



# Programmable Multi-Phase Synchronous Buck Converter with PMBus

Preliminary Technical Data

## ASP0800

### KEY FEATURES

- Selectable 1-, 2-, 3-, 4-, 5-, 6, 7 or 8- phase operation at up to 1 MHz per phase**
- PMBus Interface - enables digital programmability of set points and readback of monitored values**
- Logic-level PWM outputs for interface to external high power drivers**
- Fast-Enhanced PWM flex mode for excellent load transient performance**
- Active current balancing between all output phases**
- Built-in power-good/crowbar blanking supports on-the-fly VID code changes**
- Digitally programmable 0.375 V to 1.6 V output supports both VR11 and VR11.1 specifications**
- Programmable Offset up to  $\pm 200\text{mV}$**
- Programmable short-circuit protection with programmable latch-off delay**
- Supports PSI# – Power saving mode during light loads**
- Over – Clamping Control**

### APPLICATIONS

- CPU Power controllers for Servers, Workstations and high end Desktops.**
- Next generation Intel® VRM modules**
- POL Applications such as Memory**

### GENERAL DESCRIPTION

The ASP0800<sup>1</sup> is an integrated power control IC with a PMBus interface. The ASP0800 is a highly efficient, multiphase, synchronous buck switching regulator controller, which aids design of High Efficiency and High Density solutions. The PMBus interface enables digital programming of key system parameters to optimize system performance and provide feedback to the system. The ASP0800 is compatible for use with coupled inductors,

The ASP0800 is optimized for converting a 12 V main supply into the core supply voltage required by high performance Intel processors. It uses an internal 8-bit DAC to read the voltage identification (VID) code directly from the processor, which is used to set the output voltage between 0.375 V and 1.6 V.

This device uses a multimode PWM architecture to drive the logic-level outputs at a programmable switching frequency that can be optimized for VR size and efficiency. The ASP0800 can be programmed for 1-, 2-, 3-, 4-, 5-, 6, 7 or 8- phase operation, allowing for the construction of up to 8 complementary buck

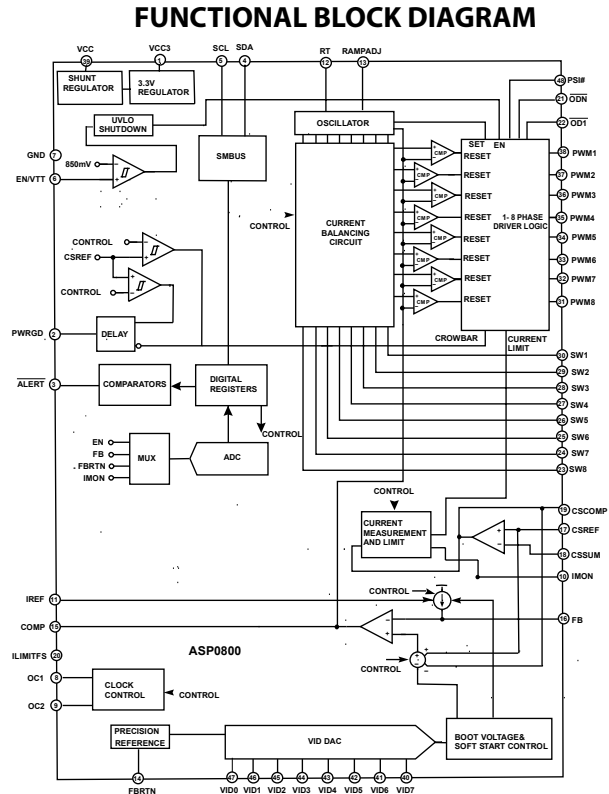


Figure 1. Functional Block Diagram

phases at light loads.

The ASP0800 includes a PMBus interface, which can be used to program system set points such as voltage offset, load line, phase balance and output voltage. Key system performance data such as CPU current, CPU voltage, and power and fault conditions can also be read back over the PMBus from the ASP0800.

The ASP0800 OC Feature allows programming different offset voltages depending on the load current being supplied. 3 OC Thresholds and 4 OC Offsets value registers are supported.

The ASP0800 has a built in shunt regulator that allows the part to be powered from the +12V system supply through a series resistor. The ASP0800 is specified over the extended commercial temperature range of 0°C to +85°C and is available in a 48 Lead LFCSP package.

<sup>1</sup> Protected by U.S. Patent Number 6,683,441; other patents pending.

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**REVISION HISTORY**

03/08—Rev P1: Conversion to ON Semiconductor

## SPECIFICATIONS

VCC = 5 V, FBRTN = GND, TA = 0°C to 85°C, unless otherwise noted.<sup>1</sup>

Table 1

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
<b>REFERENCE CURRENT</b>						
Reference Bias Voltage	V <sub>IREF</sub>		1.75	1.8	1.85	V
Reference Bias Current	I <sub>IREF</sub>	R <sub>IREF</sub> = 121 kΩ		15		μA
<b>ERROR AMPLIFIER</b>						
Output Voltage Range <sup>2</sup>	V <sub>COMP</sub>	Relative to nominal DAC output, referenced to FBRTN (see Figure 3) In startup	0		4.4	V
Accuracy	V <sub>FB</sub>		-10		+10	mV
	V <sub>FB(BOOT)</sub>		1.09	1.1	1.11	V
Load Line Positioning Accuracy			-77	-80	-83	mV
Load Line Range			-350		0	mV
Load Line Attenuation			0		100	%
Differential Nonlinearity			-1		+1	LSB
Input Bias Current	I <sub>FB</sub>	I <sub>FB</sub> = I <sub>IREF</sub>	13.5	15	16.5	μA
Offset Accuracy		VR Offset Register = TBD, VID = 1.0V		-200		mV
		VR Offset Register = TBD, VID = 1.0V		200		mV
FBRTN Current	I <sub>FBRTN</sub>			70	200	μA
Output Current	I <sub>COMP</sub>	FB forced to V <sub>OUT</sub> - 3%		500		μA
Gain Bandwidth Product	GBW <sub>(ERR)</sub>	COMP = FB		20		MHz
Slew Rate		COMP = FB		25		V/μs
BOOT Voltage Hold Time	t <sub>BOOT</sub>	Internal Timer		2		ms
<b>VID INPUTS</b>						
Input Low Voltage	V <sub>IL(VID)</sub>	VID(X)			0.3	V
Input High Voltage	V <sub>IH(VID)</sub>	VID(X)	0.8			V
Input Current	I <sub>IN(VID)</sub>			-5		μA
VID Transition Delay Time <sup>2</sup>		VID code change to FB change	400			ns
No CPU Detection Turn-Off Delay Time <sup>2</sup>		VID code change to PWM going low	5			μs
<b>OSCILLATOR</b>						
Frequency Range <sup>2</sup>	f <sub>OSC</sub>		0.25		9	MHz
Frequency Variation	f <sub>PHASE</sub>	TA = 25°C, RT = 500 kΩ, 4-phase	170	195	225	kHz
		TA = 25°C, RT = 250 kΩ, 4-phase		375		kHz
		TA = 25°C, RT = 121 kΩ, 4-phase		750		kHz
Output Voltage	V <sub>RT</sub>	RT = 500 kΩ to GND	1.9	2.0	2.1	V
RAMPADJ Output Voltage	V <sub>RAMPADJ</sub>	RAMPADJ - FB, V <sub>FB</sub> = 1V,	-50		+50	mV
RAMPADJ Input Current Range	I <sub>RAMPADJ</sub>		5		125	μA
<b>CURRENT SENSE AMPLIFIER</b>						
Offset Voltage	V <sub>OS(CSA)</sub>	CSSUM - CSREF (see Figure 3)	-1.0		+1.0	mV
Input Bias Current, CSREF	I <sub>BIAS(CSREF)</sub>	CSREF = 1V	-20		+20	μA
Input Bias Current, CSSUM	I <sub>BIAS(CSSUM)</sub>	CSREF = 1V	-10		+10	nA
Gain Bandwidth Product	GBW <sub>(CSA)</sub>	CSSUM = CSCOMP		10		MHz
Slew Rate		C <sub>CSCOMP</sub> = 10 pF		10		V/μs
Input Common-Mode Range		CSSUM and CSREF	0		3.0	V
Output Voltage Range			0.05		3.0	V
Output Current	I <sub>CSCOMP</sub>			500		μA
Current Limit Latch off Delay Time		Internal Timer		8		ms

<sup>1</sup> All limits at temperature extremes are guaranteed via correlation using standard statistical quality control (SQC).

<sup>2</sup> Guaranteed by design or bench characterization, not tested in production.

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
PSI#						
Input Low Voltage					0.3	V
Input High Voltage			0.8			V
Input Current				-5		μA
Assertion Timing		Fsw = 300kHz		3.3		μs
Deassertion Timing		Fsw = 300kHz		825		ns
IMON OUTPUT						
Clamp Voltage			1.0		1.15	V
Accuracy		$10 \times (\text{CSREF} - \text{CSCOMP}) / \text{RILIM}$	-3		3	%
Output Current					800	μA
Offset			-3		3	mV
CURRENT LIMIT COMPARATOR						
ILIM Bias Current	$I_{LIM}$	$\text{CSREF} - \text{CSCOMP} / \text{RILIM}$ , (CSREF – CSCOMP)=150 mV, RILIMC=7.5 kΩ		20		μA
Current Limit Threshold Current	$I_{CL}$	$4/3 \times I_{REF}$		20		μA
CURRENT BALANCE AMPLIFIER						
Common-Mode Range	$V_{SW(X)CM}$		-600		+200	mV
Input Resistance	$R_{SW(X)}$	SW(X) = 0 V	14	19	25	kΩ
Input Current	$I_{SW(X)}$	SW(X) = 0 V	7	12	20	μA
Input Current Matching	$\Delta I_{SW(X)}$	SW(X) = 0 V	-6		+6	%
Phase Balance Adjustment Range Low		Phase Bal Registers = 00000		-25		%
Phase Balance Adjustment Range High		Phase Bal Registers = 11111		+25		%
DELAY TIMER						
Internal Timer		Delay Time Register = 011		2		ms
Timer Range Low		Delay Time Register = 000		0.5		ms
Timer Range High		Delay Time Register = 111		4		ms
SOFT START						
Internal Timer		Soft Start Slope Register = 010		0.5		V/ms
Timer Range Low		Soft Start Slope Register = 000		0.1		V/ms
Timer Range High		Soft Start Slope Register = 111		1.5		V/ms
ENABLE INPUT						
Input Low Voltage	$V_{IL(EN)}$				0.3	V
Input High Voltage	$V_{IH(EN)}$		0.8			V
Input Current	$I_{IN(EN)}$			-1		μA
Delay Time	$t_{DELAY(EN)}$	EN > 0.8V, Internal Delay		2		ms
ODN / OD1 OUTPUTS						
Output Low Voltage	$V_{OL(ODN/1)}$	$I_{OD(SINK)} = -400 \mu A$		160	500	mV
Output High Voltage	$V_{OH(ODN/1)}$	$I_{OD(SOURCE)} = 400 \mu A$	4	5		V
$\overline{ODN} / \overline{OD1}$ Pull-Down Resistor				60		kΩ
OVER-CLOCKING OUTPUTS (OC1, OC2)						
Output Low Voltage	$V_{OL}$	$I_{OC(SINK)} = -1 \text{ mA}$		160	500	mV
POWER GOOD COMPARATOR						
Undervoltage Threshold	$V_{PWRGD(UV)}$	Relative to nominal DAC output	-600	-500	-400	mV
Undervoltage Adjustment Range Low		PWRGD_LO Register = 000		-500		mV
Undervoltage Adjustment Range High		PWRGD_LO Register = 111		-150		mV
Overvoltage Threshold	$V_{PWRGD(OV)}$	Relative to DAC output, PWRGD_Hi = 00	200	300	400	mV
Overvoltage Adjustment Range Low		PWRGD_Hi Register = 11		150		mV
Overvoltage Adjustment Range High		PWRGD_Hi Register = 00		300		mV
Output Low Voltage	$V_{OL(PWRGD)}$	$I_{PWRGD(SINK)} = -4 \text{ mA}$		150	300	mV
Power Good Delay Time						

