analog Output points for Bandcenter, Bandwidth, etc. are used for all Remote Automatic heartbeat methods.

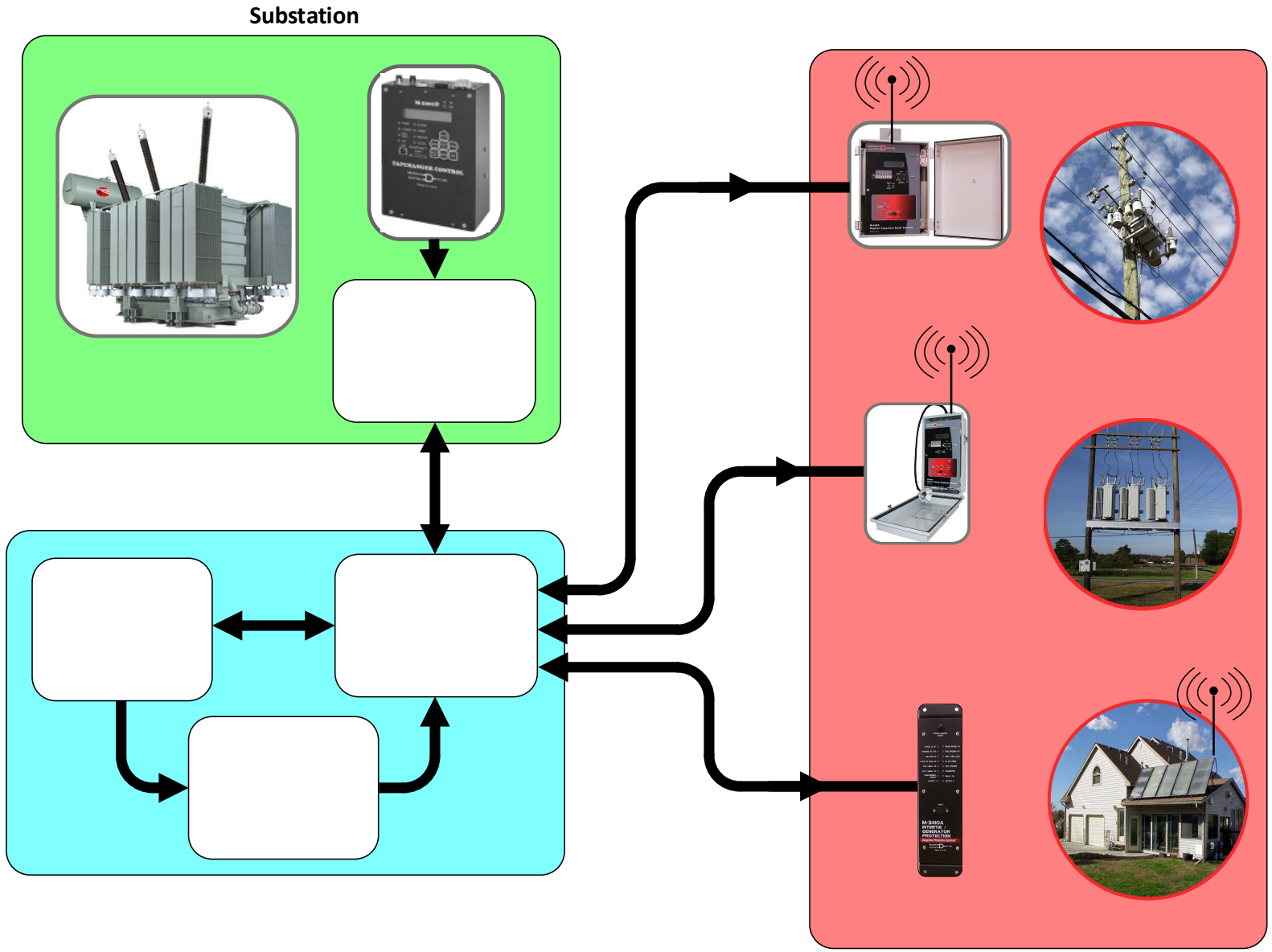
- A third method of heartbeat is the Remote Manual method.
  - This mode uses an Analog Output point called “Remote Manual Timer”.
  - Similar to the Direct method, you write a timer value to this point to enable heartbeat and keep writing to it to refresh the timer. When it is written to, it puts the unit in Remote Manual allowing Raise or Lower commands to be received and acted upon.
  - Should it time out, the unit will revert back to Local Automatic.
  - Note that, while similar, the controller also has a non-heartbeat related Remote Manual function and DNP point associated with ti that supersedes this method when used named “Block Auto Control via Comm”.

