

3-PHASE DC MOTOR TORQUE CONTROLLER



DESCRIPTION

The PWR-82521 is a high performance current regulating torque loop controller. It is designed to accurately regulate the current in the windings of 3-phase brushless DC and brush DC motors.

The PWR-82521 is a completely self-contained motor controller that converts the analog input command signal into motor current and uses the signals from Hall-effect sensors in the motor to commutate the current in the motor windings. The motor current is internally sensed and processed into an analog signal. This signal is summed together with the command signal to produce an error signal that controls the pulse width modulation

(PWM) duty cycle of the output, thus controlling the motor current. The PWR-82521 can be tuned by using an external Proportional-Integral (PI) regulator network in conjunction with the internal error amplifier.

APPLICATIONS

Packaged in a small DIP-style hybrid, the PWR-82521 are ideal for applications with limited printed circuit board area.

The PWR-82521 is ideal for application requiring current regulation and/or holding torque at zero input command. System applications include flight surface control on aircraft for horizontal stabilizers and flaps, missile fin control, fuel and hydraulic pumps, radar and countermeasures systems.

FEATURES

- **200V Rating**
- **10 Amp Continuous Output Current**
- **Complementary Four-Quadrant Operation**
- **3% Linearity Accuracy**
- **5% Current Regulating Accuracy**
- **User-Programmable Compensation**
- **10 kHz - 50 kHz PWM Frequency**
- **Operates as Current or Voltage Controller**
- **Self-Contained 3-Phase Motor Controller**
- **Built-in Current Limit**

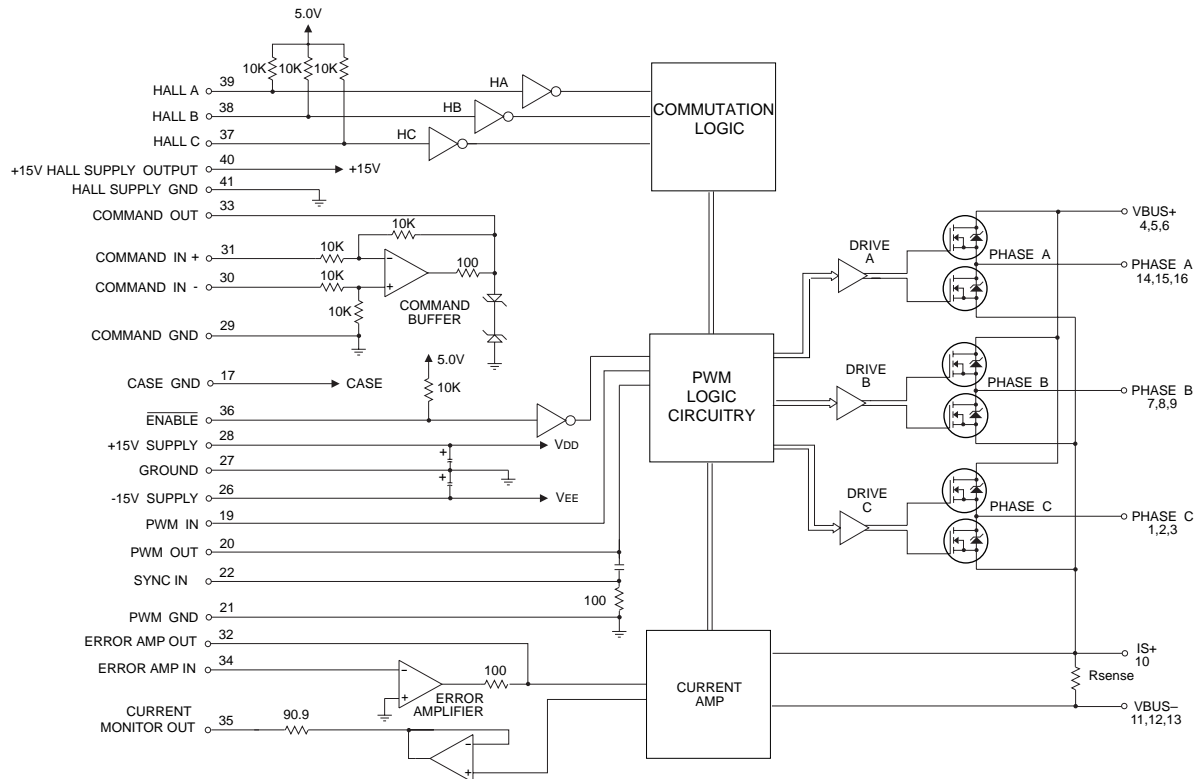


FIGURE 1. PWR-82521 BLOCK DIAGRAM

TABLE 1. ABSOLUTE MAXIMUM RATINGS (TC = +25°C UNLESS OTHERWISE SPECIFIED)

PARAMETER	SYMBOL	VALUE	UNITS
Bus Voltage	VBUS+	200	VDC
+15V Supply	V _{DD}	+17.5	VDC
-15V Supply	V _{EE}	-17.5	VDC
Continuous Output Current	I _{OC}	10	A
Peak Output Current	I _{PEAK}	18	A
Command input +	Command input+	±15	VDC
Command input -	Command input-	±15	VDC
Logic inputs	ENABLE HA, HB, HC	7.0	VDC
Sync Input	SYNC	±15.0	VDC

TABLE 2. PWR-82521 SPECIFICATIONS

(Unless otherwise specified, VBUS = 28 VDC, V_{DD} = +15V, V_{EE} = -15V, T_C = 25°C)

PARAMETERS	SYMBOL	TEST CONDITIONS	VALUE			UNITS
			MIN	TYP	MAX	
OUTPUT						
Output Current Continuous	I _{OC} (note 1)				10	A
Output Current Pulsed	I _{OP}				18	A
Current Limit	I _{CL}		15.3	18.0	19.8	A
Current Offset	I _{OFFSET}	V _{DF} = 0V	-0.3	-	+0.3	A
Output On-Resistance	R _{ON} (note 2, 3)	+25°C			0.100	Ω
Output On-Resistance	R _{ON} (note 2, 3)	+85°C			0.140	Ω
Output Conductor Resistance	R _C	+85°C		note 3		Ω
Load Inductance	L _{MIN}		100			μH
COMMAND IN+/- Differential Input	V _{DIF}		-10		+10	VDC
COMMAND OUT Internal Voltage Clamp	V _{CLMP}		-11.5		+11.5	VDC
CURRENT COMMAND Transconductance ratio	G		0.95	1.0	1.05	A/V
Non-Linearity	See FIGURE 9		-3.0		+3.0	%
CURRENT MONITOR AMP Current Monitor Gain		V _{DF} = 0V	0.97	1.0	1.03	V/A
Current Monitor Offset			-0.1	0	0.1	VDC
Output Current			-10		10	mA
Output Resistance	R _{OUT}				100	Ω
VBUS+ SUPPLY Nominal Operating Voltage	V _{NOM}		+18	+28	+140	VDC
VBUS- To PWM GND Voltage differential	V _{GNDIF}				0.250	VDC
+15 VDC Voltage	V _{S+}		+14.25	+15.0	+15.75	VDC
Current	I ₊			100	150	mA
-15 VDC Voltage	V _{S-}		-15.75	-15.0	-14.25	VDC
Current	I ₋			80	150	mA
SYNC (Note 2) Voltage		See FIGURE 7	±7.5			V
Pulse Width			130			ns
Sync range as % of free-run frequency			0		+20	%