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
During Soft Start <sup>2</sup>		Internal Timer		2		ms
VID Code Changing			100	250		μs
VID Code Static				200		ns
Crowbar Trip Point	V <sub>CROWBAR</sub>	Relative to DAC output, PWRGD_Hi = 00	200	300	400	mV
Overvoltage Adjustment Range Low		PWRGD_Hi Register = 11		150		mV
Overvoltage Adjustment Range High		PWRGD_Hi Register = 00		300		mV
Crowbar Reset Point		Relative to FBRTN	250	300	350	mV
Crowbar Delay Time	t <sub>CROWBAR</sub>	Overvoltage to PWM going low				
VID Code Changing			100	250		μs
VID Code Static				400		ns
<b>PWM OUTPUTS</b>						
Output Low Voltage	V <sub>OL(PWM)</sub>	I <sub>PWM(SINK)</sub> = -400 μA		160	500	mV
Output High Voltage	V <sub>OH(PWM)</sub>	I <sub>PWM(SOURCE)</sub> = 400 μA	4	5		V
<b>PMBus Interface</b>						
Logic High Input Voltage	V <sub>IH(SDA, SCL)</sub>		2.1			V
Logic Input Low Voltage	V <sub>IL(SDA, SCL)</sub>				0.8	V
Hysteresis				500		mV
SDA Output Low Voltage	V <sub>OL</sub>	I <sub>SDA</sub> = -6mA			0.4	V
Input Current	I <sub>IH</sub> ; I <sub>IL</sub>		-1		1	μA
Input Capacitance	C <sub>SCL, SDA</sub>			5		pF
Clock Frequency	f <sub>SCL</sub>				400	kHz
SCL Falling Edge to SDA Valid Time					1	μs
<b>ALERT FAULT OUTPUTS</b>						
Output Low Voltage	V <sub>OL</sub>	I <sub>OUT</sub> = -6mA			0.4	V
Output High Leakage Current	I <sub>OH</sub>	V <sub>OH</sub> = 5V			1	uA
<b>ANALOG/DIGITAL CONVERTER</b>						
Total Unadjusted Error (TUE)				±2		%
Differential Non linearity (DNL)		TBD Bits		1		LSB
Conversion Time		Averaging Enabled (32 averages)		80		ms
<b>SUPPLY</b>						
VCC <sup>2</sup>	VCC	V <sub>SYSTEM</sub> = 12 V, R <sub>SHUNT</sub> = 340 Ω	4.70	5	5.45	V
DC Supply Current	I <sub>VCC</sub>	V <sub>SYSTEM</sub> = 13.2 V, R <sub>SHUNT</sub> = 340 Ω		21	26	mA
UVLO Turn-On Current				6.5	11	mA
UVLO Threshold Voltage	V <sub>UVLO</sub>	VCC rising	9			V
UVLO Turn-Off Voltage		VCC falling		4.1		V
VCC3 Output Voltage	VCC3	I <sub>VCC3</sub> = 1mA	3.0	3.3	3.6	V

TEST CIRCUITS

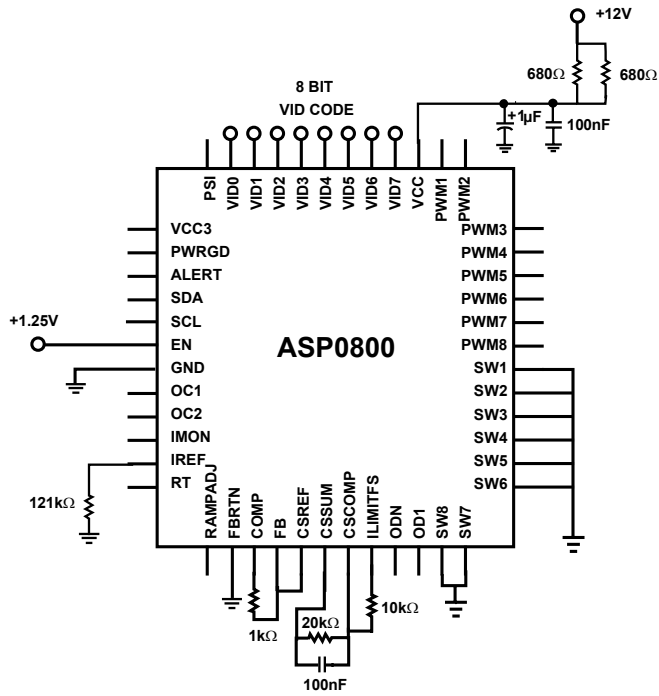


Figure 2. Closed-Loop Output Voltage Accuracy

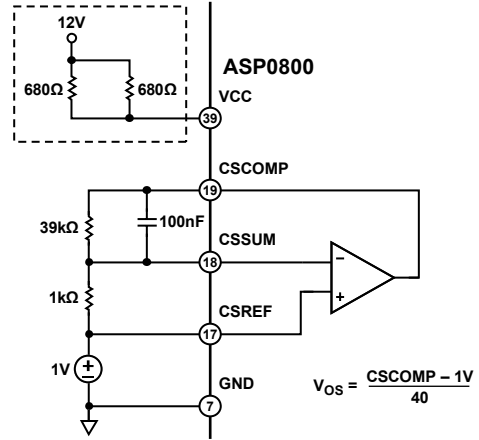
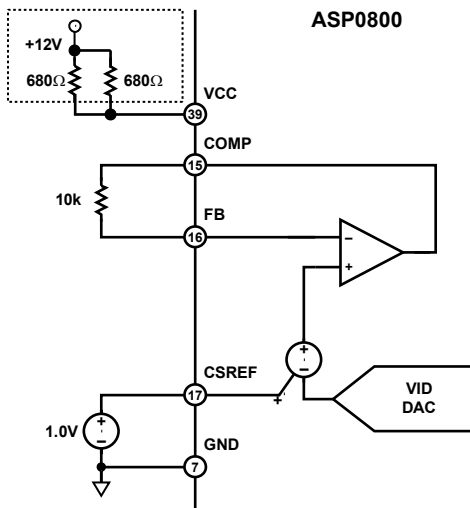


Figure 4. Positioning Voltage



$$\Delta V_{FB} = FB_{\Delta V} = 80mV - FB_{\Delta V} = 0mV$$

Figure 3. Current Sense Amplifier  $V_{OS}$

## ABSOLUTE MAXIMUM RATINGS

Table 2.

Parameter	Rating
VCC	-0.3 V to +6 V
FBRTN	-0.3 V to +0.3 V
PWM2 to PWM8, RAMPADJ	-0.3 V to VCC + 0.3 V
SW1 to SW8	-5 V to +25 V
<200 ns	-10 V to +25 V
All Other Inputs and Outputs	-0.3 V to VCC + 0.3 V
Storage Temperature Range	-65°C to +150°C
Operating Ambient Temperature Range	0°C to 85°C
Operating Junction Temperature	125°C
Lead Temperature	
Soldering (10 sec)	300°C
Infrared (15 sec)	260°C

Stresses above those listed under Absolute Maximum Ratings may cause permanent damage to the device. This is a stress rating only; functional operation of the device at these or any other conditions above those indicated in the operational

section of this specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

### THERMAL RESISTANCE

$\theta_{JA}$  is specified for the worst-case conditions, that is, a device soldered in a circuit board for surface-mount packages.

Table 3. Thermal Resistance

Package Type	$\theta_{JA}$	$\theta_{JC}$	Unit
Thermal Impedance ( $\theta_{JA}$ )	27°C/W		

### ESD CAUTION



**ESD (electrostatic discharge) sensitive device.** Charged devices and circuit boards can discharge without detection. Although this product features patented or proprietary protection circuitry, damage may occur on devices subjected to high energy ESD. Therefore, proper ESD precautions should be taken to avoid performance degradation or loss of functionality.

## PIN CONFIGURATION AND FUNCTION DESCRIPTIONS

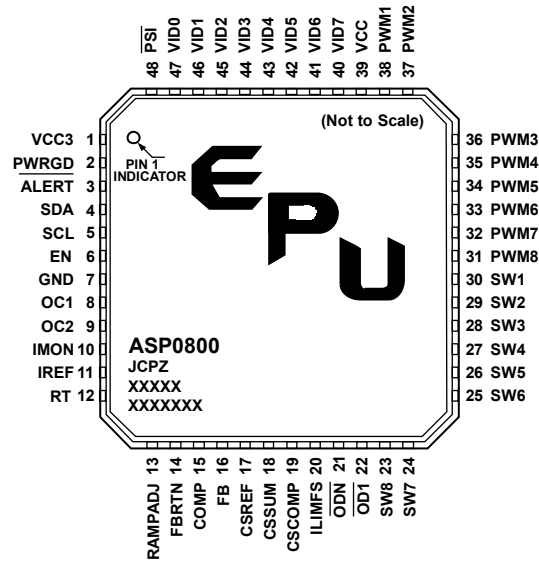


Figure 5. Pin Configuration

Table 4. Pin Function Descriptions

Pin No.	Mnemonic	Description
1	VCC3	3.3V Power Supply Output. A capacitor from this pin to ground provided decoupling for the interval 3.3V LDO.
2	PWRGD	Power-Good Output: Open-drain output that signals when the output voltage is outside of the proper operating range.
3	$\overline{\text{ALERT}}$	$\overline{\text{ALERT}}$ Output : Open drain output that asserts low when the VR exceeds a programmable limit. Can be configured for Comparator Mode or Interrupt Mode.
4	SDA	Digital Input / Output. PMBus serial data bidirectional pin. Requires PMBus pull up.
5	SCL	Digital Input. PMBus serial bus clock open drain input. Requires PMBus pull up.
6	EN	Power Supply Enable Input. Pulling this pin to GND disables the PWM outputs and pulls the PWRGD output low.
7	GND	Ground. All internal biasing and the logic output signals of the device are referenced to this ground
8	OC1	Over Clocking Bit 1 Output. The pin is connected to the clock control chip to set the over-clocking state.
9	OC2	Over Clocking Bit 2 Output. The pin is connected to the clock control chip to set the over-clocking state.
10	IMON	Total Current Output Pin.
11	IREF	Current Reference Input. An external resistor from this pin to ground sets the reference current for $I_{FB}$ , and $I_{ILIMFS}$ .
12	RT	Frequency Setting Resistor Input. An external resistor connected between this pin and GND sets the oscillator frequency of the device.
13	RAMPADJ	PWM Ramp Current Input. An external resistor from the converter input voltage to this pin sets the internal PWM ramp.
14	FBRTN	Feedback Return. VID DAC and error amplifier reference for remote sensing of the output voltage.
15	COMP	Error Amplifier Output and Compensation Point.
16	FB	Feedback Input. Error amplifier input for remote sensing of the output voltage. An external resistor between this pin and the output voltage sets the no load offset point.
17	CSREF	Current Sense Reference Voltage Input. The voltage on this pin is used as the reference for the current sense amplifier and the power-good and crowbar functions. This pin should be connected to the common point of the output inductors.
18	CSSUM	Current Sense Summing Node. External resistors from each switch node to this pin sum the average inductor currents together to measure the total output current.
19	CSCOMP	Current Sense Compensation Point. A resistor and capacitor from this pin to CSSUM determines the gain of the current sense amplifier and the positioning loop response time.
20	ILIMFS	Current Sense and Limit Scaling Pin. An external resistor from this pin to CSCOMP sets the internal current sensing signal for current-limit and IMON. This value can be over-written using the PMBus interface.
21	$\overline{\text{ODN}}$	Output Disable Logic Output for $\overline{\text{PSI}}$ operation. This pin is actively pulled low when $\overline{\text{PSI}}$ is low, otherwise it functions in the same way as $\overline{\text{OD1}}$ .
22	$\overline{\text{OD1}}$	Output Disable Logic Output. This pin is actively pulled low when the EN input is low or when VCC is below its UVLO threshold to signal to the Driver IC that the driver high-side and low-side outputs should go low.



Pin No.	Mnemonic	Description
23 to 30	SW8 to SW1	Current Balance Inputs. Inputs for measuring the current level in each phase. The SW pins of unused phases should be left open.
31 to 38	PWM8 to PWM1	Logic-Level PWM Outputs. Each output is connected to the input of an external MOSFET driver such as the ADP3121. Connecting the PWM8, PWM7, PWM6, PWM5, PWM4, PWM3 and PWM2 outputs to VCC causes that phase to turn off, allowing the ASP0800 to operate as a 1-, 2-, 3-, 4-, 5-, 6-, 7 or 8-phase controller.
39	VCC	Supply Voltage for the Device. A 340 $\Omega$ resistor should be placed between the 12 V system supply and the VCC pin. The internal shunt regulator maintains VCC = 5 V.
40 to 47	VID7 to VID0	Voltage Identification DAC Inputs. These eight pins are pulled down to GND, providing a logic zero if left open. When in normal operation mode, the DAC output programs the FB regulation voltage from 0.375 V to 1.6
48	$\overline{\text{PSI}}$	Power State Indicator. Pulling this pin low places the controller in lower power state operation.

**TYPICAL PERFORMANCE CHARACTERISTICS**

**TBD**

## THEORY OF OPERATION

The ASP0800 combines a multi-mode, fixed frequency PWM control with multi-phase logic outputs for use in multi-phase synchronous buck CPU core supply power converters. The internal VID DAC is designed to interface with the Intel 8-bit VR 11 and VR 11.1 compatible CPUs .

