Modeling the AMSC D-VAR VVO™ STATCOM in the WindMil Distribution Software

November 2, 2020

Document Revision History

Revision #	Date	Description	By	Reviewed
01	8/28/17	Initial Release (Windmil 8.6.6.9782)	JDDL	MG
02	11/02/2020	Verified applicability to WindMil 8.7.53, minor document revisions	RR	TF

Introduction

The WindMil distribution software, produced by Milsoft, is used by many municipal and COOP 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. For example, utility facilities can be placed out-of-service, and loadflow analysis will show what the new steady state voltages and currents will be.

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 to 15 kV without a transformer and can be installed in a three-phase or single-phase configuration. It is available in a three-phase configuration at 12.47 kV in 1000 kVAR, and 2000 kVAR ratings. Figure 1 shows the D-VAR VVO's three-phase and single-phase kVAR ratings at other 15 kV class voltages.

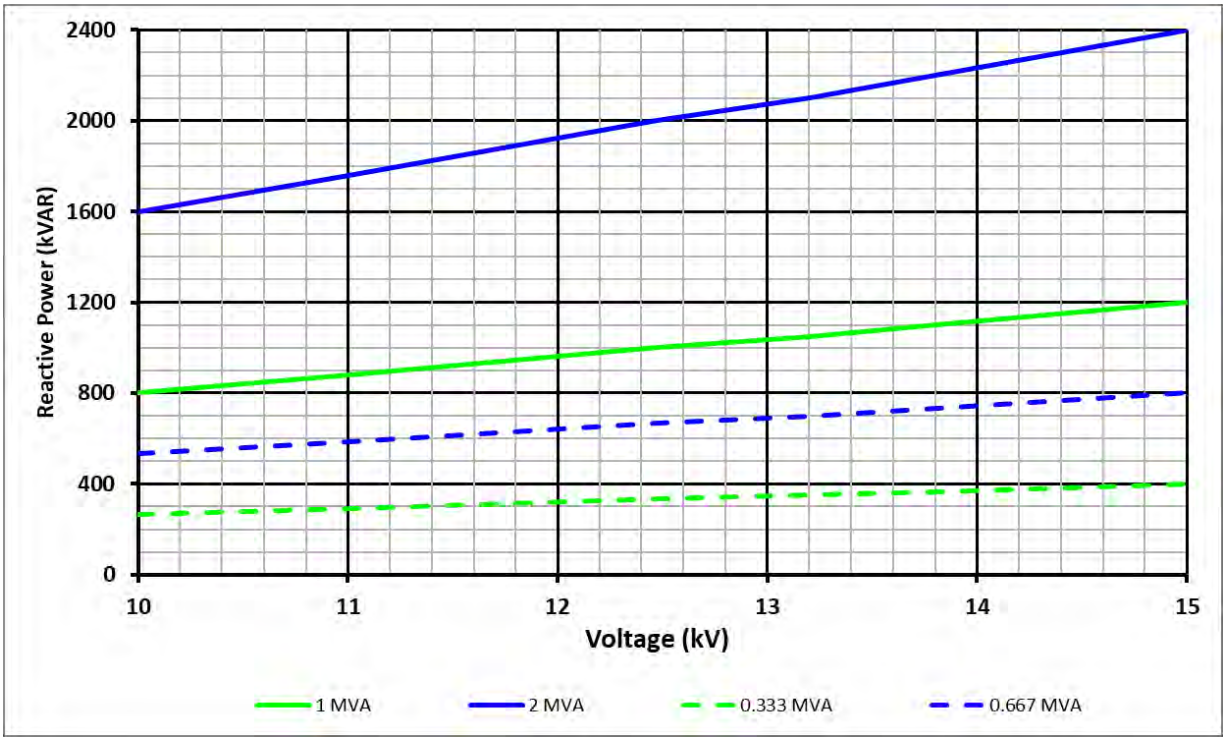


Figure 1: D-VAR VVO Rating Based Upon Voltage

The device, capable of supplying both inductive and capacitive reactive power, is used to regulate voltage or power factor on the distribution system.

The benefits of the D-VAR VVO can be studied using the WindMil software. This document provides a description of how the AMSC D-VAR VVO can be modeled in the WindMil software package using a **generator** model available in the Circuit Element Palette toolbar.

