VITA 62 3U Power Supply Parallel Operation

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Introduction

The Vicor VITA 62 power supply is a COTs power supply that is designed for 3U OpenVPX systems. The module utilizes Vicor proprietary technology to enable high efficiency and power density for this highly rugged, conduction-cooled model.

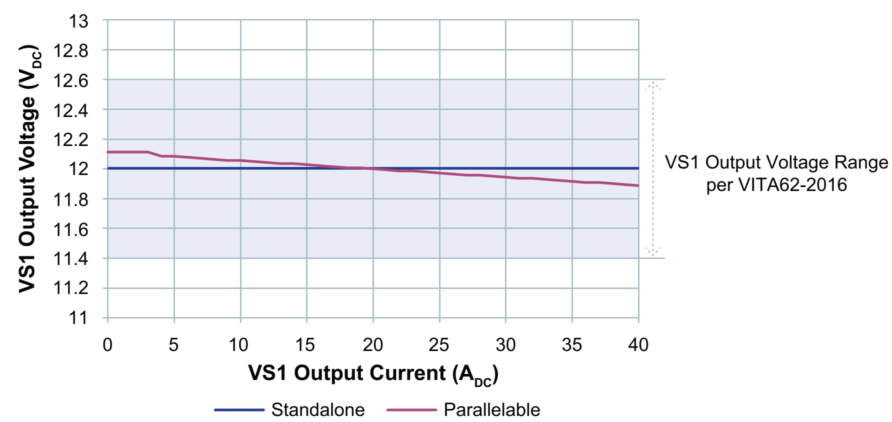
Up to four power supplies can be paralleled to increase output power capability of VS1, VS2, VS3 outputs with proprietary wireless current sharing. Conventional current-share pins are eliminated. Product data sheets available at the Vicor website.

Refer to the product-specific data sheet to assure parallel capability.

Overview

The standalone unit should not be used for parallel operation. The parallelable unit can be used as a standalone unit, and the only minor detail is a slight difference in the output voltage versus output current curves for the three main outputs (+12V_{DC} VS1 output, +3.3V_{DC} VS2 output, and the +5V_{DC} VS3 Output). The typical curve for the +12V_{DC} VS1 output is shown below.

Figure 1
Output voltage and current for standalone and parallelable units compared



Note: The nominal no-load VS1 voltage for the parallelable option is 12.11V_{DC}, and at 40A (maximum load) its drops to 11.89V_{DC}. This slight drop in voltage as a function of output current (intelligent droop) allows up to four of parallel units to share the load.

Number of Parallelable Units vs. Output Current & Power Capability

Table 1a
270V input parallel array output current and power ratings

<table>
<tr><th rowspan="2">Paralleled Units</th><th colspan="6">Output Current Ratings (A_{DC})</th><th rowspan="2">Total Array Output Power [a] (W)</th></tr>
<tr><th>VS1</th><th>VS2 [b]</th><th>VS3 [b]</th><th>+3.3V AUX</th><th>+12V AUX</th><th>–12V AUX</th></tr>
<tr><td>1</td><td>40</td><td>20</td><td>30</td><td rowspan="4">6</td><td rowspan="4">1</td><td rowspan="4">1</td><td>600</td></tr>
<tr><td>2</td><td>72</td><td>40</td><td>60</td><td>1080</td></tr>
<tr><td>3</td><td>108</td><td>60</td><td>90</td><td>1620</td></tr>
<tr><td>4</td><td>144</td><td>80</td><td>120</td><td>2160</td></tr>
</table>

Table 1b
28V input parallel array output current and power ratings

<table>
<tr><th rowspan="2">Paralleled Units</th><th colspan="6">Output Current Ratings (A_{DC})</th><th rowspan="2">Total Array Output Power [a] (W)</th></tr>
<tr><th>VS1</th><th>VS2</th><th>VS3</th><th>+3.3V AUX</th><th>+12V AUX</th><th>–12V AUX</th></tr>
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<tr><td>2</td><td>72</td><td>40</td><td>54</td><td>1080</td></tr>
<tr><td>3</td><td>108</td><td>60</td><td>81</td><td>1620</td></tr>
<tr><td>4</td><td>144</td><td>80</td><td>108</td><td>2160</td></tr>
</table>

[a] In addition to the maximum currents shown for each of the output, the combined total output power shall not exceed this value.
[b] The reason that the 10% derating is not required for the VS2 & VS3 outputs is that the modules used for these outputs have considerable derating (A 50A module is used for +5V output, and a 45A module is used for +3.3V output).

