Solectria Modbus Level 9

for models

SGI 500XTM/750XTM

Revision A

Table of Contents

1. Solectria Modbus Level 9

Introduction:

This manual explains the Modbus protocol in use for Yaskawa Solectria Solar's inverters and equipment. This does not include the history of Modbus or the details regarding the creation of the protocols. It is expected that the person(s) reading this manual have a clear understanding of Modbus.

Each register/data point contains a raw 16-bit signed or unsigned number. The appropriate multiplier must be applied to each word to obtain the scaled representation. Each word is ordered {MSB, LSB}.

Registers can be read using Modbus function code three (3) and certain registers can be written with Modbus function code six (6). Offsets are as given. The equivalent Modicon register is also provided (Offset+40001).

1.1. Determining the Modbus Level

Various Modbus levels are available on inverters produced by Solectria, depending on inverter model and firmware release. The Modbus level can be determined by performing a Modbus read (function 3) to Offset 38. All inverters implementing this particular Modbus level will return a value of nine (9) for this register.

Modbus Level Supported

Modbus Offset:	38
Modicon Register:	40039
Type:	int16u
Write:	No
Data Value:	9
Description:	Indicates Modbus Level supported by a particular inverter.

1.2. Determining the Firmware Version

Two firmware versions, D002 and D003, use Modbus level 9. Most registers are used by both firmware versions, but D003 adds additional functionality and registers. Any references to D002 or D003 refer to that specific firmware version.

To determine which firmware version is used, read Offset 35.

- 53250 (Decimal) means D002 (Hex)
- 53251 (Decimal) means D003 (Hex)

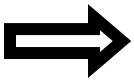
All registers or bits that are unique to D003 are marked with * next to the offset.

1.3. Definition of Acronyms

- HFRT: High Frequency Ride Through
- HVRT: High Voltage Ride Through
- LFRT: Low Frequency Ride Through
- LVRT: Low Voltage Ride Through
- PF: Power Factor
- CW: Clockwise
- CCW: Counter-Clockwise
- MSW Most Significant Word
- LSW: Least Significant Word
- RCM: Residual Current Monitoring
- LCP: Local Control Panel

1.4. Symbols in This Document

WARNING: This symbol, along with the word "**WARNING**", indicates a fact or feature important for the safety of the user and/or which can cause serious hardware damage if not applied appropriately.



NOTE: This indicates a feature that is important either for optimal and efficient use or system operation.

EXAMPLE: This indicates an example

1.5. Positive and Negative Reactive Current and Power

A positive value means the inverter appears as a capacitive load on the grid.

A negative value means the inverter appears as an inductive load on the grid.

1.6. Positive and Negative Power Factor

A positive value means the inverter appears has a capacitive Power Factor.

A negative value means the inverter appears as an inductive Power Factor.

1.7. Real and Reactive Operating Regions

The inverter has several power/current limits that define the real and reactive operating regions. These can be defined using apparent power, real power, reactive power, and power factor, see Figure 1-1.

1. Maximum Apparent Power is limited by the rated power of the inverter, either 500 (SGI 500XTM or 750 kVA (SGI 750XTM).
2. Maximum Real Power is limited by the rated real power of the inverter, either 500 (SGI 500XTM) or 750 kW (SGI 750XTM).
3. Maximum Reactive Power is limited to 60% of the rated apparent power, either 300 (SGI 500XTM) or 450 kvar (SGI 750XTM).
4. Fixed PF is ranged from ± 0.8.

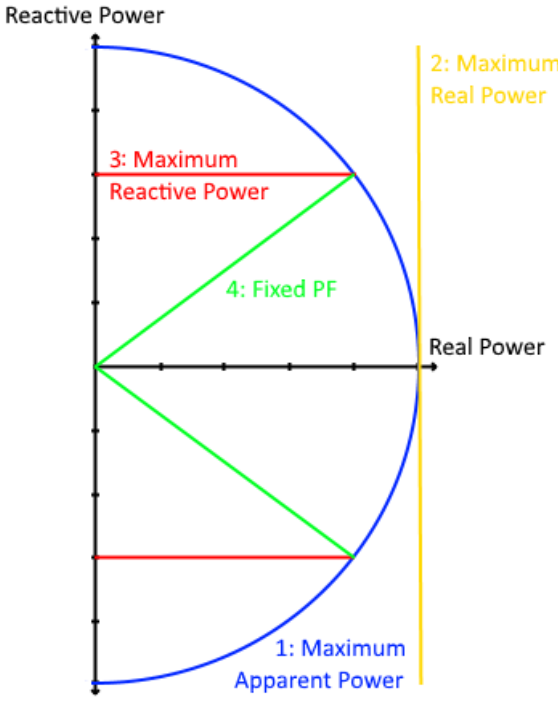


Figure 1-1 Operating Regions for Power

2. Modbus Register Tables

2.1. Group 1: Metering

Table 2-1 Metering

Modicon	Modbus	Description	Unit	Multiplier	Type	Default	Range (unscaled)	Write
40001	0	Measured DC input voltage A value of 32768 (8000 hex) means that the DC contactors are open (no DC Voltage).	V	0.1953125	int16s	N/A	N/A	No
40002	1	Apparent AC Power Output (D003) or Real AC Power Output (D002) Measured apparent power in VA (D003) or real power output in W (D002)	VA or W	19.53125	int16u	N/A	N/A	No
40003	2	AC Grid Frequency Measured grid frequency in Hz	Hz	0.00610352	int16s	N/A	N/A	No
40005	4	L1-to-L2 AC Voltage Line-to-line voltage between L1 and L2	V	0.1953125	int16s	N/A	N/A	No
40006	5	L2-to-L3 AC Voltage Line-to-line voltage between L2 and L3	V	0.1953125	int16s	N/A	N/A	No
40007	6	L1-to-L3 AC Voltage Line-to-line voltage between L1 and L3	V	0.1953125	int16s	N/A	N/A	No
40008	7	Phase Sequence Phase sequence of 3 phase system. 0=Not Locked 1=CW (ABC) 2=CCW (ACB)	-	-	enum16	N/A	[0,2]	No
40081	80	Real AC Power	W	19.53125	int16u	N/A	N/A	No
40082	81	Reactive Power A positive number means the inverter appears as a capacitive load on the grid. A negative number means the inverter appears as an inductive load on the grid.	VAr	19.53125	int16s	N/A	N/A	No
40083	82	Reactive Power Available Maximum producible reactive power given real power production.	var	19.53125	int16s	N/A	N/A	No

40094	93	Total Output Current (D003) or Inverter Output Real Current Average (D002) D002: Average real current of all three phases D003: Total output current of all three phases	A	0.0976563	int16s	N/A	N/A	No
*40509	*508	Indicated Power Factor Real time calculated power factor.	%	0.01	int16s	N/A	[0,10000]	No

2.2. Group 2: Energy Count

Table 2-2 Energy Count

Modicon	Offset	Description	Unit	Multiplier	Type	Default	Range (unscaled)	Write
40009	8	AC Energy MSW Total AC energy generated over inverter's lifetime MSW. Cumulative AC Energy = ((MSW*65536) + LSW) Note: This formula assumes the multiplier has been applied before calculating.	kWh	0.1	int16u	N/A	N/A	No
40010	9	AC Energy LSW Total AC energy generated over inverter's lifetime LSW. Cumulative AC Energy = ((MSW*65536) + LSW) Note: This formula assumes the multiplier has been applied before calculating.	kWh	0.1	int16u	N/A	N/A	No
40101	100	Cumulative Reactive Energy Generated MSW Cumulative reactive energy generated over inverter's lifetime MSW. Cumulative AC Energy = ((MSW*65536) + LSW) Note: This formula assumes the multiplier has been applied before calculating. Generated refers to a capacitive load on the grid.	kVArh	0.1	int16u	N/A	N/A	No
40102	101	Cumulative Reactive Energy Generated LSW Cumulative reactive energy generated over inverter's lifetime LSW. Cumulative AC Energy = ((MSW*65536) + LSW) Note: This formula assumes the multiplier has been applied before calculating. Generated refers to a capacitive load on the grid.	kVArh	0.1	int16u	N/A	N/A	No

40103	102	Cumulative Reactive Energy Received MSW Cumulative reactive energy received over inverter's lifetime MSW. Cumulative AC Energy = ((MSW*65536) + LSW) Note: This formula assumes the multiplier has been applied before calculating. Received refers to an inductive load on the grid.	kVArh	0.1	int16u	N/A	N/A	No
40104	103	Cumulative Reactive Energy Received LSW Cumulative reactive energy generated over inverter's lifetime LSW. Cumulative AC Energy = ((MSW*65536) + LSW) Note: This formula assumes the multiplier has been applied before calculating. Received refers to an inductive load on the grid.	kVArh	0.1	int16u	N/A	N/A	No

2.3. Group 3: Historical Stat

Table 2-3 Historical Stat

Modicon	Offset	Description	Unit	Multiplier	Type	Default	Range (unscaled)	Write
40012	11	Grid Connected Hours Total hours the inverter has been grid connected over its lifetime.	h	1	int16u	N/A	N/A	No
40013	12	Fan On-Time Hours Total hours the fan has been in operation.	h	1	int16u	N/A	N/A	No
40170	169	Residual Current Monitor (RCM) Lifetime Counter Total RCM events the inverter has experienced over its lifetime.	-	1	int16u	N/A	N/A	No

2.4. Group 4: Communications

Table 2-4 Communications

Modicon	Offset	Description	Unit	Multiplier	Type	Default	Range (unscaled)	Write
40015	14	Network ID (or Slave ID) Note that the change takes immediate effect. The next communication with the inverter has to use the new ID.	-	-	int16u	N/A	[1,247]	Yes
40138	137	Modbus Last Exception Cause Modbus Communication errors, see Modbus Exception.	-	-	enum16	N/A	N/A	No
40165	164	RCM Modes Specifies how the RCM functions. 0= RCM not installed. 1= RCM not enabled. 2= Warning only, no shutdown. Core sets RCM Warning. 3= Shut down only.	-	-	enum16	N/A	[0,3]	Yes
40166	165	RCM Daily Event Threshold Limit of RCM events in a day before shutdown. “1” would mean shutdown on the first event. If RCM is not installed, this is “0”.	-	1	int16u	N/A	[0,99]	Yes
40167	166	RCM Duration Threshold Time limit of the duration for any RCM event before shutdown. If RCM is not installed, this is “0”.	s	0.1	int16u	N/A	[0,6000]	Yes
40168	167	RCM Daily Restart Limit Limit on the number of restarts after a RCM event	-	1	int16u	N/A	[0,200]	No
40169	168	RCM Daily Counter Total RCM events the inverter has experienced during the current day. If greater than RCM Daily Event Threshold, shutdown will occur.	-	1	int16u		[0,65535]	No

2.5. Group 5: Alarms

Table 2-5 Alarms

Modicon	Offset	Description	Unit	Multiplier	Type	Default	Range (unscaled)	Write
40016	15	Critical Alarms See Critical Alarms	-	-	bitfield16	N/A	N/A	No
40017	16	Informative Alarms 1 See Informative Alarms 1	-	-	bitfield16	N/A	N/A	No
40020	19	Informative Alarms 2 See Informative Alarms 2	-	-	bitfield16	N/A	N/A	No
40140	139	UL 1741/IEEE 1547 Fault Cause See UL 1741/IEEE 1547 Fault Cause	-	-	enum16	N/A	N/A	No
40141	140	Hardware Failure Cause See Hardware Failure Cause	-	-	enum16	N/A	N/A	No
40142	141	Power Off Cause See Power Off Cause	-	-	enum16	N/A	N/A	No

2.6. Group 6: SolZone

Table 2-6 SolZone

Modicon	Offset	Description	Unit	Multiplier	Type	Default	Range (unscaled)	Write
40021	20	Zone 1 DC Current	A	0.1	int16s	N/A	N/A	No
40022	21	Zone 2 DC Current	A	0.1	int16s	N/A	N/A	No
40023	22	Zone 3 DC Current	A	0.1	int16s	N/A	N/A	No
40024	23	Zone 4 DC Current	A	0.1	int16s	N/A	N/A	No
40025	24	Zone 5 DC Current	A	0.1	int16s	N/A	N/A	No
40026	25	Zone 6 DC Current	A	0.1	int16s	N/A	N/A	No
40027	26	Zone 7 DC Current	A	0.1	int16s	N/A	N/A	No
40028	27	Zone 8 DC Current	A	0.1	int16s	N/A	N/A	No
40029	28	Total DC Current – All Zones Sum of PV zone currents.	A	0.1	int16s	N/A	N/A	No
40143	142	Zone 9 DC Current	A	0.1	int16s	N/A	N/A	No
40144	143	Zone 10 DC Current	A	0.1	int16s	N/A	N/A	No
40145	144	Zone 11 DC Current	A	0.1	int16s	N/A	N/A	No
40146	145	Zone 12 DC Current	A	0.1	int16s	N/A	N/A	No
40147	146	Zone 13 DC Current	A	0.1	int16s	N/A	N/A	No
40148	147	Zone 14 DC Current	A	0.1	int16s	N/A	N/A	No
40149	148	Zone 15 DC Current	A	0.1	int16s	N/A	N/A	No
40150	149	Zone 16 DC Current	A	0.1	int16s	N/A	N/A	No

For all Solzone registers, a value of 32768 (8000h) means that none of the SolZone sensors are connected.

2.7. Group 7: Nameplate Info

Table 2-7 Nameplate Info

Modicon	Offset	Description	Unit	Multiplier	Type	Default	Range (unscaled)	Write
40032	31	Inverter Manufacturer Year and Month Inverter Serial Number appears as YYMMDD-##, with each pair in hex; this register is for YYMM, with YY being the MSW and MM being the LSW. To read, convert the decimal to hex and separate the MSW and the LSW. Convert the MSW and LSW to decimal to calculate YY and MM, respectively. For example, 3339 → 0x0D0B. MSW = 0x0D → 13 (2013) LSW = 0x0B → 11 (November) 3339 → November, 2013	-	-	int16u	N/A	N/A	No
40033	32	Inverter Manufacturer Day and Serial Number Inverter Serial Number appears as YYMMDD-##, with each pair in hex; this register is for DD##, with DD being the MSW and ## being the LSW. To read, convert the decimal to hex and separate the MSW and the LSW. Convert the MSW and LSW to decimal to calculate DD and ##, respectively. For example, 7693 → 0x1E0D MSW = 0x1E → 30 (30th day of the month) LSW = 0x0D → 13 (serial number 13) 7693 → 30th with serial number 13	-	-	int16u	N/A	N/A	No
*40035	*34	AC Current Rating (Amps RMS)	A	1	int16u	N/A	N/A	No
40074	73	Real Power Rating	kW	1	int16u	N/A	N/A	No
40076	75	Nominal AC Voltage (Volts RMS).	V	1	int16u	N/A	N/A	No
*40080	*79	Reactive Power Rating	kvar	1	int16u	N/A	N/A	No
*40158	*157	Minimum Power Factor	-	0.0001	int16u	N/A	N/A	No
*40160	*159	Nominal Frequency	Hz	1	int16u	N/A	N/A	No
40161	160	Maximum Real Power (Same as Real Power Rating [Offset 73])	kW	1	int16u	N/A	N/A	No
*40162	*161	Maximum Apparent Power	kVA	1	int16u	N/A	N/A	No
*40163	*162	Maximum Reactive Power	kvar	1	int16u	N/A	N/A	No
*40334	*333	Power Factor Rating Minimum (absolute value) power factor produced at rated apparent power	-	1	int16u	0.8	N/A	No

2.8. Group 8: Firmware Version and Modbus Level

Table 2-8 Firmware Version and Modbus Level

Modicon	Offset	Description	Unit	Multiplier	Type	Default	Range (unscaled)	Write
40036	35	Firmware Version 53250 → Hex = D002 53251 → Hex = D003; Offsets marked with * are D003 only	-	-	int16u	N/A	N/A	No
40039	38	Modbus Level Supported Indicates Modbus Level supported by a particular inverter.	-	-	int16u	N/A	N/A	No

2.9. Group 9: AC Protection

Table 2-9 AC Protection

Modicon	Offset	Description	Unit	Multiplier	Type	Default	Range (unscaled)	Write
40041	40	AC High Voltage Setting If the voltage of the line voltage feedback is above this setting longer than the time specified by 'AC High Voltage Clearing Time' (Offset 48), an 'AC Voltage High' fault (Offset 16, Bit 4) will occur.	V	0.1953125	int16s	2140	[1946, (Offset 558)]	Yes
40042	41	AC Very High Voltage Setting If the voltage of the line voltage feedback is above this setting longer than the time specified by 'AC Very High Voltage Clearing Time' (Offset 245), an 'AC Voltage Very High' fault (Offset 16, Bit 5) will occur.	V	0.1953125	int16s	2334	[1946,(Offset 559)]	Yes
40043	42	AC Reconnect High Voltage Setting The voltage level that the line voltage feedback has to be below, for the inverter to clear the 'AC Voltage High' Fault (Offset 16, Bit 4) and reconnect to the grid.	V	0.1953125	int16s	2059	[1946, 2059]	Yes
40044	43	AC Low Voltage Setting If the voltage of the line voltage feedback is below this setting longer than the time specified by 'AC Low Voltage Clearing Time' (Offset 49), an 'AC Voltage Low fault (Offset 16, Bit 3) will occur.	V	0.1953125	int16s	1713	[(Offset 556), 1946]	Yes
40045	44	AC Very Low Voltage Setting If the voltage of the line voltage feedback is below this setting longer than the time specified by 'AC Very Low Voltage Clearing Time' (Offset 246), an 'AC Voltage Very Low' fault (Offset 16, Bit 2) will occur.	V	0.1953125	int16s	943	[(Offset 555), 1946]	No

Modicon	Offset	Description	Unit	Multiplier	Type	Default	Range (unscaled)	Write
40046	45	AC High Frequency Setting If the frequency is above this setting longer than the time specified by 'AC High Frequency Clearing Time' (Offset 248), an 'AC Frequency High' fault (Offset 16, Bit 13) will occur.	Hz	0.00610352	int16s	9912	[9830, (Offset 557)]	No
40047	46	AC Low Frequency Setting If the frequency is below this setting longer than the time specified by 'AC Low Frequency Clearing Time' (Offset 50), an 'AC Frequency Low' fault (Offset 16, Bit 12) will occur.	Hz	0.00610352	int16s	9716	[(Offset 554), 9830]	No
40048	47	AC Very Low Frequency Setting If the frequency is below this setting longer than the time specified by 'AC Very Low Frequency Clearing Time' (Offset 247), an 'AC Frequency Low' fault (Offset 16, Bit 12) will occur.	Hz	0.00610352	int16s	9339	[(Offset 555), 9830]	No
40049	48	AC High Voltage Clearing Time Duration that the line voltage has to be above the level specified by the 'AC High Voltage Setting' (Offset 40) for an 'AC Voltage High' fault (Offset 16, Bit 4) to occur.	s	0.01	int16s	100	[(Offset 561), (Offset 568)]	Yes
40050	49	AC Low Voltage Clearing Time Duration that the line voltage has to be below the level specified by the 'AC Low Voltage Setting' (Offset 43) for an 'AC Voltage Low' (Offset 16, Bit 3) fault to occur.	s	0.01	int16s	200	[(Offset 561), (Offset 567)]	Yes
40051	50	AC Low Frequency Clearing Time Duration that the frequency has to be below the level specified by 'AC Low Frequency Setting' (Offset 46) for an 'AC Frequency Low' (Offset 16, Bit 12) fault to occur.	s	0.01	int16s	16	[(Offset 560), (Offset 563)]	Yes
40052	51	UL Fault Reconnect Wait Time Setting Duration the inverter remains disconnected from the grid after a protection fault is cleared.	s	0.01	int16u	30000	[100, 60000]	Yes
40053	52	AC Low Voltage Reconnect Limit The minimum AC Voltage to reconnect after any UL Fault event.	V	0.195313	int16u	1719	N/A	No
40054	53	AC High Frequency Reconnect Limit The maximum AC Frequency to reconnect any UL Fault event.	Hz	0.195313	int16u	9914	N/A	No
40055	54	AC Low Frequency Reconnect Limit The minimum AC Frequency to reconnect after any UL Fault event.	Hz	0.195313	int16u	9714	N/A	No