In addition, the ASP0800 incorporates a serial interface to allow the programming of key system performance specifications and read back CPU data such as voltage, current and power.

Multiphase operation is important for producing the high currents and low voltages demanded by today's microprocessors. Handling the high currents in a single-phase converter would place high thermal demands on the components in the system such as the inductors and MOSFETs.

The multimode control of the ASP0800 ensures a stable, high performance topology for:

- Balancing currents and thermals between phases for both static and dynamic operation.
- High speed response at the lowest possible switching frequency and output decoupling
- FEPWM improves load step response.
- Minimizing thermal switching losses by utilizing lower frequency operation
- High current output due to 8 phase operation
- Tight load line regulation and accuracy
- Reduced output ripple due to multiphase cancellation
- PC board layout noise immunity
- Ease of use and design due to independent component selection
- Flexibility in operation for tailoring design to low cost or high performance

### START-UP SEQUENCE

The ASP0800 follows the VR11 start-up sequence shown in Figure 7. After both the EN and UVLO conditions are met, a programmable internal timer goes through one cycle TD1. This delay cycle is programmed using Delay Command, default delay = 2ms). The first eight clock cycles of TD2 are blanked from the PWM outputs and used for phase detection as explained in the following section. Then the programmable internal soft-start ramp is enabled (TD2) and the output comes up to the boot voltage of 1.1V. The boot hold time is also set by the Delay Command. This second delay cycle is called TD3. During TD3 the processor VID pins settle to the required VID code. When TD3 is over, the ASP0800 reads the VID inputs and soft starts either up or down to the final VID voltage (TD4). After TD4 has been completed and the PWRGD masking time (equal to VID on the fly masking) is finished, a

third cycle of the internal timer sets the PWRGD blanking (TD5).

The internal delay and soft start times are programmable using the serial interface and the Delay Command and Soft Start Command.

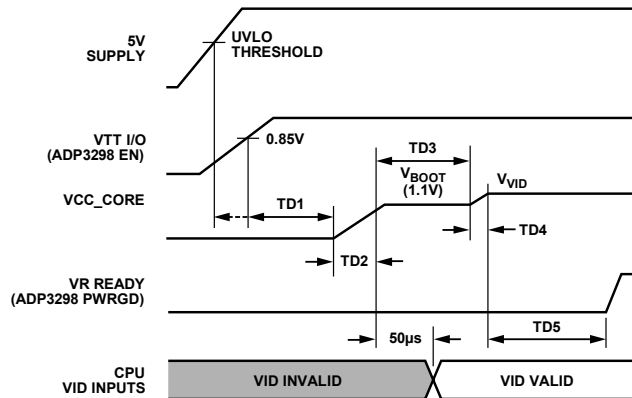


Figure 7. System Start-Up Sequence for VR11

### PHASE DETECTION SEQUENCE

During startup, the number of operational phases and their phase relationship is determined by the internal circuitry that monitors the PWM outputs. Normally, the ASP0800 operates as a 8-phase PWM controller.

To operate as a 7-phase controller connect PWM8 to VCC.

To operate as a 6-phase controller connect PWM7 and PWM8 to VCC.

To operate as a 5-phase controller connect PWM6, PWM7 and PWM8 to VCC.

To operate as a 4-phase controller connect PWM5, PWM6, PWM7 and PWM8 to VCC.

To operate as a 3-phase controller connect PWM4, PWM5, PWM6, PWM7 and PWM8 to VCC.

To operate as a 2-phase controller connect PWM3, PWM4, PWM5, PWM6, PWM7 and PWM8 to VCC.

To operate as a 1-phase controller connect PWM2, PWM3, PWM4, PWM5, PWM6, PWM7 and PWM8 to VCC.

Prior to soft start, while EN is low, the PWM8, PWM7, PWM6, PWM5, PWM4, PWM3 and PWM2 pins sink approximately 100 µA each. An internal comparator checks each pin's voltage vs. a threshold of 3 V. If the pin is tied to VCC, it is above the threshold. Otherwise, an internal current sink pulls the pin to GND, which is below the threshold. PWM1 is low during the phase detection interval that occurs during the first eight clock cycles of TD2. After this time, if the remaining PWM outputs are not pulled to VCC, the 100 µA current sink is removed, and they function as normal PWM outputs. If they are pulled to

VCC, the 100  $\mu$ A current source is removed, and the outputs are put into a high impedance state.

The PWM outputs are logic-level devices intended for driving fast response external gate drivers such as the ADP3121 and ADP3122. Because each phase is monitored independently, operation approaching 100% duty cycle is possible. In addition, more than one output can be on at the same time to allow overlapping phases.

### MASTER CLOCK FREQUENCY

The clock frequency of the ASP0800 is set with an external resistor connected from the RT pin to ground. The frequency follows the graph in Figure 6. To determine the frequency per phase, the clock is divided by the number of phases in use. If all phases are in use, divide by 6. If 4 phases are in use divide by 4.

### OUTPUT VOLTAGE DIFFERENTIAL SENSING

The ASP0800 combines differential sensing with a high accuracy VID DAC and reference, and a low offset error amplifier. This maintains a worst-case specification of  $\pm 10$  mV differential sensing error over its full operating output voltage and temperature range. The output voltage is sensed between the FB pin and FBRTN pin. FB is connected through a resistor,  $R_B$ , to the regulation point, usually the remote sense pin of the microprocessor. FBRTN is connected directly to the remote sense ground point. The internal VID DAC and precision reference are referenced to FBRTN, which has a minimal current of 70  $\mu$ A to allow accurate remote sensing. The internal error amplifier compares the output of the DAC to the FB pin to regulate the output voltage.

### OUTPUT CURRENT SENSING

The ASP0800 provides a dedicated current-sense amplifier (CSA) to monitor the total output current for proper voltage positioning vs. load current, for the IMON output and for current-limit detection. Sensing the load current at the output gives the total real time current being delivered to the load, which is an inherently more accurate method than peak current detection or sampling the current across a sense element such as the low-side MOSFET. This amplifier can be configured several ways, depending on the objectives of the system, as follows:

- Output inductor DCR sensing without a thermistor for lowest cost.
- Output inductor DCR sensing with a thermistor for improved accuracy with tracking of inductor temperature.
- Sense resistors for highest accuracy measurements.

The positive input of the CSA is connected to the CSREF pin, which is connected to the average output voltage. The inputs to the amplifier are summed together through resistors from the sensing element, such as the switch node side of the output inductors, to the inverting

input CSSUM. The feedback resistor between CSCOMP and CSSUM sets the gain of the amplifier and a filter capacitor is placed in parallel with this resistor. The gain of the amplifier is programmable by adjusting the feedback resistor.

This difference signal is used internally to offset the VID DAC for voltage positioning. This different signal can be adjusted between 50%-150% of the external value using the PMBus Loadline Calibration (0xDE) and Loadline Set (0xDF) commands.

The difference between CSREF and CSCOMP is then used as a differential input for the current-limit comparator.

To provide the best accuracy for sensing current, the CSA is designed to have a low offset input voltage. Also, the sensing gain is determined by external resistors to make it extremely accurate.

The CPU current can also be monitored over the PMBus. The current limit and the load line can be programmed over PMBus.

### OUTPUT CURRENT MONITOR

IMON is an analog output from the ASP0800 representing the total current being delivered to the load. It outputs an accurate current that is directly proportional to the current set by the ILIMFS resistor. The current is then run through a parallel RC connected from the IMON pin to the FBRTN pin to generate an accurately scaled and filtered voltage as per the VR11.1 specification. The size of the resistor is used to set the IMON scaling.

If the IMON and the OCP need to be changed based on the TDC of the CPU, then the ILIMFS resistor is the only component that needs to be changed. If the IMON scaling is the only change needed then changing the IMON resistor accomplishes this.

The IMON pin also includes an active clamp to limit the IMON voltage to 1.15V MAX while maintaining 900mV MIN full scale accurate reporting.

### ACTIVE IMPEDANCE CONTROL MODE

For controlling the dynamic output voltage droop as a function of output current, the CSA gain and load line programming can be scaled to be equal to the droop impedance of the regulator times the output current. This droop voltage is then used to set the input control voltage to the system. The droop voltage is subtracted from the DAC reference input voltage directly to tell the error amplifier where the output voltage should be. This allows enhanced feed-forward response.

**CURRENT CONTROL MODE AND THERMAL BALANCE**

The ASP0800 has individual inputs (SW1 to SW8) for each phase that are used for monitoring the current of each phase. This information is combined with an internal ramp to create a current balancing feedback system that has been optimized for initial current balance accuracy and dynamic thermal balancing during operation. This current balance information is independent of the average output current information used for positioning as described in the Output Current Sensing section.

The magnitude of the internal ramp can be set to optimize the transient response of the system. It also monitors the supply voltage for feed-forward control for changes in the supply. A resistor connected from the power input voltage to the RAMPADJ pin determines the slope of the internal PWM ramp.

The balance between the phases can be programmed using the PMBus Phase Bal SW(x) commands (TBD to TBD). This allows each phase to be adjusted if there is a difference in temperature due to layout and airflow considerations. The phase balance can be adjusted from a default gain of 5 (Bits 4:0 = 10000). The minimum gain programmable is 3.75 (Bits 4:0 = 00000) and the max gain is 6.25 (Bits 4:0 = 11111).

**VOLTAGE CONTROL MODE**

A high gain, high bandwidth, voltage mode error amplifier is used for the voltage mode control loop. The control input voltage to the positive input is set via the VID logic according to the voltages listed in Table 5. The VID code is set using the VID Input pins or it can be programmed over the PMBus using the VOUT\_Command. By default, the ASP0800 outputs a voltage corresponding to the VID Inputs. To output a voltage following the VOUT\_Command the user first needs to program the required VID Code. Then the VID\_EN Bits need to be enabled. The following is the sequence

1. Program the required VID Code to the VOUT\_Command code (0x21)
2. Set the VID\_EN bit (Bit 3) in the VR Config 1A (0xD2) and on the VR Config 1B (0xD3).

This voltage is also offset by the droop voltage for active positioning of the output voltage as a function of current, commonly known as active voltage positioning. The output

of the amplifier is the COMP pin, which sets the termination voltage for the internal PWM ramps.

The negative input (FB) is tied to the output sense location with Resistor R<sub>B</sub> and is used for sensing and controlling the output voltage at this point. A current source (equal to IREF) from the FB pin flowing through R<sub>B</sub> is used for setting the no load offset voltage from the VID voltage. The no load voltage is negative with respect to the VID DAC for Intel CPU's. The main loop compensation is incorporated into the feedback network between FB and COMP.

An offset voltage can be added to the control voltage over the serial interface. This is done using Bits <5:0> of the VOUT\_TRIM (0xDB) and VOUT\_CAL (0xDC) Commands. The max offset that can be applied is +/- 200mV (even if the sum of the offsets > 200mV). The LSB size is 6.25mV. A positive offset is applied when Bit 4 = 0. A negative offset is applied when Bit 4 = 1.

**Table 5. Offset Codes**

VOUT_TRIM CODE	TRIM OFFSET VOLTAGE	VOUT_CAL CODE	CAL OFFSET VOLTAGE	TOTAL OFFSET VOLTAGE
TBD	TBD	TBD	TBD	TBD
TBD	TBD	TBD	TBD	TBD
TBD	TBD	TBD	TBD	TBD

**DYNAMIC VID**

The ASP0800 has the ability to dynamically change the VID inputs while the controller is running. This allows the output voltage to change while the supply is running and supplying current to the load. This is commonly referred to as Dynamic VID (DVID). A DVID can occur under either light or heavy load conditions. The processor signals the controller by changing the VID inputs (or by programming a new VOUT\_Command) in a single or multiple steps from the start code to the finish code. This change can be positive or negative.

When a VID bit changes state, the ASP0800 detects the change and ignores the DAC inputs for a minimum of 200 ns. This time prevents a false code due to logic skew while the VID inputs are changing. Additionally, the first VID change initiates the PWRGD and CROWBAR blanking functions for a minimum of 100 μs to prevent a false PWRGD or CROWBAR event. Each VID change resets the internal timer.

If a VID off code is detected the ASP0800 will wait for 5μsec to ensure that the code is correct before initiating a shutdown of the controller.

The ASP0800 also uses the TON\_Transition (0xD6) to limit the DVID slew rates. These can be encountered when the system does a large single VID step for power state changes, thus the DVID slew rate needs to be limited to prevent large inrush currents.

The transition slew rate is programmed using Bits <2:0> of the Ton\_Transition (0xD6) command code. Table 6 provides the transition rate values.

