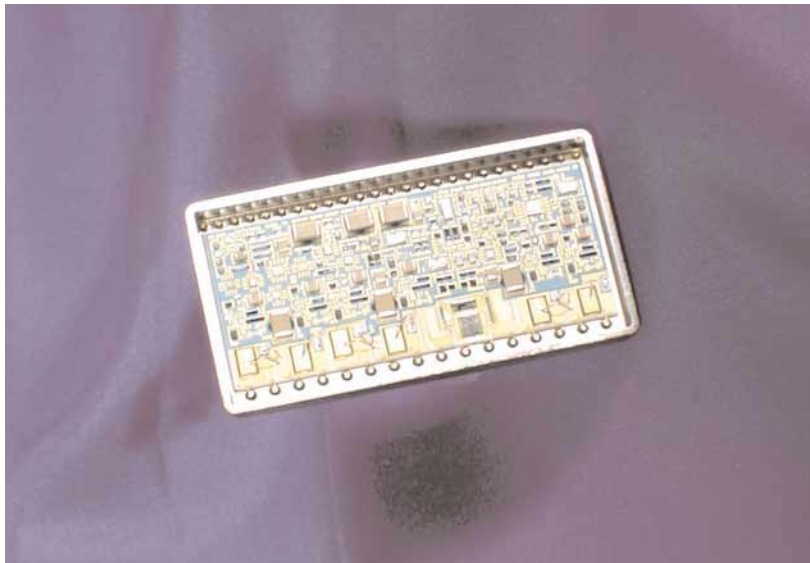


# Preliminary

## PWR-82520R

# RADIATION TOLERANT 3-PHASE DC MOTOR TORQUE CONTROLLER

Make sure the next Card you purchase has...



## DESCRIPTION

The PWR-82520R (100Vdc) is a high performance radiation tolerant current regulating torque loop controller designed to accurately regulate the current in the motor windings of 3-phase brushless DC and brush DC motors.

The PWR-82520R is a completely self-contained motor controller that converts an 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. The current 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-82520R can be tuned by using an external Proportional/Integral (PI) regulator network in conjunction with the internal error amplifier.

## APPLICATIONS

The PWR-82520R is ideal for space and radiation tolerant applications requiring current regulation and/or holding torque at zero input command. System applications that can use the PWR-82520R are: pumps, actuators, antenna position, environmental control and reaction/momentum wheel systems using brushless and brush motors. Available in a 1 and 3 amp small DIP-style or a 10 amp flat-pack hybrid package, the PWR-82520R is suitable for applications with limited printed circuit board area.

## FEATURES

- Self-Contained 3-Phase Motor Controller
- Operates as Current or Voltage Controller
- 1, 3 and 10 Amp Output Current
- Radiation Tolerant to 100Krad
- 1.5% Linearity
- 3% Current Regulating Accuracy
- User-Programmable Compensation
- 10 KHz - 100 KHz PWM Frequency
- Complementary Four-Quadrant Operation
- Holding Torque through Zero Current
- Cycle-by-Cycle Current Limit
- Non-Radiation Tolerance also available (see PWR-82520/21N data sheet)



Data Device Corporation  
105 Wilbur Place  
Bohemia, New York 11716  
631-567-5600 Fax: 631-567-7358  
[www.ddc-web.com](http://www.ddc-web.com)