Special Consideration for Parallel Operation

Share Connections

- Since the parallelable units utilize intelligent droop share method for current sharing, the three share lines (A7, B7, and C7) are not required for sharing. If these lines are already assigned to their default functions per VITA62, the unit will still function properly.

Sense Connections

- All of the +12V Sense Lines (A8) shall be connected at the +12V point-of-load or on the backplane to the +12V output (P6).
- All of the +3.3V Sense Lines (B8) shall be connected at the +3.3V point-of-load or on the backplane to the +3.3V output (LP2).
- All of the +5V Sense Lines (C8) shall be connected at the +5V point-of-load or on the backplane to the +5V output (P3).

Output Connections

- All of the +12V VS1 Output Lines (P6) shall be connected together between all of the parallel units.
- All of the +3.3V VS2 Output Lines (LP2) shall be connected together between all of the parallel units.
- All of the +5V VS3 Output Lines (P3) shall be connected together between all of the parallel units.
- All of the Power Return Lines (P4 & P5) shall be connected together between all of the parallel units.

Geographical Addressing for I^2C™ Communications

- The backplane must be configured to provide each of the parallel units with a different Geographical Address (0x20, 0x21, 0x22, or 0x23). Refer to AN:802 and AN:803 for the Geographical Addressing details.

Thermal Monitoring

Each of the power supplies support monitoring both of its rail temperatures (P1 & P6) through the IPMI Interface. Refer to the appropriate I^2C user document for details. For most applications the P6 rail will be hotter than the P1 rail, since the P6 is the primary cooling path for the DC/DC modules used to provide the VS1 and VS2 outputs. The IPMI conversion output the rail temperatures (Sensor #18 the P6 rail and Sensor #19 the P1 rail) in kelvins.
To convert the kelvin readings into degrees Celsius:

$$°C = K – 273.15$$

Slightly above the 85°C maximum allowable rail temperature the power supply will turn off all six of the outputs. If a temperature shutdown occurs, the internal 3.3 volt supply which is used powers the microcontroller is kept active; meaning the I^2C communications will be active and valid.

Example with Four Units in Parallel

Initial Verification

The first check should be to verify that all of the part numbers of the units are correct and identical. The P/N can be found on the product label, the text following the (PNO) identifier. If the part number ends in 001, the unit is standalone only and should not be configured in parallel.

Geographical Addressing

In order for the I^2C™ communication to function properly, each of the parallel power supplies must be set to a different geographical address. Since the maximum number of geographical addresses is four, the maximum number of parallel units is four. In this example, the following geographical addresses were used.

Table 2
Geographical addressing

Parallel Units	GA1* (Pin A5)	GA0* (Pin A5)	I^2C Address	IPMB Address
1	Unconnected	Unconnected	20h	40h
2		Biased to ground on the backplane	21h	42h
3	Biased to signal ground on the backplane	Unconnected	22h	44h
4		Biased to ground on the backplane	23h	46h

Note: Both primary and redundant I^2C buses have the same I^2C address and are identical in their functionality, but operate independently.

Current and Power Limits for four parallel Units

The VS1, VS2, VS3, load-sharing accuracy improves as the load increases. Typical load-sharing accuracies at maximum load are:

- Better than 3% for the VS1 (+12V main)
- Better than 8% for the VS2 (+3.3V main)
- Better than 6% for the VS3 (+5V main)

The three AUX outputs do not support load sharing. It is safe to connect these outputs in parallel, but the current limit will remain the same as a single unit.

Recommended I^2C Monitoring

Since the geographical addresses are different for each of the units, the I^2C interface can be used to separately monitor the current from each of the units. In the example loading shown in Table 3, the following loads are being applied to the paralleled power supplies.

Table 3
Example array

Paralleled Units	Output Current Ratings (A_{DC})						Total Output Power (W)
	VS1	VS2	VS3	+3.3V AUX	+12V AUX	–12V AUX	
4	144	15	22	5	1	1	1928

In Table 3, maximum load is placed on VS1 (+12V main), because this is the worst case with respect to the thermal performance. In this case, the recommendation would be to periodically use the I^2C interface to monitor the following data:

- VS1 (+12V main) current for each of the four units
- P6 Rail Temperature for each of the four units

The resolution of the IPMI Sensors (0.2A for current & 1K for temperature) is adequate for these measurements. Refer to the I^2C Application Note for alternate monitoring methods if higher resolution is desired.

Example with Four Units in Parallel (Cont.)

Get Sensor Reading for VS1 (+12V) Current (Sensor #15)

Unit 1

The +12V current for unit #1 at I^2C™ Address 0x20 is 36.2A; this unit would be supplying 25.14% of the load.

