# Modeling the AMSC D-VAR® VVO STATCOM in the CYME 8.2R1 and Above Distribution Software

## July 9, 2019

# Document Revision History

| Revision # | Date | Description | By | Reviewed |
|---|---|---|---|---|
| 01 | 1/24/17 | Initial Release | JDDL | MG |
| 02 | 1/28/19 | Update to capture the new VAR Compensator model in CYME 8.2R1 | RR | BD |
| 03 | 7/9/19 | Editorial changes and updated Figure 5 with a note for targeting 0 kVAR | RR | BD |
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## Introduction

The CYME distribution software, produced by Eaton, is used by many utilities to study their distribution systems. The software allows the user to conduct loadflow analysis – the study of the power system's voltage and current flows under steady state conditions.

AMSC manufactures a STATCOM device for use on the distribution system - the **D-VAR® VVO**. The D-VAR® VVO is a STATCOM which can be directly connected on 15 kV class feeders and is available in a 1 MVAR 3 phase rating. A single phase version, one-third the size of the three phase, is also available. The device, capable of supplying both inductive and capacitive reactive power, is used to regulate voltage or power factor on the distribution system.

CYME added significant STATCOM modeling improvements in the 8.2R1 release that more accurately reflect VVO capabilities. This document provides a description of how the AMSC D-VAR VVO can be modeled in the CYME 8.2R1 software package and above. AMSC has a separate modeling guide for older versions of CYME that can be provided by contacting AMSC Network Planning team.

## CYME Model Library – VAR Compensator

Introduced in CYME 8.2R1, a VAR Compensator under **Equipment > Power Electronics > VAR Compensator** is suitable for STATCOM modeling. Use the settings shown in Figure 1 to represent the AMSC D-VAR VVO:

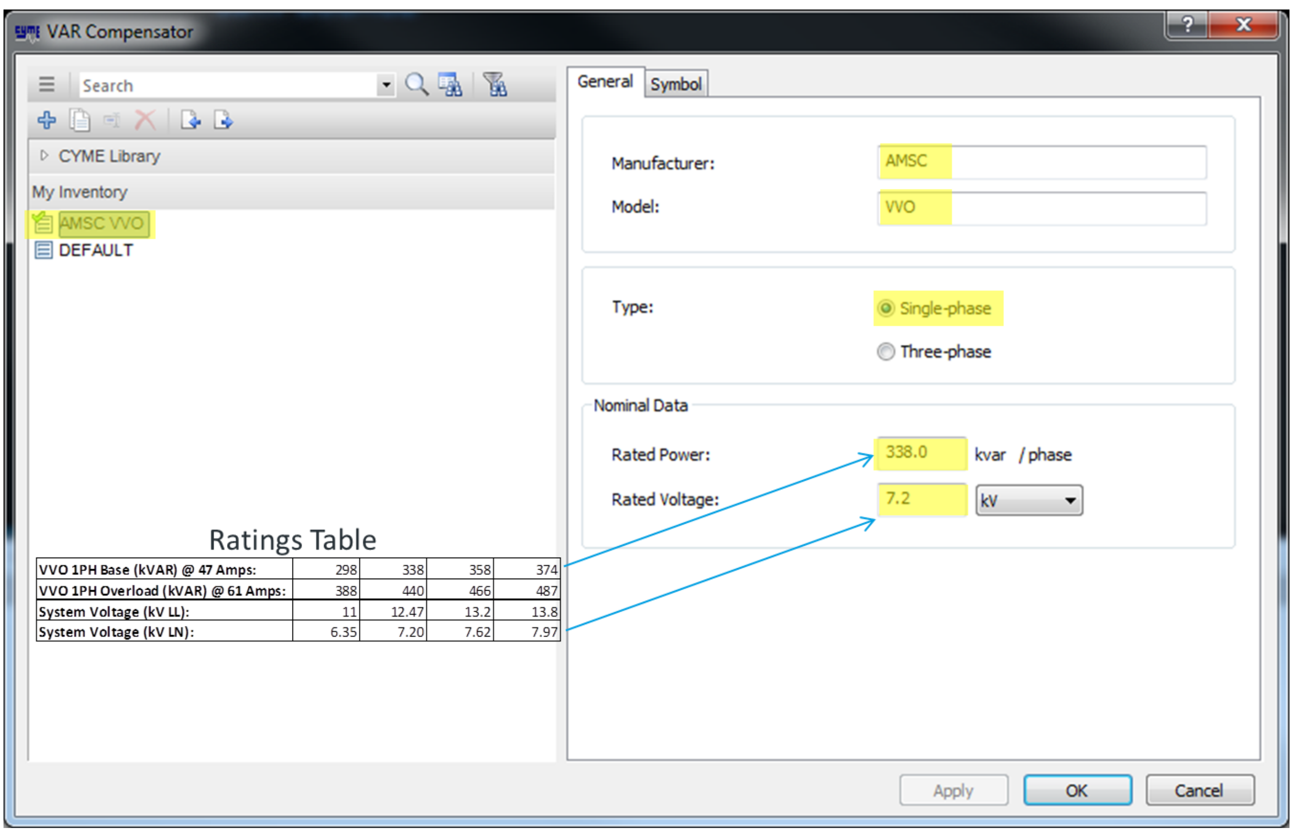


**Figure 1: Adding the VVO to CYME's Equipment Library**

For simplicity, the VVO is described as a 1000 kVAR device, or 333 kVAR/PH. This is sufficient to represent the VVO on most 15 kV feeders. More accurately, however, the VVO is capable of supplying up to 47 Amps of reactive current per phase continuously and up to 61 Amps of reactive current per phase for 60 seconds. How much reactive power this produces depends on the operating voltage at the VVO terminals according to:

$$VVO\ kVAR\ Output = \frac{(VVO\ Amps)(LL\ Voltage)(\sqrt{3})}{3} = \frac{(47A)(12.47kV)(\sqrt{3})}{3} = 338\ kVAR$$

The Ratings Table Shown in Figure 1 shows the expected kVAR output at typical nominal circuit voltages and can be used instead of 333kVAR/PH. For most analysis, the VVO 3PH base KVAR rating can be used for the VAR Compensator *Rated Power*. For some other applications that require shorter response time, such as motor start locked-rotor analysis, the VVO 3PH overload KVAR rating can be utilized.

## Installing the VAR Compensator VVO Model on a Feeder:

The **Explorer>Equipment Inventory>Power Electronics>VAR Compensator** menu will now include the VVO model. The VVO can be dragged and dropped onto the appropriate node in the model to add the device. Double-click the VVO and confirm the settings shown in Figure 2.