Modicon	Offset	Description	Unit	Multiplier	Type	Default	Range (unscaled)	Write
40057	56	AC Very High Frequency Setting If the frequency is above this setting longer than the time specified by 'AC Very High Frequency Clearing Time' (Offset 57), an 'AC Frequency High' fault (Offset 16, Bit 13) will occur.	Hz	0.00610352	int16s	9912	[9830, (Offset 557)]	Yes
40058	57	AC Very High Frequency – Clearing Time Duration that the frequency has to be above the level specified by 'AC Very High Frequency Setting' (Offset 56) for an 'AC Frequency Very High' (Offset 16, Bit 13) fault to occur.	s	0.01	int16u	16	[(Offset 560), (Offset 565)]	No
40084	83	UL Wait Time Remaining Countdown for the inverter to reconnect to the grid after a protection fault is cleared. Countdown starts from 'UL Fault Reconnect Wait Time Setting' (Offset 51).	s	0.01	int16s	N/A	N/A	No
40246	245	AC Very High Voltage Clearing Time Duration that the line voltage has to be above the level specified by the 'AC Very High Voltage Setting' (Offset 41) for an 'AC Voltage Very High' fault (Offset 16, Bit 5) to occur.	s	0.01	int16u	16	[11,16]	Yes
40247	246	AC Very Low Voltage Clearing Time Duration that the line voltage has to be below the level specified by the 'AC Very Low Voltage Setting' (Offset 44) for an 'AC Voltage Very Low' fault (Offset 16, Bit 2) to occur.	s	0.01	int16u	16	[11,60000]	Yes
40248	247	AC Very Low Frequency Clearing Time Duration that the frequency has to be below the level specified by the 'AC Very Low Frequency Setting' (Offset 47) for an 'AC Frequency Very Low' fault (Offset 16, Bit 12) to occur.	s	0.01	int16u	16	[11,60000]	Yes
40249	248	AC High Frequency Clearing Time Duration that the frequency has to be above the level specified by 'AC High Frequency Setting' (Offset 45) for an 'AC Frequency High' (Offset 16, Bit 13) fault to occur.	s	0.01	int16u	16	[11,60000]	Yes
40555	554	AC Low Frequency Setting Lower Bound Minimum frequency setting for Low Frequency.	Hz	0.0610352	int16s	9339	-	No
40556	555	AC Very Low Voltage Setting Lower Bound Minimum voltage setting for Very Low Frequency.	V	0.1953125	int16s	972	-	No

Modicon	Offset	Description	Unit	Multiplier	Type	Default	Range (unscaled)	Write
40557	556	AC Under Voltage Setting Lower Bound Minimum voltage setting for Under Voltage.	V	0.1953125	int16s	1712	-	No
40558	557	AC High Frequency Setting Upper Bound Maximum frequency setting for High Frequency.	Hz	0.0610352	int16s	9914	-	No
40559	558	AC High Voltage Setting Upper Bound Maximum voltage setting for High Voltage.	V	0.1953125	int16s	2140	-	No
40560	559	AC Very High Voltage Setting Upper Bound Maximum voltage setting for Very High Voltage.	V	0.1953125	int16s	2336	-	No
40561	560	AC Frequency Timeout Setting Lower Bound Minimum timeout setting for abnormal frequency condition.	s	0.01	int16u	11	-	No
40562	561	AC Voltage Timeout Setting Lower Bound Minimum timeout setting for abnormal voltage condition.	s	0.01	int16u	8	-	No
40563	562	AC Very Low Frequency Timeout Setting Upper Bound Maximum timeout setting for Very Low Frequency.	s	0.01	int16u	16	-	No
40564	563	AC Low Frequency Timeout Setting Upper Bound Maximum timeout setting for Low Frequency.	s	0.01	int16u	30000	-	No
40565	564	AC High Frequency Timeout Setting Upper Bound Maximum timeout setting for High Frequency.	s	0.01	int16u	60000	-	No
40566	565	AC Very High Frequency Timeout Setting Upper Bound Maximum timeout setting for Very High Frequency.	s	0.01	int16u	16	-	No
40567	566	AC Very Low Voltage Timeout Setting Upper Bound Maximum timeout setting for Very Low Voltage.	s	0.01	int16u	16	-	No
40568	567	AC Low Voltage Timeout Setting Upper Bound Maximum timeout setting for Low Voltage.	s	0.01	int16u	3000	-	No
40569	568	AC High Voltage Timeout Setting Upper Bound Maximum timeout setting for High Voltage.	s	0.01	int16u	3000	-	No
40570	569	AC Very High Voltage Timeout Setting Upper Bound Maximum timeout setting for Very High Voltage.	s	0.01	int16u	16	-	No

2.10. Group 10: Power Control

Table 2-10 Power Control

Modicon	Offset	Description	Unit	Multiplier	Type	Default	Range (unscaled)	Write
40059	58	Permanent AC Output Limit Mode This register determines whether the Permanent AC Output Limit Percentage (Offset 158) is Current limiting or Power Limiting. 0 = Limit Current. (Default) 1= Limit Power and Current. This can only be set from the front panel. For D002, a power cycle is required for this change to take place.	-	-	enum16	0	[0,1]	No
*40062	*61	Temporary AC Output Current Limit This register temporarily limits the inverter AC output current from 0 - 100% of its rating. The effects are immediate, but are cleared when the inverter is shutdown or DSP is rebooted. See the Installation and Operation manual for other operational details	%	0.0061035 15625	int16u	16384	[0,16384]	Yes
*40078	*77	Variable Save Request Used to save any Write accessible variables in Groups 1-12. Variables that are not saved do not use the new value and will revert upon reboot. Saved variables are used and will persist upon reboot (unless otherwise noted). 0: Default state. No action. 1: Request to save variables. It will be cleared once save function is done. The inverter will power down for several seconds if running to save variables.	-	-	enum16	0	[0,1]	Yes
*40079	*78	Reboot Command 0: Default state. No action. 1: Request to reboot the controller. It will be cleared once inverter reboots.	-	-	enum16	0	[0,1]	Yes
40113	112	Remote Power Disable 0: Enable Power Output 1: Disable Power Output The effects are immediate, but are cleared when the inverter is shutdown or DSP is rebooted. See the Installation and Operation manual for other operational details	-	-	enum16	0	[0,1]	Yes

Modicon	Offset	Description	Unit	Multiplier	Type	Default	Range (unscaled)	Write
40159	158	Permanent AC Output Limit Percentage Depending on the Permanent AC Output Limit Mode setting (see offset 58) either the current or power will be limited to a percentage of its nameplate rating. The range is from 0% - 100%. If an XTM 500 is set to 15401 (94%), the rating becomes 470 kW, if in Power Limiting mode or 714.4A if in current limiting mode. This can only be set from the front panel. For this limit to take effect, recycle power or wait until the next day.	%	0.0061035 15625	int16u	16384	[0,16384]	No

2.11. Group 11: Temperature

Table 2-11 Temperature

Modicon	Offset	Description	Unit	Multiplier	Type	Default	Range (unscaled)	Write
40085	84	IGBT 1 Phase A Temperature Temperature of the Phase A IGBT for the Master (top) DMGI	°C	0.0976563	int16s	N/A	N/A	No
40086	85	IGBT 1 Phase B Temperature Temperature of the Phase B IGBT for the Master (top) DMGI	°C	0.0976563	int16s	N/A	N/A	No
40087	86	IGBT 1 Phase C Temperature Temperature of the Phase C IGBT for the Master (top) DMGI	°C	0.0976563	int16s	N/A	N/A	No
40088	87	IGBT 2 Phase A Temperature Temperature of the Phase A IGBT for the Slave1 (middle) DMGI	°C	0.0976563	int16s	N/A	N/A	No
40089	88	IGBT 2 Phase B Temperature Temperature of the Phase B IGBT for the Slave1 (middle) DMGI	°C	0.0976563	int16s	N/A	N/A	No
40090	89	IGBT 2 Phase C Temperature Temperature of the Phase C IGBT for the Slave1 (middle) DMGI	°C	0.0976563	int16s	N/A	N/A	No
40091	90	IGBT 3 Phase A Temperature Temperature of the Phase A IGBT for the Slave2 (bottom) DMGI	°C	0.0976563	int16s	N/A	N/A	No
40092	91	IGBT 3 Phase B Temperature Temperature of the Phase B IGBT for the Slave2 (bottom) DMGI	°C	0.0976563	int16s	N/A	N/A	No
40093	92	IGBT 3 Phase C Temperature Temperature of the Phase C IGBT for the Slave2 (bottom) DMGI	°C	0.0976563	int16s	N/A	N/A	No
40155	154	Power Stage 1 Ambient Temperature Temperature of the power stage of the Master (top) DMGI.	°C	0.0976563	int16s	N/A	N/A	No
40156	155	Power Stage 2 Ambient Temperature Temperature of the power stage of the Slave1 (middle) DMGI.	°C	0.0976563	int16s	N/A	N/A	No
40157	156	Power Stage 3 Ambient Temperature Temperature of the power stage of the Slave2 (bottom) DMGI.	°C	0.0976563	int16s	N/A	N/A	No

2.12. Group 12 SmartGrid Controls, Status, and Triggering

Table 2-12 SmartGrid Controls, Status, and Triggering

Modicon	Offset	Description	Unit	Multiplier	Type	Default	Range (unscaled)	Write
40164	163	Power Priority Sets whether the inverter functions prioritize real or reactive power. 1=Real (Watt) priority 2=Reactive (var) priority (Default)	-	-	enum16	2	[1,2]	Yes
40172	171	Control MSW Control MSW enables/disables smart grid features for use, but does not activate them. The appropriate bit must be set high (enabled) prior to triggering. For each bit “1” means enabled, “0” means disabled. BIT4: Reactive Power Ramp Rate BIT3: Real Power Ramp Rate *Bit1: Soft Start Ramp Rate *Bit0: Normal Ramp Rate	-	-	bitfield16	0000 (Hex)	-	Yes
40173	172	Control LSW Control LSW enables/disables smart grid features for use, but does not activate them. The appropriate bit must be set high (enabled) prior to triggering. For each bit “1” means enabled, “0” means disabled. BIT15: Frequency-Watt BIT14: Remote Connect/Disconnect BIT11: HVRT BIT10: LVRT BIT7: Volt-Var BIT6: Reactive Power/Current Control BIT4: Power Factor Control BIT3: Volt-Watt BIT2: Real Power Curtailment BIT1: LFRT BIT0: HFRT	-	-	bitfield16	4000 (Hex)	-	Yes

Modicon	Offset	Description	Unit	Multiplier	Type	Default	Range (unscaled)	Write
40174	173	Status MSW Status MSW when read shows bits are currently active. For each bit, “1” means enabled, “0” means disabled. BIT4: Reactive Power Ramp Rate BIT3: Real Power Ramp Rate *Bit1: Soft Start Ramp Rate *Bit0: Normal Ramp Rate	-	-	bitfield16	0000 (Hex)	-	No
40175	174	Status LSW Status LSW when read shows bits are currently active. For each bit, “1” means enabled, “0” means disabled. BIT15: Frequency-Watt BIT14: Remote Connect/Disconnect BIT11: HVRT BIT10: LVRT BIT7: Volt-Var BIT6: Reactive Power/Current Control BIT4: Power Factor Control BIT3: Volt-Watt BIT2: Real Power Curtailment BIT1: LFRT BIT0: HFRT	-	-	bitfield16	4000 (Hex)	-	No
40176	175	Trigger MSW Trigger MSW activates/disables the corresponding smart grid feature. Control MSW must be set prior to triggering a feature. Write “1” to the appropriate bit to trigger a feature. After the bit is set, Trigger MSW will revert to “0”, and the corresponding Status MSW (offset 173) will read the new status BIT4: Reactive Power Ramp Rate BIT3: Real Power Ramp Rate *Bit1: Soft Start Ramp Rate *Bit0: Normal Ramp Rate		-	bitfield16	0000 (Hex)	-	Yes

Modicon	Offset	Description	Unit	Multiplier	Type	Default	Range (unscaled)	Write
40177	176	Trigger LSW Trigger LSW activates/disables the corresponding smart grid feature. Control MSW must be set prior to triggering a feature. Write “1” to the appropriate bit to trigger a feature. After the bit is set, Trigger LSW will revert to “0”, and the corresponding Status MSW (offset 174) will read the new status. BIT15: Frequency-Watt BIT14: Remote Connect/Disconnect BIT11: HVRT BIT10: LVRT BIT7: Volt-Var BIT6: Reactive Power/Current Control BIT4: Power Factor Control BIT3: Volt-Watt BIT2: Real Power Curtailment BIT1: LFRT BIT0: HFRT	-	-	bitfield16	0000 (Hex)	-	Yes
40178	178	Refresh MSW When read (for each bit): • 0=Function Status and Control bits do not match or the setpoints do not match. • 1= Function Status and Control bits match and the setpoints match. When written to (for each bit): • Write “1” to Refresh MSW to refresh/sync Control bits to match Status bits. Setpoints that have been changed will revert back to the previous values. BIT4: Reactive Power Ramp Rate BIT3: Real Power Ramp Rate *Bit1: Soft Start Ramp Rate *Bit0: Normal Ramp Rate	-	-	bitfield16	0000 (Hex)	-	Yes

Modicon	Offset	Description	Unit	Multiplier	Type	Default	Range (unscaled)	Write
40180	179	Refresh LSW When read (for each bit): • 0=Function Status and Control bits do not match or the values (mode, setpoints, and timing features) for the function do not match. • 1= Function Status and Control bits match and the values (mode, setpoints, and timing features) for the function match. When written to (for each bit): • Write “1” to Refresh MSW to refresh/sync Control bits to match Status bits. Modes, setpoints, and timing features that have been changed will revert back to their previous values. BIT15: Frequency-Watt BIT14: Remote Connect/Disconnect BIT11: HVRT BIT10: LVRT BIT7: Volt-var BIT6: Reactive Power/Current Control BIT4: Power Factor Control BIT3: Volt-Watt BIT2: Real Power Curtailment BIT1: LFRT BIT0: HFRT	-	-	bitfield16	0000 (Hex)	-	Yes
40181	180	Grid Support Default Settings Mode Write value: • 1: To enable custom default settings, making current settings the customer default settings. • 2: To restore factory default settings Note: For Smart Grid parameters (Groups 12-21) only. Note: When custom defaults are in use, this will read 1, otherwise it will read 2 Default settings are applied to Grid Support registers when a feature is deactivated.	-	-	enum16	2	[1,2]	Yes

2.13. Group 13 Remote Connect/Disconnect

Table 2-13 Remote Connect/Disconnect

Modicon	Offset	Description	Unit	Multiplier	Type	Default	Range (unscaled)	Write
40211	210	Connect/Disconnect Time Window	s	1	int16u	0	[0,1800]	Yes
40212	211	Connect/Disconnect Timeout Window	s	1	int16u	0	[0, 64800]	Yes

2.14. Group 14 Real Power Curtailment

Table 2-14 Real Power Curtailment

Modicon	Offset	Description	Unit	Multiplier	Type	Default	Range (unscaled)	Write
40213	212	Real Power Setpoint	%	0.01	int16u	10000	[0,10000]	Yes
40214	213	Real Power Time Window	s	1	int16u	0	[0,1800]	Yes
40215	214	Real Power Timeout Window	s	1	int16u	0	[0,64800]	Yes
40216	215	Real Power Ramp Time	s	1	int16u	0	[0,600]	Yes

2.15. Group 15 Reactive Power/Current Control

Table 2-15 Reactive Power/Current Control

Modicon	Offset	Description	Unit	Multiplier	Type	Default	Range (unscaled)	Write
*40137	*136	Reactive Power/Current Control – Reference Mode, see Section 4.2.3 for more details. 0=Available var Reference Mode (Default): Reactive Power/Current Control Setpoint (offset 216) depends on the Power Priority (offset 163). Real (1): Reactive Power/Current Control Setpoint (offset 216) is entered as a percentage of the maximum real power/current for the inverter. Reactive (2): Reactive Power/Current Control Setpoint (offset 216) is entered as a percentage of the maximum reactive power/current for the inverter. 1=Maximum Real Current Reference Mode: Reactive Power/Current Control Setpoint (offset 216) is entered as a percentage of the maximum real power/current for the inverter. 2= Maximum Reactive Current Reference Mode: Reactive Power/Current Control Setpoint (offset 216) is entered as a percentage of the maximum reactive power/current for the inverter. 3=Maximum Current Reference Mode: Reactive Power/Current Control Setpoint (offset 216) is entered as a percentage of the maximum apparent power/current for the inverter.		-	enum16	0	[0,3]	Yes
40217	216	Reactive Power/Current Control Setpoint	%	0.01	int16s	0	+/- [0,10000]	Yes
40218	217	Reactive Power/Current Control Time Window	s	1	int16u	0	[0,1800]	Yes
40219	218	Reactive Power/Current Control Timeout Window	s	1	int16u	0	[0,64800]	Yes
40220	219	Reactive Power/Current Control Ramp Time	s	1	int16u	0	[0,600]	Yes

2.16. Group 16 Fixed Power Factor

Table 2-16 Fixed Power Factor

Modicon	Offset	Description	Unit	Multiplier	Type	Default	Range (unscaled)	Write
40221	220	Fixed Power Factor Time Window	s	1	int16u	0	[0, 1800]	Yes
40222	221	Fixed Power Factor Timeout Window	s	1	int16u	0	[0, 64800]	Yes
40223	222	Fixed Power Factor Ramp Time	s	1	int16u	0	[0, 600]	Yes
40224	223	Fixed Power Factor Setpoint Multiplier and Scale depend on what mode of Power Factor Control See Offset 224 Power Factor Control for D003 For D002, Power Factor Control is permanently set to var/Watt Mode; see Offset 224	-	0.0001 or 0.0001 or 0.00390625	int16s	10000	+/- [8000,10000] or [8000,10000] or +/- [0,193]	Yes