WindMil Model Library – Generator Model

While WindMil does not have a STATCOM model, a **generator** model set as a synchronous condenser can be used. Thus, the WindMil **generator** mode is recommended. Information on the **generator** model is found under **Help > Contents > Editing Element Attributes > Circuit Element Editor > Circuit Element Editor – Generator Data Tab** and the **Circuit Element Palette toolbar**.

STATCOM Component

A STATCOM, on the distribution system, is represented by a **generator** with zero (kW) output as shown in Figure 2. Figure 3 shows the Generator Data tab. The Generator Model pulldown should be set for **"Swing kvar"**. The voltage the *generator is to hold* should be set to the magnitude of voltage the generator is tasked to maintain in **PU Volts**. The **Maximum leading output** and **Maximum lagging output** specify the STATCOM's capacitive and inductive outputs.

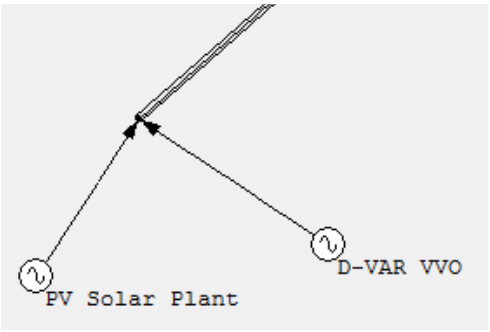


Figure 2: STATCOM (Generator) Added to PV Solar Plant's Interconnection Point

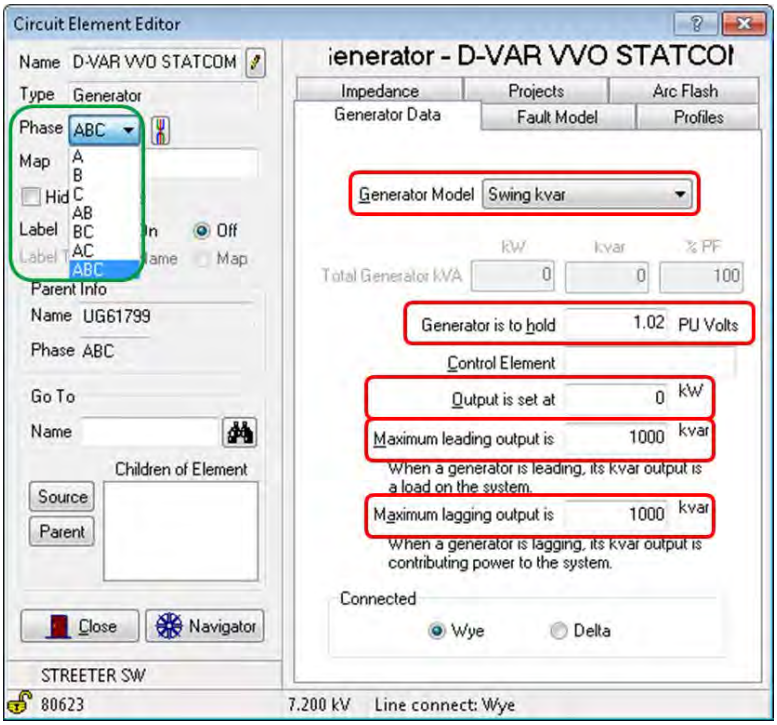


Figure 3: Generator Data Tab with STATCOM Parameters

It is also important to update the Analysis Manager settings for Voltage Drop. On the Solution Options tab, uncheck "Allow Swing Generators to exceed kVAR limits" as shown in Figure 4:

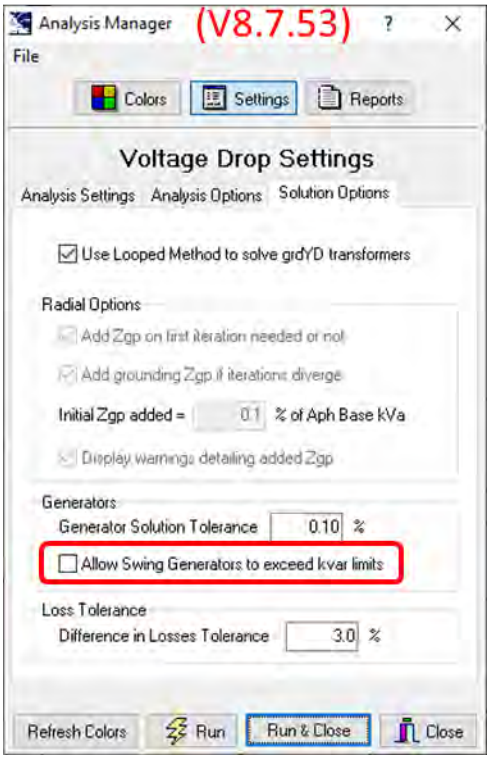


Figure 4: Analysis Manager Settings

The *Generators* section of Solution Options is not available in older versions of Windmil; it was introduced sometime between V8.7.7 and V.7.40. If the option identified in Figure 4 is not available, or is checked, the software will not limit the reactive power to the maximum leading/lagging value of 1000 kVAR. It will only flag the generator symbol graphically and on printouts when the input value is exceeded. Thus, the STATCOM's output values will have to be closely watched in older versions of Windmil to ensure they do not exceed the STATCOM's capabilities.

The D-VAR VVO STATCOM can be either a three-phase or single-phase device. The WindMil software supports both options by changing the "Phase" pulldown shown in Figure 5. If it is required that a three-phase STATCOM do unbalanced compensation, add three single-phase generators each controlling a different phase voltage. The reactive output of each single-phase STATCOM is ⅓ that of the three-phase STATCOM. See Figure 5.