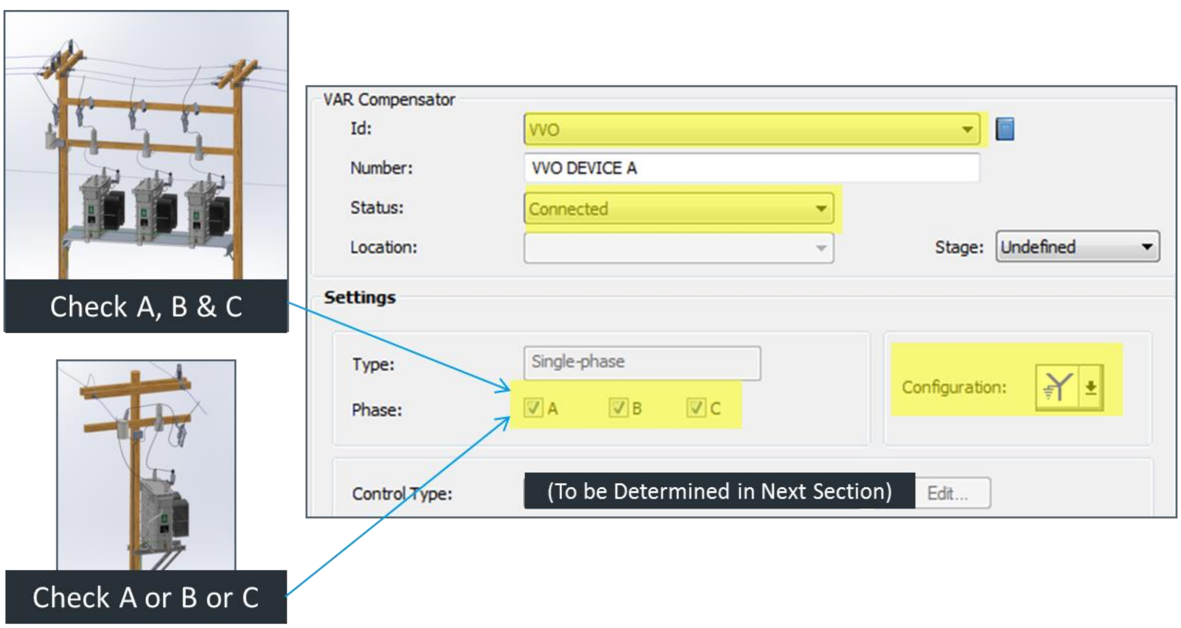


**Figure 2: Add the VVO in a CYME Feeder Model**

The VVO can be installed in the field as a Grounded Wye or Floating Wye configuration but not Delta. In the field, when the VVO is installed in Grounded Wye it can be configured to inject dissimilar or equal amounts of reactive current per phase. When the VVO is installed in the field as a Floating Wye configuration it can only inject an equal amount of reactive current per phase.

CYME offers the ability to install the VVO in Grounded Wye but not Floating Wye. CYME's Grounded Wye VAR compensator always injects dissimilar reactive current per phase based on per phase voltage readings. This difference can be ignored when the VVO is being studied on a feeder with relatively well balanced loads.

## VVO Operating Modes & CYME Modeling Equivalent

**VVO Mode #1: Volt/VAR**
**(CYME Equivalent: Volt-VAR)**

In this mode the VVO maintains the feeder voltage within a certain range at the regulated point by injecting capacitive and inductive VARs. The default Volt-VAR curve is shown in Figure 3, which can be updated with application specific settings:

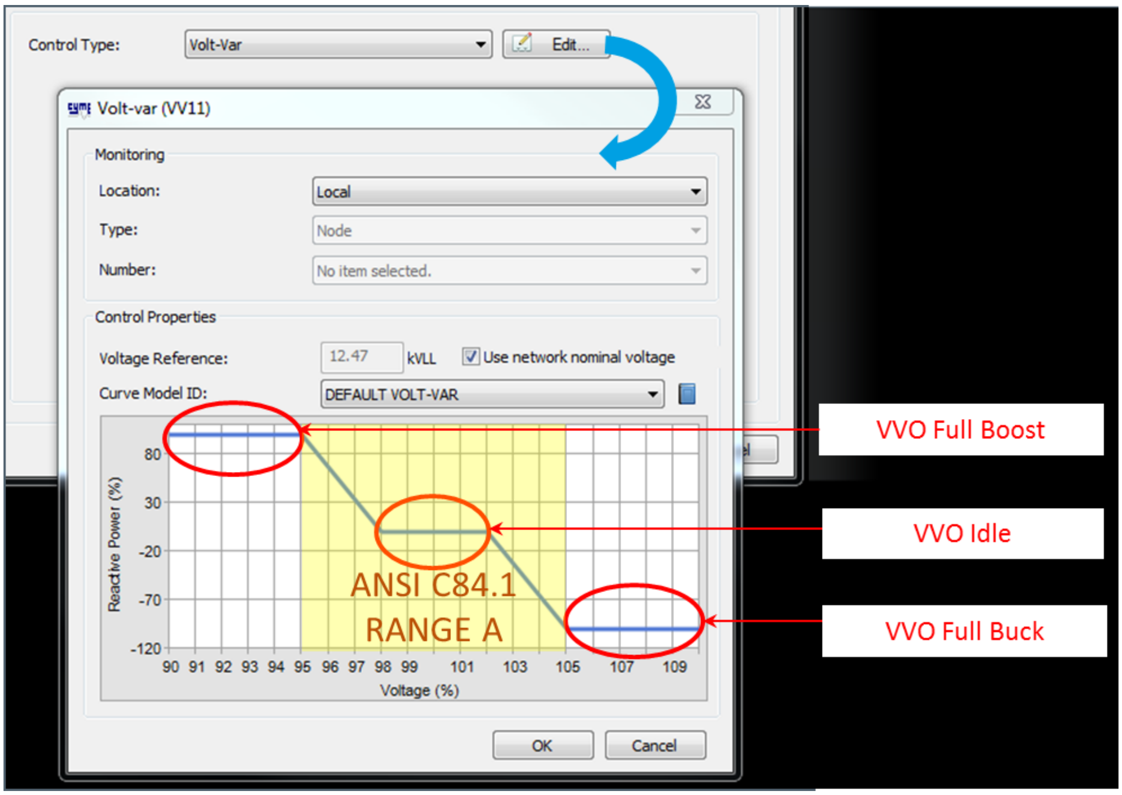


**Figure 3: CYME VAR Compensator Default Volt VAR Curve**

This default option makes sense for a VVO installed on a feeder where the goal is to maintain voltages within ANSI C84.1 Range A (95% to 105% of nominal voltage) and the existing voltage regulation devices have voltage targets near 120 V on a 120 V basis.

At its limits, CYME's VAR Compensator in Volt-VAR mode acts as a constant power device which does not properly simulate the VVO's constant current behavior. This discrepancy can be important, particularly when the feeder voltage is far from nominal.

For example, consider a VVO using the Volt-VAR curve shown in Figure 3 connected to a very stiff 12.47 kV source. If the source is raised to 1.1PU Voltage CYME will simulate the VVO absorbing 1,014 kVAR inductive, or if the source is lowered to 0.9PU Voltage CYME will simulate the VVO injecting 1,014 kVAR capacitive. In the field, the VVO will actually absorb 47 Amps inductive at 1.1PU (1,116 kVAR) or 47 Amps capacitive (914 kVAR) at 0.9PU voltage.

**VVO Mode #2: Feeder Power Factor**
**(CYME Equivalent: Power Factor Controlled)**
In this mode the VVO supplies reactive power to maintain a constant feeder power factor (as measured at the VVO) according to the power factor set point. The VVO's dynamic range can refine the power factor achievable with discrete capacitor stages and reduce unnecessary reactive power imbalances (VAR losses). Be sure to select "Constant Current" as the behavior at limits.