**Table 6. Transition Rate Codes**

Code	Transition Rate (V/msec)
000	1
001	3
010	5 = default
011	7
100	9
101	11
110	13
111	15

**ENHANCED TRANSIENTS MODE**

The ASP0800 incorporates enhanced transient response for both load step up and load release. For load step up it senses the output of the error amp to determine if a load step up has occurred and then sequences on the appropriate number of phases to ramp up the output current.

**CURRENT REFERENCE**

The IREF pin is used to set an internal current reference. This reference current sets  $I_{FB}$ . A resistor to ground programs the current based on the 1.8 V output.

$$I_{REF} = \frac{1.8V}{R_{REF}}$$

Typically,  $R_{IREF}$  is set to 121 kΩ to program  $I_{REF} = 15 \mu A$ . The following currents are then equal to

$$I_{FB} = I_{REF} = 15 \mu A$$

**INTERNAL DELAY TIMER**

The delay times for the start up timing sequence are set by an internal timer. The default time is 2msec which can be changed through the PMBus interface. This timer is used for multiple

delay timings (TD1, TD3, and TD5) during the start-up sequence. Also, it is used for timing the current limit latch off as explained in the CURRENT LIMIT section. The current limit timer is set to 4 times the delay timer.

The delay timer is programmed using Bits <2:0> of the Ton Delay command (0xD4). The delay can be programmed between 0.5msec and 4msec. Table 7 provides the programmable delay values

**Table 7. Delay Codes**

Code	Delay (msec)
000	0.5
001	1
010	1.5
011	2 = default
100	2.5
101	3
110	3.5
111	4

**SOFT START**

The Soft Start slope for the output voltage is set by an internal timer. The default value is 0.5V/msec., which can be programmed through the PMBus interface. After TD1 and the phase detection cycle have been completed, the SS time (TD2 in Figure 7) starts. The SS circuit uses the internal VID DAC to increase the output voltage in 6.25mV steps up to the 1.1 V boot voltage.

Once the SS circuit has reached the boot voltage, the boot voltage delay time (TD3) is started. The end of the boot voltage delay time signals the beginning of the second soft start time (TD4). The SS voltage changes from the boot voltage to the programmed VID DAC voltage (either higher or lower) using 6.25mV steps.

The soft start slew rate is programmed using Bits <2:0> of the Ton\_Rise (0xD5) command code.

Table 8. Soft Start Codes provides the soft start values. Figure 8 shows typical start-up waveforms for the ASP0800.

Table 8. Soft Start Codes

Code	Soft Start (V/msec)
000	0.3
001	0.3
010	0.5 = default
011	0.7
100	0.9
101	1.1
110	1.3
111	1.5

Figure 8 shows typical start up waveforms for the ASP0800.

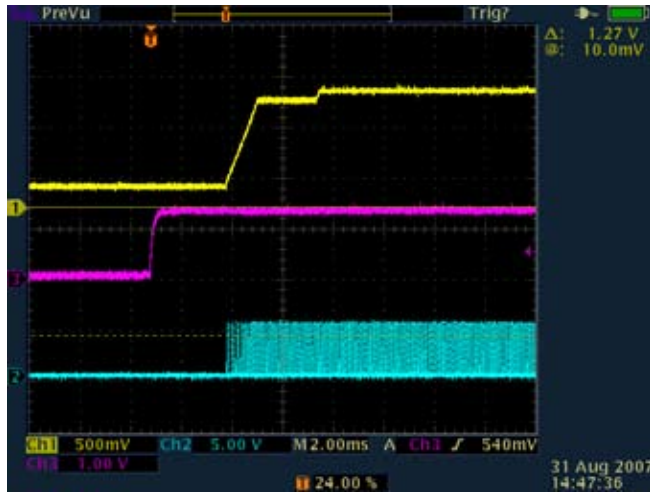


Figure 8. Typical Start up waveforms  
 Channel 1: CSREF  
 Channel 2: EN  
 Channel 3: PWM1

**CURRENT-LIMIT, SHORT-CIRCUIT, AND LATCH-OFF PROTECTION**

The ASP0800 compares a programmable current limit set point to the voltage from the output of the current sense amplifier. The level of current limit is set with the resistor from the ILIMFS pin to CSCOMP, and can be adjusted using the PMBus interface.

The current limit threshold can be modified from the resistor programmed value by using the PMBus interface using Bits <4:0> of the Current Limit Threshold command (0xE2). The limit is programmable between 50% of the external limit and 146.7% of the external limit. The resolution is 3.3%.

Table 9 gives some examples codes

Table 9. Current Limit

Code	Current Limit (% of external limit)
0 0000	50%
0 0001	53.3%
1 0000	100% = default
1 0001	103.3%
1 1110	143.3%
1 1111	146.7%

The current limit threshold can be modified from the resistor programmed value by using the serial interface.

If the limit is reached and TD5 has completed, an internal latch-off delay time will start, and the controller will shut down if the fault is not removed. This delay is four times longer than the delay time during the start-up sequence. The current limit delay time only starts after the TD5 has completed. If there is a current limit during start-up, the ASP0800 will go through TD1 to TD5, and then start the latch-off time. Because the controller continues to cycle the phases during the latch-off delay time, if the short is removed before the timer is complete, the controller can return to normal operation.

The latch-off function can be reset by either removing and reapplying the supply voltage to the ASP0800, or by toggling the EN pin low for a short time.

The OCP latch-off function can be disabled by using the PMBus interface. Setting the CLIM\_EN bit (bit 1) of the VR Config 1A (0xD2) and VR Config 1B (0xD3) registers to 0 disables the current limit latch off function. The ASP0800 can continue to operate in current limit indefinitely.

During start-up when the output voltage is below 200 mV, a secondary current limit is active. This is necessary because the voltage swing of CSCOMP cannot go below ground. This secondary current limit limits controls the internal COMP voltage to the PWM comparators to 1.5 V. This limits the voltage drop across the low-side MOSFETs through the current balance circuitry. Typical over-current latch-off waveforms are shown in Figure 9.

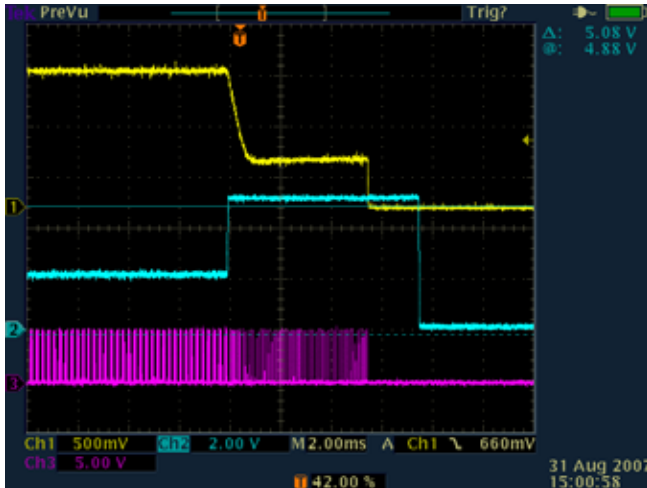


Figure 9. Overcurrent Latch-off Waveforms  
Channel 1: CSREF,  
Channel 2: COMP, Channel 3: PWM1

An inherent per phase current limit protects individual phases if one or more phases stops functioning because of a faulty component. This limit is based on the maximum normal mode COMP voltage.

### POWER-GOOD MONITORING

The power good comparator monitors the output voltage via the CSREF pin. The PWRGD pin is an open-drain output whose high level (when connected to a pull-up resistor) indicates that the output voltage is within the nominal limits specified in the specifications above based on the VID voltage setting. PWRGD goes low if the output voltage is outside of this specified range, if the VID DAC inputs are in no CPU mode, or whenever the EN pin is pulled low. PWRGD is blanked during a DVID event for a period of 100  $\mu$ s to prevent false signals during the time the output is changing.

The PWRGD circuitry also incorporates an initial turn-on delay time (TD5). Prior to the SS voltage reaching the programmed VID DAC voltage and the PWRGD masking time finishing, the PWRGD pin is held low. Once the SS circuit reaches the programmed DAC voltage, the internal timer operates.

The value for the PWRGD high limit and low limit can be programmed using the serial interface.

### POWER STATE INDICATOR

The PSI# pin is an input used to determine the operating state of the load. If this input is pulled low, the load is in a low power state and the controller asserts the  $\overline{\text{ODN}}$  pin low, which can be used to disable phases and maintain better efficiency at lighter loads.

The sequencing into and out of low power operation is maintained to minimize output deviations as well as providing full power load transients immediately after exiting a low power

### OUTPUT CROWBAR

As part of the protection for the load and output components of the supply, the PWM outputs are driven low (turning on the low-side MOSFETs) when the output voltage exceeds the upper crowbar threshold. This crowbar action stops once the output voltage falls below the release threshold of approximately 300 mV.

The value for the crowbar limit follows the programmable PWRGD high limit.

Turning on the low-side MOSFETs pulls down the output as the reverse current builds up in the inductors. If the output overvoltage is due to a short in the high-side MOSFET, this action current-limits the input supply or blows its fuse, protecting the microprocessor from being destroyed.

### OUTPUT ENABLE AND UVLO

For the ASP0800 to begin switching, the input supply current to the controller must be higher than the UVLO threshold and the EN pin must be higher than its 0.8 V threshold. This initiates a system start-up sequence. If either UVLO or EN is less than their respective thresholds, the ASP0800 is disabled. This holds the PWM outputs at ground and forces PWRGD,  $\overline{\text{ODN}}$  and  $\overline{\text{OD1}}$  signals low.

In the application circuit (see Figure TBD), the  $\overline{\text{OD1}}$  pin should be connected to the  $\overline{\text{OD}}$  inputs of the external drivers for the phases that are always on. The  $\overline{\text{ODN}}$  pin should be connected to the  $\overline{\text{OD}}$  inputs of the external drivers on the phases that are shut down during low power operation. Grounding the driver  $\overline{\text{OD}}$  inputs disables the drivers such that both DRVH and DRVL are grounded. This feature is important in preventing the discharge of the output capacitors when the controller is shut off. If the driver outputs are not disabled, a negative voltage can be generated during output due to the high current discharge of the output capacitors through the inductors.

### OVERCLOCKING (OC) LIMITS AND OFFSETS

The ASP0800 includes an overclocking function. The total output current is monitored by the ASP0800 using the  $I_{\text{MON}}$  output.

Read\_IOUT Command gives the total current in Amps

The IOUT value is compared with the Over Clocking or OC Thresholds. There are three OC thresholds

Command TBD = OC Threshold 1; Default = TBD

Command TBD = OC Threshold 2; Default = TBD

Command TBD = OC Threshold 3; Default = TBD

$I_{\text{OUT}}$  is first compared with OC3, If  $I_{\text{OUT}}$  is greater than OC3 then the system is in OC State TBD and Offset TBD is applied. If  $I_{\text{OUT}}$  is less than OC3 but greater than OC2 then the system is in OC State TBD. If  $I_{\text{OUT}}$  is less than OC2 but greater than OC1 then the system is in OC State TBD. If  $I_{\text{OUT}}$  is less than OC1 then the system is in OC State TBD. Each offset state has a



corresponding Offset voltage. The offset voltage for each state is programmable in TBD mV steps up to a max value of ±200 mV.

Register TBD VR Offset 1 = Offset voltage for State 1, default value = 0x00

Register TBD VR Offset 2 = Offset voltage for State 2, default value = 0x00

Register TBD VR Offset 3 = Offset voltage for State 3, default value = 0x00

Register TBD VR Offset 4 = Offset voltage for State 4, default value = 0x00

**PMBUS INTERFACE**

Control of the ASP0800 is carried out using the PMBus Interface. The physical protocol for PMBus closely matches that of SMBus.

The ASP0800 is connected to this bus as a slave device, under the control of a master controller.

To setup the PMBus Address the ASP0800 sources a 10uA current from the ADD pin through an external resistor. The voltage is then measured by the ADC and user to set the PMBus address. The table below gives the thresholds for each possible PMBus address and also a suitable resistor value.

**Table 10: Setting up the PMBus Address**

Address (8 Bits)	High Threshold	Low Threshold	Suggested Resistor Value
0xC0	0.1		
0xC2	0.25	0.15	
0xC4	0.5	0.3	
0xC6	0.75	0.55	
0xC8	1.0	0.8	
0xCA	1.4	1.1	
0xCC	1.9	1.5	
0xCE		2.0	

Data is sent over the serial bus in sequences of nine clock pulses: eight bits of data followed by an acknowledge bit from the slave device. Transitions on the data line must occur during the low period of the clock signal and remain stable during the high period, because a low-to-high transition when the clock is high might be interpreted as a stop signal. The number of data bytes that can be transmitted over the serial bus in a single read or

write operation is limited only by what the master and slave devices can handle.