Note:

- 1) I_{OC} is average current as measured in motor winding
- 2) Guaranteed by design, not tested.
- 3) The maximum output conductor resistance and on-resistance of FETs at +85°C are:
 $\Phi_{A_U} = 0.20\Omega$, $\Phi_{A_L} = 0.16\Omega$, $\Phi_{B_U} = 0.08\Omega$, $\Phi_{B_L} = 0.08\Omega$, $\Phi_{C_U} = 0.08\Omega$, $\Phi_{C_L} = 0.20\Omega$

TABLE 2. PWR-82521 SPECIFICATIONS (CONTINUED)
(Unless otherwise specified, V_{BUS} = 28 VDC, V_{DD} = +15V, V_{EE} = -15V, T_C = 25°C)

PARAMETERS	SYMBOL	TEST CONDITIONS	VALUE			UNITS
			MIN	TYP	MAX	
PWM IN						
+Peak	V _{P+}		9.8	10.0	10.2	V
-Peak	V _{P-}		-10.2	-10.0	-9.8	V
Frequency	f		10		60	KHz
Non-linearity	LIN		-2		+2	%
Duty Cycle	D CYCLE		49	50	51	%
PWM OUT						
Free Run Frequency			45	50	55	KHz
HALL POWER SUPPLY						
Max Current Draw	I _{MDRW}				50	mA
HALL SIGNALS						
Logic 1	HA, HB,		3.5		—	VDC
Logic 0	HC		—		0.7	VDC
ENABLE INPUT						
Enabled	ENABLE		—		0.7	VDC
Disabled			3.5		—	VDC
ISOLATION						
CASE to PIN		500 VDC HIPOT	10			MΩ
SWITCHING CHARACTERISTICS						
Upper drive						
Turn-on Rise Time	t _r				TBD	ns
Turn-off Fall Time	t _f				TBD	ns
Lower drive		I _p = 4 A				
Turn-on Rise Time	t _r				TBD	ns
Turn-off Fall Time	t _f				TBD	ns
Diode Forward Voltage Drop	V _F	I _D = 1A			1.9	V
PROPAGATION DELAY						
	T _d (on)	I _p = 4A From 0.7V on ENABLE to 10% of V _{OUT}		40		μs
	T _d (off)	From 3.5V on ENABLE to 90% of V _{OUT}		20		μs
THERMAL						
Thermal Resistance						
Junction - Case	θ _{J-C}				6	°C/W
Case - Air	θ _{C-A}				10	°C/W
Junction Temperature	T _J				+175	°C
Case Operating Temperature	T _C		-55		+125	°C
Case Storage Temperature	T _{CS}		-65		+150	°C
WEIGHT					1.7(48)	oz(gr)

INTRODUCTION

The PWR-82521 is high performance current control (torque loop) hybrid which use complementary four quadrant switching topology (See BASIC OPERATION) to provide linearity through zero current. The high Pulse Width Modulation (PWM) switching frequency makes it suitable for even low inductance motors. The PWR-82521 hybrid can accept single-ended or differential mode command signals. The current gain can be easily programmed to match the end user system requirements. With the compensation network externally wired, the hybrid can provide optimum control of a wide range of loads.

The PWR-82521 uses unique current sense technology and a non-inductive hybrid sense resistor which yields a highly linear current output over the wide military temperature range (see FIGURE 9). The output current non-linearity is better than 3%

over the operating temperature range and the total error due to all the factors such as offset, initial component accuracies etc. is maintained well below 5% of the rated output current.

The Hall sensor interface for current commutation has built-in decoder logic that separates illegal codes and ensures that there is no cross conduction. The hybrid also has a +15V supply output for powering the Hall sensors. The Hall sensor inputs are internally pulled up to +5V and they can be driven from open-collector outputs.

The PWM frequency can be programmed externally by adding a capacitor from PWM OUT to PWM GND. In addition, multiple PWR-82521's can be synchronized by using one device as a master and connecting its PWM OUT pin to the PWM IN of all the other slave devices in a system or by applying a SYNC pulse to pin 22.

The $\overline{\text{ENABLE}}$ input signal provides quick start and shutdown of the output power switches. In addition, built-in power sequence fault protection turns off the output in case of low power supply voltages.

The hybrid features dual current limiting functions. The input command amplifier output is limited to 10.8V thus limiting the current under normal operation. In addition, there is a built in over current limit which trips at 18 Amps, protecting the hybrid as well as the load.

BASIC OPERATION

The PW-82521 utilizes a complimentary four-quadrant drive technique to control current in the load. The complimentary drive has the following advantages over the standard drive:

1. Maximum holding torque and position accuracy
2. Linear current control through zero
3. No deadband at zero

The complementary drive design uses a 50% PWM duty cycle for a zero command signal. For a zero input command, a pair of MOSFETs are turned on in the drive, Phase A upper & Phase B lower as shown in FIGURE 2A, to supply current into the load for the first half of the PWM cycle. This is the same mode of operation for the standard 4-quadrant drive as shown in FIGURE 3A/B. During the second half of the PWM cycle, a second pair of transistors are turned on, Phase A lower & Phase B upper as shown in FIGURE 2B, for the flyback current and to provide load current in the opposite direction.

This is normally the dead time for standard 4-quadrant drive as shown in FIGURE 3B. The result is current flowing in both directions in the motor for each PWM cycle. The advantage this has over standard 4-quadrant drive is that at 50% duty cycle, which corresponds to zero average current in the motor, holding torque is provided. The motor current at 50% duty cycle is simply the magnetizing current of the motor winding.