## FOR MORE INFORMATION CONTACT:

Technical Support:  
1-800-DDC-5757 ext. 7677 or 7381

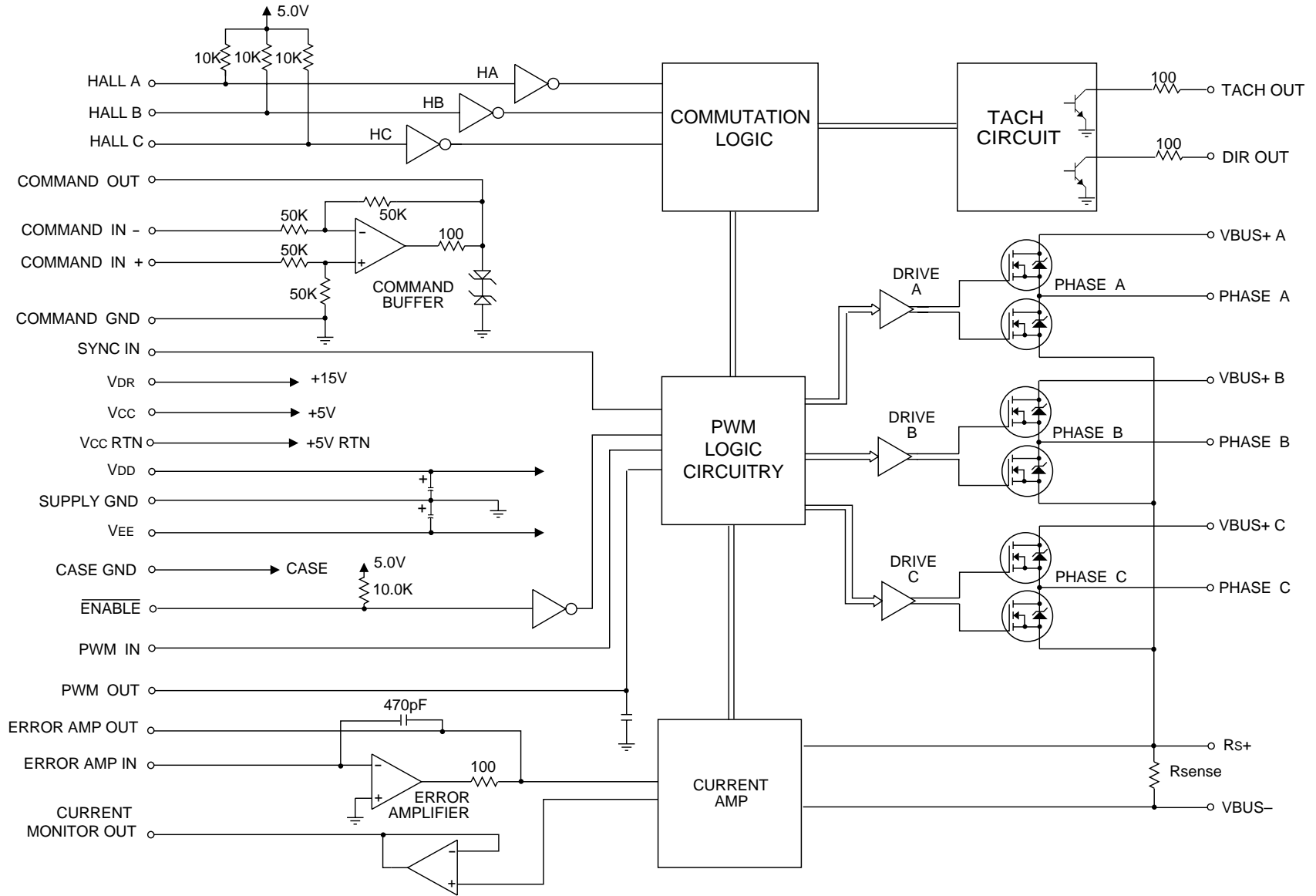


FIGURE 1. PWR-82520R BLOCK DIAGRAM

**TABLE 1. PWR-82520R ABSOLUTE MAXIMUM RATINGS (T<sub>c</sub> = +25°C UNLESS OTHERWISE SPECIFIED)**

PARAMETER	SYMBOL	VALUE	UNITS
<b>BUS VOLTAGE PWR-82520R</b>	V <sub>BUS+</sub>	100.0	V <sub>dc</sub>
<b>+15V SUPPLY</b>	V <sub>DR</sub>	+17.5	V <sub>dc</sub>
<b>+5V TO +15V</b>	V <sub>DD</sub>	+17.5	V <sub>dc</sub>
<b>+5V SUPPLY</b>	V <sub>CC</sub>	+5.5	V <sub>dc</sub>
<b>-5V TO -15V</b>	V <sub>EE</sub>	-17.5	V <sub>dc</sub>
<b>VBUS- TO GND</b> Voltage Differential	V <sub>GNDDIF</sub>	0V to V <sub>DD</sub> +1.0	V <sub>dc</sub>
<b>CONTINUOUS OUTPUT CURRENT</b> PWR-82520R1 PWR-82520R3 PWR-82520R10	I <sub>OC</sub>	1 3 10	A A A
<b>PEAK OUTPUT CURRENT (PULSED, t = 50 μS)</b> PWR-82520R1 PWR-82520R3 PWR-82520R10	I <sub>PEAK</sub>	3.0 8.0 20.0	A A A
<b>COMMAND INPUT +</b>	Command input +	±15.0	V <sub>dc</sub>
<b>COMMAND INPUT -</b>	Command input -	±15.0	V <sub>dc</sub>
<b>LOGIC INPUTS</b> ENABLE, SYNC, HA, HB, HC, ERROR AMP, PWM IN	V <sub>IH</sub>	7.0	V <sub>dc</sub>
<b>TACH OUT / DIR OUT</b>	V <sub>OH</sub>	40	V <sub>dc</sub>
<b>TACH OUT / DIR OUT</b>	I <sub>OL</sub>	20	mA

**TABLE 2. PWR-82520R SPECIFICATIONS  
(UNLESS OTHERWISE SPECIFIED, V<sub>BUS</sub>=28VDC, V<sub>DR</sub>=+15V, V<sub>CC</sub> = +5V, V<sub>DD</sub>=+5V, V<sub>EE</sub>=-5V, T<sub>C</sub> = 25°C, LL = 500 μH, 100KRAD)**

PARAMETER	SYMBOL	TEST CONDITIONS	MIN	TYP	MAX	UNITS
<b>OUTPUT (PWR-82520R1)</b> Output Current Continuous Output Current Pulsed Current Limit Current Offset Output On-Resistance  Output Conductor Resistance Diode Forward Voltage Drop	I <sub>OC</sub> I <sub>OP</sub> I <sub>CL</sub> I <sub>OFFSET</sub> R <sub>ON</sub>  R <sub>C</sub> V <sub>F</sub>	t = 50μsec  FIGURE 7, V <sub>CMD</sub> = 0V +25°C +85°C +85°C I <sub>D</sub> = 1A	-20	1.5	1 3 +20 0.60 0.90 0.08 1.5	A A A mA Ω Ω Ω V
<b>OUTPUT (PWR-82520R3)</b> Output Current Continuous Output Current Pulsed Current Limit Current Offset Output On-Resistance  Output Conductor Resistance Diode Forward Voltage Drop	I <sub>OC</sub> I <sub>OP</sub> I <sub>CL</sub> I <sub>OFFSET</sub> R <sub>ON</sub>  R <sub>C</sub> V <sub>F</sub>	t = 50μsec  FIGURE 7, V <sub>CMD</sub> = 0V +25°C +85°C +85°C I <sub>D</sub> = 3A	-20	4	3 8 +20 0.18 0.27 0.08 1.8	A A A mA Ω Ω Ω V
<b>OUTPUT (PWR-82520R10)</b> Output Current Continuous Output Current Pulsed Current Limit Current Offset Output On-Resistance  Output Conductor Resistance Diode Forward Voltage Drop	I <sub>OC</sub> I <sub>OP</sub> I <sub>CL</sub> I <sub>OFFSET</sub> R <sub>ON</sub>  R <sub>C</sub> V <sub>F</sub>	t = 50μsec  FIGURE 7, V <sub>CMD</sub> = 0V +25°C +85°C +85°C I <sub>D</sub> = 10A	-100	14.0	10 20 +100 0.055 0.075 0.08 1.9	A A A mA Ω Ω Ω V
<b>PROPAGATION DELAY</b>	T <sub>d</sub> (on) T <sub>d</sub> (off)	From 0.8V on $\overline{\text{ENABLE}}$ to 90% of V <sub>BUS</sub> From 2.4V on $\overline{\text{ENABLE}}$ to 10% of V <sub>BUS</sub>		40 20		μs μs

**TABLE 2. PWR-82520R SPECIFICATIONS (CONTINUED)**  
**(UNLESS OTHERWISE SPECIFIED, VBUS=28VDC, VDR=+15V, VCC = +5V, VDD=+5V, VEE=-5V, TC = 25°C, LL = 500 μH, 100KRAD)**

PARAMETER	SYMBOL	TEST CONDITIONS	MIN	TYP	MAX	UNITS
<b>SWITCHING CHARACTERISTICS (R1)</b>						
Upper Drive		Rise Time =				
Turn-on Rise Time	tr	90% to 10% of VBUS		75		ns
Turn-off Fall Time	tf	Fall Time =		30		ns
Lower Drive		10% to 90% of VBUS				
Turn-on Rise Time	tr	Io= 1A		50		ns
Turn-off Fall Time	tf			60		ns
<b>SWITCHING CHARACTERISTICS (R3)</b>						
Upper Drive		Rise Time =				
Turn-on Rise Time	tr	90% to 10% of VBUS		150		ns
Turn-off Fall Time	tf	Fall Time =		150		ns
Lower Drive		10% to 90% of VBUS				
Turn-on Rise Time	tr	Io= 3A		160		ns
Turn-off Fall Time	tf			130		ns
<b>SWITCHING CHARACTERISTICS(R10)</b>						
Upper Drive		Rise Time =				
Turn-on Rise Time	tr	90% to 10% of VBUS		200		ns
Turn-off Fall Time	tf	Fall Time =		200		ns
Lower Drive		10% to 90% of VBUS				
Turn-on Rise Time	tr	Io= 10A		200		ns
Turn-off Fall Time	tf			200		ns
<b>THERMAL (ALL MODELS)</b>						
Junction Temperature	Tj				+150	°C
Case Operating Temperature	Tc		-55		+125	°C
Case Storage Temperature	Tcs		-65		+150	°C
<b>THERMAL (PWR-82520R1)</b>						
Thermal Resistance						
Junction-Case	θj-c				25	°C/W
Case-Air	θc-a				10	°C/W
<b>THERMAL (PWR-82520R3)</b>						
Thermal Resistance						
Junction-Case	θj-c				9	°C/W
Case-Air	θc-a				10	°C/W
<b>THERMAL (PWR-82520R10)</b>						
Thermal Resistance						
Junction-Case	θj-c				4	°C/W
Case-Air	θc-a				5.5	°C/W
<b>RADIATION</b>						
Total dose			100			Krad
Dose Rate			0.5			Rad/Sec
SEU at LET* level			36			MeV/mg/cm <sup>2</sup>
Latch-up Immune			36			MeV/mg/cm <sup>2</sup>
<b>WEIGHT</b>						
R1, R3				1.7 (48)		oz (g)
R10				2.9 (82)		oz (g)
<b>CURRENT MONITOR AMP (ALL MODELS)</b>						
Current Monitor Offset		Ioc = 0A	-10		+10	mVdc
Output Current			-10		+10	mA
Output Resistance	Rout				1	Ω
<b>CURRENT MONITOR AMP (R1)</b>						
Current Monitor Gain				4		V/A
<b>CURRENT MONITOR AMP (R3)</b>						
Current Monitor Gain				1.33		V/A
<b>CURRENT MONITOR AMP (R10)</b>						
Current Monitor Gain				0.40		V/A