1. When all data bytes have been read or written, stop conditions are established. In write mode, the master pulls the data line high during the tenth clock pulse to assert a stop condition. In read mode, the master device overrides the acknowledge bit by pulling the data line high during the low period before the ninth clock pulse; this is known as No Acknowledge. The master takes the data line low during the low period before the tenth clock pulse, and then high during the tenth clock pulse to assert a stop condition.

Any number of bytes of data can be transferred over the serial bus in one operation, but it is not possible to mix read and write in one operation because the type of operation is determined at the beginning and cannot subsequently be changed without starting a new operation.

In the ASP0800, write operations contain one, two or three bytes, and read operations contain one or two bytes. The command code or register address determines the number of bytes to be read or written, See the register map for more information.

To write data to one of the device data registers or read data from it, the address pointer register must be set so that the correct data register is addressed (i.e. command code), and then data can be written to that register or read from it. The first byte of a read or write operation always contains an address that is stored in the address pointer register. If data is to be written to the device, the write operation contains a second data byte that is written to the register selected by the address pointer register.

This write byte operation is shown in Figure 11. The device address is sent over the bus, and then R/W is set to 0. This is followed by two data bytes. The first data byte is the address of the internal data register to be written to, which is stored in the address pointer register. The second data byte is the data to be written to the internal data register.

2. The read byte operation is shown in Figure 12. First the command code needs to be written to the ASP0800 so that the required data is sent back. This is done by performing a write to the ASP0800 as before, but only the data byte containing the register address is sent, because no data is written to the register. A repeated start is then issued and a read operation is then performed consisting of the serial bus address; R/W bit set to 1, followed by the data byte read from the data register.

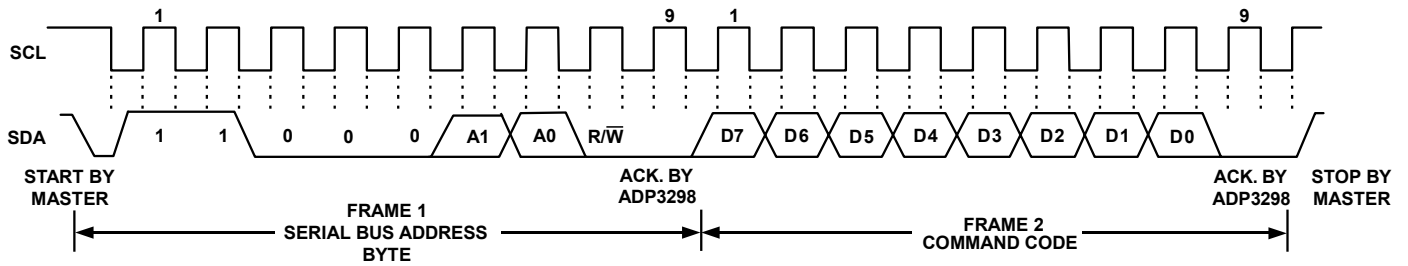


Figure 10. Send Byte

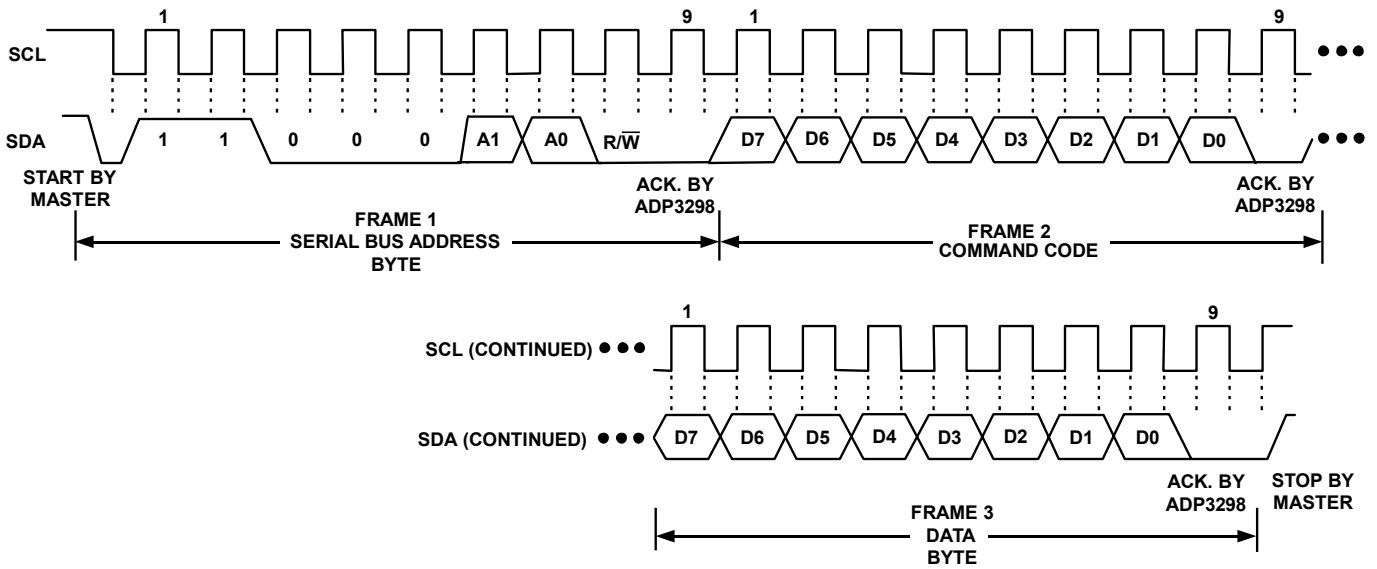


Figure 11. Write Byte

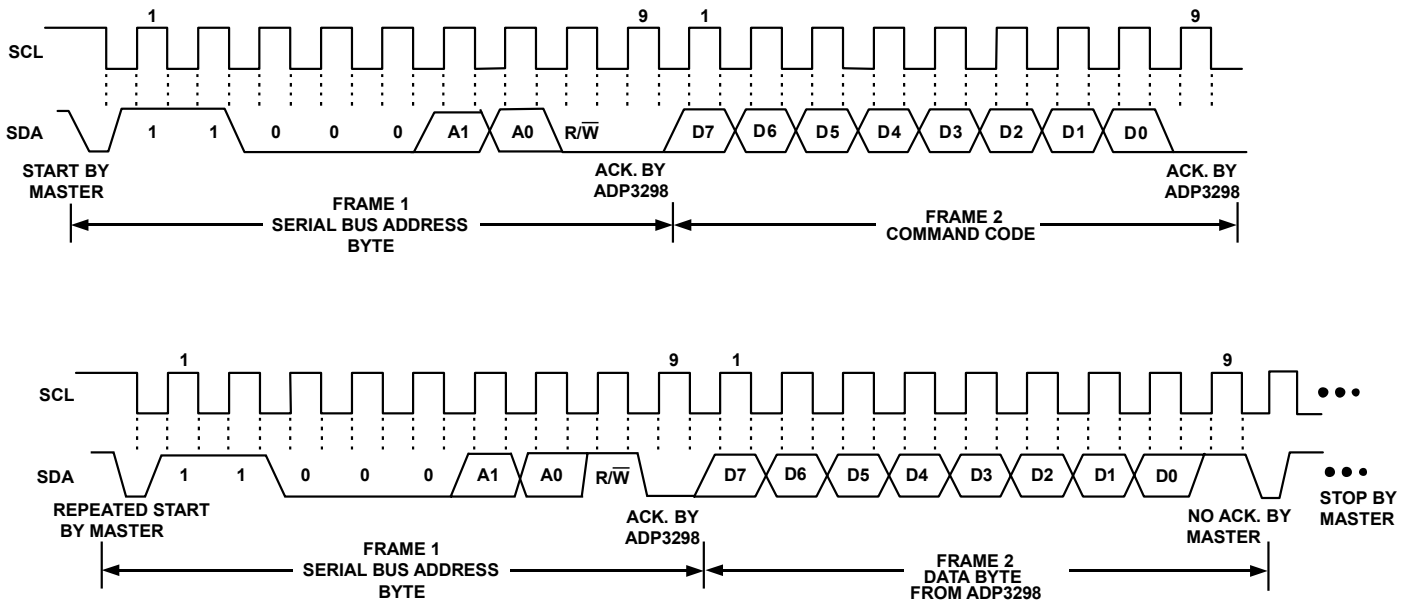


Figure 12. Read Byte

3. It is not possible to read or write a data byte from a data register without first writing to the address pointer register, even if the address pointer register is already at the correct value.

4. In addition to supporting the send byte, the ASP0800 also supports the read byte, write byte, read word and write word protocols. (See *System Management Bus Specifications Rev. 2.0* and the *PMBus Specification Rev 1.1 Part I and Part II* for more information.)

**WRITE OPERATIONS**

The PMBus specification defines several protocols for different types of read and write operations. The ones used in the ASP0800 are discussed in this section. The following abbreviations are used in the diagrams:

- S—START
- P—STOP
- R—READ
- W—WRITE
- A—ACKNOWLEDGE
- $\bar{A}$ —NO ACKNOWLEDGE

The ASP0800 uses the following PMBus write protocols.

**Send Byte**

In this operation, the master device sends a single command byte to a slave device as follows:

1. The master device asserts a start condition on SDA.
2. The master sends the 7-bit slave address followed by the write bit (low).
3. The addressed slave device asserts ACK on SDA.
4. The master sends a command code.
5. The slave asserts ACK on SDA.
6. The master asserts a stop condition on SDA and the transaction ends.

For the ASP0800, the send byte protocol is used to clear Faults. This operation is shown in Figure 13.

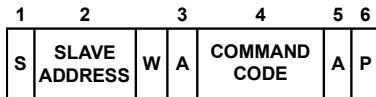


Figure 13.. Send Byte Command

If the master is required to read data from the register immediately after setting up the address, it can assert a repeat start condition immediately after the final ACK and carry out a single byte read without asserting an intermediate stop condition.

**Write Byte**

In this operation, the master device sends a command byte and one data byte to the slave device as follows:

5. The master device asserts a start condition on SDA.
6. The master sends the 7-bit slave address followed by the write bit (low).
7. The addressed slave device asserts ACK on SDA.
8. The master sends a command code.
9. The slave asserts ACK on SDA.
10. The master sends a data byte.
11. The slave asserts ACK on SDA.
12. The master asserts a stop condition on SDA and the transaction ends.

The byte write operation is shown in Figure 14.

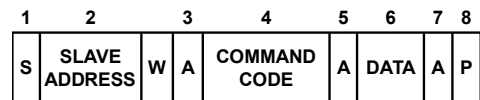


Figure 14. Single Byte Write to a Register

**Write Word**

In this operation, the master device sends a command byte and two data bytes to the slave device as follows:

1. The master device asserts a start condition on SDA.
2. The master sends the 7-bit slave address followed by the write bit (low).
3. The addressed slave device asserts ACK on SDA.
4. The master sends a command code.
5. The slave asserts ACK on SDA.
6. The master sends the first data byte.
7. The slave asserts ACK on SDA.
8. The master sends the second data byte.
9. The slave asserts ACK on SDA.
10. The master asserts a stop condition on SDA and the transaction ends.

The word write operation is shown in Figure 15.

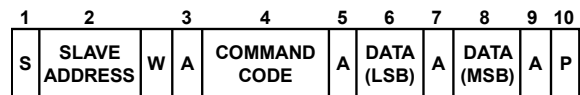


Figure 15. Single Word Write to a Register

**Block Write**

In this operation, the master device sends a command byte and a byte count followed by the stated number of data bytes to the slave device as follows:

1. The master device asserts a START condition on SDA.
2. The master sends the 7-bit slave address followed by the write bit (low).
3. The addressed slave device asserts ACK on SDA.
4. The master sends a command code
5. The slave asserts ACK on SDA
6. The master sends the byte count N
7. The slave asserts ACK on SDA
8. The master sends the first data byte
9. The slave asserts ACK on SDA
10. The master sends the second data byte.
11. The slave asserts ACK on SDA
12. The master sends the remainder of the data bytes
13. The slave asserts an ACK on SDA after each data byte.
14. After the last data byte the master asserts a STOP condition on SDA

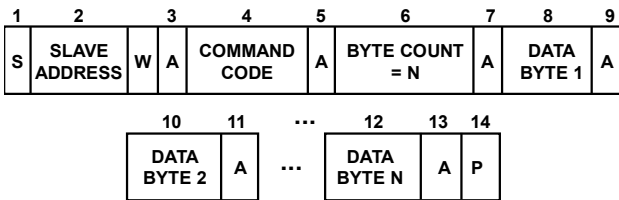


Figure 16. Block Write to a Register

**READ OPERATIONS**

The ASP0800 uses the following PMBus read protocols.