Table 4
REQUEST message transmitted to the POWER SUPPLY at I^2C address 20h

Byte	Bits								Value
	7	6	5	4	3	2	1	0	
1	rsSA = 40h (VPX IPMB address, LS is always 0)								40h
2	Net Fn (even) is 04 (Sensor/Event)						rsLUN is 0		10h
3	Checksum for the connection Header								B0h
4	rqSA = 80h (Requestor's child address, LS always 0)								80h
5	rqSeq = 1						LUN is 0		04h
6	Command 2Dh - Get Sensor Reading								2Dh
7	Sensor Number 0Fh								0Fh
8	Checksum for preceding bytes between the previous checksum								40h

Table 5
RESPONSE message transmitted from the POWER SUPPLY

Byte	Bits								Value
	7	6	5	4	3	2	1	0	
1	rqSA = 80h								80h
2	Net Fn (odd) is 05 (Sensor/Event)						rsLUN is 0		14h
3	Checksum for the connection Header								6Ch
4	rsSA = 40h (Responder's child address)								40h
5	rqSeq = 1						rsLUN is 0		04h
6	Command 2Dh - Get Sensor Reading								2Dh
7	00h (00h means Completion Code = 'OK')								00h
8	B5h Sensor Reading (Current B5h x 0.2A = 181 x 0.2A = 36.2A)								B5h
9	40h sensor information (Event message is disabled for this sensor)								40h
10	C0h Threshold Comparison (Sensor reading is within normal range)								C0h
11	Checksum for preceding bytes between the previous checksum								DAh

Example with Four Units in Parallel (Cont.)

Get Sensor Reading for VS1 (+12V) Current (Sensor #15)

Unit 2

The +12V current for unit #2 at I²C™ Address 0x21 is 36.0A; this unit would be supplying 25.0% of the load.

Table 6
REQUEST message transmitted to the POWER SUPPLY at I²C address 21h

Byte	Bits								Value
	7	6	5	4	3	2	1	0	
1	rsSA = 42h (VPX IPMB address, LS is always 0)								42h
2	Net Fn (even) is 04 (Sensor/Event)						rsLUN is 0		10h
3	Checksum for the connection Header								AEh
4	rqSA = 80h (Requestor's child address, LS always 0)								80h
5	rqSeq = 1						LUN is 0		04h
6	Command 2Dh - Get Sensor Reading								2Dh
7	Sensor Number 0Fh								0Fh
8	Checksum for preceding bytes between the previous checksum								40h

Table 7
RESPONSE message transmitted from the POWER SUPPLY

Byte	Bits								Value
	7	6	5	4	3	2	1	0	
1	rqSA = 80h								80h
2	Net Fn (odd) is 05 (Sensor/Event)						rqLUN is 0		14h
3	Checksum for the connection Header								6Ch
4	rsSA = 42h (Responder's child address)								42h
5	rqSeq = 1						rsLUN is 0		04h
6	Command 2Dh - Get Sensor Reading								2Dh
7	00h (00h means Completion Code = 'OK')								00h
8	B4h Sensor Reading (Current B4h x 0.2A = 180 x 0.2A = 36.0A)								B4h
9	40h sensor information (Event message is disabled for this sensor)								40h
10	C0h Threshold Comparison (Sensor reading is within normal range)								C0h
11	Checksum for preceding bytes between the previous checksum								D9h

Example with Four Units in Parallel (Cont.)

Get Sensor Reading for VS1 (+12V) Current (Sensor #15)

Unit 3

The +12V current for unit #3 at I^2C™ Address 0x22 is 35.8A; this unit would be supplying 24.86% of the load.

Table 8
REQUEST message transmitted to the POWER SUPPLY at I^2C address 22h

Byte	Bits								Value
	7	6	5	4	3	2	1	0	
1	rsSA = 44h (VPX IPMB address, LS is always 0)								44h
2	Net Fn (even) is 04 (Sensor/Event)						rsLUN is 0		10h
3	Checksum for the connection Header								ACh
4	rqSA = 80h (Requestor's child address, LS always 0)								80h
5	rqSeq = 1						LUN is 0		04h
6	Command 2Dh - Get Sensor Reading								2Dh
7	Sensor Number 0Fh								0Fh
8	Checksum for preceding bytes between the previous checksum								40h

Table 9
RESPONSE message transmitted from the POWER SUPPLY

Byte	Bits								Value
	7	6	5	4	3	2	1	0	
1	rqSA = 80h								80h
2	Net Fn (odd) is 05 (Sensor/Event)						rqLUN is 0		14h
3	Checksum for the connection Header								6Ch
4	rsSA = 44h (Responder's child address)								44h
5	rqSeq = 1						rsLUN is 0		04h
6	Command 2Dh - Get Sensor Reading								2Dh
7	00h (00h means Completion Code = 'OK')								00h
8	B3h Sensor Reading (Current B3h x 0.2A = 179 x 0.2A = 35.8A)								B3h
9	40h sensor information (Event message is disabled for this sensor)								40h
10	C0h Threshold Comparison (Sensor reading is within normal range)								C0h
11	Checksum for preceding bytes between the previous checksum								D8h

Example with Four Units in Parallel (Cont.)