\* LET = Linear Energy Threshold

**TABLE 2. PWR-82520R SPECIFICATIONS (CONTINUED)**  
**(UNLESS OTHERWISE SPECIFIED, VBUS=28VDC, VDR=+15V, VCC = +5V, VDD=+5V, VEE=-5V, TC = 25°C, LL = 500 μH, 100KRAD)**

PARAMETER	SYMBOL	TEST CONDITIONS	MIN	TYP	MAX	UNITS
<b>CURRENT COMMAND</b> Transconductance Ratio PWR-82520R1 PWR-82520R3 PWR-82520R10 Non-Linearity Temperature Coefficient of G	G	FIGURE 7	0.24 0.73 2.40 -1.5	0.25 0.75 2.50 0.035	0.26 0.77 2.60 +1.5	A/V A/V A/V % FSR % FSR/°C
<b>VBUS+ SUPPLY</b> Nominal Operating Voltage	Vnom		18	28	70	Vdc
<b>+15V SUPPLY</b> Voltage Current Current R1 R3 R10	VDR IDR IDR	$\overline{\text{ENABLE}}$ = high $\overline{\text{ENABLE}}$ = low	+13.5	+15.0 100 8 18 40	+16.5 15 25 60	Vdc mA mA mA mA
<b>+5V SUPPLY</b> Voltage Current	VCC ICC		+4.5	+5.0 40	+5.5 60	Vdc mA
<b>+5V TO +15V SUPPLY</b> Voltage Current	VDD IDD		+4.5	35	+16.5 50	Vdc mA
<b>-5V TO -15V SUPPLY</b> Voltage Current	VEE IEE		-16.5	40	-4.5 50	Vdc mA
<b>SYNC</b> Low High Duty Cycle SYNC range as % of free-run frequency	SYNC IN		2.4 100	50	0.8 120	Vdc Vdc % %
<b>PWM IN</b> + Peak - Peak Frequency Linearity Error Duty Cycle	VP+ VP- f LIN D CYCLE	VCC = 4.5 - 5.5V	2.3 -2.7 10 -2 49	2.5 -2.5	2.7 -2.3 110 +2 51	V V KHz % %
<b>PWM OUT</b> Free Run Frequency R10 R1, R3 Accuracy Stability, Temperature	fPWM fPWM Full Temp Range		47.5 95	50 100 ±10 0.5	52.5 105 2.0	KHz KHz KHz %
<b>HALL SIGNALS</b> Logic 0 Logic 1	HA, HB, HC		2.4		0.8	Vdc Vdc
<b>ENABLE</b> Enabled Disabled	$\overline{\text{ENABLE}}$		2.4		0.8	Vdc Vdc
<b>TACH OUT/ DIR OUT</b> Current Sink	VOL	Open Collector @ 1mA		0.7	1.2	Vdc
<b>ISOLATION</b> Case to Ground		500 Vdc HIPOT	10			MΩ
<b>COMMAND IN+/-</b> Differential Input Input Offset Input Offset Drift	VCMD		-4	2	+4 800	Vdc μV μV/°C
<b>COMMAND OUT</b> Internal Voltage Clamp Slew Rate Settling Time	VCLAMP Vo = 0.2 - 4.5V		-5	3 1.4	+5	Vdc V/μs μs to 0.1%

## INTRODUCTION

The PWR-82520R is a, radiation hardened, 3-phase high performance current control (torque loop) hybrid, which provides true four-quadrant control through zero current. Its high Pulse Width Modulation (PWM) switching frequency makes it suitable for operation with low inductance motors. The PWR-82520R hybrids can accept either single-ended or differential mode command signals. The current gain can be easily programmed to match the end user system requirements. The addition of an externally wired compensation network provides the user with optimum control of a wide range of loads.

The PWR-82520R uses single point current sense technology with an internal non-inductive hybrid sense resistor ( $R_{SENSE}$ ), which yields a highly linear current output over the wide  $-55^{\circ}\text{C}$  to  $+125^{\circ}\text{C}$  military temperature range. The output current non-linearity is less than 1.5% and the total error due to all the factors such as offset, initial component accuracy etc. is maintained well below 3% of the full scale rated output current.

The Hall sensor interface for current commutation has built-in decoder logic that ignores illegal codes and ensures that there is no cross conduction. The Hall sensor inputs are internally pulled up to +5V and can be driven from open-collector outputs

The PWM frequency can be programmed externally by adding a capacitor from PWM OUT to PWM GND. Multiple PWR-82520R's can be synchronized in two ways: 1) by using one device as a master and connecting its PWM OUT pin to the

PWM IN of all the other slave devices, or 2) by applying a master SYNC pulse from an external source to the PWM IN pins on all devices to be synchronized.

The **ENABLE** input signal provides quick start and shutdown of the internal PWM. In addition, built-in under voltage fault protection turns off the output in case of improper power supply voltages. The hybrid features dual current limiting functions. The input command amplifier output is limited to  $\pm 5\text{V}$ , limiting the motor current under normal operation. In addition, there is a cycle-by-cycle current limit, which kicks in to protect the hybrid as well as the load (see ICL TABLE 2 for limits).

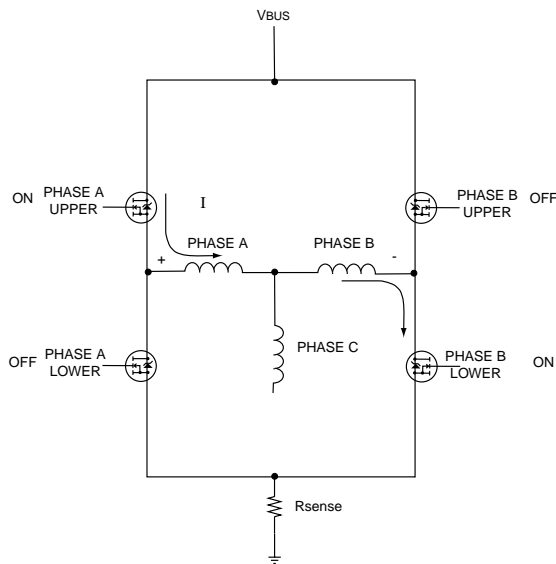
## BASIC OPERATION AND ADVANTAGES

The PWR-82520R utilize a complementary four-quadrant drive technique to control current in the load. The complementary drive has the following advantages over the standard drive:

1. Holding torque in the motor at zero commanded current
2. Linear current control through zero
3. No deadband at zero

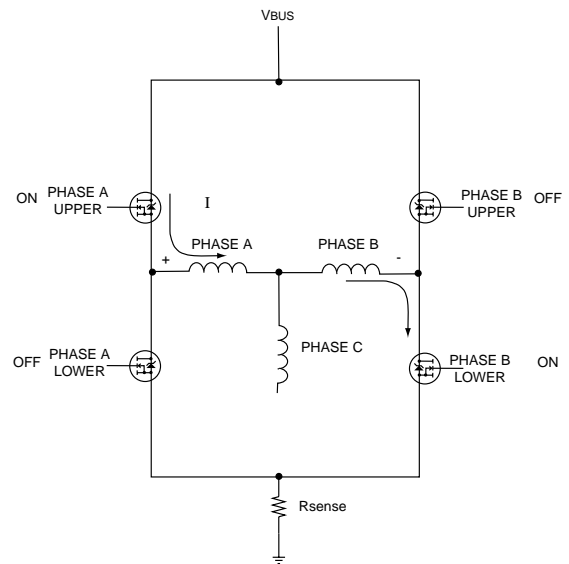
The complementary drive design produces a 50% PWM duty cycle in response to a zero current command. During a zero current command the benefit of a complementary 4 quadrant drive over a standard 4 quadrant is shown in the following figures (FIGURES 2A, 2B, 3A, and 3B).