**Read Byte**

In this operation, the master device receives a single byte from a slave device as follows:

1. The master device asserts a start condition on SDA.
2. The master sends the 7-bit slave address followed by the write bit (low).
3. The addressed slave device asserts ACK on SDA.
4. The master sends a command code.
5. The slave asserted ACK on SDA.
6. The master sends a repeated start condition on SDA
7. The master sends the 7 bit slave address followed by the read bit (high)
8. The slave asserts ACK on SDA
9. The slave sends the Data Byte
10. The master asserts NO ACK on SDA.
11. The master asserts a stop condition on SDA and the transaction ends.

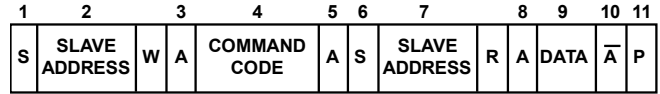


Figure 17. Single Byte Read from a Register

**Read Word**

In this operation, the master device receives two data bytes from a slave device as follows:

1. The master device asserts a start condition on SDA.
2. The master sends the 7-bit slave address followed by the write bit (low).
3. The addressed slave device asserts ACK on SDA.
4. The master sends a command code.
5. The slave asserted ACK on SDA.
6. The master sends a repeated start condition on SDA
7. The master sends the 7 bit slave address followed by the read bit (high)
8. The slave asserts ACK on SDA
9. The slave sends the first Data Byte (low Data Byte)
10. The master asserts ACK on SDA.
11. The slave sends the second Data Byte (high Data Byte)
12. The masters asserts a No ACK on SDA
13. The master asserts a stop condition on SDA and the transaction ends.

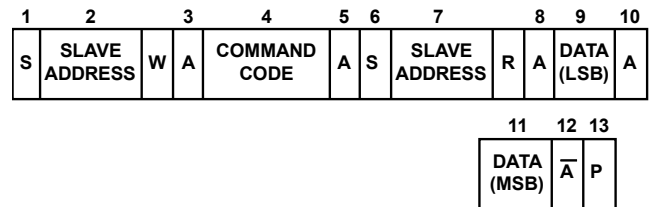


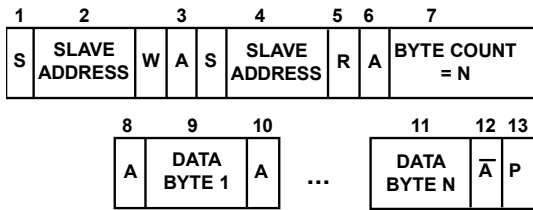
Figure 18. Word Read from a Command Code

**Block Read**

In this operation, the master device sends a command byte, the slave sends a byte count followed by the stated number of data bytes to the master device as follows:

1. The master device asserts a START condition on SDA.
2. The master sends the 7-bit slave address followed by the write bit (low).
3. The addressed slave device asserts ACK on SDA.
4. The master sends a REPEATED START condition on SDA
5. The master sends the 7-bit slave address followed by the read bit (high).
6. The slave asserts ACK on SDA
7. The slave sends the byte count N
8. The master asserts ACK on SDA
9. The slave sends the first data byte
10. The master asserts ACK on SDA
11. The slave sends the remainder of the data bytes, the master asserts an ACK on SDA after each data byte.

- 12. After the last data byte the master asserts a No ACK on SDA.
- 13. The master asserts a STOP condition on SDA



- 14.

Figure 19. Block Write to a Command Coder

**PMBus TIMEOUT**

The ASP0800 includes an PMBus timeout feature. If there is no PMBus activity for 35 ms, the ASP0800 assumes that the bus is locked and releases the bus. This prevents the device from locking or holding the PMBus expecting data. Some PMBus controllers cannot handle the PMBus timeout feature, so it can be disabled.

**Configuration Register 1 (0xTBD)**

Bit 3 SMB\_TO\_EN = 1; PMBus timeout enabled.

Bit 3 TODIS = 0; PMBus timeout disabled (default).

**Table 11. VR11 and VR10.x VID Codes for the ASP0800**

OUTPUT	VR11 DAC CODES: VIDSEL = HIGH							
	VID7	VID6	VID5	VID4	VID3	VID2	VID1	VID0
OFF	0	0	0	0	0	0	0	0
OFF	0	0	0	0	0	0	0	1
1.60000	0	0	0	0	0	0	1	0
1.59375	0	0	0	0	0	0	1	1
1.58750	0	0	0	0	0	1	0	0
1.58125	0	0	0	0	0	1	0	1
1.57500	0	0	0	0	0	1	1	0
1.56875	0	0	0	0	0	1	1	1
1.56250	0	0	0	0	1	0	0	0
1.55625	0	0	0	0	1	0	0	1
1.55000	0	0	0	0	1	0	1	0
1.54375	0	0	0	0	1	0	1	1
1.53750	0	0	0	0	1	1	0	0
1.53125	0	0	0	0	1	1	0	1
1.52500	0	0	0	0	1	1	1	0
1.51875	0	0	0	0	1	1	1	1
1.51250	0	0	0	1	0	0	0	0
1.50625	0	0	0	1	0	0	0	1
1.50000	0	0	0	1	0	0	1	0
1.49375	0	0	0	1	0	0	1	1
1.48750	0	0	0	1	0	1	0	0
1.48125	0	0	0	1	0	1	0	1
1.47500	0	0	0	1	0	1	1	0
1.46875	0	0	0	1	0	1	1	1
1.46250	0	0	0	1	1	0	0	0
1.45625	0	0	0	1	1	0	0	1
1.45000	0	0	0	1	1	0	1	0
1.44375	0	0	0	1	1	0	1	1
1.43750	0	0	0	1	1	1	0	0
1.43125	0	0	0	1	1	1	0	1
1.42500	0	0	0	1	1	1	1	0
1.41875	0	0	0	1	1	1	1	1
1.41250	0	0	1	0	0	0	0	0
1.40625	0	0	1	0	0	0	0	1
1.40000	0	0	1	0	0	0	1	0
1.39375	0	0	1	0	0	0	1	1
1.38750	0	0	1	0	0	1	0	0
1.38125	0	0	1	0	0	1	0	1
1.37500	0	0	1	0	0	1	1	0
1.36875	0	0	1	0	0	1	1	1
1.36250	0	0	1	0	1	0	0	0
1.35625	0	0	1	0	1	0	0	1
1.35000	0	0	1	0	1	0	1	0
1.34375	0	0	1	0	1	0	1	1
1.33750	0	0	1	0	1	1	0	0
1.33125	0	0	1	0	1	1	0	1
1.32500	0	0	1	0	1	1	1	0
1.31875	0	0	1	0	1	1	1	1
1.31250	0	0	1	1	0	0	0	0

	VR11 DAC CODES: VIDSEL = HIGH							
OUTPUT	VID7	VID6	VID5	VID4	VID3	VID2	VID1	VID0
1.30625	0	0	1	1	0	0	0	1
1.30000	0	0	1	1	0	0	1	0
1.29375	0	0	1	1	0	0	1	1
1.28750	0	0	1	1	0	1	0	0
1.28125	0	0	1	1	0	1	0	1
1.27500	0	0	1	1	0	1	1	0
1.26875	0	0	1	1	0	1	1	1
1.26250	0	0	1	1	1	0	0	0
1.25625	0	0	1	1	1	0	0	1
1.25000	0	0	1	1	1	0	1	0
1.24375	0	0	1	1	1	0	1	1
1.23750	0	0	1	1	1	1	0	0
1.23125	0	0	1	1	1	1	0	1
1.22500	0	0	1	1	1	1	1	0
1.21875	0	0	1	1	1	1	1	1
1.21250	0	1	0	0	0	0	0	0
1.20625	0	1	0	0	0	0	0	1
1.20000	0	1	0	0	0	0	1	0
1.19375	0	1	0	0	0	0	1	1
1.18750	0	1	0	0	0	1	0	0
1.18125	0	1	0	0	0	1	0	1
1.17500	0	1	0	0	0	1	1	0
1.16875	0	1	0	0	0	1	1	1
1.16250	0	1	0	0	1	0	0	0
1.15625	0	1	0	0	1	0	0	1
1.15000	0	1	0	0	1	0	1	0
1.14375	0	1	0	0	1	0	1	1
1.13750	0	1	0	0	1	1	0	0
1.13125	0	1	0	0	1	1	0	1
1.12500	0	1	0	0	1	1	1	0
1.11875	0	1	0	0	1	1	1	1
1.11250	0	1	0	1	0	0	0	0
1.10625	0	1	0	1	0	0	0	1
1.10000	0	1	0	1	0	0	1	0
1.09375	0	1	0	1	0	0	1	1
OFF	N/A							
OFF	N/A							
OFF	N/A							
OFF	N/A							
1.08750	0	1	0	1	0	1	0	0
1.08125	0	1	0	1	0	1	0	1
1.07500	0	1	0	1	0	1	1	0
1.06875	0	1	0	1	0	1	1	1
1.06250	0	1	0	1	1	0	0	0
1.05625	0	1	0	1	1	0	0	1
1.05000	0	1	0	1	1	0	1	0
1.04375	0	1	0	1	1	0	1	1
1.03750	0	1	0	1	1	1	0	0
1.03125	0	1	0	1	1	1	0	1
1.02500	0	1	0	1	1	1	1	0

	VR11 DAC CODES: VIDSEL = HIGH							
OUTPUT	VID7	VID6	VID5	VID4	VID3	VID2	VID1	VID0
1.01875	0	1	0	1	1	1	1	1
1.01250	0	1	1	0	0	0	0	0
1.00625	0	1	1	0	0	0	0	1
1.00000	0	1	1	0	0	0	1	0
0.99375	0	1	1	0	0	0	1	1
0.98750	0	1	1	0	0	1	0	0
0.98125	0	1	1	0	0	1	0	1
0.97500	0	1	1	0	0	1	1	0
0.96875	0	1	1	0	0	1	1	1
0.96250	0	1	1	0	1	0	0	0
0.95625	0	1	1	0	1	0	0	1
0.95000	0	1	1	0	1	0	1	0
0.94375	0	1	1	0	1	0	1	1
0.93750	0	1	1	0	1	1	0	0
0.93125	0	1	1	0	1	1	0	1
0.92500	0	1	1	0	1	1	1	0
0.91875	0	1	1	0	1	1	1	1
0.91250	0	1	1	1	0	0	0	0
0.90625	0	1	1	1	0	0	0	1
0.90000	0	1	1	1	0	0	1	0
0.89375	0	1	1	1	0	0	1	1
0.88750	0	1	1	1	0	1	0	0
0.88125	0	1	1	1	0	1	0	1
0.87500	0	1	1	1	0	1	1	0
0.86875	0	1	1	1	0	1	1	1
0.86250	0	1	1	1	1	0	0	0
0.85625	0	1	1	1	1	0	0	1
0.85000	0	1	1	1	1	0	1	0
0.84375	0	1	1	1	1	0	1	1
0.83750	0	1	1	1	1	1	0	0
0.83125	0	1	1	1	1	1	0	1
0.82500	0	1	1	1	1	1	1	0
0.81875	0	1	1	1	1	1	1	1
0.81250	1	0	0	0	0	0	0	0
0.80625	1	0	0	0	0	0	0	1
0.80000	1	0	0	0	0	0	1	0
0.79375	1	0	0	0	0	0	1	1
0.78750	1	0	0	0	0	1	0	0
0.78125	1	0	0	0	0	1	0	1
0.77500	1	0	0	0	0	1	1	0
0.76875	1	0	0	0	0	1	1	1
0.76250	1	0	0	0	1	0	0	0
0.75625	1	0	0	0	1	0	0	1
0.75000	1	0	0	0	1	0	1	0
0.74375	1	0	0	0	1	0	1	1
0.73750	1	0	0	0	1	1	0	0
0.73125	1	0	0	0	1	1	0	1
0.72500	1	0	0	0	1	1	1	0
0.71875	1	0	0	0	1	1	1	1
0.71250	1	0	0	1	0	0	0	0