Modicon	Offset	Description	Unit	Multiplier	Type	Default	Range (unscaled)	Write
40225	224	Power Factor Control Mode Firmware Version D003 (read/write): 0=Signed PF Mode: Power factor setpoint is entered within either the range [-9999,-8000] or [8000,10000]. Use the formula below to calculate the power factor setpoint. • Positive value denotes capacitive reactive current (increasing voltage) • Negative value denotes inductive reactive current (decreasing voltage) Power factor Setpoint (offset 223) = $\pm\frac{pf}{0.0001}$ Note: use only +1 for unity power factor 1=Capacitive Mode: Power factor is entered within the range [8000,10000]. Use the formula below to calculate the power factor setpoint. • Value denotes capacitive reactive current (increasing voltage). Power factor Setpoint (offset 223) = $\frac{pf}{0.0001}$ Note: use only +1 for unity power factor 2=Inductive Mode: Power factor is entered within range Power factor is entered within the range [8000,10000]. Use the formula below to calculate the power factor setpoint. • Value denotes inductive reactive current (decreasing voltage). Power factor Setpoint (offset 223) = $\frac{pf}{0.0001}$ Note: use only +1 for unity power factor 3=Var/Watt Mode: Acceptable power factors range from -0.8 to 0.8. The power factor setpoint is calculated using the following formula. Power factor Setpoint (offset 223) = $\pm\frac{\left(\sqrt{\frac{1}{pf^2}-1}\right)}{0.00390625}$ • Positive value denotes capacitive (increasing voltage) Negative numbers denote inductive (decreasing voltage) Firmware Version D002 (read only): 0=var/Watt Mode: Acceptable power factors range from -0.8 to 0.8. The power factor septpoint is calculated using the following formula. Power factor Setpoint (offset 223) = $\pm\frac{\left(\sqrt{\frac{1}{pf^2}-1}\right)}{0.00390625}$ Positive value denotes capacitive (increasing voltage) ratio, and negative numbers denote inductive (decreasing voltage). Default for both Firmware Versions is 0.	-	-	enum16	0	[0,3] / [0]	Yes / No

2.17. Group 17 Ramp Rates

Table 2-17 Ramp Rates

Modicon	Offset	Description	Unit	Multiplier	Type	Default	Range (unscaled)	Write
*40225	*225	Normal Ramp Rate	%	0.01	int16u	10000	[0,10000]	Yes
*40230	*229	Soft Start Ramp Rate	%	0.01	int16u	10000	[0,10000]	Yes
40244	243	Real Power Ramp Rate	%	0.01	int16u	10000	[0,10000]	Yes
40245	244	Reactive Power Ramp Rate	%	0.01	int16u	10000	[0,10000]	Yes

2.18. Group 18 Voltage Ride Through

Table 2-18 Voltage Ride Through

Modicon	Offset	Description	Unit	Multiplier	Type	Default	Range (unscaled)	Write
*40250	*249	Low Voltage Cessation Level	%	0.01	int16u	5000	[4500, 10000]	Yes
40251	250	LVRT – Number of Points	-	1	int16u	3	[0,10]	Yes
40252	251	LVRT – Must Remain Connected Volt% (#1)	%	0.01	int16u	5000	[0,12000]	Yes
40253	252	LVRT – Must Remain Connected Time (#1)	s	0.01	int16u	100	[0,60000]	Yes
40254	253	LVRT – Must Remain Connected Volt% (#2)	%	0.01	int16u	7000	[0,12000]	Yes
20255	254	LVRT – Must Remain Connected Time (#2)	s	0.01	int16u	1000	[0,60000]	Yes
40256	255	LVRT – Must Remain Connected Volt% (#3)	%	0.01	int16u	8800	[0,12000]	Yes
40257	256	LVRT – Must Remain Connected Time (#3)	s	0.01	int16u	2000	[0,60000]	Yes
40258-40270 (odd)	257-269 (odd)	LVRT – Must Remain Connected Volt% (#4-10)	%	0.01	int16u	0	[0,12000]	Yes
40259-40271 (even)	258-270 (even)	LVRT – Must Remain Connected Time (#4-10)	s	0.01	int16u	0	[0,60000]	Yes
40292	291	HVRT – Number of Points	-	1	int16u	2	[0,10]	Yes
40293	292	HVRT – Must Remain Connected Volt% (#1)	%	0.01	int16u	12000	[0,12000]	Yes
40294	293	HVRT – Must Remain Connected Time (#1)	s	0.01	int16u	0	[0,60000]	Yes
40295	294	HVRT – Must Remain Connected Volt% (#2)	%	0.01	int16u	11000	[0,12000]	Yes
40296	295	HVRT – Must Remain Connected Time (#2)	s	0.01	int16u	1200	[0,60000]	Yes
40297-40311 (odd)	296-310 (even)	HVRT – Must Remain Connected Volt% (#3-10)	%	0.01	int16u	0	[0,12000]	Yes
40298-40312 (odd)	297-311 (odd)	HVRT – Must Remain Connected Time (#3-10)	s	0.01	int16u	0	[0,60000]	Yes
*40333	*332	High Voltage Cessation Level	%	0.01	int16u	11000	[10000, 12000]	Yes

2.19. Group 19 Volt-Watt

Table 2-19 Volt-Watt

Modicon	Offset	Description	Unit	Multiplier	Type	Default	Range (unscaled)	Write
40335	334	Volt Watt – Time Window	s	1	int16u	0	[0, 1800]	Yes
40336	335	Volt Watt - Timeout Window	s	1	int16u	0	[0, 64800]	Yes
40337	336	Volt Watt – Ramp Time	s	1	int16u	0	[0, 600]	Yes
40338	337	Volt Watt – Number of Points	-	1	int16u	0	[2, 10]	Yes
40339-40357 (odd)	338-356 (even)	Volt Watt – Volt % (#1-10)	volt	0.01	int16u	-	[0, 12000]	Yes
40340-40358 (even)	339-357 (odd)	Volt Watt – Watt % (#1-10)	%	0.01	int16u	-	[0, 10000]	Yes
*40379	*378	Watts Reference (Volt-Watt) Determines whether the Watt % (339-357 odd) are referencing the rated power or the instantaneous (active power just prior to curtailing power in response to a voltage excursion). 0=Rated Power 1=Instantaneous Power	-	-	enum16	0	[0,1]	Yes

2.20. Group 20 Frequency-Watt

Table 2-20 Frequency-Watt

Modicon	Offset	Description	Unit	Multiplier	Type	Default	Range (unscaled)	Write
40171	170	Watts Reference (Frequency Watt) Determines whether the Watt % (385-403 odd) are referencing the rated power or the snapshot (active power just prior to curtailing power in response to a voltage excursion). 0=Rated Power 1=Snapshot/ Active Power	-	-	enum16	0	[0,1]	Yes
40381	380	Freq Watt Time Window	s	1	int16u	0	[0, 1800]	Yes
40382	381	Freq Watt Timeout Window	s	1	int16u	0	[0, 64800]	Yes
40383	382	Freq Watt Ramp Time	s	1	int16u	0	[0, 600]	Yes
40384	383	Freq Watt - Number of Points	-	1	int16u	0	[2, 10]	Yes
40385-40403 (odd)	384-402 (even)	Freq Watt – Freq % (#1-10)	%	0.01	int16u	0	[8340, 11580]	Yes
40386-40404 (even)	385-403 (odd)	Freq Watt – Watt % (#1-10)	%	0.01	int16u	0	[0, 10000]	Yes

2.21. Group 21 Frequency Ride Through

Table 2-21 Frequency Ride Through

Modicon	Offset	Description	Unit	Multiplier	Type	Default	Range (unscaled)	Write
*40425	*424	High Frequency Cessation Level	%	0.01	int16u	11666	[10000, 11580]	Yes
*40426	*425	Low Frequency Cessation Level	%	0.01	int16u	8333	[8340, 10000]	Yes
40427	426	LFRT – Number of Points	-	1	int16u	2	[0,10]	Yes
40428	427	LFRT – Must Remain Connected Freq % (#1)	%	0.01	int16u	9500	[8340, 10000]	Yes
40429	428	LFRT – Must Remain Connected Time (#1)	s	0.01	int16u	0	[0, 60000]	Yes
40430	429	LFRT – Must Remain Connected Freq % (#2)	%	0.01	int16u	9750	[8340, 10000]	Yes
40431	430	LFRT – Must Remain Connected Time (#2)	s	0.01	int16u	29900	[0, 60000]	Yes
40432-40446 (even)	431-445 (odd)	LFRT – Must Remain Connected Freq % (#3-10)	%	0.01	int16u	0	[8340, 10000]	Yes
40433-40447 (odd)	432-446 (even)	LFRT – Must Remain Connected Time (#3-10)	s	0.01	int16u	0	[0, 60000]	Yes
40468	467	HFRT – Number of Points	-	1	int16u	2	[0,10]	Yes
40469	468	HFRT – Must Remain Connected Freq % (#1)	%	0.01	int16u	10333	[10000, 11580]	Yes
40470	469	HFRT – Must Remain Connected Time (#1)	s	0.01	int16u	0	[0, 60000]	Yes
40471	470	HFRT – Must Remain Connected Freq % (#2)	%	0.01	int16u	10083	[10000, 11580]	Yes
40472	471	HFRT – Must Remain Connected Time (#2)	s	0.01	int16u	29900	[0, 60000]	Yes
40473-40487 (odd)	472-486 (even)	HFRT – Must Remain Connected Freq % (#3-10)	%	0.01	int16u	0	[10000, 11580]	Yes
40474-40488 (even)	473-487 (odd)	HFRT – Must Remain Connected Time (#3-10)	s	0.01	int16u	0	[0, 60000]	Yes

2.22. Group 23 Volt-Var

Table 2-22 Volt-Var

Modbus	Offset	Description	Unit	Multiplier	Type	Default	Range (unscaled)	Write
*40510	*509	Volt Var - Reference Mode, see Section 4.2.3 for more details. 0=Available var Reference Mode (Default): Volt-var setpoints (Offsets 519-533 odd) depend on the Power Priority (offset 163). Real (1): Setpoints (offsets 519-533 odd) are entered as a percentage of the maximum power/real current for the inverter. Reactive (2): Setpoints (offsets 519-533 odd) are entered as a percentage of the maximum reactive power/current for the inverter. 1=Maximum Real Current Reference Mode: Setpoints (offsets 519-533 odd) are entered as a percentage of the maximum real power/current for the inverter. 2= Maximum Reactive Current Reference Mode: Setpoints (offsets 519-533 odd) are entered as a percentage of the maximum reactive power/current for the inverter. 3=Maximum Current Reference Mode: Setpoints (offsets 519-533 odd) are entered as a percentage of the maximum apparent power/current for the inverter.	-	-	enum16	0	[0,3]	Yes
40511	510	Volt Var – Time Window	s	1	int16u	0	[0,1800]	Yes
40512	511	Volt Var – Timeout Window	s	1	int16u	0	[0,64800]	Yes
40513	512	Volt Var – Ramp Time	s	1	int16u	0	[0, 600]	Yes
40514	513	Volt Var - Number of Points	-	1	int16u	0	[2,10]	Yes
40515	514	Volt Var - Volt % (#1)	%	0.01	int16u	0	[0,12000]	Yes
40516	515	Volt Var - Var % (#1)	%	0.01	int16s	0	+/- [0,10000]	Yes
40517	516	Volt Var - Volt % (#2)	%	0.01	int16u	0	[0,12000]	Yes
40518	517	Volt Var - Var % (#2)	%	0.01	int16s	0	+/- [0,10000]	Yes
40519-40533 (odd)	518-532 (even)	Volt Var - Volt % (#3-10)	%	0.01	int16u	0	[0,12000]	Yes
40520-50334 (even)	519-533 (odd)	Volt Var - Var % (#3-10)	%	0.01	int16s	0	+/- [0,10000]	Yes

All registers or bits that are unique to D003 are marked with * next to the offset.

3. Alarm Definitions

NOTE: UL Fault Cause, Hardware Failure Cause, and Power Off Cause are unique to firmware version D003.

3.1. Critical Alarms

Table 3-1 Critical Alarms

Bit	Alarm Description	AC Power Produced?	Site Visit Recommended?
15	Reserved	-	-
14	Reserved	-	-
13	Shunt Trip	No	Yes
12	RCM Fault	No	Yes
11	Incorrect Phase	No	Yes
10	Reserved	-	-
9	Open Phase Failure	No	Yes*
8	VAC Sense Circuit Failure	No	Yes
7	Ground Fault Failure	No	Yes
6	MOV Failure	Yes	Yes
5	AC Current Sensor Circuit Failure	No	Yes
4	Contactor Failure	No	Yes
3	Power Stage Desaturation	No	Yes
2	Power Stage Temperature Out of Range	No	Yes
1	Reserved	-	-
0	Temperature Sensor Failure	No	Yes

* Open phase alerts may be due to temporary grid disturbances not related to the Inverter. In case of open phase alerts that do not clear, a site visit is required to investigate.

3.2. Informative Alarms

Table 3-2 Informative Alarms 1

Bit	Alarm Description	AC Power Produced?	Site Visit Recommended?
15	Unintentional Islanding	No	No
14	Waiting for Grid	No	No
13	AC Frequency High	No	No
12	AC Frequency Low	No	No
11	Fan Life Reached	Yes	Yes
10	Low DC Power Shutdown	No	No
9	Recovery from Grid Event	No	No
8	Power Stage Temperature Limit Exceeded	Yes	No
7	Current Limiting, Out of MPPT Range	Yes	No
6	Low DC Power Wait	No	No
5	AC Voltage Very High	No	No
4	AC Voltage High	No	No
3	AC Voltage Low	No	No
2	AC Voltage Very Low	No	No
1	DC Voltage High	No	No
0	Low DC Voltage	No	Yes

Table 3-3 Informative Alarms 2

Bit	Alarm Description	AC Power Produced?	Site Visit Recommended?
15	Slave Temperature Sensor Error	Yes	Yes
14	Master Temperature Sensor Error	Yes	Yes
13	Soft Shutdown	No	No
12	Reserved	-	-
11	Reserved	-	-
10	Remote Shutdown	No	No
9	RCM Error	Yes	Yes
8	Reserved	-	-
7	Reserved	-	-
6	Reserved	-	-
5	DC Contactor Failure	Yes	Yes
4	Reserved	-	-
3	Slave Trip	Yes	Yes, if condition persists
2	Reserved	-	-
1	Reserved	-	-
0	Reserved	-	-

3.3. UL 1741/IEEE 1547 Fault Cause

Table 3-4 UL 1741 /IEEE 1547 Fault Cause

Value	Fault
1	Low Voltage Event
2	Very Low Voltage Event
3	High Voltage Event
4	Very High Voltage Event
5	Low Frequency Event
6	High Frequency Event
7	Very Low Frequency Event
8	Island Detected
9	Lost Utility (or Lost Voltage Sensing or DSP Reboot)
10	Open Phase Detected
14	Frequency Too Low to Reconnect
15	Frequency Too High to Reconnect
16	Voltage Too Low to Reconnect
17	Voltage Too High to Reconnect
18	Very High Frequency Event
19	Ride Through Low Voltage Event
20	Ride Through High Voltage Event
21	Ride Through Low Frequency Event
22	Ride Through High Frequency Event
23	High Voltage Protect

3.4. Hardware Failure Cause

Table 3-5 Hardware Failure Cause

Value (Hex)	Value (Decimal)	Fault
0001	1	AC Contactor Failure
0002	2	Voltage Sense Failure
0008	8	Current Sensor Offset Calibration Failed
0020	32	Incorrect Phase Sequence
0040	64	Power Stage Failure – Desaturation Detected
0080	128	IGBT Temp
0100	256	Power Stage Error
0200	512	Ground Fault Detected
0300	768	Cannot Lock Angle to Voltage Waveform
0800	2048	PS Wakeup Failure
0B00	2816	Parameter Configuration Failure
0C00	3072	Parameter Backup Failure
0D00	3328	Voltage Sensing Firmware Mismatch
0E00	3584	Powerboard Mismatch
0F00	3840	Powerboard Fault
2000	8192	Filter Contactor Open
2100	8448	Shunt Trip
2200	8704	Other Error
2A00	10752	Power Stage Trip
2B00	11008	Hardware Interlock Fault
8100	33024	Follower Lost Communications
8200	33280	Follower Lost CAN synchronization
8300	33536	Follower Lost Fast Loop synchronization
8400	33792	Invalid Master State
8500	34048	Invalid Slave State
8700	34560	Token Mismatch
8800	34816	Serial Number Missing

3.5. Power Off Cause

Table 3-6 Power Off Cause

Value	Fault
1	Early Break or Clicker Open
2	High DC Voltage
3	Low DC Voltage
4	Remote Shut Down Commanded
5	Waiting to Recover from UL 1741 and/or IEEE 1547 event
6	Rapid DC Voltage Increase
7	Waiting for Slave Core to Reset
9	Residual Current Detected
10	Soft Shutdown Commanded (ESC)
11	Waiting for Daily Reset
12	Grid Support Disconnect
13	Grid Support Cease Energize
14	Clear After Ride Through Limits Exceeded
15	Waiting for Slaves to Recover from Very Low AC Voltage
16	V-Sense Phase Unlocked from AC Waveform
17	Waiting for Phase Lock after Very Low AC Voltage
18	Very Low AC Voltage
19	Power Stage Not Ready
20	Slave PWM Cannot Remain Synchronized
21	Slave Core Cannot Synchronize to Master Core
22	V-Sense Not Communicating
24	Slave Communications with Master Failure
25	Inverter Locked to EEPROM Mode
26	Power Stage Calculation Failure
27	Master/Slave Synchronization Message Failure
28	Inverter Cannot Lock to V-Sense Angle
29	Remote Reboot
30	Open Phase Check
31	High Voltage or Frequency Protect

3.6. Modbus Exception

Table 3-7 Modbus Exception

Value (Dec)	Value (Hex)	Modbus Exception
0	0x0000	No Failure
1	0x0001	Function Code Not Supported
1538	0x0602	Read Register Address Not Supported
1539	0x0603	Number of Registers Too Low (<1) or Too High (>125)
1540	0x0604	Read Address Illegal
4354	0x1102	Write Address Not Supported
4356	0x1104	Write Address Illegal
4357	0x1105	Write to Read-Only Register Not Allowed
4358	0x1106	Write Value Out of Range
4359	0x1107	Password Protected
4360	0x1108	Password Protected
4361	0x1109	Wrong Com Mode (Should be 0 or 3)
4481	0x1181	Grid Support Function Busy
4482	0x1182	Grid Support Function Already OFF (When Writing OFF)
4483	0x1183	Grid Support Function Not Supported
4484	0x1184	VAR Functions Mutually Exclusive (Triggering Multiple Functions)
4485	0x1185	D002 Only: Hysteresis Required for Listed Inputs (Hysteresis Disabled and Inputs Not Increasing)
4486	0x1186	Inputs Out of Order
4487	0x1187	High Band Not Greater Than or Equal to Lower Bound
4488	0x1188	Number of Points Exceeds Table Length (20)
4490	0x1190	D002 Only: Grid Support Function Already On (When Writing ON)
4491	0x1191	Software Error

4. SmartGrid Features

4.1. Introduction

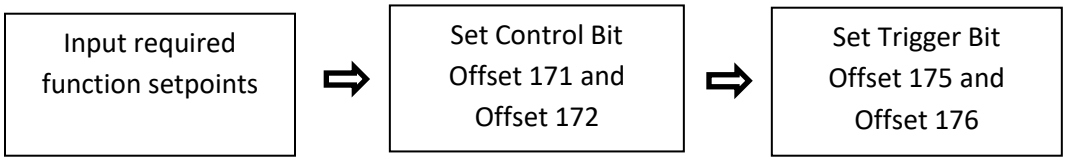
The XTM firmware provides several features intended to improve the compatibility of the inverter with the electrical grid. These features are activated, updated and deactivated either using the inverter front panel or using the XTM third-party interface using Modbus RTU over an RS-485 serial interface. Features included are:

1. Remote Connect/Disconnect
2. Real Power Curtailment
3. Reactive Power/Current Control
4. Fixed Power Factor Control
5. Ramp Rates
6. Voltage Ride Through
7. Voltage-Watt Control
8. Frequency-Watt Control
9. Frequency Ride Through
10. Volt-Var Control

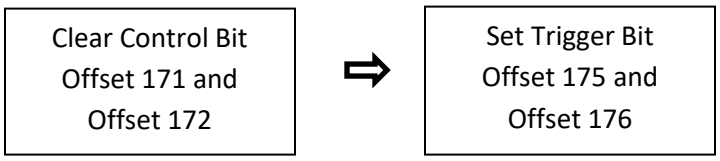
4.1.1. Activation, Deactivation, Updating, and Checking the Status

Activation, deactivation, and updating of SmartGrid features is a multi-step process.