Using the complimentary 4-quadrant technique allows the motor direction to be defined by the duty cycle. Relative to a given switch pair, i.e. Phase A upper and Phase B lower, a duty cycle greater than 50% will result in a clockwise rotation whereas a duty cycle less than 50% will result in a counter clockwise rotation. Therefore, with the use of average current mode control, direction can be controlled without the use of a direction bit and the current can be controlled through zero in a very precise and linear fashion.

The PW-82521 contains all the circuitry required to close an average current mode control loop around a complimentary 4-quadrant drive. The PWR-82521 use of average current mode control simplifies the control loop by eliminating the need for slope compensation and eliminating the pole created by the motor inductance. These two effects are normally associated with 50% duty cycle limitations when implementing standard peak current mode control.

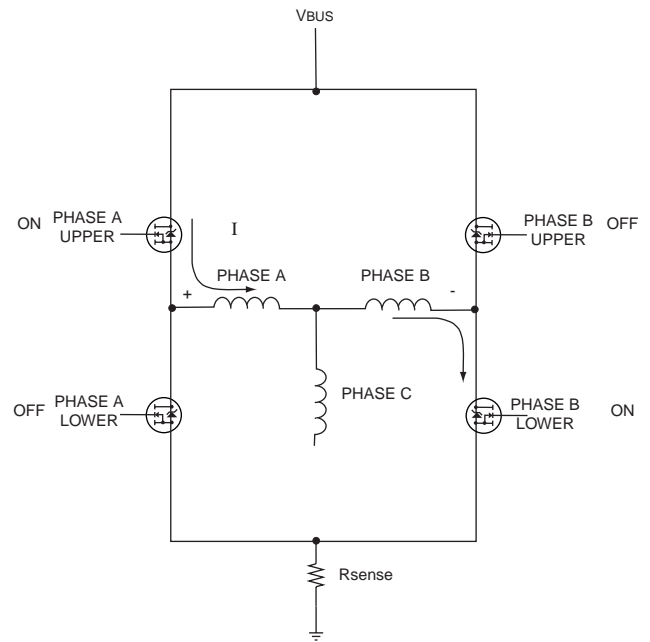


FIGURE 2A. COMPLEMENTARY 4-QUADRANT DRIVE FIRST HALF OF PWM CYCLE

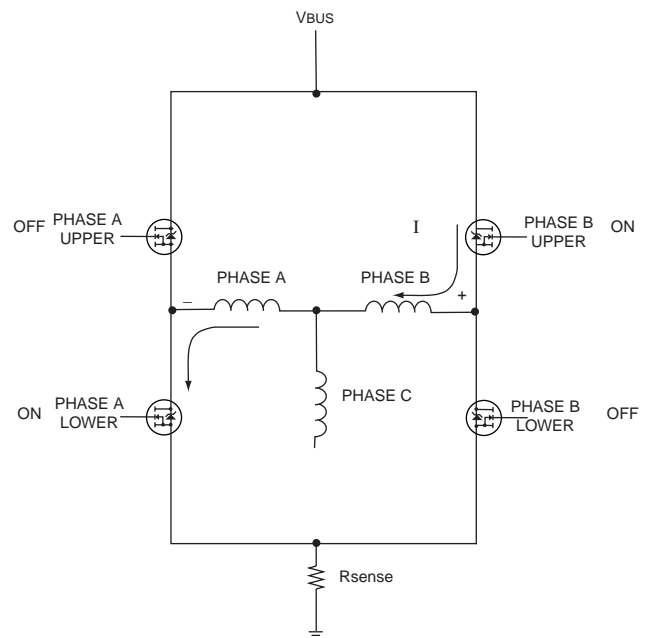


FIGURE 2B. COMPLEMENTARY 4-QUADRANT DRIVE SECOND HALF OF PWM CYCLE

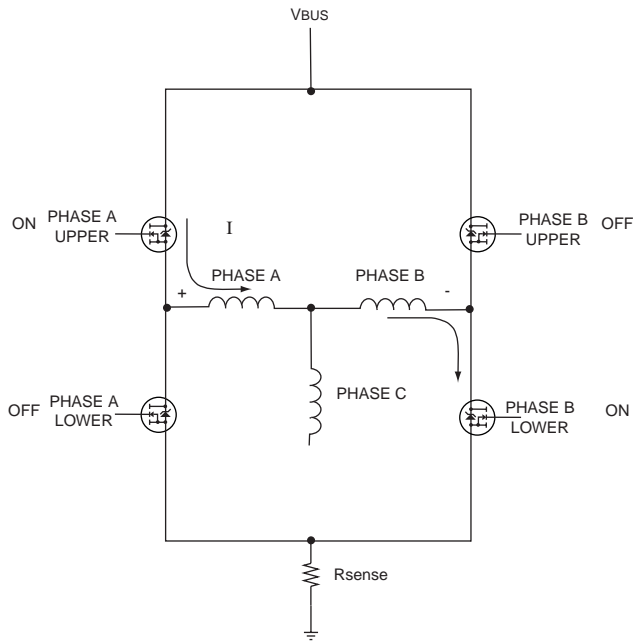


FIGURE 3A. STANDARD 4 QUADRANT DRIVE FIRST HALF OF PWM CYCLE

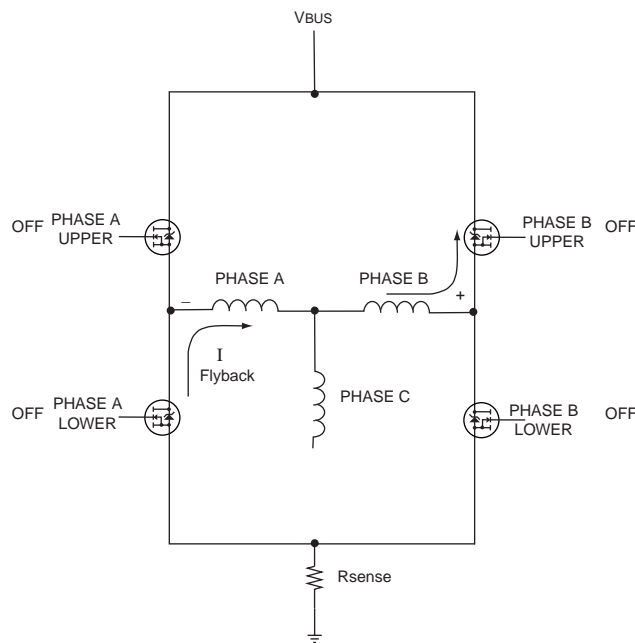


FIGURE 3B. STANDARD 4 QUADRANT DRIVE SECOND HALF OF PWM CYCLE

FUNCTIONAL AND PIN DESCRIPTIONS:

COMMAND IN+, COMMAND IN- (Pins 30 & 31)

The command amplifier has a differential input that operates from a ± 10 V analog current command. The differential input voltage may vary between ± 10 VDC, maximum, corresponding to \pm maximum voltage or current for the output. Either input (COMMAND IN + or COMMAND IN-) may be referenced to the command ground (Pin 29) and the other input varied from ± 10 VDC to obtain full output. The COMMAND OUT signal is internally limited to approximately ± 11.5 VDC; that is, inputs above or below ± 11.5 VDC will be clamped to ± 11.5 VDC. The input impedance of the Command Amplifier is 10K Ohms.