During the first half of the PWM cycle, one pair of MOSFETs (Phase A upper & Phase B lower) are turned on, to supply current into the load as shown in FIGURE 2A.



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

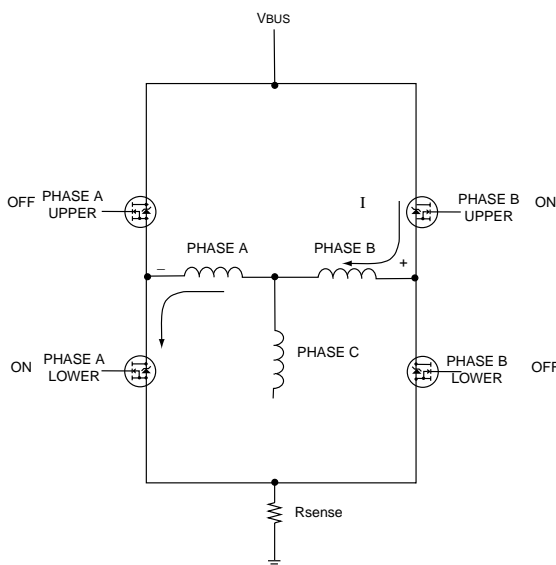
During the first half of the PWM cycle the Standard 4 Quadrant Drive operation in FIGURE 3A is identical to the Complementary 4 Quadrant Drive shown in FIGURE 2A.



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

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, to provide load current in the opposite direction.

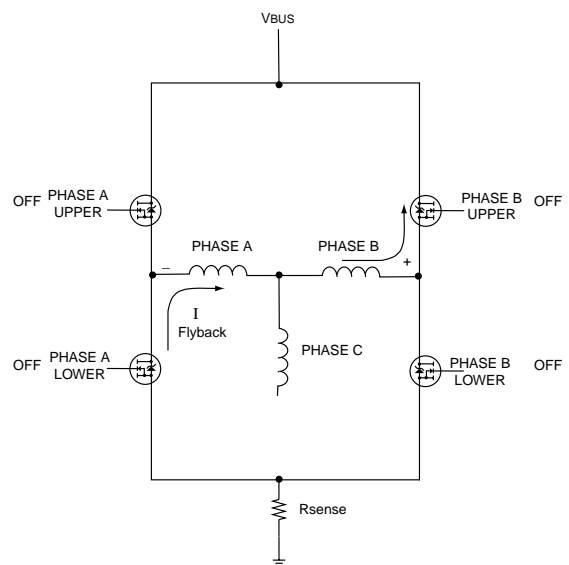
Current flowing in both directions results in, zero average current in the motor that provides a holding torque.



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

During the second half of the PWM cycle this drive operates in dead time where the motor current continues to flow (I Flyback) in the same direction through the power device diodes for standard 4-quadrant drive as shown in FIGURE 3B.

This results in an average current flow through the motor in one direction, producing in a net torque in one direction.



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

## MAJOR ADVANTAGES

The advantage of a complementary 4 quadrant drive over a standard 4-quadrant drive is during a zero current command, zero average current in the motor, that provides positive holding torque to maintain position. 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-82520R contains all the circuitry required to close an average current mode control loop around a complimentary 4-quadrant drive. The PWR-82520R 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. Slope compensation and the pole created by the motor inductance are two limitations normally associated with implementing standard 4 quadrant current mode controls.

## FUNCTIONAL PIN DESCRIPTIONS

### VBUS+A, VBUS+B, VBUS+C

The VBUS+ supply is the power source for the motor phases. The normal operating voltage is 28Vdc and may vary from +18 to +70Vdc with respect to VBUS-. The power stage MOSFETS in the hybrid have an absolute maximum VBUS+ supply voltage rating of 100V. The user must supply sufficient external capacitance or circuitry to prevent the bus supply from exceeding the maximum recommended voltages at the hybrid power terminals under any conditions.

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

### VBUS-

This is the high current ground return for VBUS+. This point must be closely connected to **SUPPLY GND** for proper operation of the current loop.

### VCC (+5V SUPPLY) AND VCC RTN

These inputs are used to power the digital circuitry of the hybrid.

### VDR (+15V SUPPLY)

This input is used to power the gate driver circuitry for the output MOSFETS. There is no power consumption from VDR when the hybrid is disabled.

### VDD (+5V TO +15V SUPPLY), AND VEE (-5V TO -15V SUPPLY)

These inputs can vary from  $\pm 5V$  to  $\pm 15V$  as long as they are symmetrical. VDD and VEE are used to power the small signal analog circuitry of the hybrid. Please note that using  $\pm 5V$  supply will reduce the quiescent power consumption by approximately 60% when compared to  $\pm 15V$  operation.

### SUPPLY GND

SUPPLY GND is the return for the VDR, VEE, VDD supplies. The phase current sensing technique of the PWR-82520R requires that VBUS- and SUPPLY GND (see FIGURES 6 and 7) be connected together externally (see VBUS- supply).

### CASE GND

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

### HALL A, B, C SIGNALS

These are logic signals from the motor Hall-effect sensors. 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 with VBC, and HC is in phase with VCA. Logic "1" (or HIGH) is defined by an input greater than 2.4Vdc or an open circuit to the controller; Logic "0" (or LOW) is defined as any Hall voltage input less than 0.8Vdc. Internal to the PWR-82520R are 10K pull-up resistors tied to +5Vdc on each Hall input.