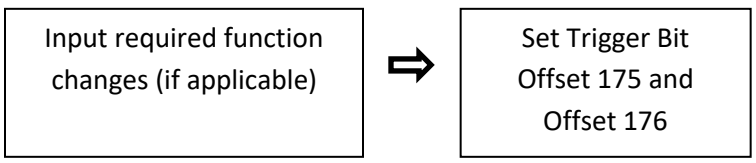
Activation: Enable a Smart Grid function.



Deactivation: Disable a Smart Grid function that is currently enabled.



Updating: Make changes to a Smart Grid function that is currently enabled.



NOTE: The trigger bit will clear itself immediately.

All SmartGrid functions have corresponding Status Bits, see Offset 173 and Offset 174. The status bits are set high when a function is currently active, i.e. the control bit is set high and the trigger has been previously set.

Figure 4-1, shows the activation and deactivation of a function using the trigger bit.

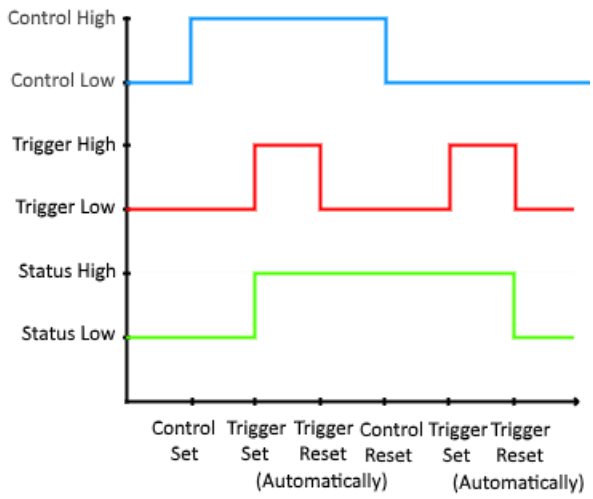


Figure 4-1 Activation and Deactivation

Figure 4-2 Activation and Deactivation by Timeout.shows the activation of a function using the trigger. The function then deactivates after the time out expires.

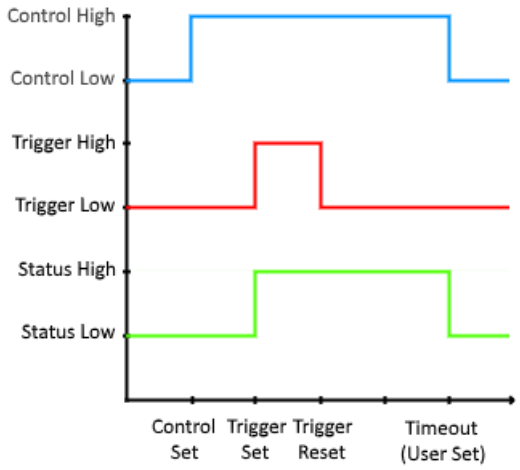


Figure 4-2 Activation and Deactivation by Timeout.

To verify whether the settings entered into Modbus registers are the active settings, read refresh offsets Offset 178 and Offset 179. When written to, the registers will revert to the active settings.

NOTE: All settings for Smart Grid functions will persist when the inverter reboots.

4.1.2. Smart Grid Features

Most Smart Grid Functions have three supported time related features. These features work similarly across all Smart Grid Functions. For sections 4.1.2.1 through 4.1.2.3 reference Figure 4-3.

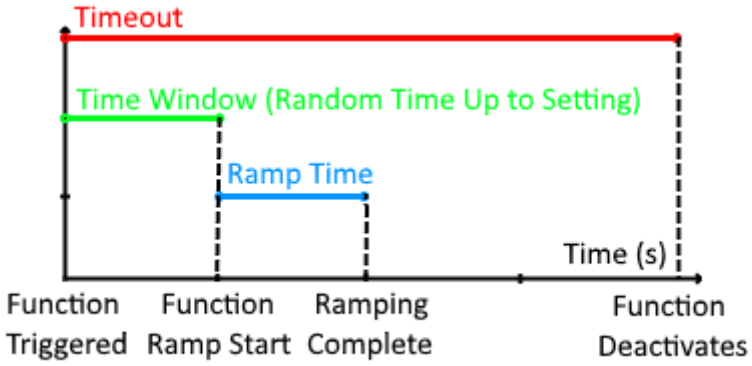


Figure 4-3 Timing of Timeout, Time Window, and Ramp Time

4.1.2.1. Timeout

Timeout, when enabled, allows for a function to revert to the function's deactivated state after operating for the specified time.

Maximum timeout setting is 18 hours. If AC power to the inverter is interrupted, the timer stops until power is restored.

4.1.2.2. Time Window

Time window, allows a Smart Grid function to activate, deactivate, or update with a random delay no greater than the specified time. This feature is commonly used to allow a group of inverters to cascade their response to a broadcasted command. The maximum time window setting is 30 minutes.

For firmware version D002, time window for Volt-Var Control, Constant Reactive Power/Current Control, and Fixed Power Factor Control is not supported.

4.1.2.3. Ramp Time

Ramp time allows a Smart Grid function to activate or update using a specific ramp time. The ramp is linear from initial to final setting.

For functions using a fixed setting, such as Real Power Curtailment, Fixed Power Factor Control, and Constant Reactive Power/Current Control, the respective output parameters are ramped linearly between settings. See Figure 4-4 for an example.

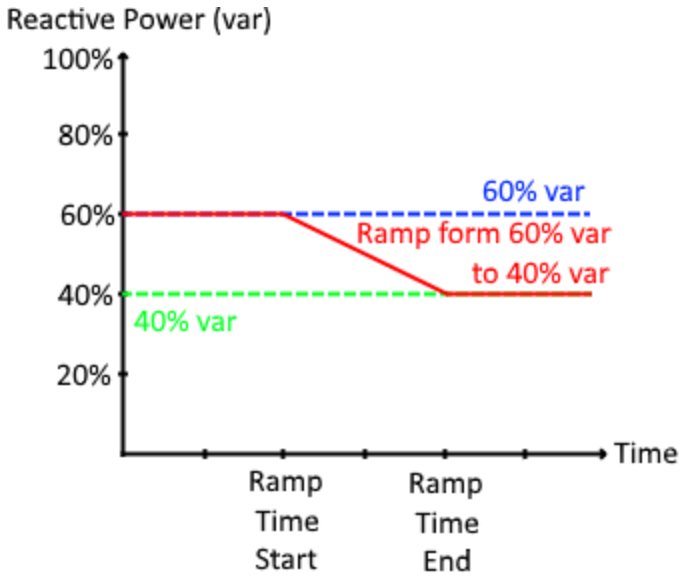


Figure 4-4 Example of Ramp Time from 60% var to 40% var

For features using curves or hysteresis bands, such as Volt-Var Control, Frequency-Watt Control, and Volt-Watt Control, the inverter ramps linearly by weighting the initial curve or band and the final curve or band based on the elapsed time. The maximum time is 10 minutes.

For firmware version D002, ramp time for Fixed Power Factor Control, Constant Reactive Power/Current Control, and Volt-Var Control is not supported.

4.1.3. Available Real and Reactive Power

Many functions reference maximum apparent, real, and reactive power. These values are limited by the Permanent AC Output Limit (Offset 158), which can only be changed through the front panel.

The available reactive current for reactive priority is shown in Equation 4.3.

$$Available\ Reactive\ Current = Maximum\ Apparent\ Current * 60\% * Offset\ 158 \quad (4.3)$$

The available real current for real priority is the lesser of Equations 4.4 and 4.5.

$$Available\ Real\ Current = Maximum\ Apparent\ Current * 60\% * Offset\ 158 \quad (4.4)$$

$$Available\ Real\ Current = Offset\ 158 * \sqrt{(Maximum\ Apparent\ Current)^2 - (Real\ Current)^2}$$

4.1.4. Power Priority

Power priority changes the way certain var related Smart Grid functions behave.

4.1.4.1. Reactive Power Priority: The inverter will produce power to meet the reactive power setpoint (Reactive Power/Current Control and Volt-Var Control) or power factor (Fixed Power Factor Control).

4.1.4.2. Real Power Priority: The inverter will produce power to meet the reactive power setpoint (Reactive Power/Current Control and Volt-Var Control) or power factor (Fixed Power Factor Control) until the inverter reaches full power. Once maximum apparent power is reached, it will produce only real power.

See Fixed Power Factor Control, Constant Reactive Power/Current Control, and Volt-Var Control for more information on how these features interact with power priority.

4.1.5. Real Power Power Limits

Real power can be limited by power control functions, AC voltage, and nameplate limits. All of these must be taken into account when calculating output power.

Real Power Curtailment, Volt-Watt Control, and Frequency-Watt Control are not mutually exclusive and can affect each other by limiting the real power.

The control limit is the lowest resulting output value from Real Power Curtailment, Volt-Watt Control, and Frequency-Watt Control.

For example, if all three functions are simultaneously enabled and Real Power Curtailment is limited to 60%, Volt-Watt Control is limited to 55% at the current voltage, and Frequency-Watt Control is limited to 50% at the current frequency, the control limit will be 50%.

- Current Limiting:

$$Power\ Limit = \ Rated\ Power * Offset\ 158 * Control\ Limit * \frac{AC\ Voltage}{380} \quad (4.4)$$

- Power Limiting Mode (AC Voltage < 380 VAC)

$$Power\ Limit = \ Rated\ Power * Offset\ 158 * Control\ Limit * \frac{AC\ Voltage}{380} \quad (4.5)$$

- Power Limiting Mode (AC Voltage > 380 VAC)

$$Power\ Limit = \ Rated\ Power * Offset\ 158 * Control\ Limit \quad (4.6)$$

4.2. Function Description

4.2.1. Remote Connect/Disconnect

4.2.1.1. Function

This function allows the inverter to be enabled or disabled remotely.

- Control, Offset 172 Bit 14, see Group 12 SmartGrid Controls, Status, and Triggering
- Trigger, Offset 176 Bit 14, see Group 12 SmartGrid Controls, Status, and Triggering
- Status, Offset 174 Bit 14, see Group 12 SmartGrid Controls, Status, and Triggering

See Activation, Deactivation, and Updating for more information.

4.2.1.2. Supported Features

- Timeout – Enables/disables the inverter after the specified time has elapsed, see Offset 211. The inverter will revert to the opposite state commanded after the timeout has elapsed.
- Time Window – Allows for a random delay of the enable/disable signal. Max delay time (s) is specified by Offset 210. If the commanded state is the same as the initial state, the inverter will remain in the initial state.

4.2.1.3. Example

Have the disconnected inverter remotely connect starting at a random time no greater than 5 minutes. Have the inverter disconnect 100 minutes after the command is sent (default state is disconnected).

- Read offset 174 Bit 14 to view current status (should be “0”)
- Write “300” (seconds) to offset 210 so that the inverter will wait a random amount of time, no greater than 5 minutes before connecting
- Write “6000” (seconds) to offset 211 so that the inverter will disconnect after 100 minutes
- Write “1” to offset 172 Bit 14 to enable the inverter to connect upon trigger
- Write “1” to offset 176 Bit 14 to trigger the enable signal

4.2.2. Real Power Curtailment

4.2.2.1. Function

This function allows the output power of the inverter to be curtailed to a certain percentage of the inverter nameplate rating, Offset 73, multiplied by the permanent power limit, Offset 158, which is set by the front panel.

- Control, Offset 172 Bit 2, see Group 12 SmartGrid Controls, Status, and Triggering
- Trigger, Offset 176 Bit 2, see Group 12 SmartGrid Controls, Status, and Triggering

- Status, Offset 174 Bit 2, see Group 12 SmartGrid Controls, Status, and Triggering
- Setpoint, Offset 215, see Group 14 Real Power Curtailment

NOTE: the real power output may also be limited by Frequency-Watt Control, Volt-Watt Control, or the temporary power limit register (Offset 61).

4.2.2.2. Supported Features

- Timeout – Disables the feature after the specified time has elapsed, see Offset 214.
- Time Window – Allows for a random delay of the enable/disable signal. Max delay time(s) is specified by Offset 213.
- Ramp Time – Sets the linear ramp time for this feature, see Offset 215.

4.2.2.3. Example

Have a 500kW inverter curtail real power to 300kW starting at a random time no greater than 5 minutes. After the time delay, have it ramp down from 500kW to 300kW linearly over 6 minutes. The inverter should cease power curtailment 100 minutes after the command is sent. Currently, the inverter is limited to 80% power (400kW) by the permanent power limit register (Offset 158), thus it only has to be limited 75% to reach 300kW. Frequency-watt control and volt-watt control are inactive.

- Read offset 174 Bit 2 to view current status of real power curtailment (should be “0”)
- Read offset 174 Bit 15 to view current status of frequency-watt control (should be “0”)
- Read offset 174 Bit 3 to view current status of volt-watt control (should be “0”)
- Read offset 73 to get nameplate power (should be 500kW)
- Read offset 158 to get power limited by the front panel (should be 80%)
- Write “7500” (0.01% increments) to offset 212 so that it will curtail the remaining 75%
- Write “300” (seconds) to offset 213 so that the inverter will wait up to 5 minutes to begin curtailment
- Write “6000” (seconds) to offset 214 so that the inverter will cease curtailment after 100 minutes
- Write “360” (seconds) to offset 215 to set the ramp time to 6 minutes
- Write “1” to offset 172 Bit 2 to enable the inverter to curtail real power upon trigger
- Write “1” to offset 176 Bit 2 to trigger the enable signal

4.2.3. Reactive Power/Current Control

4.2.3.1. Function

This function allows the inverter to produce a constant reactive output.

For firmware version D003, the output range is 60% capacitive (+) to 60% inductive (-). If voltage is above nominal, the output is with respect to maximum power; if voltage is below nominal, the output is with respect to maximum current.

For firmware version D002, the range is 60% capacitive (+) to 60% inductive (-) of maximum real current.

- Control, Offset 172 Bit 6, see Group 12 SmartGrid Controls, Status, and Triggering
- Trigger, Offset 176 Bit 6, see Group 12 SmartGrid Controls, Status, and Triggering
- Status, Offset 174 Bit 6, see Group 12 SmartGrid Controls, Status, and Triggering
- Setpoint, Offset 216, see Group 15 Reactive Power/Current Control
- Mode (D003) only, Offset 136, see Group 15 Reactive Power/Current Control
- Power Priority, Offset 163

See Activation, Deactivation, and Updating for more information.

When Reactive Power/Current Control is activated, Fixed Power Factor Control and Volt-Var Control are deactivated, because var related functions are mutually exclusive.

The Reactive Power/Current Control Reference Mode (Offset 136) in firmware version D003 offers four modes. These modes describe what the setpoint (Offset 216) is based on. For D002, Offset 136 is not available and Offset 216 uses Available var like mode 0 in D003.

- 0 = Available var Reference Mode (Default)
- 1 = Maximum Real Current Reference Mode
- 2 = Maximum Reactive Current Reference Mode
- 3 = Maximum Current Reference Mode

1. Available var Reference Mode (Default):
   In this mode, the setpoint (Offset 216) depends on Power Priority (Offset 163):

   - **Real Priority**: Reactive Power/Current Control Setpoint (Offset 216) is entered as a percentage of maximum real current for the inverter. Reference Table 4-1 and Figure 4-5 for the three example setpoints:
     - Curve A: If setpoint is set to 10,000 (100%), the inverter will operate along the curve A. Note that curve A is at 60% on the reactive axis because the maximum available var is limited to 60% of rated apparent power. Inverter will still operate along curve A for setpoints between 6,000 (60%) to 10,000 (100%).
     - Curve B: If setpoint is set to 5,000 (50%), the inverter will operate along curve B.
     - Curve C: If setpoint is set to 3,000 (30%), the inverter will operate along curve C.

Table 4-1 Reactive Power/Current Control – Available VAR – Real Priority

Curve	Setpoint %	Setpoint Value
A	100	10000
B	50	5000
C	30	3000

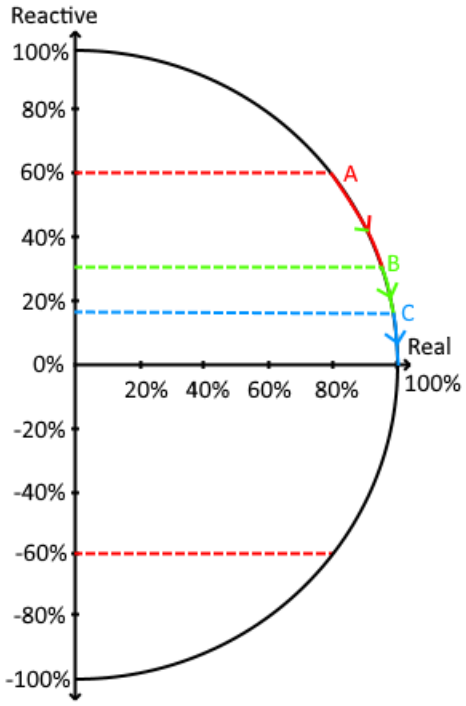


Figure 4-5 Reactive Power/Current Control – Available VAR – Real Priority

Important: For all the above example cases as soon as inverter hits full power, it will switch to produce only real power (Power Factor = 1.0) as shown in Figure 4-5.

- **Reactive Priority**: Reactive Power/Current Control Setpoint (Offset 216) is entered as a percentage of maximum reactive current for the inverter. The maximum reactive current/power is 60% (capacitive or inductive) of the maximum apparent current/power. Reference Table 4-2 Reactive Power/Current Control – Available VAR – Reactive Priority and Figure 4-6 for the three example setpoints:
    - Curve A: If setpoint is set to 10,000 (100%), the inverter will operate along the curve A. Note that curve A is at 60% on the reactive axis he maximum reactive current/power is 60% (capacitive or inductive) of the maximum apparent current/power.
    - Curve B: If setpoint is set to 5,000 (50%), the inverter will operate along curve B. which is at 30% on the reactive axis.
    - Curve C: If setpoint is set to 3,000 (30%), the inverter will operate along curve C. which is at 18% along the reactive axis.