Reg Control Heartbeat DNP Option – Wake Up Screen

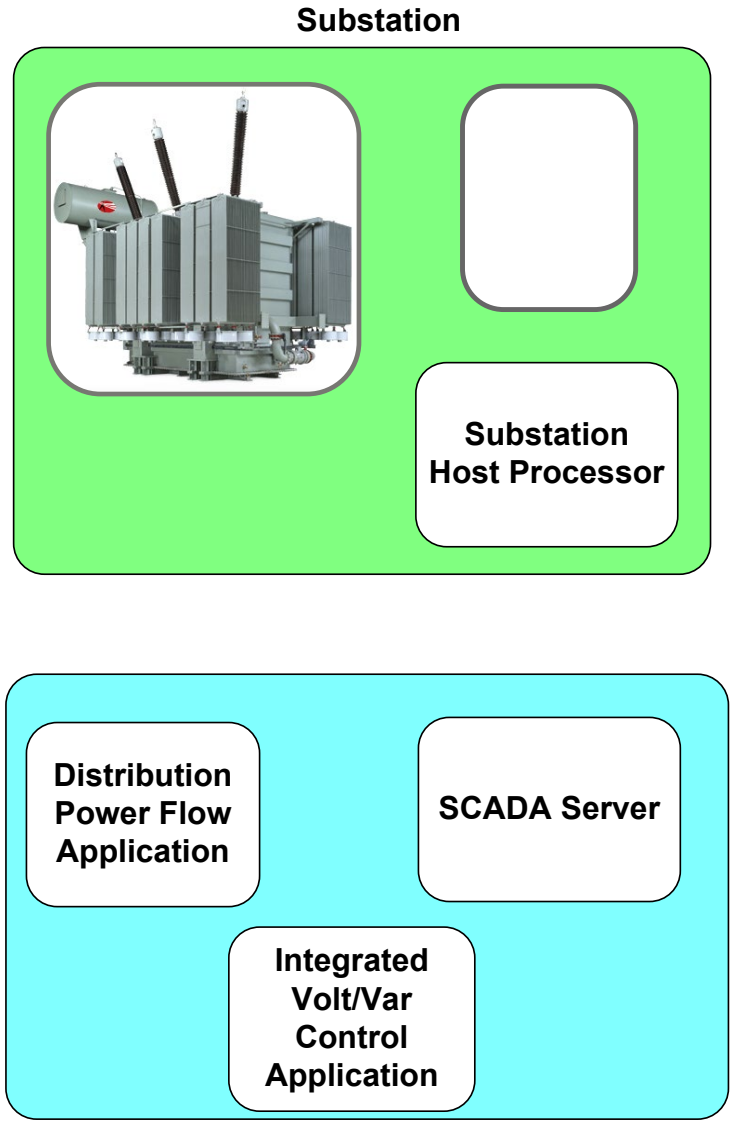
Here is the wake screen setup showing the heartbeat settings that can be seen from the front panel when the Wake button is pressed.