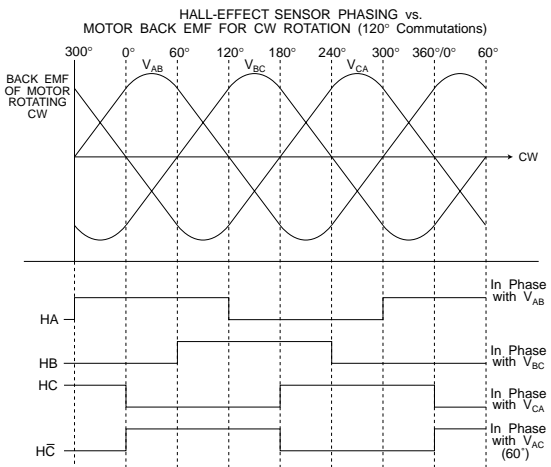


FIGURE 4. HALL PHASING

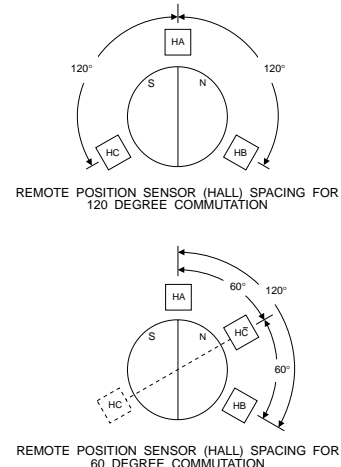
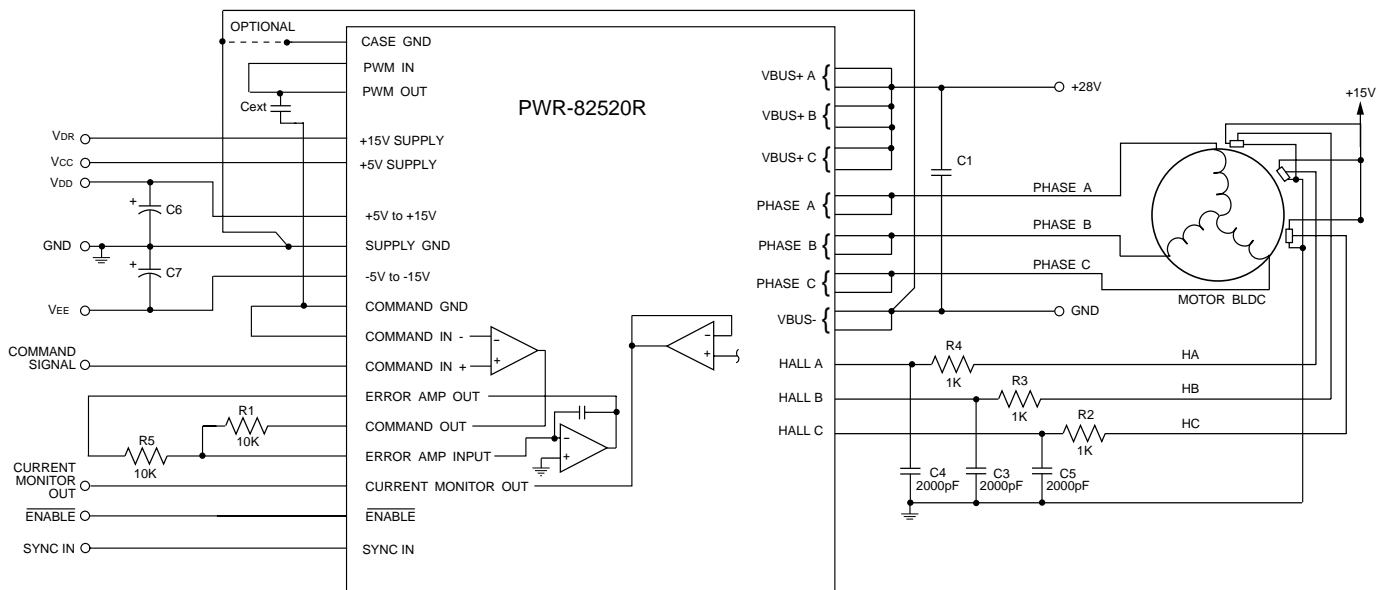
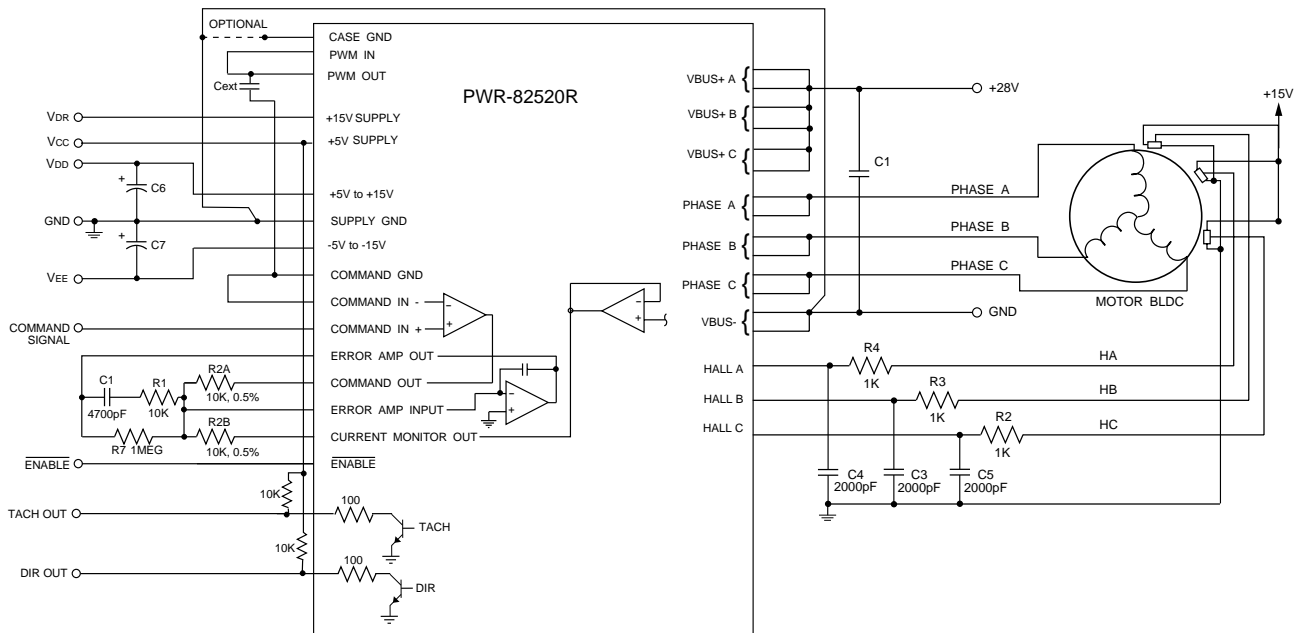


FIGURE 5. HALL SENSOR SPACING





**FIGURE 6. VOLTAGE CONTROL HOOK-UP**



**FIGURE 7. TORQUE (CURRENT) CONTROL HOOK-UP**

The PWR-82520R will alternately operate with Hall phasing of 60° electrical spacing. If 60° commutation is used, then the output of HC must be inverted as shown in FIGURES 4 and 5. FIGURE 4 illustrates the Hall sensor outputs along with the corresponding back emf voltage they are in phase with.

**HALL INPUT SIGNAL CONDITIONING**

When the motor is located more than two feet away from the PWR-82520R controller in a noisy electrical environment the Hall inputs require filtering from noise. It is recommended to use a 1KΩ 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 FIGURES 6 and 7.

**PHASE A, B, C**

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

**ENABLE**

The Enable input is an active low (L) logic signal that enables or disables the internal PWM. In the disable mode (H), the PWM is shut down and the outputs, Phase A, Phase B and Phase C, are in an "off" state and no voltage is applied to the motor.

**TACH OUT**

The TACH OUT provides a tachometer signal that is a square wave clock with a frequency relative to motor speed that is derived from the three Hall inputs HA, HB, HC. The tachometer circuitry combines these three signals into a single pulse train as a 50%-duty-cycle pulse. There are three pulses that occur every 360 electrical degree. The number of pulses per motor revolution is formulated below:

$$Pr = \frac{P}{2} \times 3 \text{ (e.g., 6 pulses/revolution for a 4 pole motor)}$$

The motor RPM is:

$$RPM = \frac{Tf \times 60}{Pr}$$

where:

- P = number of motor poles
- Pr = number of pulses per revolution
- Tf = Tach output frequency cycles/second

**DIR OUT**

The DIR OUT indicates the direction the motor is rotating, clockwise (CW) for a HI (open collector), or counterclockwise (CCW), indicated as a logic LOW (ground).

**CURRENT MONITOR OUT**

This is a bipolar analog output voltage representative of motor current. The CURRENT MONITOR OUT will have the same scaling as the COMMAND IN inputs.

**SYNC IN**

This input, as shown in FIGURE 9, is used to synchronize the PWM switching frequency with an external clocking device. The PWM switching frequency can be pulled to up-to 20% faster than its free running frequency.

**PWM IN**

PWM comparator inputs used to control the PWM pulse width. PWM OUT or an external triangular waveform is connected to this pin.

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

**PWM FREQUENCY**

The PWM frequency from the PWR-82520R1/R3 (PWR-82520R10) PWM OUT pin will free-run at a frequency of 100KHz ± 5KHz (50KHz ± 2.5KHz). The PWM frequency is user adjustable from 100KHz (50KHz) down to 10KHz through the addition of an external capacitor. The PWM triangular waveform generated internally is brought out to the PWM OUT pin. This output, or an external triangular waveform generated by the user, may be connected to PWM IN on the hybrid.