Table 4-2 Reactive Power/Current Control – Available VAR – Reactive Priority

Curve	Setpoint %	Setpoint Value
A	100	10000
B	50	5000
C	30	3000

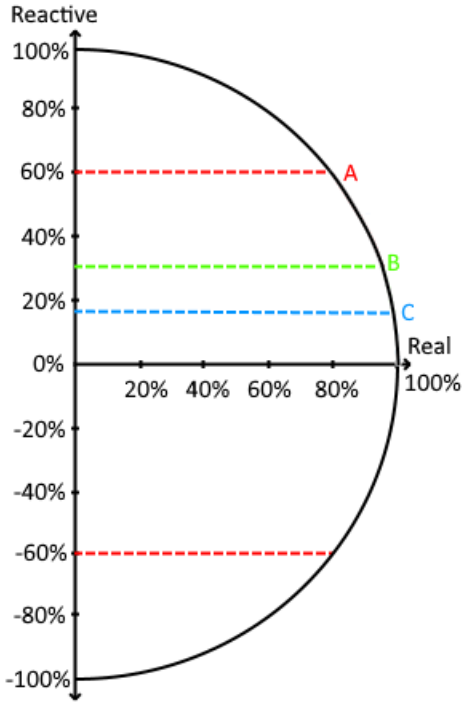


Figure 4-6 Reactive Power/Current Control – Available VAR – Reactive Priority

2. Maximum Real Current Reference Mode:
   In this mode, the setpoint (Offset 216) is entered as a percentage of maximum real power/current. The maximum real current/power of the inverter is equal to the maximum apparent current/power. Reference Table 4-3 and Figure 4-7 for the three example setpoints:
   - Curve A: If setpoint is set to 10,000 (100%), the inverter will operate along the curve A. Note that curve A is at 60% on the reactive axis because the maximum available var is limited to 60% of rated apparent power. Inverter will still operate along curve A for setpoints between 6,000 (60%) and 10,000 (100%).
   - Curve B: If setpoint is set to 5,000 (50%), the inverter will operate along curve B.
   - Curve C: If setpoint is set to 3,000 (30%), the inverter will operate along curve C.

Table 4-3 Reactive Power/Current Control – Maximum Real Current Reference Mode

Curve	Setpoint %	Setpoint Value
A	100	10000
B	50	5000
C	30	3000

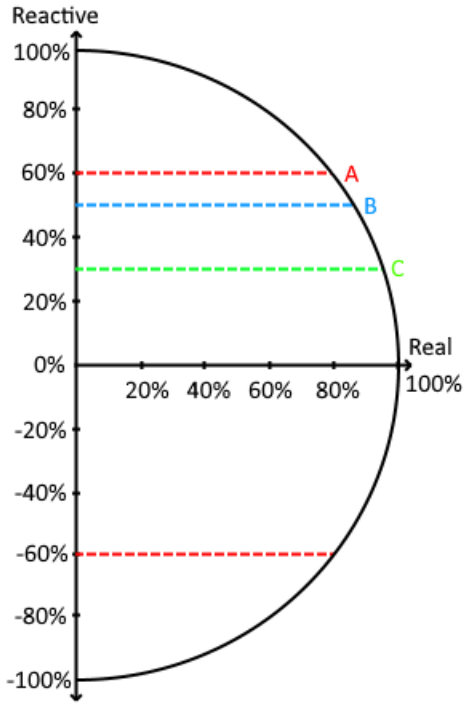


Figure 4-7 Reactive Power/Current Control – Maximum Real Current Reference Mode

3. Maximum Reactive Current Reference Mode:
   In this mode, the setpoint (Offset 216) is entered as a percentage of maximum reactive current/power. Reference Table 4-4 and Figure 4-8 for the three example setpoints:
   - Curve A: If setpoint is set to 10,000 (100%), the inverter will operate along the curve A. Note that curve A is at 60% on the reactive axis he maximum reactive current/power is 60% (capacitive or inductive) of the maximum apparent current/power.
   - Curve B: If setpoint is set to 5,000 (50%), the inverter will operate along curve B. which is at 30% on the reactive axis.
   - Curve C: If setpoint is set to 3,000 (30%), the inverter will operate along curve C. which is at 18% along the reactive axis.

Table 4-4 Reactive Power/Current Control – Maximum Reactive Current Reference Mode

Curve	Setpoint %	Setpoint Value
A	100	10000
B	50	5000
C	30	3000

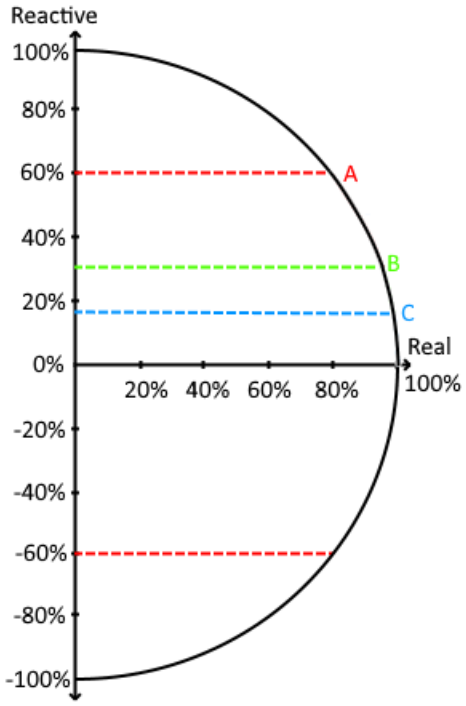


Figure 4-8 Reactive Power/Current Control – Maximum Real Current Reference Mode

4. Maximum Current Reference Mode:
   In this mode, the setpoint (Offset 216) is entered as a percentage of the maximum apparent power/current for the inverter. Reference Table 4-5 Reactive Power/Current Control – Maximum Current Reference Modeand Figure 4-9 for the three example setpoints:
   - Curve A: If setpoint is set to 10,000 (100%), the inverter will operate along the curve A. Note that curve A is at 60% on the reactive axis because the maximum available var is limited to 60% of rated apparent power. Inverter will still operate along curve A for setpoints between 6,000 (60%) to 10,000 (100%).
   - Curve B: If setpoint is set to 5,000 (50%), the inverter will operate along curve B.
   - Curve C: If setpoint is set to 3,000 (30%), the inverter will operate along curve C.

Table 4-5 Reactive Power/Current Control – Maximum Current Reference Mode

Curve	Setpoint %	Setpoint Value
A	100	10000
B	50	5000
C	30	3000

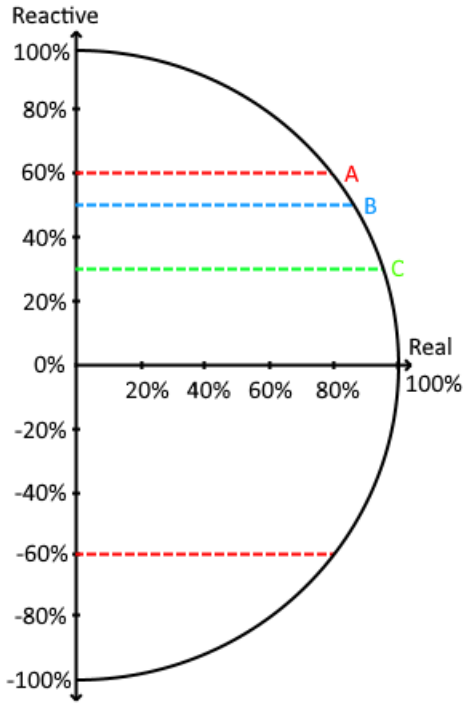


Figure 4-9 Reactive Power/Current Control – Maximum Current Reference Mode

For firmware version D002, changing between Reactive Power/Current Control, Fixed Power Factor Control, and Volt-Var Control while using Time Window or Ramp Time is not supported.

4.2.3.2. Supported Features

- Timeout – Disables the feature after the specified time has elapsed, see Offset 218.
- Time Window – Allows for a random delay of the enable/disable signal. Max delay time (s) is specified by Offset 217.
- Ramp Time – Sets the linear ramp time for this feature. See Offset 219.

4.2.3.3. Example

Have the inverter produce a reactive current of 75% of maximum inductive in reactive power priority mode, starting at a random time no greater than 5 minutes and disable reactive power/current control 100 minutes after the command is sent. Have the inverter ramp linearly to the desired reactive current over 6 minutes. Volt-var control and fixed power factor control are inactive.

- Read offset 174 Bit 6 to view current status of reactive power curtailment (should be “0”)
- Read offset 174 Bit 7 to view current status of volt-var control (should be “0”)
- Read offset 174 Bit 4 to view current status of fixed power factor control (should be “0”)
- Read offset 163 to determine power priority (should be “2”)

- Write “-7500” (0.01% increments) to offset 216 so that it will produce reactive current at 75% inductive
- Write “300” (seconds) to offset 217 so that the inverter will wait up to 5 minutes to begin producing reactive current
- Write “6000” (seconds) to offset 218 so that the inverter will cease producing reactive current after 100 minutes
- Write “360” (seconds) to offset 219 to set the ramp time to 6 minutes
- Write “1” to offset 172 Bit 6 to enable the inverter produce reactive current upon trigger
- Write “1” to offset 176 Bit 6 to trigger the enable signal

4.2.4. Fixed Power Factor Control

4.2.4.1. Function

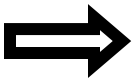
This function allows the inverter to regulate its output to a preset power factor (PF). The range for the PF is 0.8 to unity, either capacitive or inductive.

- Control, Offset_172_Bit 4, see Group 12 SmartGrid Controls, Status, and Triggering
- Trigger, Offset_176_Bit 4, see Group 12 SmartGrid Controls, Status, and Triggering
- Status, Offset_174_Bit 4, see Group 12 SmartGrid Controls, Status, and Triggering
- PF Setpoint, Offset 223
- PF Mode, used to calculate the PF setpoint, Offset 224
- Power Priority, Offset 163

See Activation, Deactivation, and Updating for more information.

The Power Factor Control Mode (Offset 224) in firmware version D003 offers four modes. These modes describe how the setpoint (Offset 223) is input to achieve desired power factor. Refer to 2.16 for details.

- 0 = Signed PF Mode (Default)
- 1 = Capacitive Mode
- 2 = Inductive Mode
- 3 = Var/Watt Mode



NOTE: In D002, Offset 224 is a read only field, only Mode 3 is available.

Depending on what the Mode (Offset 224) is set to and the Power Priority, the inverter behaves in two different ways as explained below:

1. Inverter will operate at a fixed PF as set by setpoint 223 irrespective of the output power for the following modes. Reference Table 4-6 Table 4-5 Reactive Power/Current Control – Maximum Current Reference Modeand Figure 4-10 for the three PF setpoints.
    - 0 = Signed PF Mode
    - 1 = Capacitive Mode
    - 2 = Inductive Mode

- 3 = var/Watt Mode with Power Priority set to reactive power priority

Table 4-6 Fixed Power Factor Control – Reactive Priority

Curve	Signed PF	Unsigned Capacitive PF	Unsigned Inductive PF
A	0.8	0.8	N/A
B	0.9	0.9	N/A
C	-0.9	N/A	0.9

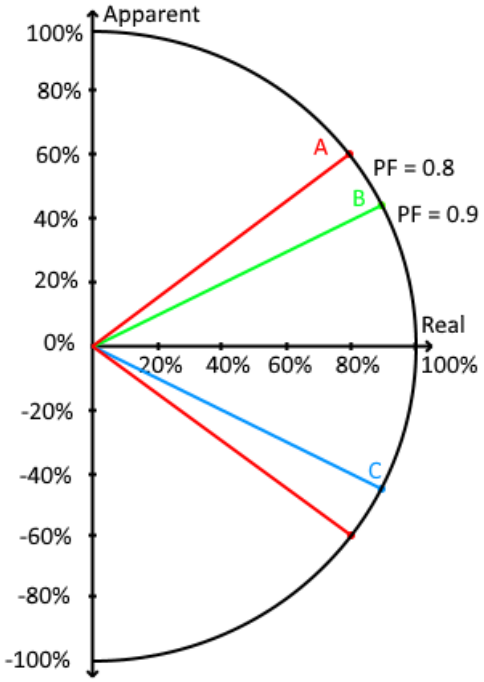


Figure 4-10 Fixed Power Factor Control – Reactive Priority

2. If the Mode (offset 224) set to 3 and Power Priority is set to Real Power Priority, inverter will operate at a fixed PF until it reaches full power production at which point inverter will only produce real power (PR = 1.0). Reference Table 4-7 Table 4-5 Reactive Power/Current Control – Maximum Current Reference Modeand Figure 4-11 Fixed Power Factor Control – Real Priorityfor three setpoints

Table 4-7 Fixed Power Factor Control – Real Priority

Line	Var/Watt Setpoint
A	192
B	124
C	-124

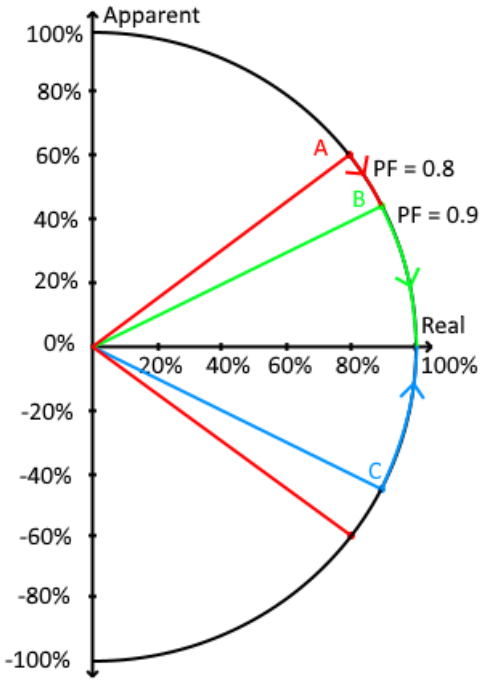


Figure 4-11 Fixed Power Factor Control – Real Priority

The power factor can be entered using four separate modes, see Offset 224:

0: Signed PF [(+) is capacitive, (-) is inductive]
1: Unsigned Capacitive PF
2: Unsigned Inductive PF
3: Var/Watt Setpoint [(+) is capacitive, (-) is inductive]

When Fixed Power Factor Control is activated, Reactive Power/Current Control and Volt-Var Control are deactivated automatically because var related functions are mutually exclusive.

For firmware version D002, changing between these var related functions while using Time Window or Ramp Time is not supported.

4.2.4.2. Supported Features

- Timeout – Disables the feature after the specified time has elapsed, see Offset 221.
- Time Window – Allows for a random delay of the enable/disable signal. Max delay time (s) is specified by Offset 220.
- Ramp Time – Sets the linear ramp time for this feature. See Offset 222.

NOTE: There are issues using ramp time with firmware version D002.

4.2.4.3. Example (D003)

Have the inverter set the PF, using signed PF mode, to 0.8 inductive. It should change the PF from the initial setting to the final setting over the course of 10 seconds, starting at a random time no greater than 5 minutes. The inverter's power priority (Offset 163) is set to reactive power.

$$PF\ Setpoint = \pm\frac{pf}{0.0001}$$

- Read offset 163 to determine power priority (should be "2")
- Write "0" to offset 224 so that signed PF mode is enabled
- Write "-8000" to offset 223, resulting in PF 0.8 inductive
- Write "10" (seconds) to offset 222 so the inverter will change from the initial to the final PF over 10 seconds
- Write "300" (seconds) to offset 220 so that the inverter will implement the PF at a random delay no greater than 5 minutes
- Write "1" to the control bit (Offset 172 Bit 4) to enable the fixed power factor control feature.
- Write "1" to the trigger bit (Offset 176 Bit 4) to send the command.

4.2.4.4. Example (D002)

Have the inverter, currently disabled, to set its PF to 0.8 inductive. The inverter's power priority (Offset 163) is set to reactive power.

- Calculate the setpoint using the following equation:
    - Power factor Setpoint (offset 223) = $\pm\frac{\left(\sqrt{\frac{1}{pf^2}-1}\right)}{0.00390625}$, where *pf=-0.8*.
    - Setpoint = -192, (-) indicates inductive.
- Read offset 163 to determine power priority (should be "2")
- Write "3" to offset 224 so that the Var/Watt mode is enabled
- Write "-192" to offset 223, resulting in PF 0.8 inductive
- Write "1" to the control bit (Offset 172 Bit 4) to enable the fixed power factor control feature.
- Write "1" to the trigger bit (Offset 176 Bit 4) to send the command.

4.2.5. Ramp Rates

4.2.5.1. Function

D002 and D003 support ramp rate features. Ramp rates are specified by percentage of rated current per second. The acceptable operating range is 0.01% to 100% of rated current per second. Real and reactive ramp rates can be assigned separate values simultaneously. Four* ramp rate functions are described below.

- Real power ramp rate: Allows the user to control the real current ramp rate.
  - Control, Offset 171 Bit 3, see Group 12 SmartGrid Controls, Status, and Triggering
  - Trigger, Offset 175 Bit 3, see Group 12 SmartGrid Controls, Status, and Triggering
  - Status, Offset 173 Bit 3, see Group 12 SmartGrid Controls, Status, and Triggering
  - Setpoint, Offset 243, see Group 17 Ramp Rates
- Reactive power ramp rate: Allows the user to control the reactive current ramp rate.
  - Control, Offset 171 Bit 4, see Group 12 SmartGrid Controls, Status, and Triggering
  - Trigger, Offset 175 Bit 4, see Group 12 SmartGrid Controls, Status, and Triggering
  - Status, Offset 173 Bit 4, see Group 12 SmartGrid Controls, Status, and Triggering
  - Setpoint, Offset 244, see Group 17 Ramp Rates
- *Soft start ramp rate: (This still needs to be defined)
  - Control, Offset 171 Bit 1, see Group 12 SmartGrid Controls, Status, and Triggering
  - Trigger, Offset 175 Bit 1, see Group 12 SmartGrid Controls, Status, and Triggering
  - Status, Offset 173 Bit 1, see Group 12 SmartGrid Controls, Status, and Triggering
  - Setpoint, Offset 229, see Group 17 Ramp Rates
- *Normal ramp rate: (This still needs to be defined)
  - Control, Offset 171 Bit 0, see Group 12 SmartGrid Controls, Status, and Triggering
  - Trigger, Offset 175 Bit 0, see Group 12 SmartGrid Controls, Status, and Triggering
  - Status, Offset 173 Bit 0, see Group 12 SmartGrid Controls, Status, and Triggering
  - Setpoint, Offset 225, see Group 17 Ramp Rates

* D003 Only.
See Activation, Deactivation, and Updating for more information.

If a command is sent to the inverter to curtail power, again the inverter will limit its power either by the ramp rate function or power curtailment, whichever is less.

- Real Power Ramp Rate

Real power ramp rate sets the rate the real power ramps either up or down. The range is 0.1 to 100% of rated current per second.

- Reactive Power Ramp Rate

Reactive power ramp rate sets the rate the reactive power ramps either up or down. The range is 0.1 to 100% of rated current per second.

- *Soft Start Ramp Rate

Soft start ramp rate sets the rate the real power ramps up during startup. The range is 0.1 to 100% of rated current per second. The accuracy of the ramp is 1% per second from 0.15 to 100%.

If both the real ramp rate and soft start ramp rate are enabled, the lesser of the two is used.

If the inverter has an irradiance decrease during startup, such as shown in

Figure 4-12 Normal and Soft Start Ramp Rates

, the inverter will switch to normal ramp (if enabled) until it catches up to the limit imposed by the soft start ramp rate.

Soft start ramp rate only ramps up, never down.

- *Normal Ramp Rate

Normal ramp rate sets the rate the inverter ramps up after an irradiance loss or after curtailment is removed or reduced. The range is 0.1 to 100% of rated current per second. The accuracy of the ramp is 1% per second from 0.15 to 100%.

If an irradiance decrease occurs during startup, the normal ramp rate will be used until the inverter reaches the limit imposed by the soft start ramp rate (if enabled). See

Figure 4-12 Normal and Soft Start Ramp Rates

.

If the inverter has reached full power (after any real curtailment), any increase due to removing or reducing real power curtailment, normal ramp rate will be used to ramp up to the new full power. If the inverter reached full power and then had an irradiance decrease, the inverter uses normal ramp rate to ramp up when the irradiance increases. See

Figure 4-12 Normal and Soft Start Ramp Rates

.