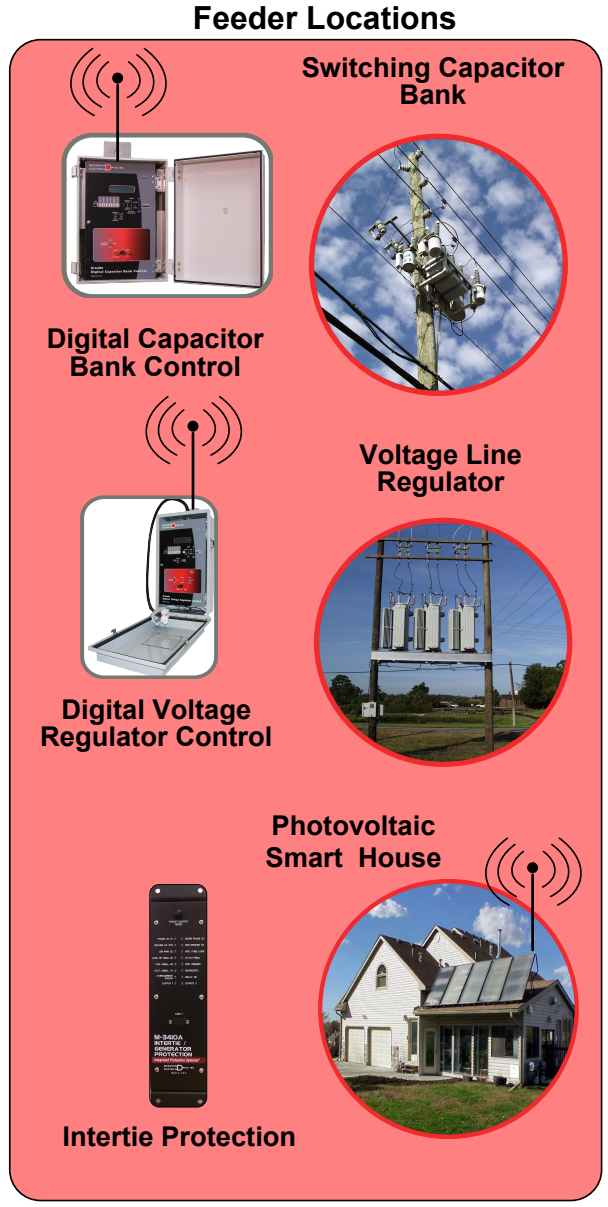


Example of Centralized with communications using the Real- Time Power Flow method