**PWM OUT**

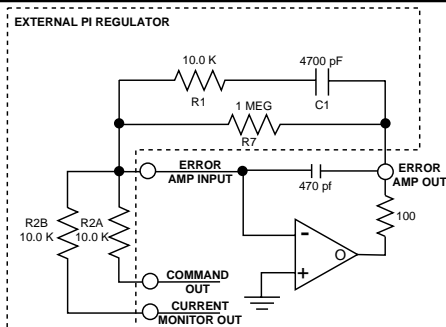
This is the output of the internally generated PWM triangular waveform. It is normally connected to PWM IN. The frequency of this output may be lowered by connecting an NPO capacitor (Cext) between PWM OUT and COMMAND GND. The PWM frequency is determined by the following formulas:

PWR-82520R1, R3:

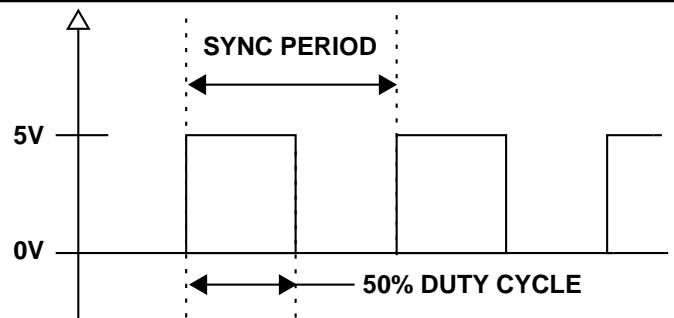
$$\frac{33.0E-6}{330pF + CEXTpF}$$

PWR-82520R10:

$$\frac{16.5E-6}{330pF + CEXTpF}$$



**FIGURE 8. STANDARD PI CURRENT LOOP**



**FIGURE 9. SYNC INPUT SIGNAL**

### ERROR AMP IN, ERROR AMP OUT

These are the input and output pins for the error amplifier and are used for compensation.

#### COMPENSATION

The PI regulator in the PWR-82520R can be tuned to a specific load for optimum performance. FIGURE 8 shows the standard current loop configuration and tuning components. By adjusting R1, R2 and C1, the amplifier can be tuned. The value of R1, C1 will vary, depending on the loop bandwidth requirement.

### COMMAND IN+, COMMAND IN-, COMMAND GROUND, COMMAND OUT

These are the connection pins for the command amplifier. The command amplifier has a differential input that operates from a  $\pm 4V_{dc}$  full-scale analog current command. The command amplifier output signal is internally limited to approximately  $\pm 5V_{dc}$  to prevent the amplifier from saturating. The input impedance of the command amplifier is 50K $\Omega$ .

The PWR-82520R can be used either as a current or voltage mode controller. When used as a torque controller (current mode), the input command signal is processed through the command buffer, which is internally limited to  $\pm 5V_{dc}$ . The output of the buffer (command out) is summed with the current monitor output into the error amplifier. External compensation is used on the error amplifier, so the response time can be adjusted to meet the application.

When used in the voltage mode, the voltage command signal is applied to the command amplifier, to control the voltage applied to the motor. The command amplifier output is coupled into the error amplifier. The error amplifier directly varies the PWM duty cycle to control the voltage applied to the motor phase. The nominal PWM frequency in the voltage mode is 50% with zero volts applied to the command input. The PWM duty cycle is varied by the voltage applied to the command input according to the transfer function, 12% per volt applied to the command input.

**TABLE 3. COMMUTATION TRUTH TABLE**

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 >2.4Vdc, 0=Logic voltage < 0.8Vdc  
 \*\* DIR is based on the convention shown in FIGURE 4.  
 Actual motor set up might be different.

The duty cycle range of the output voltage is limited to approximately 5-95% in both current and voltage modes.

#### COMMAND GND

COMMAND GND is used when the command buffer is used single-ended and the COMMAND IN- or COMMAND IN+ are tied to COMMAND GND.

#### TRANSCONDUCTANCE RATIO AND OFFSET

When the PWR-82520R is used in the current mode, the command inputs (COMMAND IN+ and COMMAND IN-) are designed such that  $\pm 4V_{dc}$  on either input, with the other input connected to ground will result in  $\pm$  full-scale current loc flow into the load. The dc current transfer ratio accuracy is  $\pm 5\%$  of the rated current including offset and initial component accuracy. The initial output dc current offset with both COMMAND IN+ and COMMAND IN- tied to the ground will be as shown in TABLE 2 (loffset) when measured using a load of 0.5mH and 1.0W at ambient room temperature with standard current loop compensation (see FIGURE 7). The winding phase current error shall be within the cumulative limits of the transconductance ratio error and the offset error.

#### Rs +

Rs + is the high side of the sense resistor used for test purposes only. Accuracy is not guaranteed.

### OUTPUT CURRENT

Output current derating as a function of the hybrid case temperature is provided in FIGURES 11 and 12. 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-82520R does not have short circuit protection. The PWR-82520R must see a minimum of 100 $\mu$ H inductive load or enough line-to-line resistance to limit the continuous output current to less than loc at all times. Operation into a short or a condition that requires excessive output current will damage the hybrid.

**TABLE 4. HALL INPUTS FOR H-BRIDGE CONTROLLER**

INPUTS					OUTPUTS		
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

## THERMAL OPERATION

It is recommended that the PWR-82520R 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 11.

## RADIATION

### TOTAL DOSE

The hybrid shall operate, as specified in TABLE 2, when subjected to a total dose radiation environment of 100KRad (Si) at a dose rate of 0.5 Rad/sec.

### SINGLE EVENT UPSET

The hybrid shall be Single Event Upset (SEU) immune and still meet the requirements of TABLE 2 for a Linear Energy Transfer (LET) level of 36 MeV/mg/cm<sup>2</sup>.

### LATCH-UP

The hybrid is latch-up immune and meets the requirement of TABLE 2 for a LET (Linear Energy Threshold) level of 36 MeV/mg/cm<sup>2</sup>.

**NOTE:** 100KRad (Si) total dose of radiation is usually two to three times the operational level of commercial and military satellites. This is a large cost saving for the end users since Lot Acceptance Tests (LAT) are usually not required.

## BRUSH MOTOR OPERATION

The PWR-82520R can also be used as a brush motor controller for current or voltage control in an H-Bridge configuration. The PWR-82520R would be connected as shown in FIGURE 10.

All other connections are as shown in either FIGURES 6 or 7 depending on voltage or current 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.

## OPTIONAL FEATURES

### EXTERNAL SENSING RESISTOR

The external sensing point available for the end users to install an external resistor (non-inductive). The resistance of the resistor is scaled to the applicable current range. Please contact factory for this option.