The PWR-82521 can be used either as a current or voltage mode controller. When the PWR-82521 is used as a torque amplifier (current mode) as shown in FIGURE 13, the transfer function of the command amplifier is 1.0 A/V. The input command signal is processed through the command buffer. The output of the buffer (COMMAND OUT) is summed with the current monitor output into the error amplifier. When external compensation is used on the error amp, as shown in FIGURE 6A, the response time can be adjusted to meet the application.

When used in the voltage mode the Voltage Command uses the same differential input terminals to control the voltage applied to the motor (see FIGURE 12). The error amp directly varies the PWM duty cycle of the voltage applied to the motor phase. The transfer function in the voltage mode is 4.7% /V $\pm 5\%$ variation of the PWM duty cycle vs. input command. The duty cycle range of the output voltage is limited to approximately 5-95% in both current and voltage modes.

TRANSCONDUCTANCE RATIO AND OFFSET

When the PWR-82521 is used in the Current Mode, the command inputs (COMMAND IN+ and COMMAND IN-) are designed such that ± 10 VDC on either input, with the other input connected to Ground, will result in ± 10 DC Average Amperes of current into the load. The DC current transfer ratio accuracy is $\pm 5\%$ of the rated output current. The initial output DC current offset will be less than 100 mA when measured using a load of 0.5 mH and 1.0 Ohms at room ambient with standard current loop compensation (see FIGURE 6A). The winding phase current error shall be within the cumulative limits of the transconductance ratio error and the offset error.

HALL A,B,C SIGNALS (Pins 37, 38 and 39)

These are logic signals from the motor Rotor Position Sensors (HA, HB, HC). They use a phasing convention referred to as 120 degree spacing; that is, the output of HA is in phase with motor back EMF voltage VAB, HB is in phase VBC, and HC is in phase with VCA. Logic "1" (or HIGH) is defined by an input greater than 3.5 VDC or an open circuit to the controller; Logic "0" (or LOW) is defined as any Hall voltage input less than 0.7 VDC. Internal to the PWR-82520 are 5K pull-up resistors tied to +5 VDC on each Hall input.

The PWR-82521 will operate with Hall phasing of 60° or 120° electrical spacing. If 60° commutation is used, then the output of

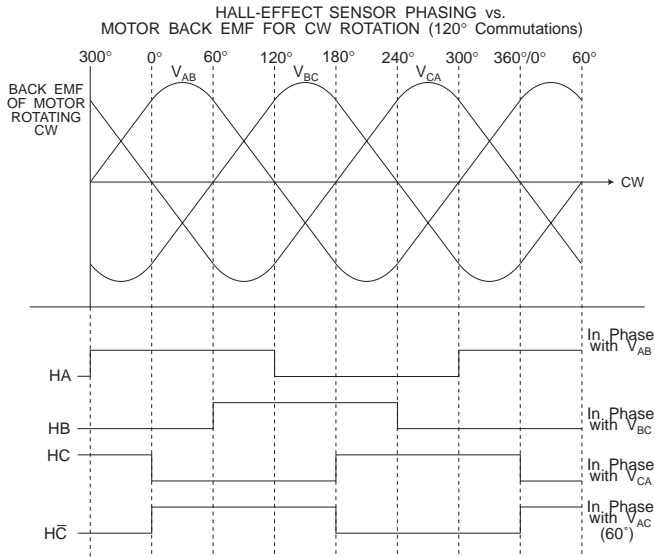
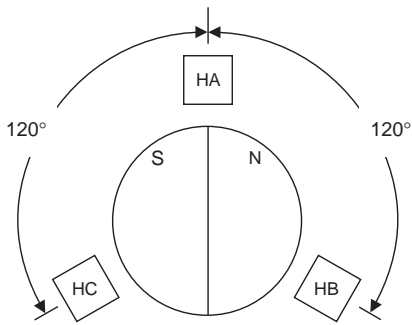
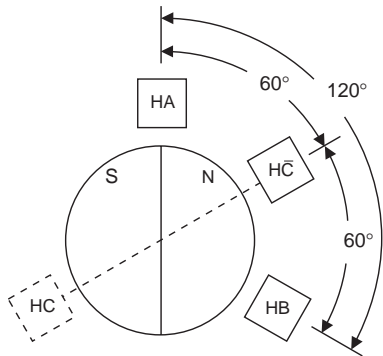


FIGURE 4. HALL PHASING



REMOTE POSITION SENSOR (HALL) SPACING FOR 120 DEGREE COMMUTATION



REMOTE POSITION SENSOR (HALL) SPACING FOR 60 DEGREE COMMUTATION

FIGURE 5. HALL SENSOR SPACING

HC must be inverted as shown in FIGURES 4 and 5. In FIGURE 4, the Hall sensor outputs are shown with the corresponding voltage they are in phase with.

Hall Input Signal Conditioning: When the motor is located more than two feet away from the PWR-82520 controller the Hall inputs require filtering from noise. It is recommended to use a 1 kΩ resistor in series with the Hall signal and a 2000 pF capacitor from the Hall input pin to the Hall supply ground pin as shown in FIGURE 12 and 13.

COMPENSATION

The PI regulator in the PWR-82521 can be tuned to a specific load for optimum performance. FIGURE 6A shows the standard current loop configuration and tuning components, and FIGURE 6B shows the frequency response for the PI regulator. By adjusting R1, R2 and C1, the amplifier can be tuned. The value of R1, C1 will vary, depending on the loop bandwidth requirement.