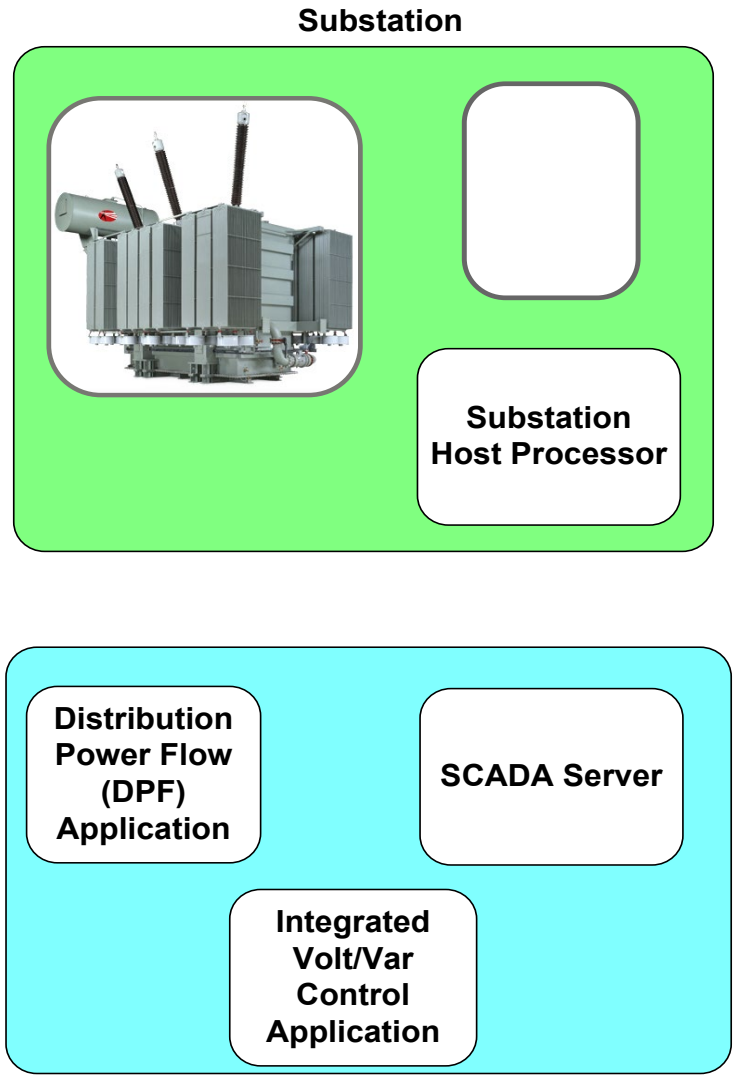


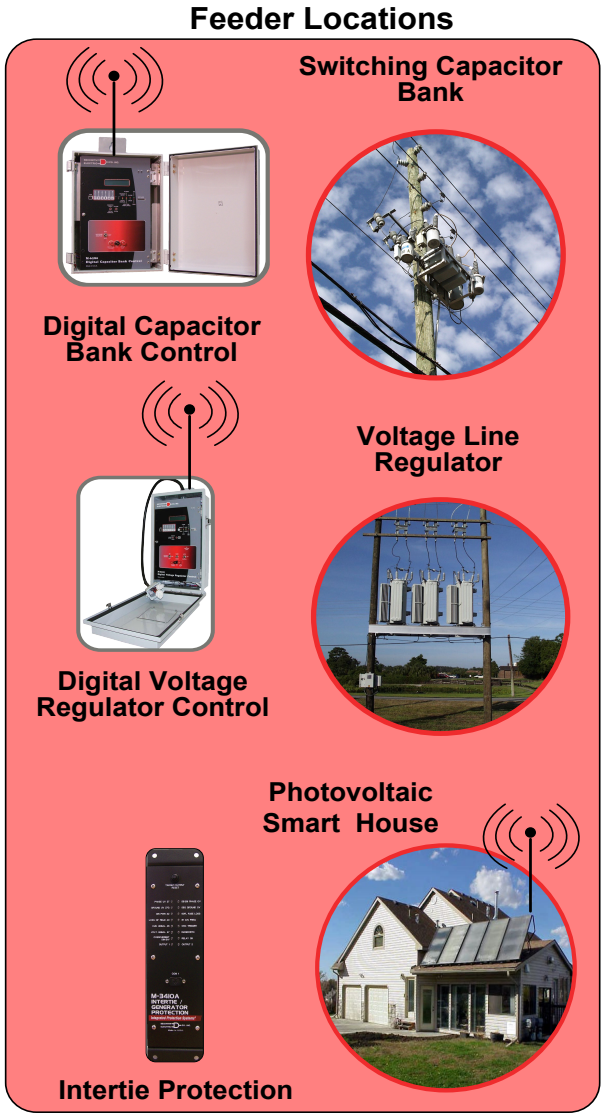
Example of Centralized with communications using the Real- Time Power Flow method