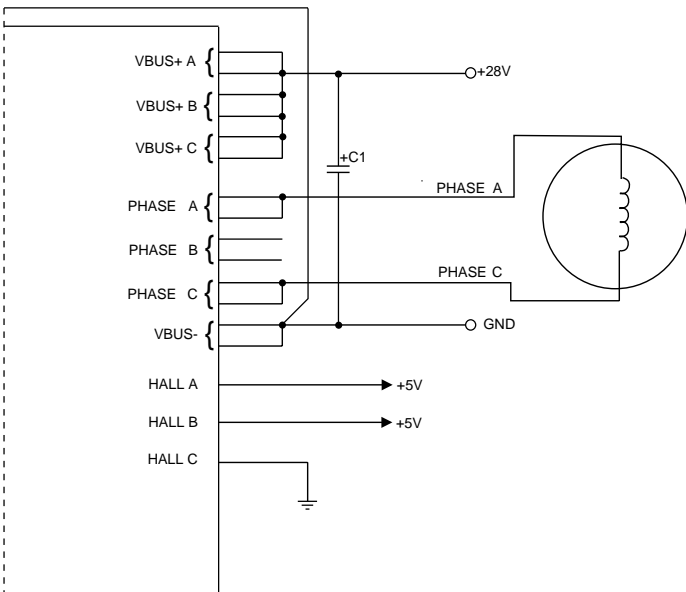


FIGURE 10. BRUSH MOTOR HOOK-UP

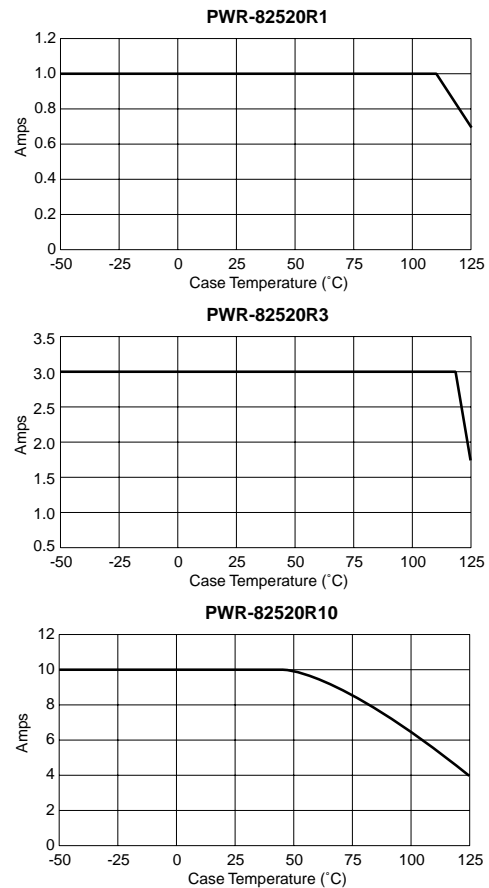


FIGURE 11. OUTPUT CURRENT FOR CONTINUOUS COMMUTATION (ELECTRICAL > 600RPM, VBUS+ = 28V, PWM = 50KHZ)

## PWR-82520X POWER DISSIPATION

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

An example calculation is shown below:

VBUS = +28 V (Bus Voltage)

IOA = 3 A, IOB = 7 A (see FIGURE 12)

fo = 50 KHz (switching frequency)

ton = 36 μs, T = 40 μs (90% duty cycle) (see FIGURE 12)

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 12)

### 1. TRANSISTOR CONDUCTION LOSSES (PT)

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

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

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

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

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

### 2. SWITCHING LOSSES (Ps)

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

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

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

### 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

$$P_{qc} = P_q (0.33)$$

$$P_{qc} = (2.54) \times (0.33)$$

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

### TOTAL HYBRID POWER DISSIPATION

$$P_{\text{TOTAL}} = (P_q + P_c) \times 2$$

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

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

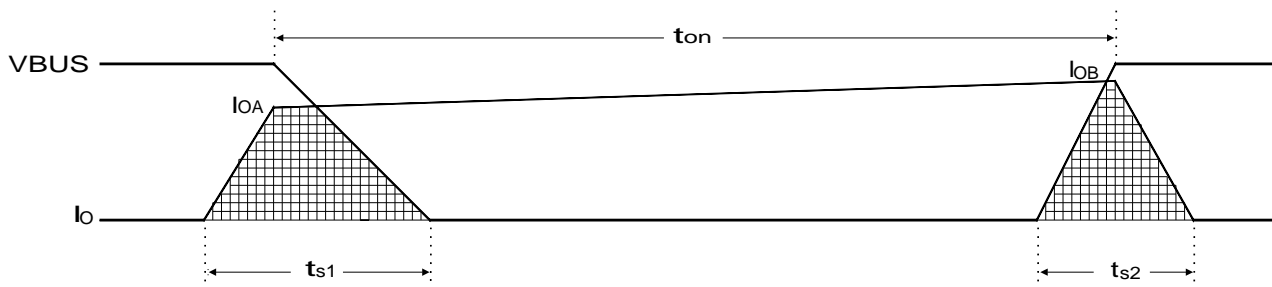


FIGURE 12. OUTPUT CHARACTERISTICS

**TABLE 5A. PIN FUNCTIONS  
PWR-82520 R1 AND R3**

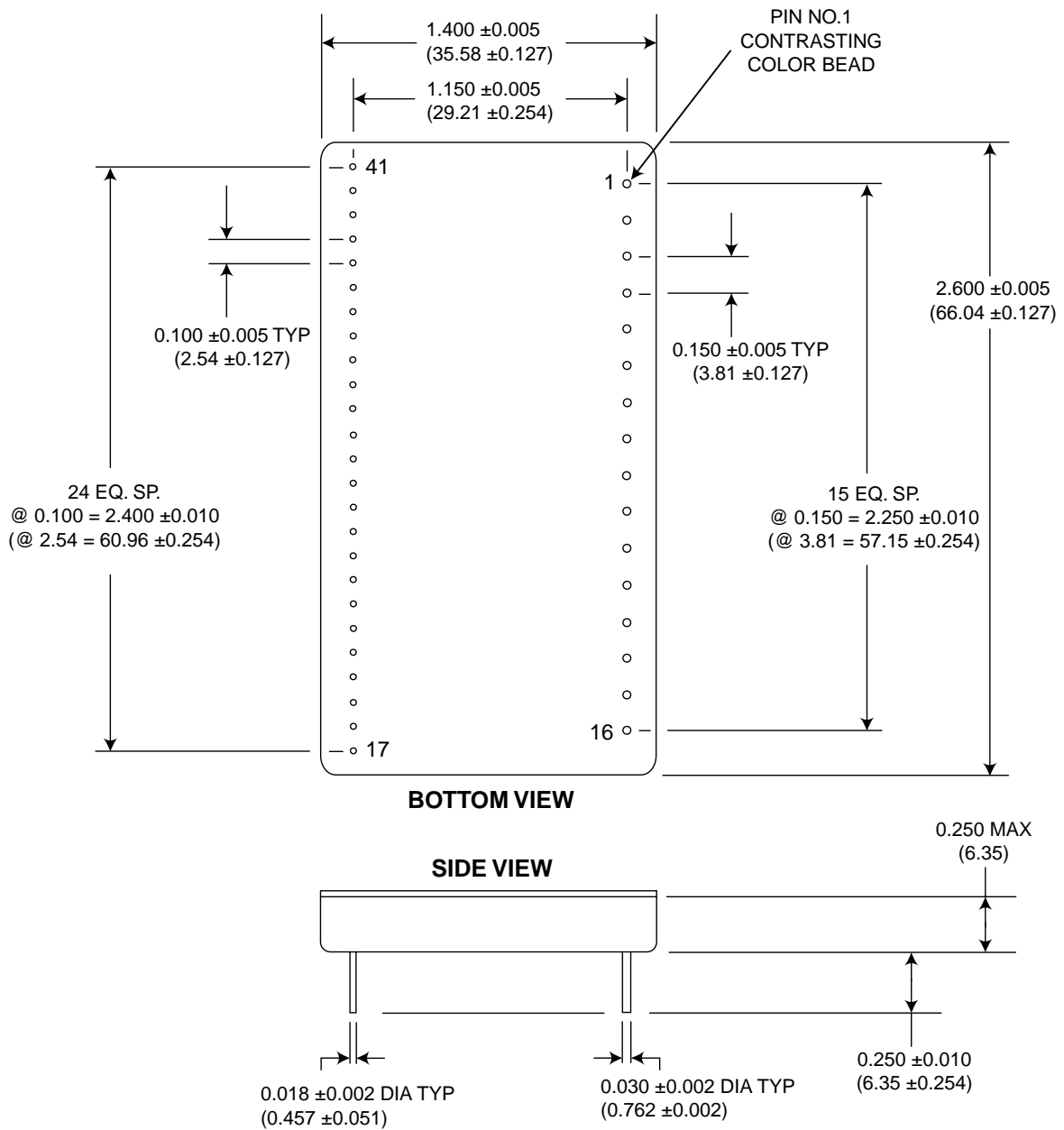
PIN	FUNCTION	PIN	FUNCTION
1	VBUS+ A	41	TACH OUT
2	VBUS+ A	40	DIR OUT
3	PHASE A	39	HALL C
4	PHASE A	38	HALL B
5	VBUS+ B	37	HALL A
6	VBUS+ B	36	ENABLE
7	PHASE B	35	V <sub>CC</sub>
8	PHASE B	34	V <sub>CC</sub> RTN
9	VBUS-	33	V <sub>DR</sub>
10	VBUS-	32	SYNC IN
11	Rs+	31	V <sub>DD</sub>
12	Rs+	30	SUPPLY GND
13	VBUS+ C	29	V <sub>EE</sub>
14	VBUS+ C	28	N/C
15	PHASE C	27	N/C
16	PHASE C	26	CURRENT MONITOR OUT
		25	ERROR AMP IN
		24	ERROR AMP OUT
		23	COMMAND OUT
		22	COMMAND IN -
		21	COMMAND IN +
		20	COMMAND GND
		19	PWM OUT
		18	PWM IN
		17	CASE GND