	VR11 DAC CODES: VIDSEL = HIGH							
OUTPUT	VID7	VID6	VID5	VID4	VID3	VID2	VID1	VID0
0.70625	1	0	0	1	0	0	0	1
0.70000	1	0	0	1	0	0	1	0
0.69375	1	0	0	1	0	0	1	1
0.68750	1	0	0	1	0	1	0	0
0.68125	1	0	0	1	0	1	0	1
0.67500	1	0	0	1	0	1	1	0
0.66875	1	0	0	1	0	1	1	1
0.66250	1	0	0	1	1	0	0	0
0.65625	1	0	0	1	1	0	0	1
0.65000	1	0	0	1	1	0	1	0
0.64375	1	0	0	1	1	0	1	1
0.63750	1	0	0	1	1	1	0	0
0.63125	1	0	0	1	1	1	0	1
0.62500	1	0	0	1	1	1	1	0
0.61875	1	0	0	1	1	1	1	1
0.61250	1	0	1	0	0	0	0	0
0.60625	1	0	1	0	0	0	0	1
0.60000	1	0	1	0	0	0	1	0
0.59375	1	0	1	0	0	0	1	1
0.58750	1	0	1	0	0	1	0	0
0.58125	1	0	1	0	0	1	0	1
0.57500	1	0	1	0	0	1	1	0
0.56875	1	0	1	0	0	1	1	1
0.56250	1	0	1	0	1	0	0	0
0.55625	1	0	1	0	1	0	0	1
0.55000	1	0	1	0	1	0	1	0
0.54375	1	0	1	0	1	0	1	1
0.53750	1	0	1	0	1	1	0	0
0.53125	1	0	1	0	1	1	0	1
0.52500	1	0	1	0	1	1	1	0
0.51875	1	0	1	0	1	1	1	1
0.51250	1	0	1	1	0	0	0	0
0.50625	1	0	1	1	0	0	0	1
0.50000	1	0	1	1	0	0	1	0
OFF	1	1	1	1	1	1	1	0
OFF	1	1	1	1	1	1	1	1

Table 1. PMBus Commands for the ASP0800

Cmd Code	R/W	Default	Description	# Bytes	Comment																					
0x01	R/W	0x80	Operation	1	00xx xxxx – Immediate Off 01xx xxxx – Soft Off 1000 xxxx – On (slew rate set by soft start) - Default 1001 01xx – Margin Low (Ignore Fault) 1001 10xx – Margin Low (Act on Fault) 1010 01xx – Margin High (Ignore Fault) 1010 10xx – Margin High (Act on Fault)																					
0x02	R/W	0x17	ON_OFF_Config	1	Configures how the controller is turned on and off <table border="1"> <thead> <tr> <th>Bit</th> <th>Default</th> <th>Comment</th> </tr> </thead> <tbody> <tr> <td>7..5</td> <td>000</td> <td>Reserved for Future Use</td> </tr> <tr> <td>4</td> <td>1</td> <td>This bit is read only. Switching starts when commanded by the Control Pin and the Operation Command, as set in Bits 3:0</td> </tr> <tr> <td>3</td> <td>0</td> <td>0 : Unit ignores OPERATION commands over the PMBus 1: Unit responds to OPERATION command, power up may also depend upon Control input, as described in Bit 2</td> </tr> <tr> <td>2</td> <td>1</td> <td>0: Unit ignores EN pin 1: Unit responds EN pin, power up may also depend upon the Operation Register, as described for Bit 3</td> </tr> <tr> <td>1</td> <td>1</td> <td>Control Pin polarity 0 = Active Low 1 = Active High</td> </tr> <tr> <td>0</td> <td>1</td> <td>This bit is read only. 1 means that when the controller is disabled it will either immediately turn off or soft off (as set in the Operation Command)</td> </tr> </tbody> </table>	Bit	Default	Comment	7..5	000	Reserved for Future Use	4	1	This bit is read only. Switching starts when commanded by the Control Pin and the Operation Command, as set in Bits 3:0	3	0	0 : Unit ignores OPERATION commands over the PMBus 1: Unit responds to OPERATION command, power up may also depend upon Control input, as described in Bit 2	2	1	0: Unit ignores EN pin 1: Unit responds EN pin, power up may also depend upon the Operation Register, as described for Bit 3	1	1	Control Pin polarity 0 = Active Low 1 = Active High	0	1	This bit is read only. 1 means that when the controller is disabled it will either immediately turn off or soft off (as set in the Operation Command)
Bit	Default	Comment																								
7..5	000	Reserved for Future Use																								
4	1	This bit is read only. Switching starts when commanded by the Control Pin and the Operation Command, as set in Bits 3:0																								
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2	1	0: Unit ignores EN pin 1: Unit responds EN pin, power up may also depend upon the Operation Register, as described for Bit 3																								
1	1	Control Pin polarity 0 = Active Low 1 = Active High																								
0	1	This bit is read only. 1 means that when the controller is disabled it will either immediately turn off or soft off (as set in the Operation Command)																								
0x03	W	NA	Clear_Faults	0	Writing any value to this command code will clear all Status Bits immediately. The SMBus ALERT is deasserted on this command. If the fault is still present the fault bit shall immediately be asserted again.																					
0x10	R/W	0x00	Write Protect	1	The Write_Protect command is used to control writing to the PMBus device. There is also a lock bit in the Manufacture Specific Registers that once set will disable writes to all commands until the power to the ASP0800 is cycled. <table border="1"> <thead> <tr> <th>Data Byte</th> <th>Comment</th> </tr> </thead> <tbody> <tr> <td>1000 0000</td> <td>Disables all writes except to the Write_Protect Command</td> </tr> <tr> <td>0100 0000</td> <td>Disables all writes except to the Write_Protect and Operation Commands</td> </tr> <tr> <td>0010 0000</td> <td>Disables all writes except to the Write_Protect, Operation, ON_OFF_Config and VOUT_COMMAND Commands</td> </tr> <tr> <td>0000 0000</td> <td>Enables writes to all commands</td> </tr> <tr> <td>0001 0000</td> <td>Disables all writes except to WRITE_PROTECT, PAGE and all MFR-SPECIFIC Commands</td> </tr> </tbody> </table>	Data Byte	Comment	1000 0000	Disables all writes except to the Write_Protect Command	0100 0000	Disables all writes except to the Write_Protect and Operation Commands	0010 0000	Disables all writes except to the Write_Protect, Operation, ON_OFF_Config and VOUT_COMMAND Commands	0000 0000	Enables writes to all commands	0001 0000	Disables all writes except to WRITE_PROTECT, PAGE and all MFR-SPECIFIC Commands									
Data Byte	Comment																									
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Cmd Code	R/W	Default	Description	# Bytes	Comment		
0x19	R	0xB0	Capability	1	This command allows the host to get some information on the PMBus device		
					<b>Bit</b>	<b>Default</b>	<b>Comment</b>
					7	1	PEC (Packet Error Checking is supported)
					6:5	01	Max supported bus speed is 400kHz
					4	1	ASP0800 has an SMBus ALERT pin and ARA is supported
3:0	000	Reserved for future use					
0x20	R	0x20	VOUT_MODE	1	The ASP0800 supports VID mode for programming the output voltage.		
0x21	R/W	0x00	VOUT_COMMAND	2	Sets the output voltage using VID.		
0x25	R/W	0x0020	VOUT_MARGIN_HIGH	2	Sets the output voltage when operation command is set to Margin High. Programmed in VID Mode.		
0x26	R/W	0x00B2	VOUT_MARGIN_LOW	2	Sets the output voltage when operation command is set to Margin Low. Programmed in VID Mode.		
0x38	R/W	0x0001	IOUT_CAL_GAIN	2	Sets the ratio of voltage sensed to current output. Scale is Linear and is expressed in $1/\Omega$		
0x39	R/W	0x0000	IOUT_CAL_OFFSET	2	This offset is used to null out any offsets in the output current sensing circuitry. Units are Amps		
0x4A	R/W	0x0064	IOUT_OC_WARN_LIMIT	2	This sets the high current limit. Once this limit is exceeded IOUT_OC_WARN_LIMIT bit is set in the Status_IOUT register and an ALERT is generated. This limit is set in Amps.		
0x6A	R/W	0x012C	POUT_OP_WARN LIMIT	2	This sets the output power over power warn limit. Once exceeded Bit 0 of the Status IOUT Command gets set and the ALERT output gets asserted (if not masked)		
0x78	R	0x00	STATUS BYTE	1	<b>Bit</b>	<b>Name</b>	<b>Description</b>
					7	BUSY	A fault was declared because the ASP0800 was busy and unable to respond
					6	OFF	This bit is set whenever the ASP0800 is not switching
					5	VOUT_OV	This bit gets set whenever the ASP0800 goes into OVP mode.
					4	IOUT_OC	This bit gets set whenever the ASP0800 latches off due to an over current event.
					3	VIN_UV	Not supported
					2	TEMP	Not supported
					1	CML	A Communications, memory or logic fault has occurred
					0	None of the Above	A fault has occurred which is not one of the above

Cmd Code	R/W	Default	Description	# Bytes	Comment			
					Byte	Bit	Name	Description
0x79	R	0x0000	STATUS WORD	2	Low	7	Res	Reserved for future use
					Low	6	OFF	This bit is set whenever the ASP0800 is not switching
					Low	5	VOUT_OV	This bit gets set whenever the ASP0800 goes into OVP mode
					Low	4	IOUT_OC	This bit gets set whenever the ASP0800 latches off due to an over current event
					Low	3	Res	Reserved for future use
					Low	2	TEMP	Not supported
					Low	1	CML	A Communications, memory or logic fault has occurred
					Low	0	None of the Above	A fault has occurred which is not one of the above
					High	7	VOUT	This bit gets set whenever the measured output voltage goes outside its power good limits or an OVP event has taken place, i.e. any bit in Status VOUT is set
					High	6	Iout/Output	This bit gets set whenever the measured output current or power exceeds its warning limit or goes into OCP. i.e. any bit in Status IOUT is set
					High	5	INPUT	Not supported
					High	4	MFR	A manufacturer specific warning or fault has occurred
					High	3	POWER_GOOD#	The Power Good signal is deasserted. Same as PowerGood in General Status
					High	2	Res	Reserved for future use
					High	1	OTHER	A Status bit in Status Other is asserted
					High	0	Res	Reserved for future use

Cmd Code	R/W	Default	Description	# Bytes	Comment		
					Bit	Name	Description
0x7A	R	0x00	STATUS VOUT	1	7	Res	Not supported
					6	VOUT_OVERVOLTAGE WARNING	This bit gets set whenever the measured output voltage goes above its powergood limit
					5	VOUT_UNDERVOLTAGE WARNING	This bit gets set whenever the measured output voltage goes below its powergood limit
					4	Res	Reserved for future use
					3	VOUT_MAX Warning	Not supported, Can't program an output greater than max VID as there are no bits to program it
					2	Res	Not supported
					1	Res	Not supported
					0	Res	Not supported
					0x7B	R	0x00
6	Reserved	Reserved for future use					
5	IOUT Overcurrent Warning	This bit gets set if IOUT exceeds its programmed high warning limit					
4	Reserved	Reserved for future use					
3	Reserved	Reserved for future use					
2	Reserved	Reserved for future use					
1	Res	Not supported					
0	POUT Over Power Warning	This bit gets set if the measured POUT exceeds the Warn Limit					
0x7E	R	0x00	STATUS CML	1			
					6	Invalid or Unsupported Data Received	Supported
					5	PEC Failed	Supported
					4	Memory Fault Detected	Not supported
					3	Processor Fault Detected	Not supported
					2	Reserved	Supported
					1	A communication fault other than the ones listed has occurred	Supported
					0	Other memory or Logic Fault has occurred	Not supported

Cmd Code	R/W	Default	Description	# Bytes	Comment		
					Bit	Name	Description
0x80	R	0x00	STATUS_ALERT	1	7	Res	Reserved for future use
					6	Res	Reserved for future use
					5	Res	Reserved for future use
					4	Res	Reserved for future use
					3	Res	Reserved for future use
					2	VMON WARN	Gets asserted when VMON exceeds its programmed WARN limits
					1	Res	Reserved for future use
					0	Res	Reserved for future use
					0x8B	R	0x00
0x8C	R	0x00	READ_IOUT	2	Readback output current. Current is read back in Linear Mode (Amps)		
0x96	R	0x00	READ_POUT	2	Readback Output Power, read back in Linear Mode in W's.		
0x99	R	0x41	MFR_ID	1	0x41		
0x9A	R	0x4000	MFR_MODEL	2	0x3298		
0x9B	R	0x00	MFR_REVISION	1	0		

**Table 2. Manufacturer Specific Command Codes for the ASP0800**

Cmd Code	R/W	Default	Description	# Bytes	Comment		
					Bit	Name	Description
0xD0	R/W	0x00	Lock/Reset	1	1	Reset	Resets all registers to their POR Value. Has no effect if Lock bit is set
					0	Lock	Logic 1 locks all limit values to their current settings. Once this bit is set, all lockable registers become read-only and cannot be modified until the ASP0800 is powered down and powered up again. This prevents rogue programs such as viruses from modifying critical system limit settings. (Lockable.)
0xD1	R/W	0x07	Mfr Config	1	7:6	PSI#	These bits sets the number of phases turned on during PSI. 00 = CL set for 1 Phase (default) 01 = CL set for 2 Phases 10 = CL set for 3 Phases 11 = CL set for 1 Phase
					5	OC_Inv	OC Invert Bit. When set to 1 this bit inverts the polarity of the OC outputs.
					4	ALERT Mode	1 = ?? 0 = ??
					3	PMB_TO_EN	PMBus Timeout Enable. When the PMB_TO_EN bit is set to 1, the PMBus Timeout feature is enabled. In this state if, at any point during an PMBus transaction involving the ASP0800, activity ceases for more than 35 ms, the ASP0800 assumes the bus is locked and releases the bus. This allows the ASP0800 to be used with SMBus controllers that cannot handle SMBus timeouts. (Lockable.)
					2	Reserved	Reserved for future use
					1	ALERT_EN	Enable the ALERT pin
					0	ENABLE_MONITOR	When the ENABLE_MONITOR bit is set to 1, the ASP0800 starts conversions with the ADC and monitors the voltages and temperatures.