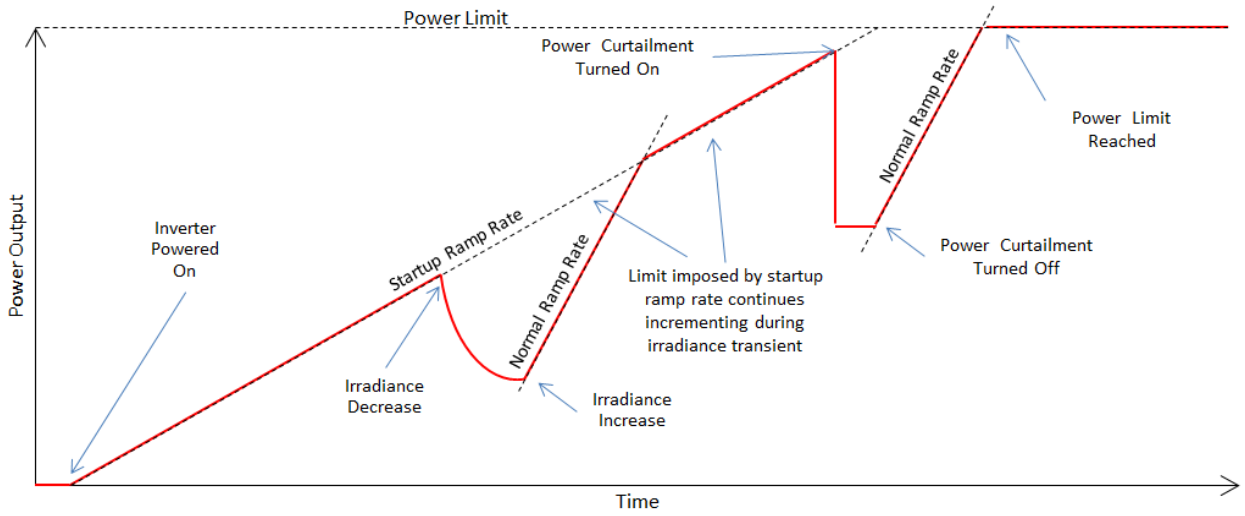


Figure 4-12 Normal and Soft Start Ramp Rates

For firmware version D002, when real power is ramping up, the rate is often determined by the maximum power point tracking algorithm, which may limit further than this setting (what is the limitation). For firmware version D003, the inverter tracks the ramp rate until maximum attainable power or maximum output power is reached.

All ramp rates are applied after factoring in Power Priority, if applicable. A change in the reactive current or real power command using ramp rates enabled could cause faster ramping or could temporarily prioritize reactive power even when set to real power priority.

4.2.5.2. Supported Features

- No features are supported.

4.2.5.3. Example

Have the inverter ramp real current at 2% of rated value per second. The power priority is set to real power.

- Read offset 173 Bit 3 to view current status of real current ramp rate (should be “0”)
- Read offset 163 to determine power priority (should be “1”)
- Write 200 (0.01%) to offset 243 so that it will ramp real current at 2% of rated value per second
- Write “1” to offset 171 Bit 3 to enable the inverter to ramp real power
- Write “1” to offset 175 Bit 3 to trigger the enable signal

4.2.6. Voltage Ride Through

4.2.6.1. Function

This function allows the inverter to ride through abnormal low (LVRT) and high (HVRT) voltage conditions.

- Control, Offset 172 (Bit 10 for LVRT, Bit 11 for HVRT), see Group 12 SmartGrid Controls, Status, and Triggering
- Trigger, Offset 176 (Bit 10 for LVRT, Bit 11 for HVRT), see Group 12 SmartGrid Controls, Status, and Triggering
- Status, Offset 174 (Bit 10 for LVRT, Bit 11 for HVRT), see Group 12 SmartGrid Controls, Status, and Triggering
- Define the number of LVRT ordered pairs, Offset 250, see Group 18 Voltage Ride Through
- LVRT Ordered pair setpoints [%Volts, Time (s)], Offsets 251 to 269 odd and Offsets 252 to 270 even, respectively, see Group 18 Voltage Ride Through
- Define the number of HVRT ordered pairs, Offset 291, see Group 18 Voltage Ride Through
- HVRT ordered pair setpoints [%Volts, Time (s)], Offsets 292 to 310 even, Offsets 293 to 311 odd, respectively, see Group 18 Voltage Ride Through

See Activation, Deactivation, and Updating for more information.

When enabled, these features override UL1741/IEEE1547 voltage protection setpoints defined in Group 9, AC Protection.

NOTE: LVRT and HVRT can be enabled separately, only the associated under/over voltage setpoint will be overridden.

LVRT and HVRT functionality is implemented using a maximum of 10 ordered pairs. Ordered pairs use the following format, [%Volts, Time (s)]. For multiple ordered pairs, points should be entered in order with time ascending and voltage approaching nominal. These points define the “Must Ride Through” level and time, respectively, as indicated with blue lines in Figure 4.2. As shown in Figure 4.2, If the voltage remains above the %Volts setpoint, operation will continue indefinitely. If voltage drops below the %Volts setpoint the inverter will continue to export power during the specified time window. Only when the voltage remains below the %Volts setpoint and remains below longer than the specified time, will the inverter cease to export power.

The inverter has a stated accuracy of 1% of rated nominal voltage. The minimum time required to trip in response to an abnormal voltage is 160 milliseconds. These two limitations define the “May Trip” zone as shown in Figure 4-13, indicated with the white band.

If the abnormal voltage event occurs for more than 160 milliseconds and the voltage during this period exceeds the trip setting by 1% of the rated nominal voltage, the inverter will always cease to produce power. This is defined as the “Must Trip” region in Figure 4-13.

Figure 4.2 demonstrates three potential outcomes during an abnormal voltage event:

- Event A, the inverter must not cease operation
- Event B, the inverter may trip after the timeout period, but it is not required to trip
- Event C, the inverter must trip.

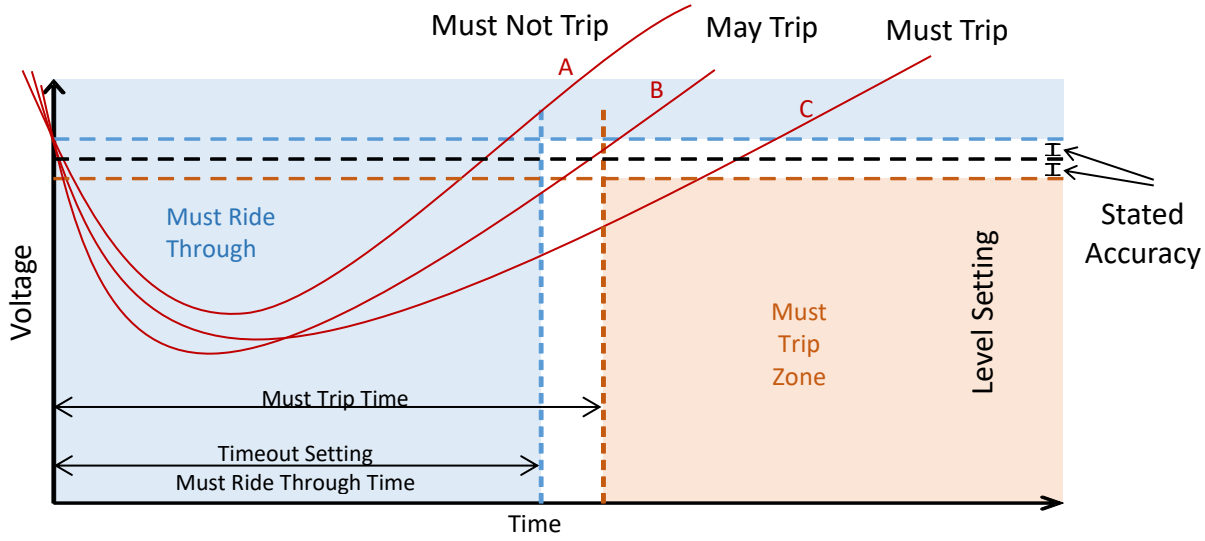


Figure 4-13 Low Voltage Ride Through (D003 Shown)

The inverters operating range is defined below. The ride through curves are confined by these values.

- Full operating current: 45% - 120% of nominal voltage
- Reduced operating current (%10 of rated current): 0% - 45% of nominal voltage (D003)
- No output, momentary cessation: 0%-45% of nominal voltage (D002)
- Reduced operating current (%10 of rated current): greater than 120%

WARNING: Inverter operation during conditions where the AC voltage exceeds 120% of nominal may result in permanent damage to the inverter or its internal components.

After cessation, full output power can be achieved within 2 seconds (D003) or several seconds (D002).

For firmware version D003, customizable cessation levels are added, which allow a reduction in the range for which the inverter can transfer power above 10% of rated. The default values are 50% for LVRT and 110% for HVRT. See Offset 249 and Offset 332 for low and high voltage cessation levels.

4.2.6.2. Supported Features

- No features are supported.

4.2.6.3. Example

Have the inverter ride through an abnormal low voltage, using the points shown on the interpolated curve in Figure 4-14. The points must be set in time ascending order to generate this curve.

Point 1: [50% V, 0.01s] → apply multiplier [5000, 100]
Point 2: [70% V, 100s] → apply multiplier [7000, 10000]
Point 3: [88% V, 200s] → apply multiplier [8800, 20000]

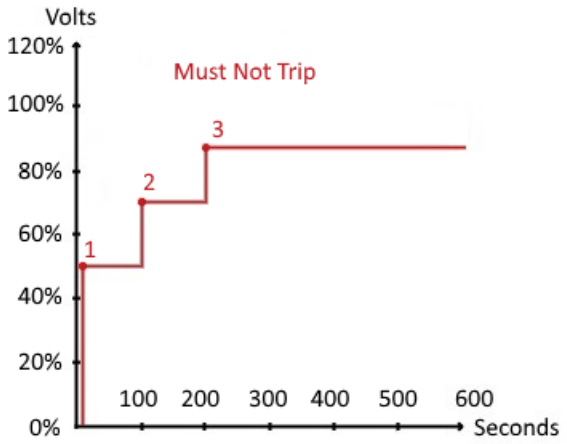


Figure 4-14 Low Voltage Ride Through Example

- Read offset 174 Bit 10 to view current status of LVRT (should be "0")
- Write "3" (points) to offset 250 to set number of points on the hysteresis band
- Write "5000" (% Volt) to offset 251 to set volts for point 1
- Write "100" (0.01 seconds) to offset 252 to set time for point 1
- Write "7000" (% Volt) to offset 253 to set volts for point 2
- Write "10000" (0.01 seconds to offset 254 to set time for point 2
- Write "8800" (% Volt) to offset 255 to set volts for point 3
- Write "20000" (0.01 seconds) to offset 256 to set time for point 3
- Write "1" to offset 172 Bit 10 to enable LVRT upon trigger
- Write "1" to offset 176 Bit 10 to trigger the enable signal

4.2.7. Volt-Watt Control

4.2.7.1. Function

This function enables real power curtailment as a function of grid voltage.

- Define the number of volt-watt ordered pairs (up to 10), Offset 337
- Watt Reference (D003 only), Offset 378
- Volt-watt ordered pair setpoints [%Volts, %Watts], Offset 338 to 356 even, Offset 339 to 357 odd, respectively.
- Control, see Offset 172 Bit 3
- Trigger, see Offset 176 Bit_3
- Status, see Offset 174 Bit 3

See Activation, Deactivation, and Updating for more information.

The Watts Reference, Offset 378 in firmware version D003 offers two modes, Rated Power mode and *Instantaneous Power mode.

0=Rated Power mode
1=Instantaneous Power mode*

- In Rated Power mode, the inverter will curtail power based on the inverter's rated power. It is important to consider other power limiting function/factors in addition to the name plate rating, as they have a multiplying effect on the inverter's rated power. Limiting factors include; the limit set using the front panel (Offset 158) and current limiting/power limiting as described by the Power-Limiting Curve.

- *In Instantaneous Power mode, the inverter will curtail power based on the output power at the time the function is triggered. This instantaneous output power is used as the reference point for all curtailment calculations. In the Volt-Watt ordered pairs, the %Watt is calculated based on the instantaneous at the time the function is triggered.

NOTE: Instantaneous Power mode is not available in D002.

A curve or band must be defined to use this function. See Interpolated Curve/Hysteresis Band Programming for more information.

NOTE: The real power output may be further limited by Real Power Curtailment or Frequency-Watt Control.

NOTE: This feature is not ETL certified.

4.2.7.2. Supported Features

- Timeout – Disables the feature after the specified time has elapsed, see Offset 335.
- Time Window – Allows for a random delay of the enable/disable signal. Max delay time (s) is specified by Offset 334.
- Ramp Time – Sets the linear ramp time for this feature, based on the curve or hysteresis band. See Offset 336.

4.2.7.3. Example (No power limiting)

Limit real power output based on changes in grid voltage using the hysteresis band shown below in Figure 4-15. Power limiting should begin at a random time, no greater than 5 minutes. The function should be enabled with a 6 minute ramp time. Volt-Watt Control should then be disabled 100 minutes after the command is sent. The Watts Reference (Offset 378) is currently set to Rated Power Mode (0). No other power limiting functions are enabled and onsite voltage is assumed to be at nominal.

- Determine the input/output ordered pairs required to implement the hysteresis band shown in Figure 4.4.

Point 1: [100% V, 100% W] → apply multiplier [10000, 10000]
Point 2: [102.5% V, 100% W] → apply multiplier [10250, 10000]
Point 3: [115.8% V, 0% W] → apply multiplier [11580, 0]
Point 4: [100.9% V, 0% W] → apply multiplier [10090, 0]

NOTE: To implement the hysteresis band as shown in Figure 4-15, ensure the high band input points are entered in increasing order and the low band input points are entered in decreasing order.

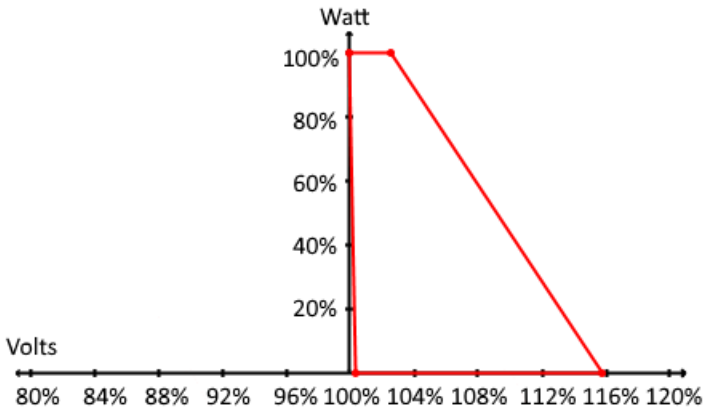


Figure 4-15 Volt-Watt Control Example

- Read offset 174 Bit 3 to view current status of frequency-watt control (should be “0”)
- Read offset 170 to determine watt reference (should be “0”)
- Write “4” (points) to offset 337 to set number of points on the hysteresis band
- Write “10000” (% Volt) to offset 338 to set volts for point 1
- Write “10000” (% Watts x 0.01) to offset 339 to set watts for point 1
- Write “10250” (% Volt x 0.01) to offset 340 to set volts for point 2
- Write “10000” (% Watts x 0.01) to offset 341 to set watts for point 2
- Write “11580” (% Volt x 0.01) to offset 342 to set volts for point 3
- Write “0” (% Watts) to offset 343 to set watts for point 3
- Write “10090” (% Volt x 0.01) to offset 344 to set volts for point 4
- Write “0” (% Watts) to offset 345 to set watts for point 4
- Write “300” (seconds) to offset 334 so that the inverter will wait up to 5 minutes to begin producing responsive real power
- Write “6000” (seconds) to offset 335 so that the inverter will cease producing responsive real power after 100 minutes
- Write 360 (seconds) to offset 336 to set the ramp time to 6 minutes
- Write “1” to offset 172 Bit 3 to enable the inverter limit real power in response to changes in grid voltage upon trigger
- Write “1” to offset 176 Bit 3 to trigger the enable signal

4.2.8. Frequency-Watt Control

4.2.8.1. Function

This function enables real power curtailment as a function of grid frequency.

- Control, see Offset 172 Bit 15
- Trigger, see Offset 176 Bit_15
- Status, see Offset 174 Bit 15
- Define the number of frequency-watt ordered pairs (up to 10), Offset 383
- Frequency-watt ordered pair setpoints [%Frequency, %Watts], Offset 384 to 402 even, Offset 385 to 403 odd respectively.

See Activation, Deactivation, and Updating for more information.

The Watts Reference, (Offset 170) in firmware version D003 offers two modes, Rated Reference mode and *Instantaneous Power mode.

0=Rated Power mode
1=Instantaneous Power mode*

- In Rated Reference mode, the inverter will curtail power based on the inverter's rated power. It is important to consider other power limiting function/factors in addition to the name plate rating, as they have a multiplying effect on the inverter's rated power. Limiting factors include; low onsite voltage, the limit set using the front panel (Offset 158), and current limiting/power limiting as described by the Power-Limiting Curve.

- *In Instantaneous Power mode, the inverter will curtail power based on the output power at the time the function is triggered. This instantaneous output power is used as the reference point for all curtailment calculations. In the Frequency-Watt ordered pairs, the %Watt is calculated based on the instantaneous at the time the function is triggered.

NOTE: Instantaneous Power mode is only available in D003.

A curve or band must be defined to use this function. See Interpolated Curve/Hysteresis Band Programming for more information.

NOTE: The real power output may be further limited by Real Power Curtailment or Volt-Watt Control.

NOTE: This feature is not ETL certified.

4.2.8.2. Supported Features

- Timeout – Disables the feature after the specified time has elapsed, see Offset 381.
- Time Window Allows for a random delay of the enable/disable signal. Max delay time (s) is specified by Offset 380.

- Ramp Time – Sets the linear ramp time for this feature, based on the curve or hysteresis band. See Offset 382.

4.2.8.3. Example (No Power Limiting)

Limit real power output based on changes in grid frequency using the hysteresis band shown below in Figure 4-16. Power limiting should begin at a random time, no greater than 5 minutes. The function should be enabled with a 6 minute ramp time. Frequency-Watt Control should then be disabled 100 minutes after the command is sent. The Watts Reference (Offset 170) currently set to Instantaneous Reference Mode (1). No other power limiting functions are enabled and onsite voltage is assumed to be at, or above nominal.

- Determine the input/output ordered pairs required to implement the hysteresis band shown in Figure 4.5.

Point 1: [100%, 100%] → apply multiplier [10000, 10000]
Point 2: [102.5%, 100%] → apply multiplier [10250, 10000]
Point 3: [115.8%, 0%] → apply multiplier [11580, 0]
Point 4: [100.9%, 0%] → apply multiplier [10090, 0]

NOTE: To implement the hysteresis band as shown in Figure 4-16, ensure the high band input points are entered in increasing order and the low band input points are entered in decreasing order.