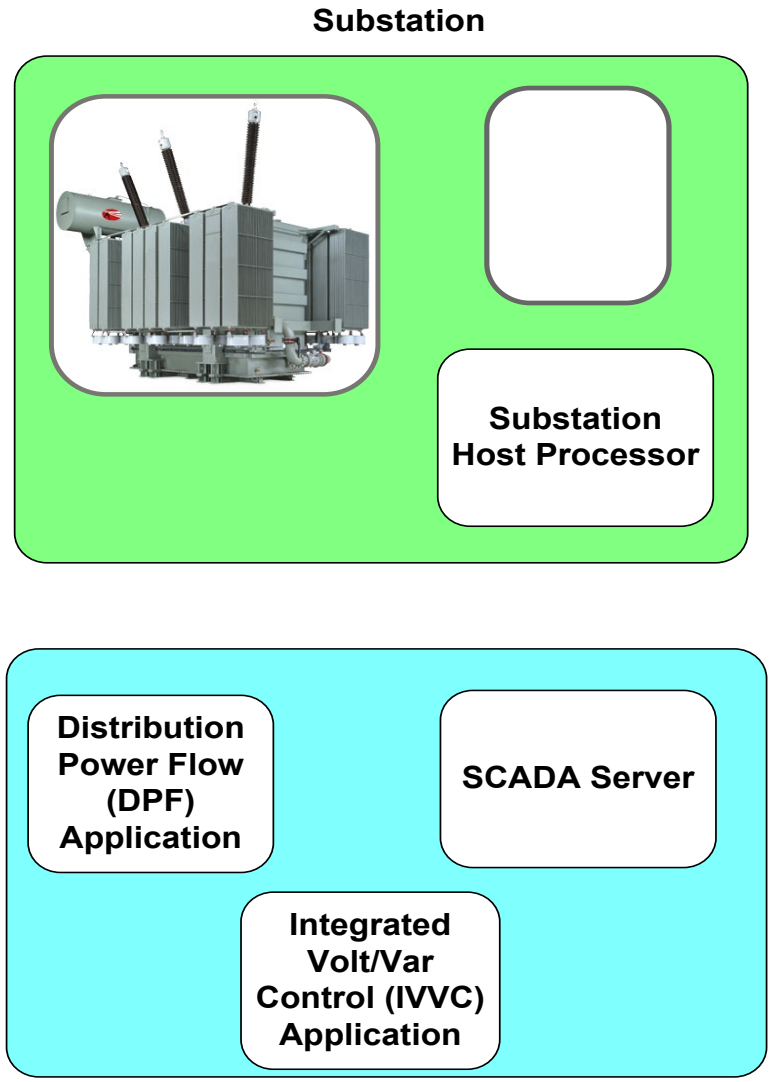


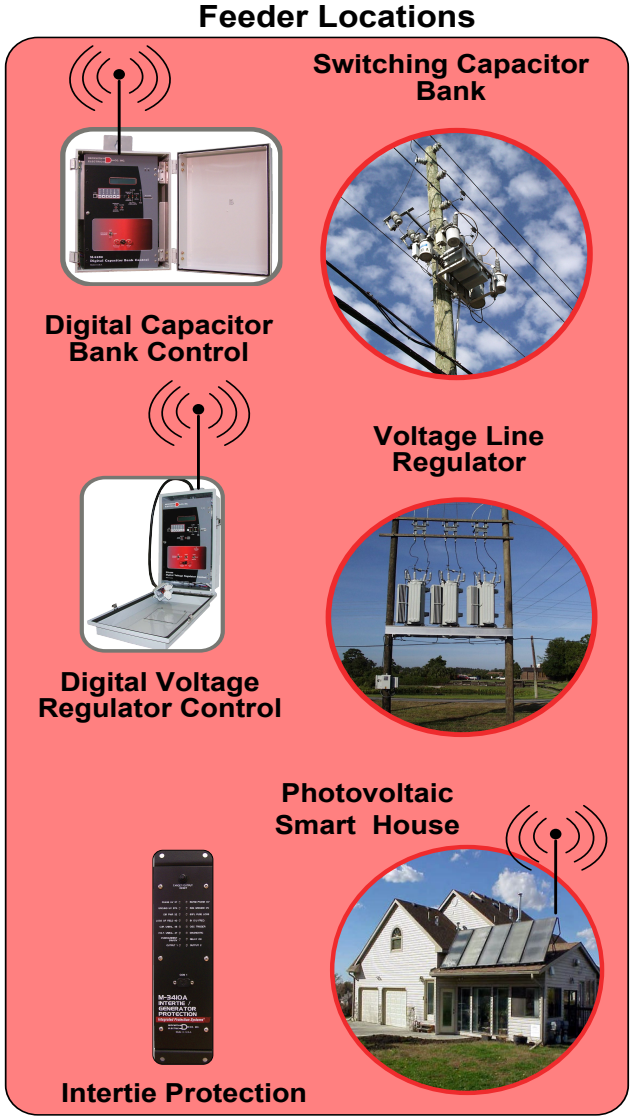
Example of Centralized with communications using the Real- Time Power Flow method

