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

## November 2, 2020



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## **Document Revision History**

Revision #	Date	Description	Ву	Reviewed		
01	8/28/17	Initial Release (Windmil 8.6.6.9782)	JDDL	MG		
02	11/02/2020	1/02/2020 Verified applicability to WindMil 8.7.53, minor document revisions		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.

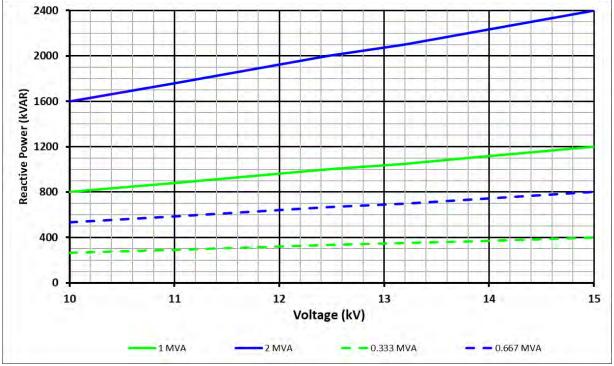


Figure 1: D-VAR VVO Rating Based Upon Voltage

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.

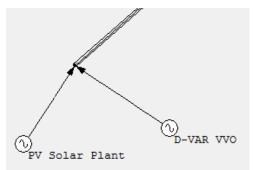
## WindMil Model Library – Generator Model

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

Name D-VAR VVO STATCOM 🖉	ienerator - D-	-VAR VVC	) STA	TCOI			
ype Generator	Impedance	Projects	s Arc Flas				
	Generator Data	Fault Model		Profiles			
Map A B Hid C AB	Generator Model	Swing kvar		•			
abel BC In Off		RW 1	cyar	% PF			
ABC ABC AMAP	Total Generator KVA	0	0	100			
Name UG61799	Generate	or is to hold	1.02	PU Volts			
Phase ABC	Control Element						
Go To	Outp	out is set at	0	kW			
Name 🏄	<u>M</u> aximum leadin	ig output is	1000	kvar			
Children of Element	When a gene a load on the	erator is leading, it system.	s kvar outp	outis			
Parent	M <u>a</u> ximum laggin		1000	kvar			
		rator is lagging, it ower to the syste		out is			
	Connected						
Close 🛞 Navigator	Wye	e 💿 Del	ta				
STREETER SW							

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:

-	
	Voltage Drop Settings alysis Settings Analysis Options Solution Options
Hrid	tites serunds what second second second
	Use Looped Method to solve grdYD transformers
ł	Radial Options
	Add Zgp on limit Relation needed or not
	Real Add grounding Zgp If iterations diverge
	Initial Zgp added = 0.1 % of Aph Base kVa
	🔄 Dieplay warnings detailing added Zgp
(	Generators Generator Solution Tolerance 0.10 %
1	Allow Swing Generators to exceed kvar limits
1	
1	Loss Tolerance

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 <u>not</u> 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  $\frac{1}{3}$  that of the three-phase STATCOM. See Figure 5.



	BAVAR VVO Phase A	Circuit Element Editor	? 💌
,		Name D-VAR VVO Phase C 👔	Generator - D-VAR VVO Phase C
		Type Generator	Impedance Projects Arc Flash
l l		Phase C 🗸	Generator Data Fault Model Profiles
		Map A B	
		🕅 Hid C 💿	Generator Model Swing kvar 👻
	D-VAR VVO Phase B	AB Label BC Dn @ Off	
	U-VAR VVO FILABE B	Label TAC Jama O Man	kW kvar % PF
		Parent Info	Total Generator kVA 0 0 100
		Name UG61799	Generator is to hold 1.02 PU Volts
	D-VAR VVO Phase C	Phase ABC	Control Element
			1317
		Go To	
		Name 🏄	Maximum leading output is 333 kvar
		Children of Element	When a generator is leading, its kvar output is a load on the system.
		Source	Maximum lagging output is 333 kvar
		Parent	When a generator is lagging, its kvar output is
			contributing power to the system.
			Connected
		📃 Close 🛞 Navigator	💿 Wye 💿 Delta
1		STREETER SW	
		-	7.200 kV Line connect: Wye
			•

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.

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		

#### Table 1: Key Model Parameters

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.



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

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		-	~	Radial Dist p			Circuit Eleme	nt Editor				2 2
					eeder		Name D-	VAR VVO Phase A	Generator	- D-VA	RVVC	Phase A
	/	D-VAR	VO Phase C	Radial Dist	Feeder		Type Ge Phase A		Impedance Generator Data	Relia Fau	bility It Model	Projects Profiles
/	/	D-VAR VVO Pha	O Phase B se A	Underground ABC Phase (A) 119.9 (B) 119.9	94 V		Map		Generator Mod	lel Swing k	var	•
/				<pre>(C) 120.0 (A) -138.3 (B) -138.2 (C) -133.5</pre>	89 A 95 A 19 A		Label Debet Tex Parent In	On Off Name Map fo	Total Generator HV/	kai/	live 0	0 - 50F 0 180
O PV Solar	Flan			(B) -0.0.	25 VD 21 VD 27 VD		Name P Phase A	Radial Dist Feeder BC	Generat	or is to <u>h</u> old		1 PU Volts
D-VAR VV	OP	hase A	D-VAR	/VO Phase B	D-VAR V	VO Phase C	Go To Name	A	Qut	out is set at		0 KW
Kvar On Element	A	0.00	В	0.00 0.00	C	0.00	Source	Children of Element	<u>M</u> aximum leadi	ng output is		333 kvar
Kw On Element	A	0.00	В	0.00	с	0.00	Parent		Mgximum laggi Connected	ng output is		333 kvar
Thru Kvar	A	292.96 292.96	В	292.08 292.08	c	238.55 238.55		ose 🛞 Navigator	e W	ye	O Delta	
Thru Kw	A	-0.03 -0.03	В	0.05	с	-0.02 -0.02	<b>1</b> 75	7.200 kV	Line connect: Wye			

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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