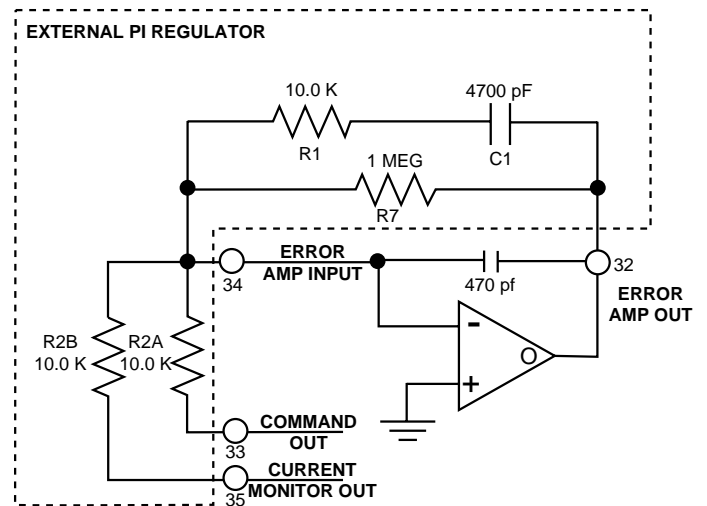


FIGURE 6A. STANDARD PI CURRENT LOOP

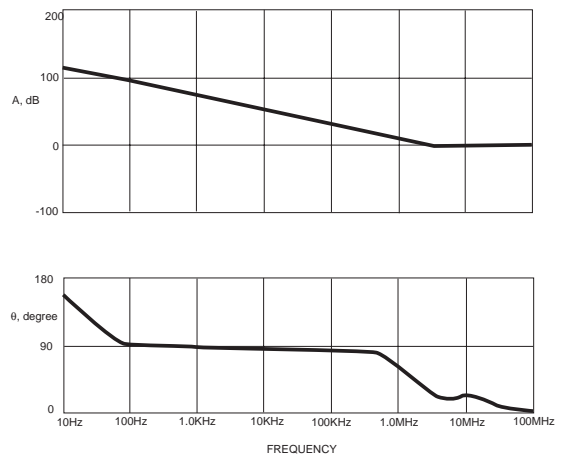


FIGURE 6B. PI REGULATOR FREQUENCY RESPONSE

ENABLE (Pin 36)

This is a logic input to the controller that enables or disables the controller. In the disabled state, no voltage shall be applied to the motor phases. The disabled state occurs when the $\bar{\text{Enable}}$ input is greater than 3.5 VDC or is left open; to enable the controller, this input must be pulled to less than 0.7 VDC. The $\bar{\text{Enable}}$ input has a 10K pull-up resistor tied to +5 VDC.

VBUS+ (Pins 4, 5 and 6)

The VBUS+ supply is the power source for the motor phases and is nominally +28 VDC. The normal operating voltage may actually vary from +18 to +140 VDC with respect to Vbus-. The power stage MOSFETS in the hybrid have an absolute maximum VBUS+ Supply voltage rating of 200V. The user must supply sufficient external capacitance or circuitry to prevent the bus supply from exceeding +200 VDC at the hybrid power terminals under any conditions.

The VBUS should be applied at least 50 ms after ± 15 VDC to allow the internal analog circuitry to stabilize. If this is not possible, the hybrid must be powered up in the "disabled" mode.

VBUS- (Pins 11, 12, and 13)

This is the high current ground return for VBUS+. This point **must** be externally connected to Ground for proper operation of the current loop. The voltage difference between Vbus- and the Ground connections must be less than 0.250 VDC including transients.

GROUND S

SUPPLY GND (Pin 27): This is the return line for the ± 15 VDC supplies. The phase current sensing technique of the PWR-82521 requires that VBUS- and Supply Ground be connected together externally (see VBUS- supply).

PWM GND (Pin 21): This is used for the return side of the external PWM capacitor (Cext) when switching frequencies below 50 KHz are required.

COMMAND GND (Pin 29): This is used when the command buffer is used single-ended and the COMMAND IN- or COMMAND IN+ are tied to COMMAND GND.

HALL GND (Pin 41): This is used for the return of the +15V HALL supply and should be tied to SUPPLY GROUND.

± 15 VDC (+15V Supply, Pin 28 / -15V Supply, Pin 26)

These inputs are used to power the small signal analog and digital circuitry of the hybrid. An internal +5 VDC supply is derived from the +15 VDC source. These inputs should not vary more than $\pm 5\%$, maximum. The absolute maximum voltage ratings of these inputs are ± 17.5 VDC. **Reversal of the power supplies will result in destruction of the hybrid.**

SYNC IN (Pin 22)

The Sync pulse, as shown in FIGURE 7, can be used to synchronize the switching frequency up to 20% faster than the free running frequency of all the slave devices.

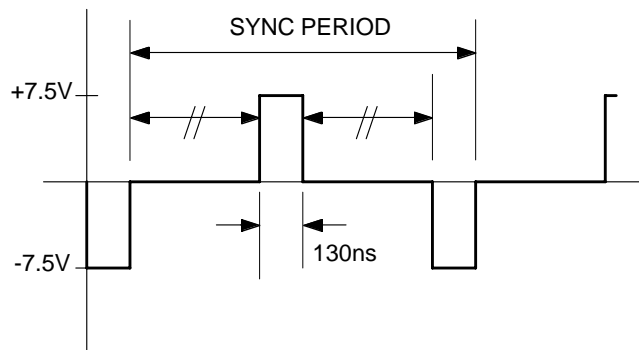


FIGURE 7. SYNC INPUT SIGNAL

PWM FREQUENCY

The PWM frequency from the PWM OUT pin will free-run at a frequency of 50 kHz ± 10 kHz. The user can adjust this frequency down to 10 kHz through the addition of an external capacitor. The PWM triangle wave generated internally is brought out to the PWM OUT pin. This output, or an external triangle waveform generated by the user, may be connected to PWM IN on the hybrid.

WARNING: Never apply power to the hybrid without connecting either PWM OUT or an external triangular wave to PWM IN! Failure to do so may result in one or more outputs latching on.

PWM OUT (Pin 20)

This is the output of the internally generated PWM triangle waveform. It is normally connected to PWM IN. The frequency of this output may be lowered by connecting an NPO capacitor (Cext) between PWM OUT and PWM GND. The typical PWM frequency is determined by the following formula:

$$\frac{16.5E-6}{330 \text{ pF} + C_{\text{EXT}} \text{ pF}}$$

CASE (Pin 17)

This pin is internally connected to the hybrid case. In some applications the user may want to tie Pin 17 to Ground for EMI considerations.

PHASES A, B, C (Pin A 14-16, B 7-9, C 1-3)

These are the power drive outputs to the motor and switch between VBUS+ Input and VBUS- Input or become high impedance - see TABLE 3.

+15 VDC HALL SUPPLY OUTPUT (Pin 40)

This output provides power to the Hall Sensors in the motor. Maximum current drawn from this supply by the user must not exceed 50 mA.