Get Sensor Reading for VS1 (+12V) Current (Sensor #15)

Unit 4

The +12V current for unit #4 at I²C™ Address 0x23 is 36.0A; this unit would be supplying 25.00% of the load.

Table 10
REQUEST message transmitted to the POWER SUPPLY at I²C address 23h

Byte	Bits								Value
	7	6	5	4	3	2	1	0	
1	rsSA = 46h (VPX IPMB address, LS is always 0)								46h
2	Net Fn (even) is 04 (Sensor/Event)						rsLUN is 0		10h
3	Checksum for the connection Header								AAh
4	rqSA = 80h (Requestor's child address, LS always 0)								80h
5	rqSeq = 1						LUN is 0		04h
6	Command 2Dh - Get Sensor Reading								2Dh
7	Sensor Number 0Fh								0Fh
8	Checksum for preceding bytes between the previous checksum								40h

Table 11
RESPONSE message transmitted from the POWER SUPPLY

Byte	Bits								Value
	7	6	5	4	3	2	1	0	
1	rqSA = 80h								80h
2	Net Fn (odd) is 05 (Sensor/Event)						rqLUN is 0		14h
3	Checksum for the connection Header								6Ch
4	rsSA = 46h (Responder's child address)								46h
5	rqSeq = 1						rsLUN is 0		04h
6	Command 2Dh - Get Sensor Reading								2Dh
7	00h (00h means Completion Code = 'OK')								00h
8	B4h Sensor Reading (Current B4h x 0.2A = 180 x 0.2A = 36.0A)								B4h
9	40h sensor information (Event message is disabled for this sensor)								40h
10	C0h Threshold Comparison (Sensor reading is within normal range)								C0h
11	Checksum for preceding bytes between the previous checksum								D5h

Example with Four Units in Parallel (Cont.)

Get Sensor Reading for P6 Rail Temperature (Sensor #18)

Unit 1

344K = 71°C which is below the +85°C maximum

Table 12
REQUEST message transmitted to the POWER SUPPLY at I^2C™ address 20h

Byte	Bits								Value
	7	6	5	4	3	2	1	0	
1	rsSA = 40h (VPX IPMB address, LS is always 0)								40h
2	Net Fn (even) is 04 (Sensor/Event)						rsLUN is 0		10h
3	Checksum for the connection Header								B0h
4	rqSA = 80h (Requestor's child address, LS always 0)								80h
5	rqSeq = 1						LUN is 0		04h
6	Command 2Dh - Get Sensor Reading								2Dh
7	Sensor Number 12h (Card Edge P6)								12h
8	Checksum for preceding bytes between the previous checksum								3Dh

Table 13
RESPONSE message transmitted from the POWER SUPPLY

Byte	Bits								Value
	7	6	5	4	3	2	1	0	
1	rqSA = 80h								80h
2	Net Fn (odd) is 05 (Sensor/Event)						rqLUN is 0		14h
3	Checksum for the connection Header								6Ch
4	rsSA = 40h (Responder's child address)								40h
5	rqSeq = 1						rsLUN is 0		04h
6	Command 2Dh - Get Sensor Reading								2Dh
7	00h (00h means Completion Code = 'OK')								00h
8	90h Sensor Reading (Temperature = 200K + 90h K = 344K)								90h
9	40h sensor information (Event message is disabled for this sensor)								40h
10	C0h Threshold Comparison (Sensor reading is within normal range)								C0h
11	Checksum for preceding bytes between the previous checksum								FFh

Example with Four Units in Parallel (Cont.)

Get Sensor Reading for P6 Rail Temperature (Sensor #18)

Unit 2

353K = 80°C which is below the +85°C maximum but getting close to the limit.