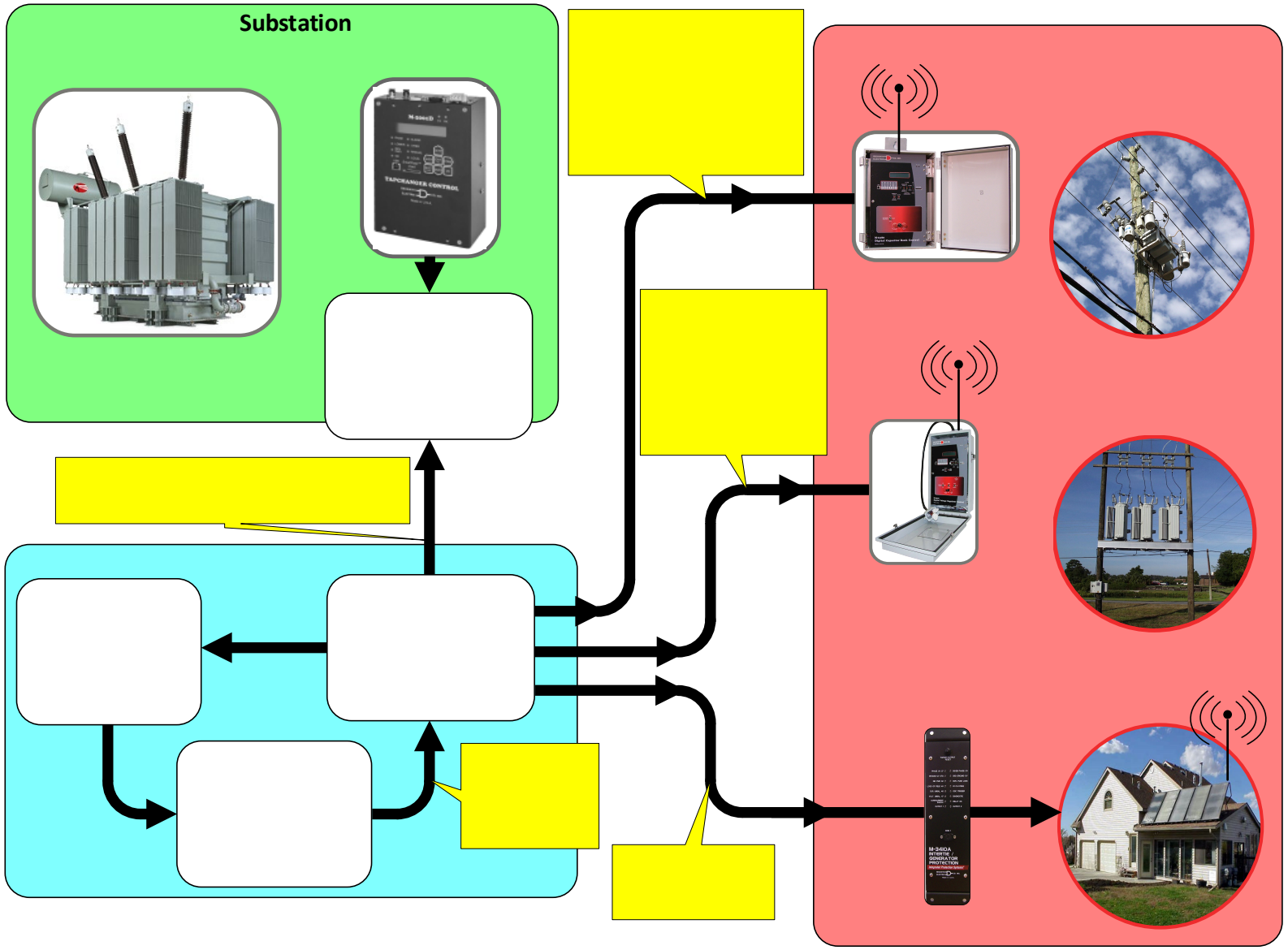




Example of Centralized with communications using the Real- Time Power Flow method






Substation

References

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- https://www.dnp.org/Portals/0/AboutUs/DNP3%20Primer%20Rev%20A.pdf
- https://www.trianglemicroworks.com/docs/default-source/referenced-documents/DNP3_Overview.pdf

An overview of SCADA and Heartbeat functionality as it relates to VVO

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