INPUTS					OUTPUTS		
ENABLE	DIR **	HA	HB	HC	PHASE A	PHASE B	PHASE C
L	CW	1	0	0	H	L	Z
L	CW	1	1	0	H	Z	L
L	CW	0	1	0	Z	H	L
L	CW	0	1	1	L	H	Z
L	CW	0	0	1	L	Z	H
L	CW	1	0	1	Z	L	H
L	CCW	1	0	1	Z	H	L
L	CCW	0	0	1	H	Z	L
L	CCW	0	1	1	H	L	Z
L	CCW	0	1	0	Z	L	H
L	CCW	1	1	0	L	Z	H
L	CCW	1	0	0	L	H	Z
H	—	—	—	—	Z	Z	Z

1=Logic Voltage >3.5 VDC, 0=Logic voltage < 0.7 VDC
 ** DIR is based on the convention shown in Figure 4. Actual motor set up might be different.

CURRENT MONITOR OUT (Pin 35)

This is a bipolar analog output voltage representative of motor current. The Current Monitor Output will have the same scaling as the Current Command input, 1.0 V/A. The output resistance will be less than 100 Ω.

BRUSH MOTOR OPERATION

The PWR-82521 can also be used as a brush motor controller for current or voltage control in an H-Bridge configuration. The PWR-82521 would be connected as shown in FIGURE 8. All other connections are as shown in either FIGURE 12 or 13 depending on current or voltage mode operation. The Hall inputs are wired per TABLE 4. A positive input command will result in positive current to the motor out of Phase A.

INPUT					OUTPUT		
ENABLE	COMMAND IN	HA	HB	HC	PH A	PH B	PH C
L	Positive	1	1	0	H	Z	L
L	Negative	1	1	0	L	Z	H
H	—	1	1	0	Z	Z	Z

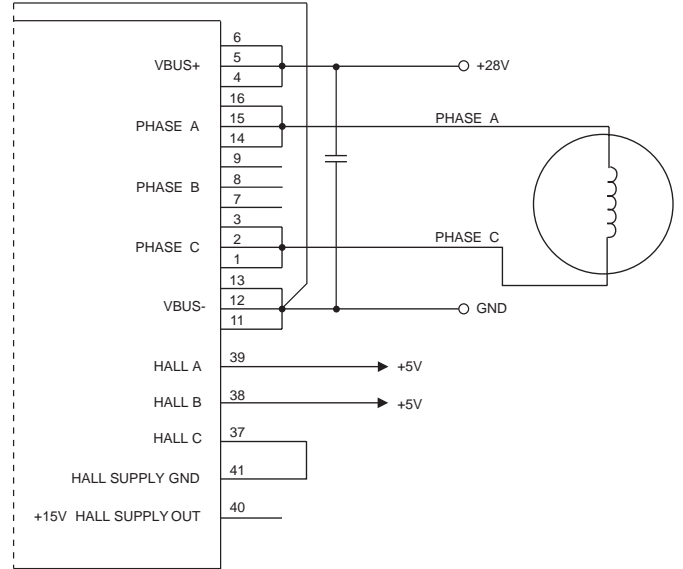


FIGURE 8. BRUSH MOTOR HOOK UP

OUTPUT CURRENT

Output current derating as a function of the hybrid case temperature is provided in FIGURE 10. The hybrid contains internal pulse by pulse current limit circuitry to limit the output current during fault conditions.(See TABLE 2) Current Limit accuracy is +10/-15%.

WARNING: The PWR-82521 does not have short circuit protection. The PWR-82521 must see a minimum of 100uH inductive load or enough line-to-line resistance to limit the output current to <10A at all times. Operation into a short or a condition that requires excessive output current will damage the hybrid.

THERMAL OPERATION

It is recommended the PWR-82520 be mounted to a heat sink. This heat sink shall have the capacity to dissipate heat generated by the hybrid at all levels of current output, up to the peak limit, while maintaining the case temperature limit as per FIGURE 10.

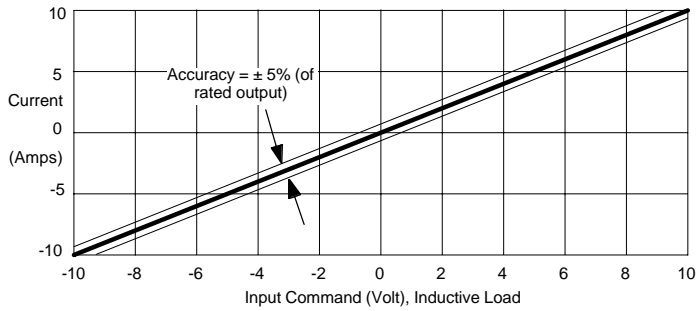


FIGURE 9. LINEARITY CURVE

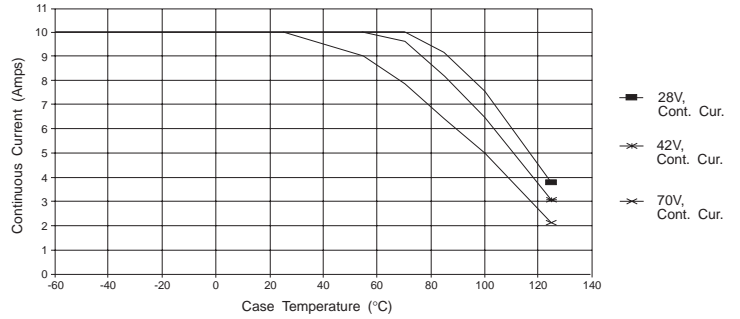


FIGURE 10. MOTOR CURRENT DRIVE

PWR-82521 POWER DISSIPATION (SEE FIGURE 11)

There are two major contributors to power dissipation in the motor driver: conduction losses and switching losses.