Table 14
REQUEST message transmitted to the POWER SUPPLY at I^2C™ address 21h

Byte	Bits								Value
	7	6	5	4	3	2	1	0	
1	rsSA = 42h (VPX IPMB address, LS is always 0)								42h
2	Net Fn (even) is 04 (Sensor/Event)						rsLUN is 0		10h
3	Checksum for the connection Header								AEh
4	rqSA = 80h (Requestor's child address, LS always 0)								80h
5	rqSeq = 1						LUN is 0		04h
6	Command 2Dh - Get Sensor Reading								2Dh
7	Sensor Number 12h (Card Edge P6)								12h
8	Checksum for preceding bytes between the previous checksum								3Dh

Table 15
RESPONSE message transmitted from the POWER SUPPLY

Byte	Bits								Value
	7	6	5	4	3	2	1	0	
1	rqSA = 80h								80h
2	Net Fn (odd) is 05 (Sensor/Event)						rqLUN is 0		14h
3	Checksum for the connection Header								6Ch
4	rsSA = 42h (Responder's child address)								42h
5	rqSeq = 1						rsLUN is 0		04h
6	Command 2Dh - Get Sensor Reading								2Dh
7	00h (00h means Completion Code = 'OK')								00h
8	99h Sensor Reading (Temperature = 200K + 99h K = 353K)								99h
9	40h sensor information (Event message is disabled for this sensor)								40h
10	C0h Threshold Comparison (Sensor reading is within normal range)								C0h
11	Checksum for preceding bytes between the previous checksum								F4h

Example with Four Units in Parallel (Cont.)

Get Sensor Reading for P6 Rail Temperature (Sensor #18)

Unit 3

347K = 74°C which is below the +85°C maximum.

Table 16
REQUEST message transmitted to the POWER SUPPLY at I^2C™ address 22h

Byte	Bits								Value
	7	6	5	4	3	2	1	0	
1	rsSA = 44h (VPX IPMB address, LS is always 0)								44h
2	Net Fn (even) is 04 (Sensor/Event)						rsLUN is 0		10h
3	Checksum for the connection Header								ACh
4	rqSA = 80h (Requestor's child address, LS always 0)								80h
5	rqSeq = 1						LUN is 0		04h
6	Command 2Dh - Get Sensor Reading								2Dh
7	Sensor Number 12h (Card Edge P6)								12h
8	Checksum for preceding bytes between the previous checksum								3Dh

Table 17
RESPONSE message transmitted from the POWER SUPPLY

Byte	Bits								Value
	7	6	5	4	3	2	1	0	
1	rqSA = 80h								80h
2	Net Fn (odd) is 05 (Sensor/Event)						rqLUN is 0		14h
3	Checksum for the connection Header								6Ch
4	rsSA = 44h (Responder's child address)								44h
5	rqSeq = 1						rsLUN is 0		04h
6	Command 2Dh - Get Sensor Reading								2Dh
7	00h (00h means Completion Code = 'OK')								00h
8	93h Sensor Reading (Temperature = 200K + 93h K = 347K)								93h
9	40h sensor information (Event message is disabled for this sensor)								40h
10	C0h Threshold Comparison (Sensor reading is within normal range)								C0h
11	Checksum for preceding bytes between the previous checksum								F8h

Example with Four Units in Parallel (Cont.)

Get Sensor Reading for P6 Rail Temperature (Sensor #18)

Unit 4

345K = 72°C which is below the +85°C maximum

Table 18
REQUEST message transmitted to the POWER SUPPLY at I²C™ address 23h

Byte	Bits								Value
	7	6	5	4	3	2	1	0	
1	rsSA = 43h (VPX IPMB address, LS is always 0)								46h
2	Net Fn (even) is 04 (Sensor/Event)						rsLUN is 0		10h
3	Checksum for the connection Header								AAh
4	rqSA = 80h (Requestor's child address, LS always 0)								80h
5	rqSeq = 1						LUN is 0		04h
6	Command 2Dh - Get Sensor Reading								2Dh
7	Sensor Number 12h (Card Edge P6)								12h
8	Checksum for preceding bytes between the previous checksum								3Dh

Table 19
RESPONSE message transmitted from the POWER SUPPLY

Byte	Bits								Value
	7	6	5	4	3	2	1	0	
1	rqSA = 80h								80h
2	Net Fn (odd) is 05 (Sensor/Event)						rqLUN is 0		14h
3	Checksum for the connection Header								6Ch
4	rsSA = 46h (Responder's child address)								46h
5	rqSeq = 1						rsLUN is 0		04h
6	Command 2Dh - Get Sensor Reading								2Dh
7	00h (00h means Completion Code = 'OK')								00h
8	91h Sensor Reading (Temperature = 200K + 91h K = 345K)								91h
9	40h sensor information (Event message is disabled for this sensor)								40h
10	C0h Threshold Comparison (Sensor reading is within normal range)								C0h
11	Checksum for preceding bytes between the previous checksum								F8h

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