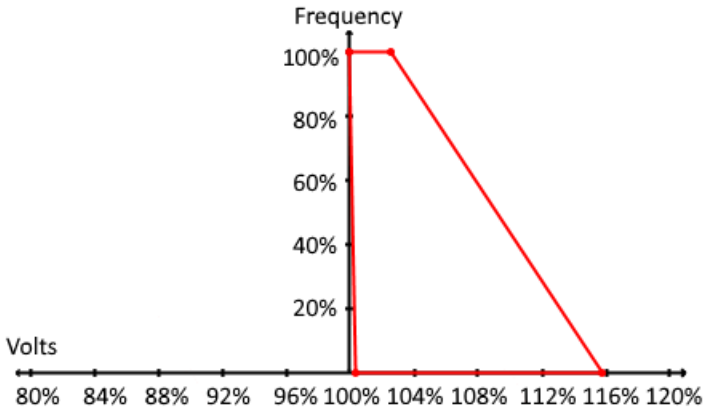


Figure 4-16 Frequency-Watt Control Example

- Read offset 174 Bit 15 to view current status of frequency-watt control (should be “0”)
- Read offset 170 to determine watt reference (should be “1”)
- Write “4” (points) to offset 383 to set number of points on the hysteresis band
- Write “10000” (% Frequency x 0.01) to offset 384 to set frequency for point 1
- Write “10000” (% Watts x 0.01) to offset 385 to set watts for point 1
- Write “10250” (% Frequency x 0.01) to offset 386 to set frequency for point 2

- Write “10000” (% Watts x 0.01) to offset 387 to set watts for point 2
- Write “11580” (% Frequency x 0.01) to offset 388 to set frequency for point 3
- Write “0” (% Watts) to offset 389 to set watts for point 3
- Write “10090” (% Frequency x 0.01) to offset 390 to set frequency for point 4
- Write “0” (% Watts) to offset 391 to set watts for point 4
- Write “300” (seconds) to offset 380 so that the inverter will wait up to 5 minutes to begin producing responsive reactive current
- Write “6000” (seconds) to offset 381 so that the inverter will cease producing responsive reactive current after 100 minutes
- Write 360 (seconds) to offset 382 to set the ramp time to 6 minutes
- Write “1” to offset 172 Bit 15 to enable the inverter limit real power in response to changes in grid frequency upon trigger
- Write “1” to offset 176 Bit 15 to trigger the enable signal

4.2.9. Frequency Ride Through

4.2.9.1. Function

This function allows the inverter to ride through abnormal low (LFRT) and high (HFRT) frequency conditions.

- Control, see Offset 172 (Bit 1 for LFRT, Bit 0 for HFRT)
- Trigger, see Offset 176 (Bit 1 for LFRT, Bit 0 for HFRT)
- Status, see Offset 174 (Bit 1 for LFRT, Bit 0 for HFRT)
- Define the number of LFRT ordered pairs, Offset 426.
- LFRT ordered pair setpoints [%Frequency, Time (s)], Offset 427 to 445 odd, Offset 428 to 446 even, respectively.
- Define the number of HFRT ordered pairs, Offset 467.
- HFRT ordered pair setpoints [%Frequency, Time (s)], Offset 468 to 486 even, Offset 469 to 487 odd, respectively.

See Activation, Deactivation, and Updating for more information.

When enabled, these features override UL1741/IEEE1547 frequency protection setpoints defined in Group 9, AC Protection.

NOTE: LFRT and HFRT can be enabled separately, only the associated under/over frequency setpoints will be overridden.

LFRT and HFRT functionality is implemented using a maximum of 10 ordered pairs. Ordered pairs use the following format, [%Frequency, Time (s)]. These points define the “Must Ride Through” level and time, respectively, as indicated with blue lines in Figure 4-17. When multiple points are used, the order in which they are entered is important. Order pairs must be entered with the Time(s) value in ascending order and the %Frequency values approaching nominal.

If the frequency does not exceed the %Frequency setpoint, operation will continue indefinitely. If frequency exceeds the %Frequency setpoint the inverter will continue to export power during the specified time window. Only when the frequency exceeds the %Frequency setpoint and remains outside the limit longer than the specified time, will the inverter cease to produce power.

The inverter has a stated accuracy of 0.1 Hz (D002) or 0.05 Hz (D003). The minimum time required to trip in response to an abnormal frequency 1 second (D002) or 0.5 seconds (D003). These two limitations define the “May Trip” section as shown in Figure 4-17, indicated with the white band.

If the abnormal frequency event occurs for more than 0.5 seconds (D003) or 1 second (D002) and the frequency during this period exceeds the trip setting by 0.1 Hz (D002) or (0.05 Hz), the inverter will always cease to produce power. This is defined as the “Must Trip” region in Figure 4-17.

Figure 4.6 demonstrates three potential outcomes during an abnormal voltage event:

- Event A, the inverter must ride through
- Event B, the inverter may trip after the timeout period, but it is not required to trip
- Event C, the inverter must trip

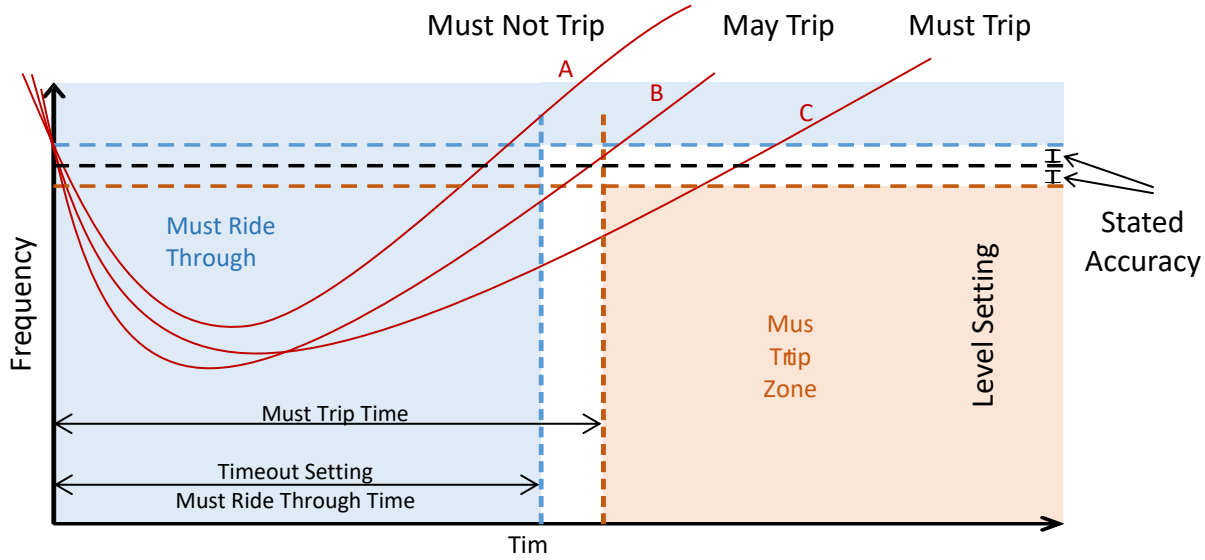


Figure 4-17 Low Frequency Ride Through (D003 Shown)

If the inverter was not required to trip, it will recover within 500 ms.
The inverters operating range is defined below.

- Full operating current: 50Hz to 70Hz (69.5Hz D002)
- No output, momentary cessation: 0Hz to 50Hz
- No output, momentary cessation: Greater than 70Hz (69.5Hz D002)

WARNING: Inverter operation during conditions where the AC frequency exceeds 70Hz may result in permanent damage to the inverter or its internal components.

After cessation, full output power can be achieved within 2 seconds (D003) or several seconds (D002).

For firmware version D003, customizable cessation levels are added, which allow a reduction in the range for which the inverter can transfer power above 10% of rated. See Offset 425 and Offset 424 for low and high frequency cessation levels.

4.2.9.2. Supported Features

- No features are supported.

4.2.9.3. Example

Have the inverter ride through an abnormal low frequency, using the points shown on the interpolated curve shown in Figure 4-18.

- Determine the input/output ordered pairs required to implement the interpolated curve Figure 4-18. Make sure to enter points in time ascending order.

Point 1: [50Hz, 0.1s] → convert to %Frequency [83.33%, 0.1s] → apply multiplier [8333, 100]
Point 2: [54Hz, 100s] → convert to %Frequency [90%, 100s] → apply multiplier [9000, 10000]
Point 3: [57Hz, 200s] → convert to %Frequency [95%, 200s] → apply multiplier [9500, 20000]

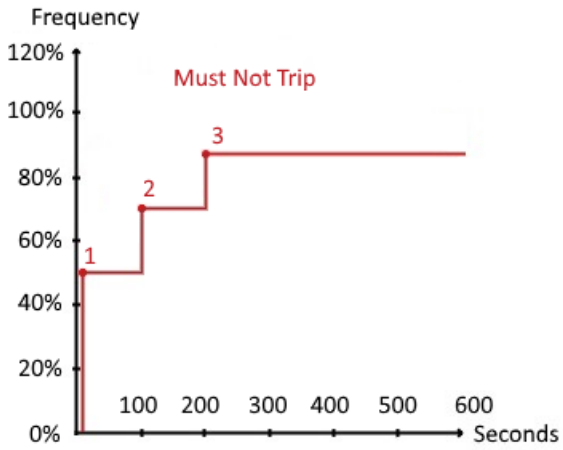


Figure 4-18 Low Frequency Example

- Read offset 174 Bit 1 to view current status of LFRT (should be “0”)
- Write “3” (points) to offset 426 to set number of points on the hysteresis band
- Write “8333” (% Frequency) to offset 427 to set frequency for point 1
- Write “100” (0.01 seconds) to offset 428 to set seconds for point 1
- Write “9000” (% Frequency) to offset 429 to set frequency for point 2
- Write “10000” (0.01 seconds to offset 430 to set seconds for point 2
- Write “9500” (% Frequency) to offset 431 to set frequency for point 3

- Write “20000” (0.01 seconds) to offset 432 to set seconds for point 3
- Write “1” to offset 172 Bit 1 to enable LFRT upon trigger
- Write “1” to offset 176 Bit 1 to trigger the enable signal

4.2.10. Volt-Var Control

4.2.10.1. Function

This function allows the inverter to produce reactive current as a function of grid voltage. A curve or band must also be defined to use this function, see Figure 4-19 below. See Interpolated Curve/Hysteresis Band Programming for more information on defining the curve or band.

For firmware version D003, the var values are based off of maximum power or maximum current based on if the AC voltage is above or below nominal voltage, respectively.

For firmware version D002, the var values are based off of the maximum real current.

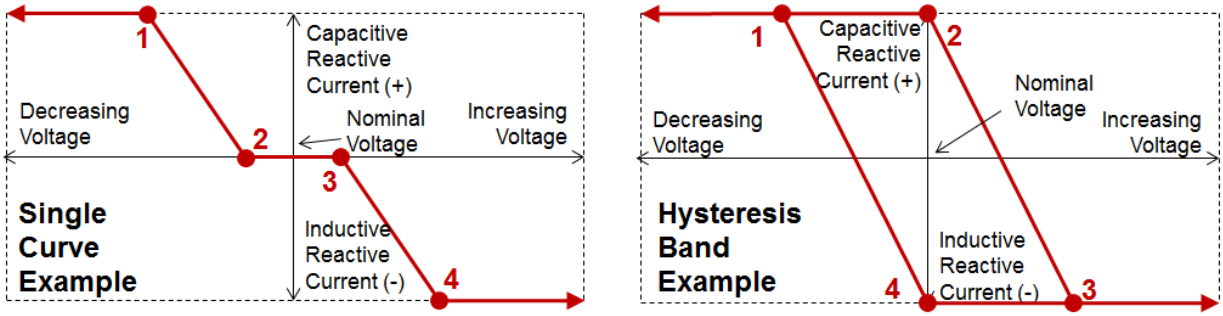


Figure 4-19 Interpolated Curve (Left) and Hysteresis Band (Right) for Volt-Var

- Control, see Offset 172 Bit 7
- Trigger see Offset 176 Bit 7
- Status, see Offset 174 Bit 7
- Define the number of ordered pairs, Offset 513
- Ordered pair setpoints [%Volts, % var] Offset 514 to 532 even, Offset 515 to 533 odd respectively.
- Volt-var Reference Mode, see Offset 509
- Power Priority, Offset 163

For See Activation, Deactivation, and Updating for more information.

The Volt Var Reference Mode (Offset 509) in firmware version D003 offers four modes. These modes describe what the setpoints (Offset 515 to 533 odd) is based on. For D002, Offset 509 is not available and Offsets 515 to 533 odd use Available var like mode 0 in D003.

- 0 = Available var Reference Mode (Default)
- 1 = Maximum Real Current Reference Mode
- 2 = Maximum Reactive Current Reference Mode

- 3 = Maximum Current Reference Mode

1. Available var Reference Mode (Default):
   In this mode, the setpoints (Offset 515 to 533 odd) depends on Power Priority (Offset 163):

   - **Real Priority**: Volt Var setpoints (Offsets 515 to 533 odd) are entered as percentages of maximum real current for the inverter. Reference Table 4-8 and Figure 4-20 for the three example setpoints:
     - Curve A: If setpoint is set to 10,000 (100%), the inverter will operate along the curve A. Note that curve A is at 60% on the reactive axis because the maximum available var is limited to 60% of rated apparent power. Inverter will still operate along curve A for setpoints between 6,000 (60%) to 10,000 (100%).
     - Curve B: If setpoint is set to 5,000 (50%), the inverter will operate along curve B.
     - Curve C: If setpoint is set to 3,000 (30%), the inverter will operate along curve C.

Table 4-8 Volt-Var – Available Var – Real Priority

Curve	Setpoint %	Setpoint Value
A	100	10000
B	50	5000
C	30	3000

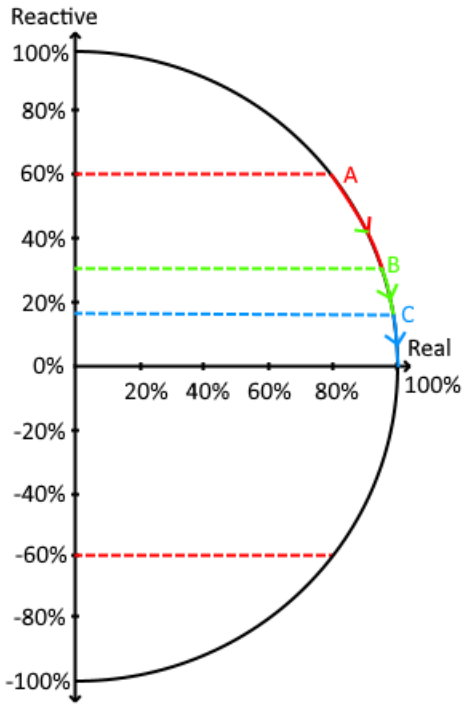


Figure 4-20 Volt-Var – Available Var – Real Priority

Important: For all the above example cases as soon as inverter hits full power, it will switch to produce only real power (Power Factor = 1.0) as shown in Figure 4-20.

- **Reactive Priority**: Volt Var setpoints (Offsets 515 to 533 odd) are entered as percentages of maximum reactive current for the inverter. The maximum reactive current/power is 60% (capacitive or inductive) of the maximum apparent current/power. Reference Table 4-9 and Figure 4-21 for the three example setpoints:
    - Curve A: If setpoint is set to 10,000 (100%), the inverter will operate along the curve A. Note that curve A is at 60% on the reactive axis he maximum reactive current/power is 60% (capacitive or inductive) of the maximum apparent current/power.
    - Curve B: If setpoint is set to 5,000 (50%), the inverter will operate along curve B. which is at 30% on the reactive axis.
    - Curve C: If setpoint is set to 3,000 (30%), the inverter will operate along curve C. which is at 18% along the reactive axis.

Table 4-9 Volt-Var – Available Var – Reactive Priority

Curve	Setpoint %	Setpoint Value
A	100	10000
B	50	5000
C	30	3000

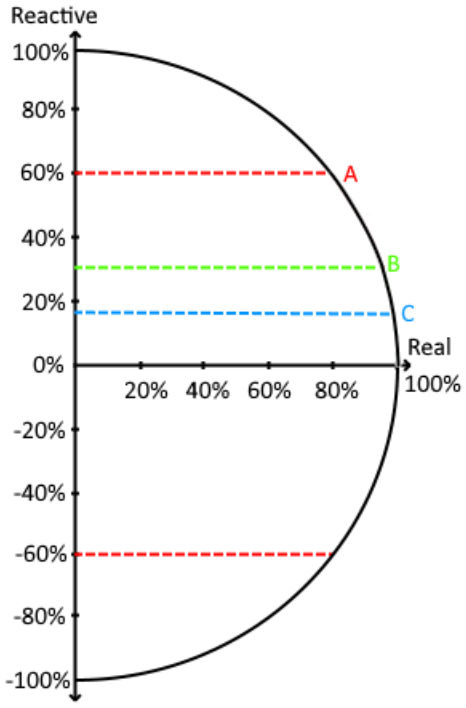


Figure 4-21 Volt-Var – Available Var – Reactive Priority

2. Maximum Real Current Reference Mode:

In this mode, the setpoints (Offset 515 to 533 odd) are entered as percentages of maximum real power/current. The maximum real current/power of the inverter is equal to the maximum apparent current/power. Reference Table 4-10 and Figure 4-22 for the three example setpoints:

- Curve A: If setpoint is set to 10,000 (100%), the inverter will operate along the curve A. Note that curve A is at 60% on the reactive axis because the maximum available var is limited to 60% of rated apparent power. Inverter will still operate along curve A for setpoints between 6,000 (60%) and 10,000 (100%).
- Curve B: If setpoint is set to 5,000 (50%), the inverter will operate along curve B.
- Curve C: If setpoint is set to 3,000 (30%), the inverter will operate along curve C.

Table 4-10 Volt-Var – Maximum Real Current Reference Mode

Curve	Setpoint %	Setpoint Value
A	100	10000
B	50	5000
C	30	3000

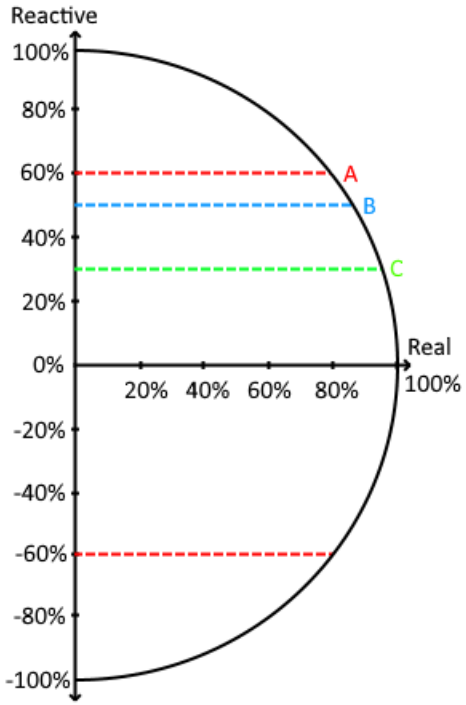


Figure 4-22 Volt-Var – Maximum Real Current Reference Mode

3. Maximum Reactive Current Reference Mode:
   In this mode, the setpoints (Offset 515 to 533 odd) are entered as percentages of maximum reactive current/power. Reference Table 4-11 and Figure 4-23 for the three example setpoints:
   - Curve A: If setpoint is set to 10,000 (100%), the inverter will operate along the curve A. Note that curve A is at 60% on the reactive axis he maximum reactive current/power is 60% (capacitive or inductive) of the maximum apparent current/power.

- Curve B: If setpoint is set to 5,000 (50%), the inverter will operate along curve B. which is at 30% on the reactive axis.
- Curve C: If setpoint is set to 3,000 (30%), the inverter will operate along curve C. which is at 18% along the reactive axis.