VBUS = +28 V (Bus Voltage)

IOA = 3 A, IOB = 7 A (see FIGURE 11)

ton = 36 μs, T = 40 μs (period) (see FIGURE 11)

Ron = 0.055 Ω (on-resistance, see TABLE 2)

Rc = 0.133 Ω (conductor resistance, see TABLE 2,)

ts1 = 125 ns, ts2 = 200 ns (see FIGURE 11)

fo = 50 kHz (switching frequency)

1. Transistor Conduction Losses (PC)

$$P_T = (I_{\text{motor rms}})^2 \times (R_{\text{on}})$$

$$I_{\text{motor rms}} = \sqrt{\left(I_{\text{OB}} I_{\text{OA}} + \frac{(I_{\text{OB}} - I_{\text{OA}})^2}{3} \right) \left(\frac{t_{\text{on}}}{T} \right)}$$

$$I_{\text{motor rms}} = \sqrt{\left(7 \times 3 + \frac{(7 - 3)^2}{3} \right) \left(\frac{36}{40} \right)}$$

$$P_T = (4.87)^2 \times (0.055)$$

$$P_T = 1.30 \text{ Watts}$$

2. Switching Losses (Ps)

$$P_s = [V_{\text{cc}} (I_{\text{OA}} (t_{\text{s1}}) + I_{\text{OB}} (t_{\text{s2}})) f_o] / 2$$

$$P_s = [28 \text{ V} (3 \text{ A} (125 \text{ ns}) + 7 \text{ A} (200 \text{ ns})) 50 \text{ kHz}] / 2$$

$$P_s = 1.24 \text{ Watts}$$

TRANSISTOR POWER DISSIPATION (Pq)