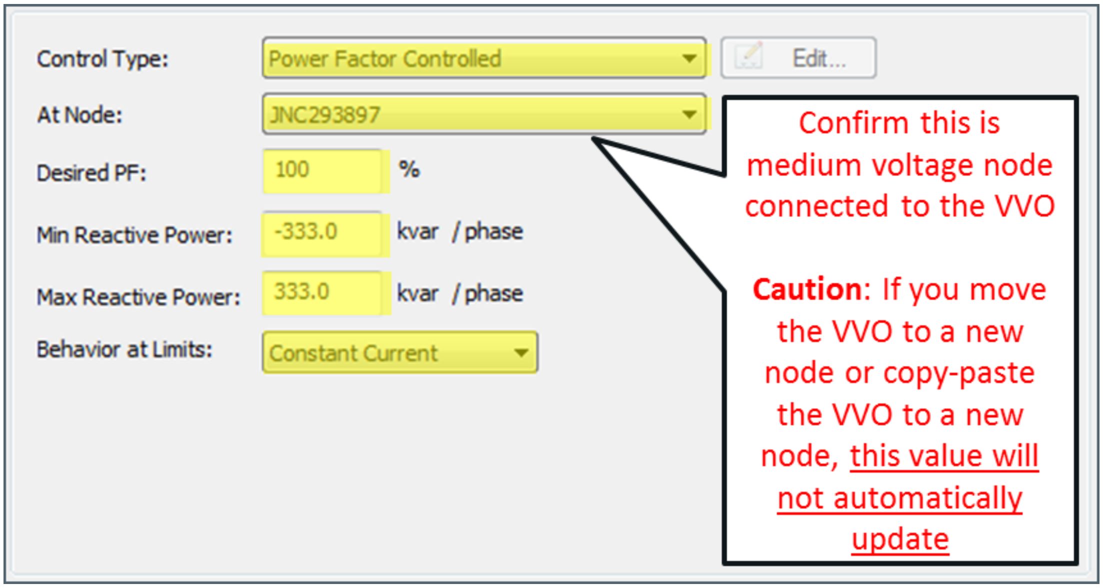


**Figure 4: CYME Var Compensator Power Factor Control Options**

When the VVO is installed to optimize power factor on a Feeder it's recommended to use *Desired PF = 100%*.

**VVO Mode #3: Feeder VAR**
**(CYME Equivalent: Var Controlled)**
The Feeder VAR mode measures the reactive current flow on the feeder line and injects reactive current to meet a certain net VAR target at the monitored node. This mode has the fastest speed-of-response compared to all other modes which makes it ideal for addressing voltage sag caused by sudden changes in downstream reactive demand. A common example is when a large motor is started across the line. Use the VVO overload ratings shown in Figure 1 for motor start studies since the VVO will utilize it's 1.3X overload capability during these sudden voltage dips induced by the locked-rotor condition of the motor.

The Feeder VAR mode is only concerned with the net measured kVAR, unlike Power Factor mode which is concerned with the relationship between measured kW and kVAR.

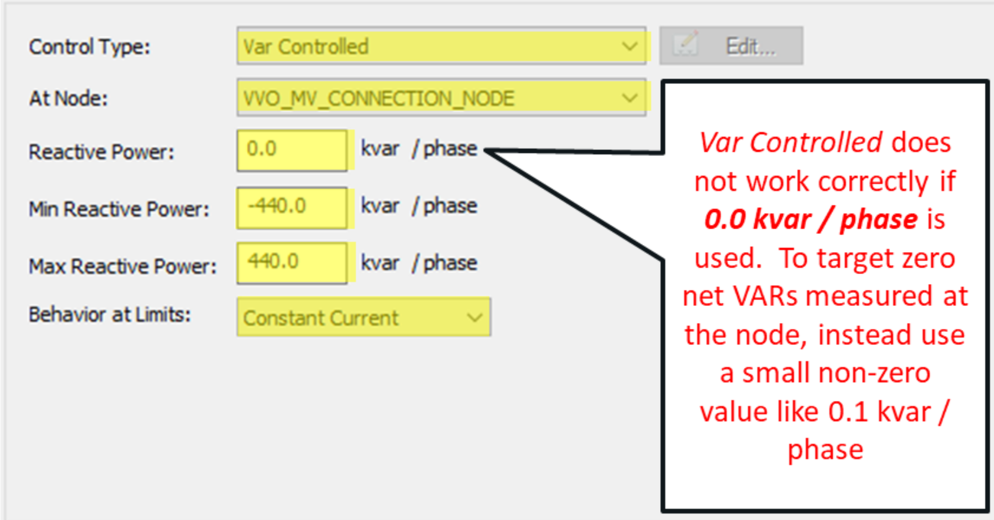


**Figure 5: CYME Power Factor Control Used to Simulate VVO Feeder Var Mode**

**VVO Mode #4: Reactive Demand Mode**
**(CYME Equivalent: Fixed Var)**

In this mode the VVO maintains a constant reactive current output at the terminals of the power electronic units. This means that the VVO will vary its injected current as the operating voltage changes so that a fixed VAR value (inductive or capacitive) is maintained.