Cmd Code	R/W	Default	Description	# Bytes	Comment		
					Bit	Name	Description
0xD2	R/W	0x52	VR Config. 1A	1	6:4	Phase Enable Bits	000 = Phase 1 001 = Phase 2 010 = Phase 3 011 = Phase 4 100 = Phase 5 101 = Phase 6 110 = Phase 7 111 = Phase 8
					3	VID_EN	When the VID_EN bit is set to 1, the VID code in the VOUT_COMMAND register sets the output voltage. When VID_EN is set to 0, the output voltage follows the VID input pins.
					2	LOOP_EN	When the LOOP_EN bit is set to 1 in both registers, the control loop test function is enabled. This allows measurement of the control loop AC gain and phase response with appropriate instrumentation. The control loop signal insertion pin is IMON. The control loop output pin is COMP.
					1	CLIM_EN	When CLIM_EN is set to 1, the current limit time out latch off functions normally. When this bit is set to 0 in both registers, the current limit latch off is disabled. In this state, the part can be in current limit indefinitely.
					0	Res	Reserved for future use
0xD3	R/W	0x52	VR Config. 1B	1	This register is for security reasons. It has the same format as register 0xD2. Bits need to be set in both registers for the function to take effect.		
0xD4	R/W	0x03	Ton Delay	1			
0xD5	R/W	0x02	Ton Rise	1			
0xD6	R/W	0x03	Ton Transition	1			
0xD7	R	0x00	VMON Voltage	2	This is a 16 bit value that reports back the voltage measured between FB and FBRTN		
0xD8	R	0x00	EN/VTT Voltage	2	This is a 16 bit value that reports back the voltage on the VTT Pin.		
0xD9	R/W	0x00	OC Offset 1	1	This offset is added to the VID Code when in overclocking state 00		
0xDA	R/W	0x00	OC Offset 2	1	This offset is added to the VID Code when in overclocking state 01		
0xDB	R/W	0x00	OC Offset 3	1	This offset is added to the VID Code when in overclocking state 10		
0xDC	R/W	0x00	OC Offset 4	1	This offset is added to the VID Code when in overclocking state 11		
0xDC	R/W	0x00	VOUT_CAL	1	Offset Command Code for Vout, max +/- 200mV		
0xDE	R/W	0x10	Load Line Calibration	1	This value sets the internal load line attenuation DAC calibration value. The maximum load line is controlled externally by setting the gain of the current sense amplifier as explained in the applications section. This maximum load line can then be adjusted from 100% to 0% in 30 steps. Each LSB represents a 3.33% change in the load line. 00000 = No Load Line 10000 = 50% of external load line 11111 = 100% of external Load Line		

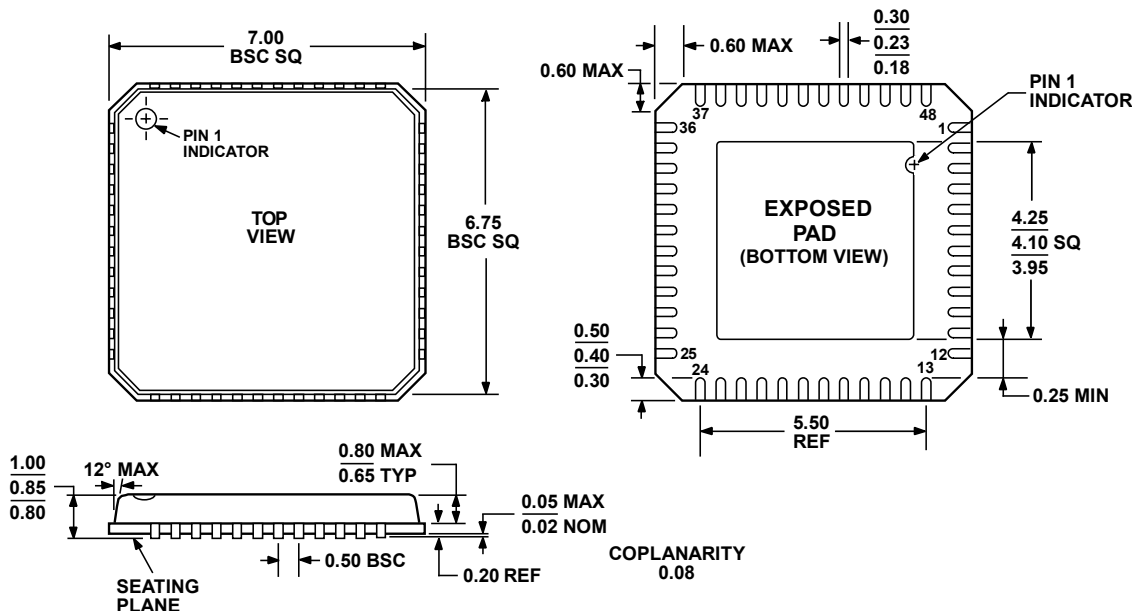


Cmd Code	R/W	Default	Description	# Bytes	Comment
0xDF	R/W	0x00	Load Line Set	1	This value sets the internal load line attenuation DAC value. The maximum load line is controlled externally by setting the gain of the current sense amplifier as explained in the applications section. This maximum load line can then be adjusted from 100% to 0% in 30 steps. Each LSB represents a 3.33% change in the load line. 00000 = No Load Line 10000 = 50% of external load line 11111 = 100% of external Load Line
0xE0	R/W	0x00	PWRGD Hi Threshold	1	This value sets the PWRGD Hi Threshold and the CROWBAR Threshold: Code = 00, PWRGD HI = 300mV (default) Code = 01, PWRGD HI = 250mV Code = 10, PWRGD HI = 200mV Code = 11, PWRGD HI = 150mV
0xE1	R/W	0x00	PWRGD Lo Threshold	1	This value sets the PWRGD Lo Threshold: Code = 000, PWRGD Lo = -500mV (default) Code = 001, PWRGD Lo = -450mV Code = 010, PWRGD Lo = -400mV Code = 011, PWRGD Lo = -350mV Code = 100, PWRGD Lo = -300mV Code = 101, PWRGD Lo = -250mV Code = 110, PWRGD Lo = -200mV Code = 111, PWRGD Lo = -150mV
0xE2	R/W	0x10	Current Limit Threshold	1	This value sets the internal current limit adjustment value. The default current limit is programmed using a resistor to ground on the LIMIT pin. The value of this register adjusts this value by a percentage between 50% and 146.7%. Each LSB represents a 3.33% change in the current limit threshold. 11111 = 146.7% of external current limit 10000 = 100% of external current limit (default) 00000 = 50% of external current limit
0xE3	R/W	0x10	Phase Bal SW1	1	These values adjust the gain of the internal phase balance amplifiers. The nominal gain is set to 5. These registers can adjust the gain by +/-25% from 3.75 to 6.25. Code = 00000, Gain of 3.75 Code = 10000, Gain of 5 (default) Code = 11111, Gain of 6.25
0xE4	R/W	0x10	Phase Bal SW2	1	These values adjust the gain of the internal phase balance amplifiers. The nominal gain is set to 5. These registers can adjust the gain by +/-25% from 3.75 to 6.25. Code = 00000, Gain of 3.75 Code = 10000, Gain of 5 (default) Code = 11111, Gain of 6.25
0xE5	R/W	0x10	Phase Bal SW3	1	These values adjust the gain of the internal phase balance amplifiers. The nominal gain is set to 5. These registers can adjust the gain by +/-25% from 3.75 to 6.25. Code = 00000, Gain of 3.75 Code = 10000, Gain of 5 (default) Code = 11111, Gain of 6.25
0xE6	R/W	0x10	Phase Bal SW4	1	These values adjust the gain of the internal phase balance amplifiers. The nominal gain is set to 5. These registers can adjust the gain by +/-25% from 3.75 to 6.25. Code = 00000, Gain of 3.75 Code = 10000, Gain of 5 (default) Code = 11111, Gain of 6.25

Cmd Code	R/W	Default	Description	# Bytes	Comment																											
0xE7	R/W	0x10	Phase Bal SW5	1	These values adjust the gain of the internal phase balance amplifiers. The nominal gain is set to 5. These registers can adjust the gain by +/-25% from 3.75 to 6.25. Code = 00000, Gain of 3.75 Code = 10000, Gain of 5 (default) Code = 11111, Gain of 6.25																											
0xE8	R/W	0x10	Phase Bal SW6	1	These values adjust the gain of the internal phase balance amplifiers. The nominal gain is set to 5. These registers can adjust the gain by +/-25% from 3.75 to 6.25. Code = 00000, Gain of 3.75 Code = 10000, Gain of 5 (default) Code = 11111, Gain of 6.25																											
0xE9	R/W	0x10	Phase Bal SW7	1	These values adjust the gain of the internal phase balance amplifiers. The nominal gain is set to 5. These registers can adjust the gain by +/-25% from 3.75 to 6.25. Code = 00000, Gain of 3.75 Code = 10000, Gain of 5 (default) Code = 11111, Gain of 6.25																											
0xEA	R/W	0x10	Phase Bal SW8	1	These values adjust the gain of the internal phase balance amplifiers. The nominal gain is set to 5. These registers can adjust the gain by +/-25% from 3.75 to 6.25. Code = 00000, Gain of 3.75 Code = 10000, Gain of 5 (default) Code = 11111, Gain of 6.25																											
0xEC	R/W	0x00	OC_Counter Limit	1																												
0xEE	R/W	0x00	OC Threshold 1	1																												
0xEF	R/W	0xFF	OC Threshold 2	1																												
0xF0	R/W	0xFF	OC Threshold 3	1																												
0xF1	R	0x00	ICPU MSB	1																												
0xF2	R	0x00	OC Status	1																												
0xF6	R/W	0x0002	VMON Warn Limit	2	VMON Warn Limit																											
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0xFA	R/W	0x00	Mask FAULT	1	<table border="1"> <thead> <tr> <th>Bit</th> <th>Name</th> <th>Description</th> </tr> </thead> <tbody> <tr> <td>7</td> <td>Mask Vout FAULT</td> <td>Masks any ALERT caused by OVP</td> </tr> <tr> <td>6</td> <td>Mask IOU<sup>T</sup> FAULT</td> <td>Masks any ALERT caused by OCP</td> </tr> </tbody> </table>	Bit	Name	Description	7	Mask Vout FAULT	Masks any ALERT caused by OVP	6	Mask IOU <sup>T</sup> FAULT	Masks any ALERT caused by OCP																		
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Cmd Code	R/W	Default	Description	# Bytes	Comment		
					Bit	Name	Description
0xFB	R	0x0C	General Status	1	6	ALERT	
					5	POWER GOOD	Replaced by Bit 3 of the Status Word Command
					4	RDY	
0xFC	R	0x00	Phase Status	1	7	Phase 8	This bit is set to 1 when Phase 8 is enabled
					6	Phase 7	This bit is set to 1 when Phase 7 is enabled
					5	Phase 6	This bit is set to 1 when Phase 6 is enabled
					4	Phase 5	This bit is set to 1 when Phase 5 is enabled
					3	Phase 4	This bit is set to 1 when Phase 4 is enabled
					2	Phase 3	This bit is set to 1 when Phase 3 is enabled
					1	Phase 2	This bit is set to 1 when Phase 2 is enabled
					0	Phase 1	This bit is set to 1 when Phase 1 is enabled

OUTLINE DIMENSIONS



COMPLIANT TO JEDEC STANDARDS MO-220-VKGD-2

Figure 20. 48-Lead Lead Frame Chip Scale Package [LFCSP\_VQ]

ORDERING GUIDE

Model	Temperature Range	Package Description	Package Option	Ordering Quantity
ASP0800JCPZ-RL <sup>1</sup>	0°C to 85°C	48-Lead Lead Frame Chip Scale Package [LFCSP_VQ]	CP-48	2,500

<sup>1</sup> Z = Pb-free part.

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