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

**TABLE 5B. PIN FUNCTIONS  
PWR-82520 R10**

PIN	FUNCTION	PIN	FUNCTION
1	CASE GND	27	VBUS+ A
2	N/C	28	VBUS+ A
3	PWM IN	29	PHASE A
4	PWM OUT	30	PHASE A
5	COMMAND GND	31	VBUS+ B
6	COMMAND IN+	32	VBUS+ B
7	COMMAND IN-	33	PHASE B
8	COMMAND OUT	34	PHASE B
9	ERROR AMP OUT	35	VBUS-
10	ERROR AMP IN	36	VBUS-
11	CURRENT MONITOR OUT	37	Rs+
12	N/C	38	Rs+
13	N/C	39	VBUS+ C
14	V <sub>EE</sub>	40	VBUS+ C
15	SUPPLY GND	41	PHASE C
16	V <sub>DD</sub>	42	PHASE C
17	SYNC IN	43	N/C
18	V <sub>DR</sub>		
19	V <sub>CC</sub> RTN		
20	V <sub>CC</sub>		
21	ENABLE		
22	HALL A		
23	HALL B		
24	HALL C		
25	DIR OUT		
26	TACH OUT		

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



NOTES:

1. DIMENSIONS IN INCHES (MM). TOL =  $\pm 0.005$  ( $\pm 0.127$ )
2. LEAD IDENTIFICATION NUMBERS ARE FOR REFERENCE ONLY.

**FIGURE 13. MECHANICAL OUTLINE (R1, & R3)**

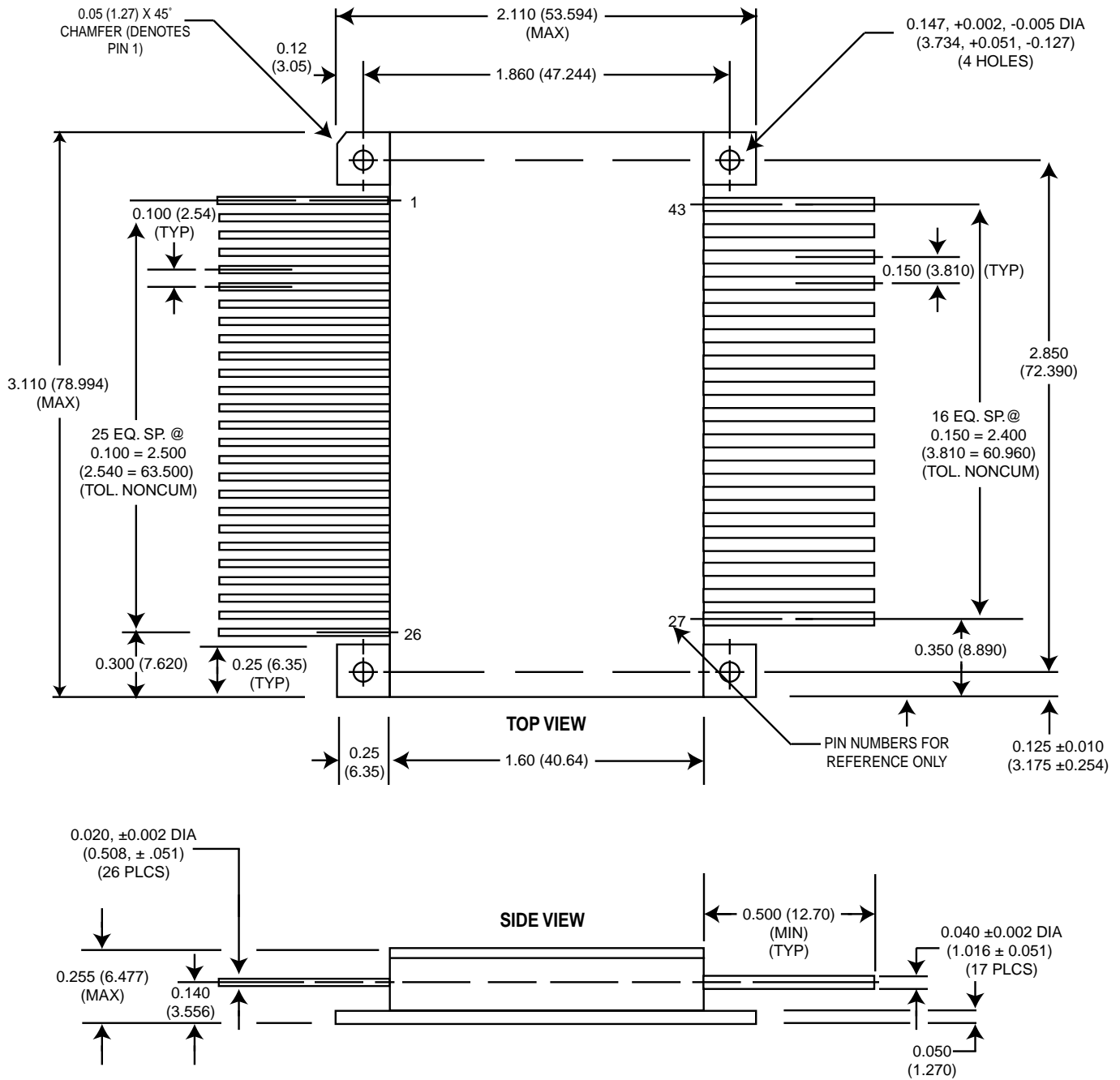


FIGURE 14. MECHANICAL OUTLINE (R10)



## ORDERING INFORMATION

PWR-82520RX- X X 0

**Reliability Grade:**

- 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 Range:**

- 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

**Rating:**

- 1 - 1A
- 3 - 3A
- 10 - 10A

Consult factory for class K processing.

\*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	—

**NOTES:**

**NOTES:**

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.



105 Wilbur Place, Bohemia, New York 11716-2482

**For Technical Support - 1-800-DDC-5757 ext. 7677 or 7381**

**Headquarters** - Tel: (631) 567-5600 ext. 7677 or 7381, Fax: (631) 567-7358

**West Coast** - Tel: (714) 895-9777, Fax: (714) 895-4988

**Southeast** - Tel: (703) 450-7900, Fax: (703) 450-6610

**United Kingdom** - Tel: +44-(0)1635-811140, Fax: +44-(0)1635-32264

**Ireland** - Tel: +353-21-341065, Fax: +353-21-341568

**France** - Tel: +33-(0)1-41-16-3424, Fax: +33-(0)1-41-16-3425

**Germany** - Tel: +49-(0)8141-349-087, Fax: +49-(0)8141-349-089

**Japan** - Tel: +81-(0)3-3814-7688, Fax: +81-(0)3-3814-7689

**World Wide Web** - <http://www.ddc-web.com>