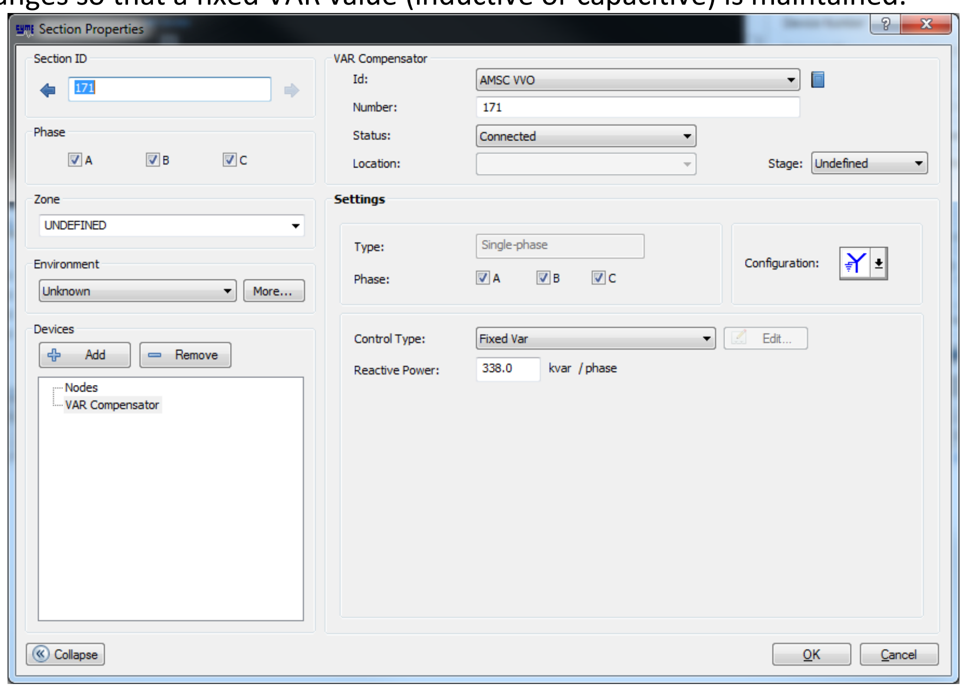


**Figure 6: CYME VAR Compensator in Fixed Var Mode**

The CYME equivalent is shown Figure 6. This accurately represents the VVO in constant susceptance mode except when "Reactive Power" in Figure 6 is set to the maximum VVO rating and the system operating voltage is below nominal.

Since the VVO is a constant current device limited to 47 Amps steady-state it cannot maintain its rated kVAR value as a constant susceptance if the voltage is below nominal. If the VVO is set to maintain 338 kVAR/phase and voltage drops to 0.9 PU on a 12.47kV System, the VVO would generate 304 kVAR/phase before reaching its current limit:

$$VVO\ kVAR = \frac{(VVO\ Amps)(LL\ Voltage)(\sqrt{3})}{3} = \frac{(47A)(12.47kV * 0.9)(\sqrt{3})}{3} = 304\ kVAR$$

The CYME equivalent acts as a constant power device rather than constant current and assumes the VVO could inject 51.5 Amps at 0.9 PU in order to maintain constant susceptance of 338 kVAR/phase.

To avoid this discrepancy, input a Reactive Power setting on the Fixed Var Control Mode that the VVO can achieve with 47 Amps at the lowest expected operating voltage. For instance set Reactive Power to a maximum of 304 kVAR in the case of a 12.47 kV system that could operate as low as 0.9 PU voltage at the VVO terminals.

**QUESTIONS?**

**Contact AMSC:**
**Ryan Rainville**
**NetworkPlanning@amsc.com**