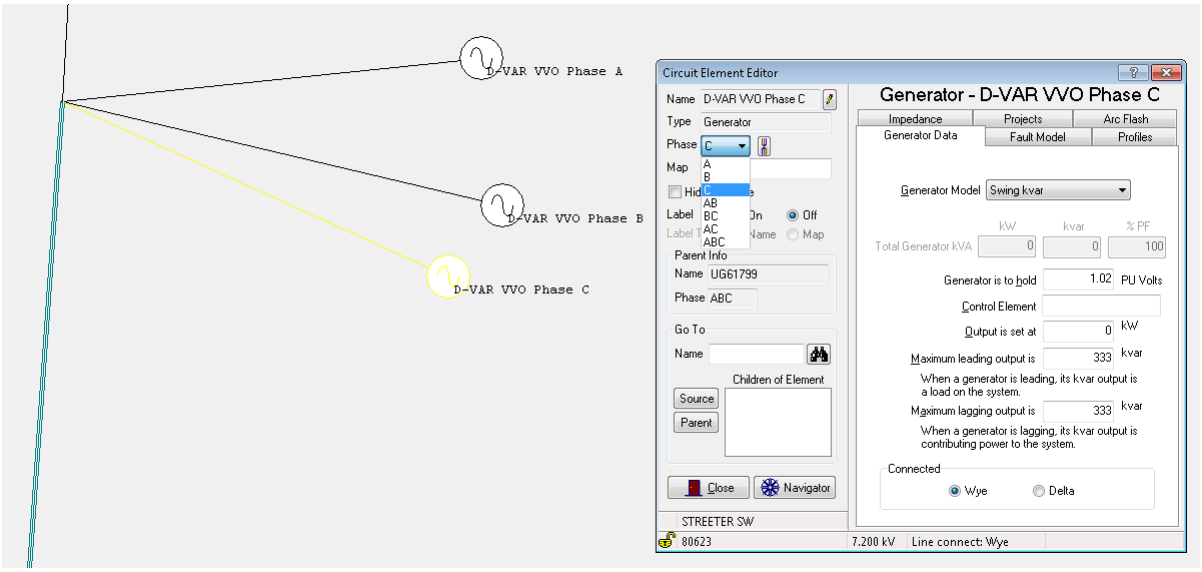


Figure 5: Three Single-Phase STATCOMs Set for Unbalanced 3-Phase Compensation

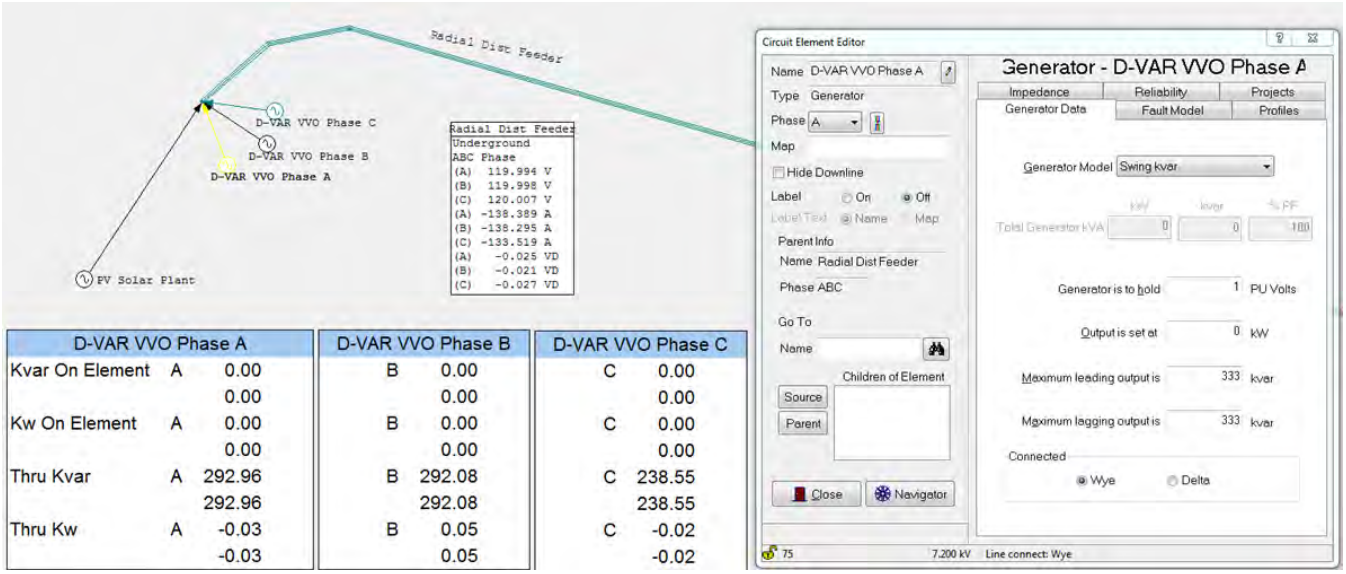
STATCOM Settings

The key model parameters and example settings are defined in Table 1 below.

Table 1: Key Model Parameters

STATCOM Model Parameters	Parameter Definition	Example Settings
Status	The status can place the model in-service (Connect Circuit) or out-of-service (Disconnect Circuit)	Connect Circuit
Control Type	Select Swing kVAR (This is voltage control)	Swing kVAR
Desired Voltage (PU Volts)	The desired voltage is the regulated voltage set point that the STATCOM will hold	1.000
Maximum Leading Output (kVAR)	This defines the STATCOM capacitive rating	1000
Maximum Lagging Output (kVAR)	This defines the STATCOM inductive rating	1000

Figure 6 shows some loadflow results using three single-phase STATCOMs holding unity (1.000 pu) voltage. The phase voltages are very close to 120 volts which would be unity voltage. The three STATCOMs, modeled as synchronous condensers, show a slight kW output/input due to a slight loadflow mismatch at the interconnection point.



D-VAR VVO Phase A			D-VAR VVO Phase B		D-VAR VVO Phase C	
Kvar On Element	A	0.00	B	0.00	C	0.00
		0.00		0.00		0.00
Kw On Element	A	0.00	B	0.00	C	0.00
		0.00		0.00		0.00
Thru Kvar	A	292.96	B	292.08	C	238.55
		292.96		292.08		238.55
Thru Kw	A	-0.03	B	0.05	C	-0.02
		-0.03		0.05		-0.02

Figure 6: Loadflow Results for Three Single-Phase STATCOM VVOs

Any type of rotating machine, like a synchronous condenser, will add significant fault power to the location that the device is connected to. That is not the case for an inverter based device like the D-VAR VVO STATCOM. The STATCOM can only contribute its output current during the fault and only as long as the fault is greater than 50% voltage. Below 50% voltage the STATCOM will inhibit it's out (zero output current) until the voltage is greater than 50% once again.

When the D-VAR VVO is connected grounded wye, the fault power behavior is the following:

- Three phase fault: 61 amps (47amps*1.3 overload factor) in each phase capacitive (below 50% remaining voltage, inhibit gating yields no fault current contribution)
- Single phase fault: 61 amps in the faulted phase capacitive (below 50% remaining voltage, inhibit gating yields no fault current contribution)
- Line-Line fault: 61amps in each faulted phase capacitive (below 50% remaining voltage, inhibit gating yields no fault current contribution)

The fault current contribution is low enough that a zero fault contribution can be used as an estimate.

QUESTIONS?

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