$$P_Q = P_T + P_s$$

$$P_Q = 1.30 + 1.24 = 2.54 \text{ Watts}$$

OUTPUT CONDUCTOR DISSIPATION

$$P_C = (I_{\text{motor rms}})^2 \times (R_c)$$

$$P_C = (4.87)^2 \times (0.133)$$

$$P_C = 3.15 \text{ Watts}$$

TRANSISTOR POWER DISSIPATION FOR CONTINUOUS COMMUTATION

$$P_{\text{QC}} = P_Q (0.33)$$

$$P_{\text{QC}} = (2.54) \times (0.33)$$

$$P_{\text{QC}} = 0.84 \text{ Watts}$$

TOTAL HYBRID POWER DISSIPATION

$$P_{\text{TOTAL}} = (P_Q + P_C) \times 2$$

$$P_{\text{TOTAL}} = (2.54 + 3.15) \times 2$$

$$P_{\text{TOTAL}} = 11.38 \text{ Watts}$$

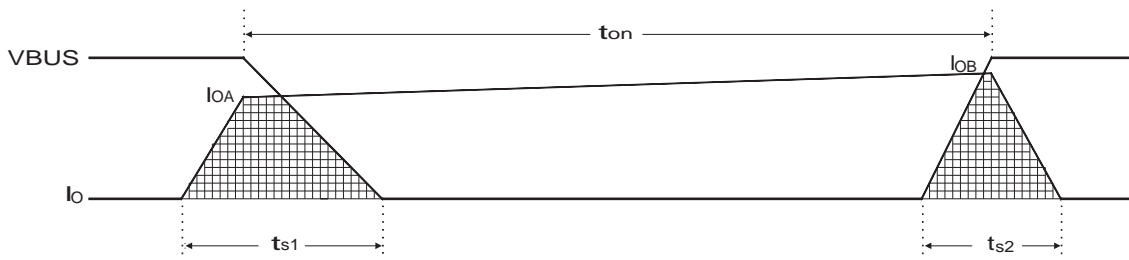


FIGURE 11. OUTPUT CHARACTERISTICS

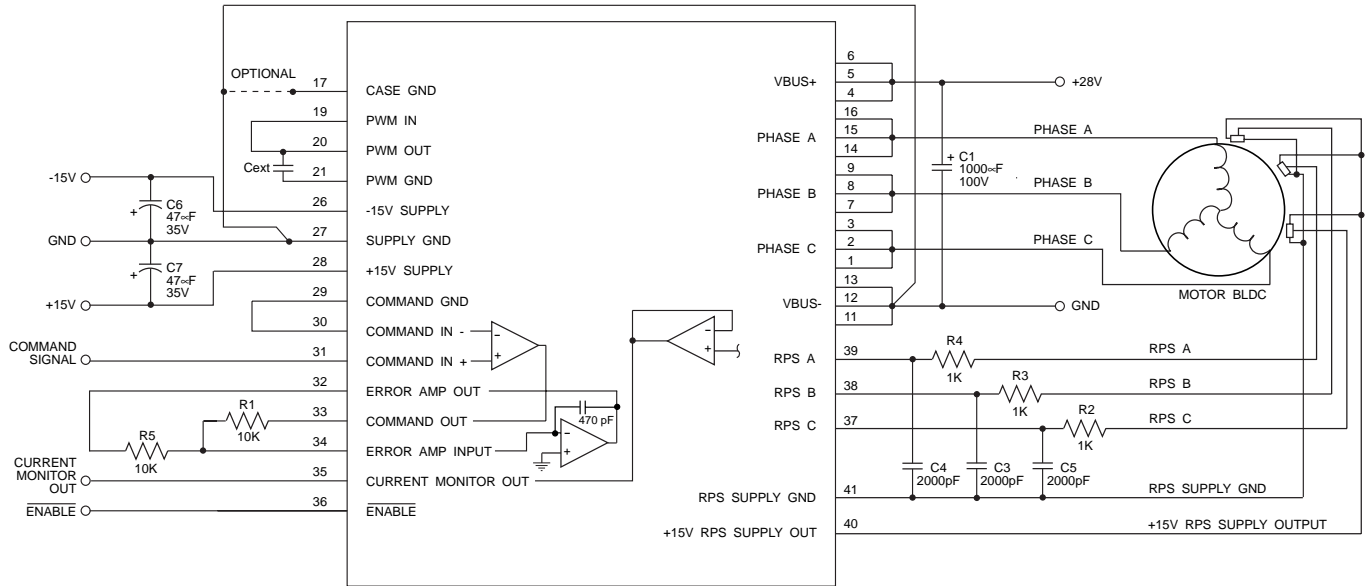


FIGURE 12. VOLTAGE CONTROL HOOK-UP

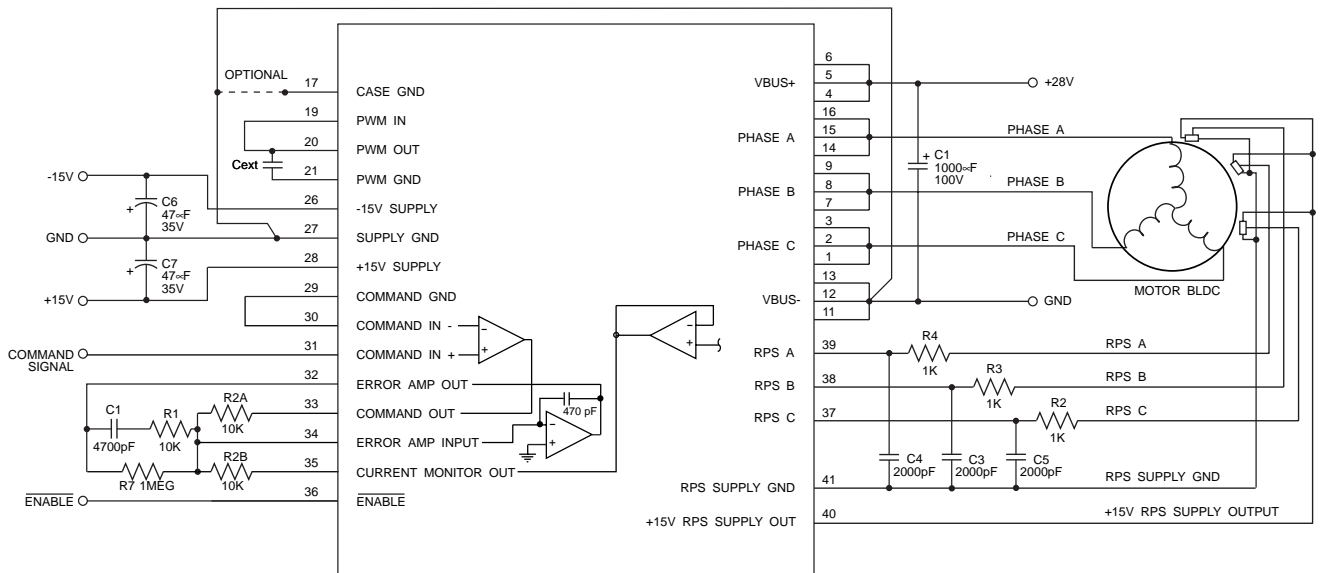


FIGURE 13. TORQUE CONTROL HOOK-UP

TABLE 5. PIN ASSIGNMENTS			
PIN	FUNCTION	PIN	FUNCTION
1	PHASE C	41	HALL SUPPLY GND
2	PHASE C	40	+15V HALL SUPPLY OUTPUT
3	PHASE C	39	HA
4	VBUS +	38	HB
5	VBUS +	37	HC
6	VBUS +	36	ENABLE
7	PHASE B	35	CURRENT MONITOR OUTPUT
8	PHASE B	34	ERROR AMP INPUT
9	PHASE B	33	COMMAND OUT
10	IS+	32	ERROR AMP OUT
11	VBUS -	31	COMMAND IN +
12	VBUS -	30	COMMAND IN -
13	VBUS -	29	COMMAND GND
14	PHASE A	28	+15V SUPPLY
15	PHASE A	27	SUPPLY GND
16	PHASE A	26	-15V SUPPLY
—		25	N/C
—		24	N/C
—		23	N/C
—		22	SYNC
—		21	PWM GND
—		20	PWM OUT
—		19	PWM IN
—		18	N/C
—		17	CASE GND

Note:

1. N/C pins have internal connections for factory test purposes.

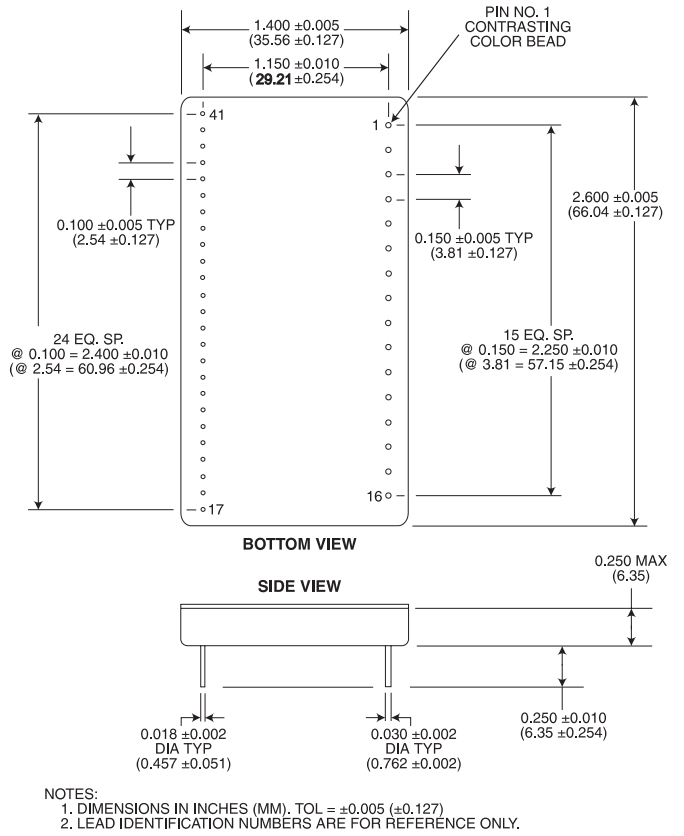


FIGURE 14. MECHANICAL OUTLINE

ORDERING INFORMATION

PWR-82521-XX0X

Supplemental Process Requirements:

- S = Pre-Cap Source Inspection
- L = Pull Test
- Q = Pull Test and Pre-Cap Inspection
- K = One Lot Date Code
- W = One Lot Date Code and PreCap Source
- Y = One Lot Date Code and 100% Pull Test
- Z = One Lot Date Code, PreCap Source and 100% Pull Test
- Blank = None of the Above

Process Requirements:

- 0 = Standard DDC Processing, no Burn-In (See table below.)
- 1 = MIL-PRF-38534 Compliant
- 2 = B*
- 3 = MIL-PRF-38534 Compliant with PIND Testing
- 4 = MIL-PRF-38534 Compliant with Solder Dip
- 5 = MIL-PRF-38534 Compliant with PIND Testing and Solder Dip
- 6 = B* with PIND Testing
- 7 = B* with Solder Dip
- 8 = B* with PIND Testing and Solder Dip
- 9 = Standard DDC Processing with Solder Dip, no Burn-In (See table below.)

Temperature Grade/Data Requirements:

- 1 = -55°C to +125°C
- 2 = -40°C to +85°C
- 3 = 0°C to +70°C
- 4 = -55°C to +125°C with Variables Test Data
- 5 = -40°C to +85°C with Variables Test Data
- 8 = 0°C to +70°C with Variables Test Data

*Standard DDC Processing with burn-in and full temperature test — see table below.

STANDARD DDC PROCESSING		
TEST	MIL-STD-883	
	METHOD(S)	CONDITION(S)
INSPECTION	2009, 2010, 2017, and 2032	—
SEAL	1014	A and C
TEMPERATURE CYCLE	1010	C
CONSTANT ACCELERATION	2001	A
BURN-IN	1015, Table 1	—

The information in this data sheet is believed to be accurate; however, no responsibility is assumed by Data Device Corporation for its use, and no license or rights are granted by implication or otherwise in connection therewith. Specifications are subject to change without notice.



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