Table 4-11 Volt-Var Maximum Reactive Current Reference Mode

Curve	Setpoint %	Setpoint Value
A	100	10000
B	50	5000
C	30	3000

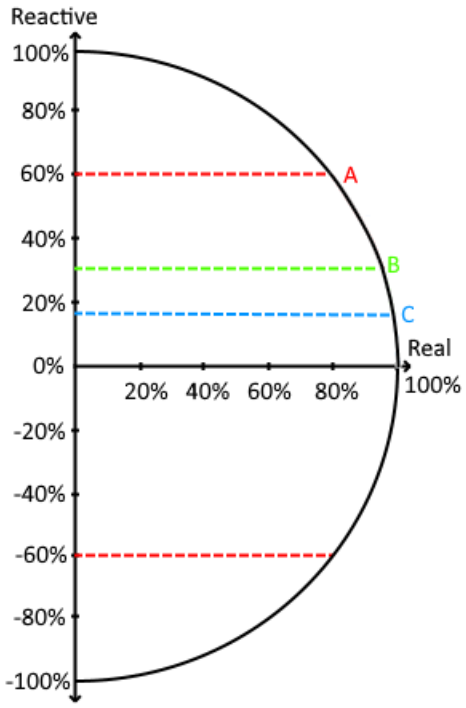


Figure 4-23 Volt-Var Maximum Reactive Current Reference Mode

4. Maximum Current Reference Mode:
   In this mode, the setpoints (Offset 515 to 533 odd) are entered as percentages of the maximum apparent power/current for the inverter. Reference Table 4-12 and Figure 4-24 for the three example setpoints:
   - Curve A: If setpoint is set to 10,000 (100%), the inverter will operate along the curve A. Note that curve A is at 60% on the reactive axis because the maximum available var is limited to 60% of rated apparent power. Inverter will still operate along curve A for setpoints between 6,000 (60%) to 10,000 (100%).
   - Curve B: If setpoint is set to 5,000 (50%), the inverter will operate along curve B.
   - Curve C: If setpoint is set to 3,000 (30%), the inverter will operate along curve C.

Table 4-12 Volt-Var Maximum Current Reference Mode

Curve	Setpoint %	Setpoint Value
A	100	10000
B	50	5000
C	30	3000

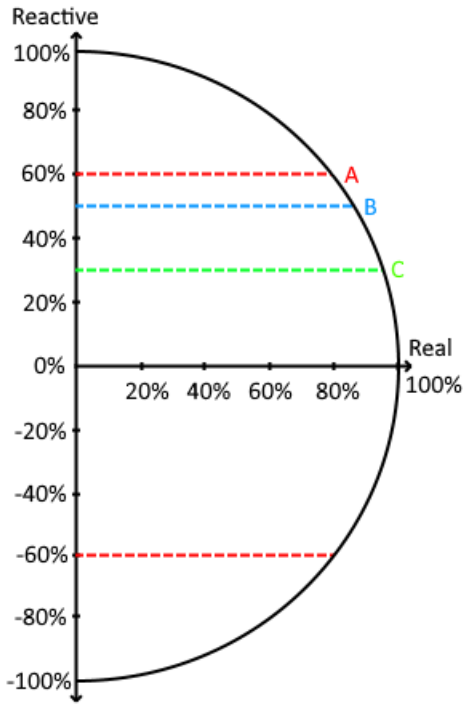


Figure 4-24 Volt-Var Maximum Current Reference Mode

When Volt-var Control is activated, Fixed Power Factor Control and Constant Reactive Power/Current Control are deactivated because var related functions are mutually exclusive.

For firmware version D002, changing between Volt-Var Control, Fixed Power Factor Control, and Constant Reactive Power/Current Control using Time Window or Ramp Time is not supported.

4.2.10.2. Supported Features

- Timeout – Disables the feature after the specified time has elapsed, see Offset 511.
- Time Window – Allows for a random delay of the enable/disable signal. Max delay time (s) is specified by Offset 510.
- Ramp Time – Sets the linear ramp time for this feature, based on the curve or hysteresis band. See Offset 512.

4.2.10.3. Example

Implement the volt-var function using the hysteresis band shown in Figure 4-25. The volt-var function should be implemented with a random delay of no greater than 5 minutes. Have the inverter ramp linearly to the hysteresis band over 6 minutes. Volt-Var Control should be disabled 100 minutes after the command is sent.

- Determine the input/output ordered pairs for the hysteresis band shown in Figure 4-25.

1: [80%, 100%] → apply multiplier [8000, 10000]
2: [100%, 100%] → apply multiplier [10000, 10000]
3: [120%, -100%] → apply multiplier [12000, -10000]
4: [100%, -100%] → apply multiplier [10000, -10000]

Note: To implement the hysteresis band as shown in Figure 4-25, ensure the high band input voltage points are entered in increasing order and the low band input voltage points are entered in decreasing order.

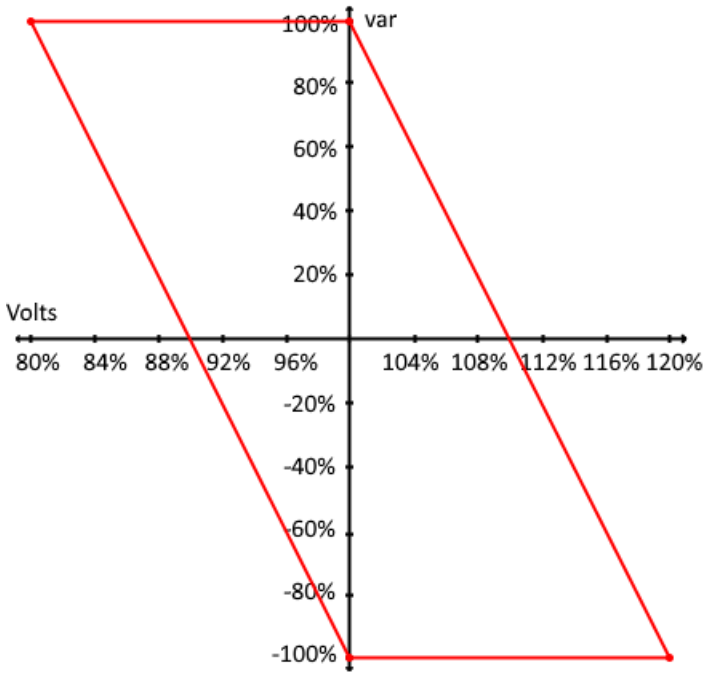


Figure 4-25 Volt-Var Control Example

- Read offset 174 Bit 7 to view current status of volt-var control (should be “0”)
- Read offset 174 Bit 6 to view current status of reactive power curtailment (should be “0”)
- Read offset 174 Bit 4 to view current status of fixed power factor control (should be “0”)
- Read offset 163 to determine power priority (should be “1”)
- Write “4” (points) to offset 513 to set number of points on the hysteresis band
- Write “8000” (% Volt x 0.01) to offset 514 to set volts for point 1
- Write “10000” (% VAR x 0.01) to offset 515 to set VARs for point 1

- Write “10000” (% Volt x 0.01) to offset 516 to set volts for point 2
- Write “10000” (% VAR x 0.01) to offset 517 to set VARs for point 2
- Write “12000” (% Volt x 0.01) to offset 518 to set volts for point 3
- Write “-10000” (% VAR x 0.01) to offset 519 to set VARs for point 3
- Write “10000” (% Volt x 0.01) to offset 520 to set volts for point 4
- Write “-10000” (% VAR x 0.01) to offset 521 to set VARs for point 4
- Write “300” (seconds) to offset 510 so that the inverter will wait up to 5 minutes to begin producing responsive reactive current
- Write “6000” (seconds) to offset 511 so that the inverter will cease producing responsive reactive current after 100 minutes
- Write 360 (seconds) to offset 512 to set the ramp time to 6 minutes
- Write “1” to offset 172 Bit 7 to enable the inverter produce reactive current upon trigger
- Write “1” to offset 176 Bit 7 to trigger the enable signal

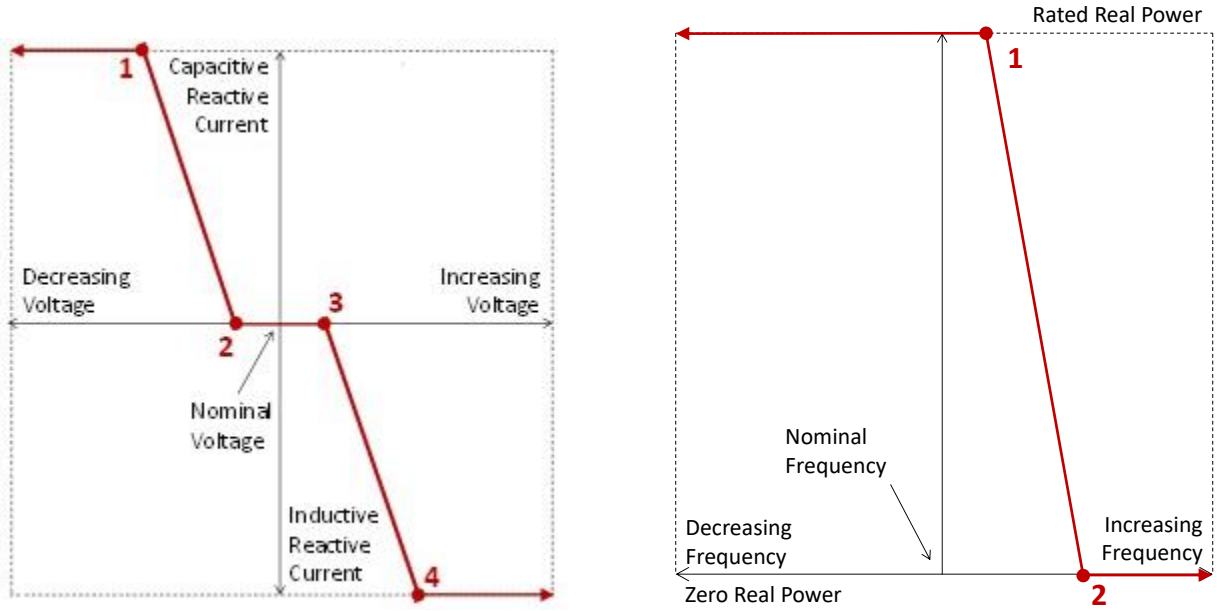
4.3. Additional Information (should be part of introduction)

4.3.1. Interpolated Curve/Hysteresis Band Programming

Volt-Var Control, Frequency-Watt Control, and Volt-Watt Control use an interpolated curve and/or hysteresis bands to implement their controls. Curves or bands are entered using 10 input/output ordered pairs [Input, Output].

4.3.1.1. Interpolated Curves

If the Input values of the ordered pairs are listed in increasing order, the inverter uses an interpolated curve, as shown in Figure 4-26.



(a) Volt-Var Curve with Dead Band ***(b) Frequency-Watt Curve***

Figure 4-26 Interpolated Curve Examples

Figure 4-26(a) shows a volt-var curve with a dead band. For voltages above the dead band, inductive current is produced; for voltages lower than the dead band, capacitive current is produced. Figure 4-26(b) shows a typical frequency-watt curve without hysteresis. As frequency increases the power output is reduced for grid stability.

4.3.1.2. Hysteresis Bands

If the input values of the ordered pairs are listed in increasing order then decreasing order, the inverter uses a hysteresis curve as shown in Figure 4.10 Hysteresis Band Examples. The values in increasing order form the high band, while the values in decreasing order form the low band.

If inverters input variable exceeds the specified range (i.e. not included within the hysteresis band) the output of the inverter will be limited by the maximum specified output values. See Figure 4-27.

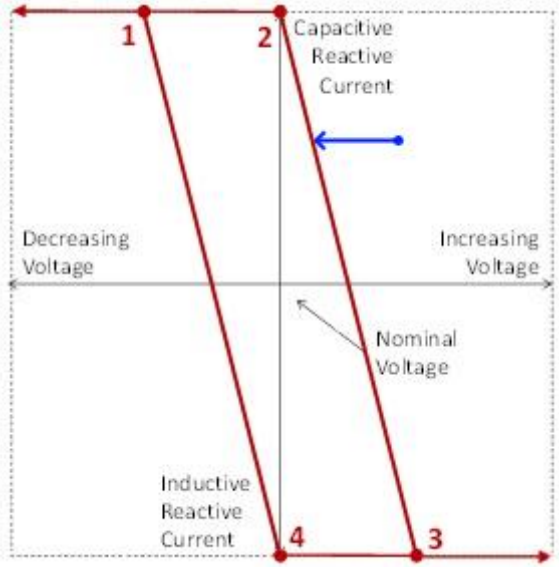
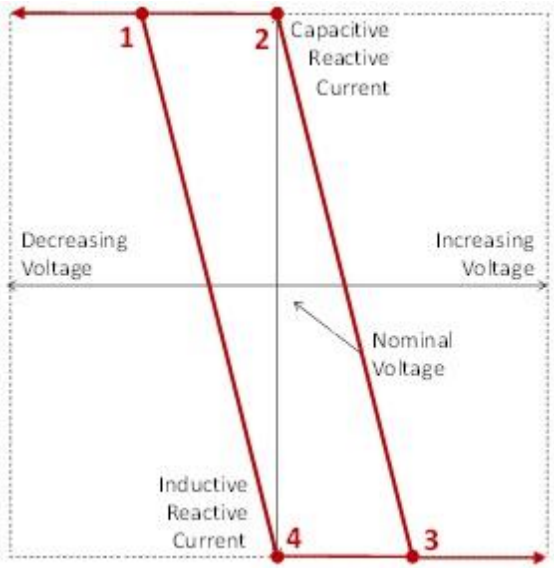


Figure 4-27 Operation Outside the Hysteresis Band

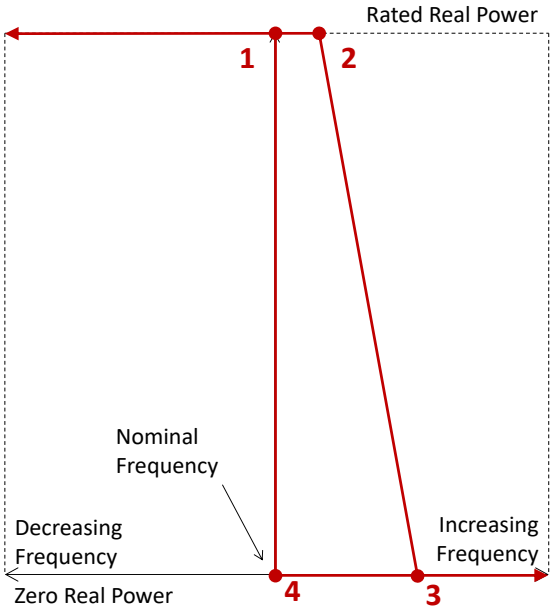
Figure 4-29(a) shows a volt-var hysteresis band. During times of high voltage conditions, the inverter favors inductive current. During times of low voltage, the inverter favors capacitive current. The hysteresis band helps to stabilize the inverter output when changing from capacitive to inductive production.

Figure 4-29(b) shows a frequency-watt hysteresis band. The inverter will curtail power as frequency increases (between points 2 and 3). If the frequency increases to a critical level, the inverter will cease to produce power (point 3). After disconnecting in response to high frequency, the inverter will not reconnect until the grid frequency returns to nominal (point 4). Once the grid frequency returns to normal, it will begin producing real power again (point 1).

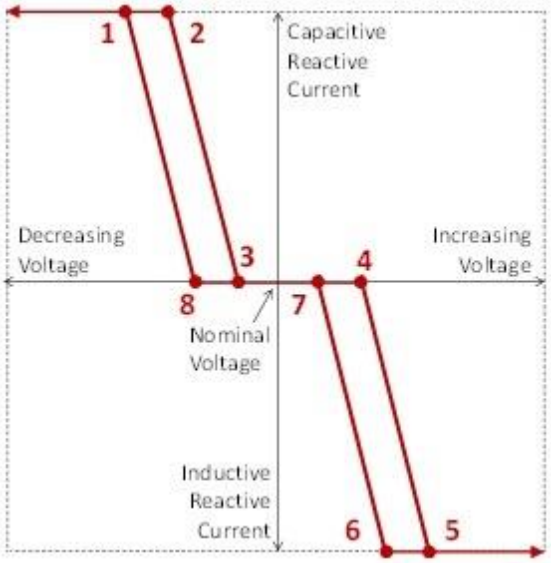
Figure 4-29(c) shows a volt-var hysteresis band with a dead band. In the dead band, no reactive current is generated. Outside of the dead band, it behaves similarly to the band in Figure 4-29(a).



(a) Volt-Var Hysteresis with No Dead Band



(b) Frequency-Watt Hysteresis Band



(c) Volt-Var Hysteresis with Dead Band

Figure 4-28 Hysteresis Band Examples

4.3.2. Power-Limiting Curve

The standard inverter configuration operates as a current limited device. The AC output current limit is set to equate to nameplate power at nominal AC voltage. The current limit is not modified up or down to maintain rated power level as AC voltages change from nominal. If the grid AC voltage is below nominal the inverter will not provide full power. If the grid AC voltage is above nominal the inverter is capable of outputting more than its nameplate power rating. Power limiting is an AC voltage-driven inverter function that occurs when the AC voltage is higher than nominal. As AC voltage increases the

current limit decreases to maintain nameplate power. If AC voltage is below nominal the AC current limit does not change. Either of these functions can be configured.

The inverter can be configured for either power-limiting or current-limiting mode. Figure 4-29 shows the normal power-limiting and current-limiting curves plotted on the same graph. 100% power is the nameplate power, Offset 73, multiplied by any adjustments to power made at the front panel, Offset 158. If the inverter is in power-limiting mode and is above nominal voltage, the inverter will limit power. If the inverter is in current-limiting mode and is above nominal voltage, the inverter limits current. Below nominal voltage, current is the limiting factor regardless of the power limiting mode.

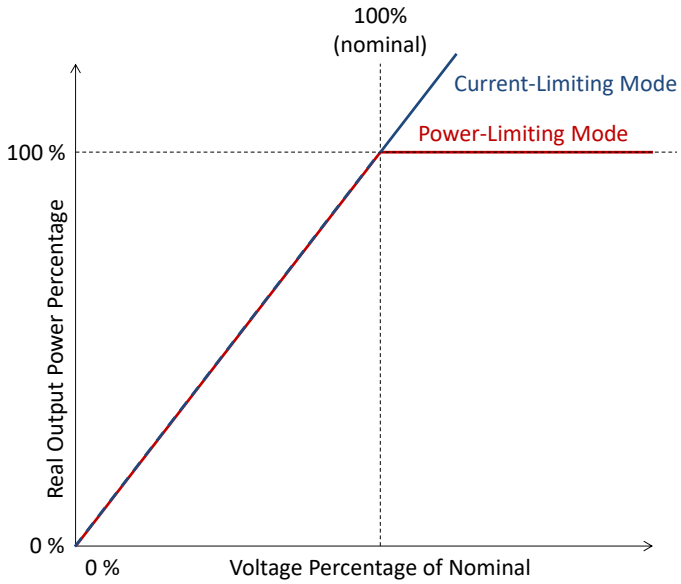


Figure 4-29 Power Limiting Curve

4.3.3. Default Settings

When a grid support function is deactivated all Modbus registers associated with the feature are returned to their default settings. Also, when a feature is activated or updated, ramp time, time window and timeout registers, if available for the feature, are set back to their default values. The default settings for grid support features are set in the factory, but may also be modified using the inverter front panel.