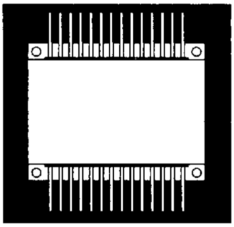
FULL-FEATURED 'SMART-POWER' MODULES for HIGH CURRENT DIRECT DRIVE for 3-PHASE BRUSHLESS DC MOTORS



20 Amp, Push-Pull, Smart-Power Hybrid Commutates, Controls, And Directly Drives High-Power 3-Phase BLDC Motors

FEATURES

- Merged Commutation, Control, and Power Electronics 'System'
- High-Current, Low ON Resistance NMOS and PMOS Power FETs
- Output Current Continuous to 20 Amperes
- Peak Output Current to 40 Amperes
- Efficient, Low-Power, Bipolar Analog Circuitry
- Directly Compatible with Open-Collector Hall Sensor ICs
- Internal Reference Powers Sensors and Tachometer IC
- Programmable Overcurrent Sensing (*Custom Options)
- Convenient Single Supply Operation (Internal Regulator)
- Operating Voltage Ranges: (*Custom Options)
  - OM9313: 10V to 30V (12V to 26V Applications)
  - OM9314: 18V to 38V (28V Aircraft/Vehicle Systems)
  - OM9315: 30V to 50V (36V Industrial/Battery Systems)
- Analog Speed Control (*Custom Options)
- Closed Loop Operation (*Custom Options)
- PWM Speed Control (μP Compatible)
- Tachometer Output (RPM Indicator)
- Forward/Reverse (Direction) Control
- Selectable Sensor Angle Spacing (60°/300° or 120°/240°)
- Output Enable Function
- Dynamic Braking
- Fault Output (Diagnostic)
- Under voltage Lockout (Commutator/Controller IC)
- *Custom Options (Provisions for Integrating Additional Components)

2.1

DESCRIPTION

The OM9313SF, OM9314SF, and OM9315SF provide full-featured, versatile 'smart-power' electronics via integrating the 3-phase commutation, control, and power outputs for delta and wye connected brushless dc (BLDC) motors. Only Hall effect sensors for rotational and directional signals are necessary to complete the essential 3θ motor electronics. An internal regulator (optional connection) permits single supply operation, and simplifies the design of 'stand-alone', single supply motor control electronics.

The three operating voltage ranges afford solutions for a variety of systems needs, and customizing the operating voltage range can be accommodated. Analog and/or PWM speed control is readily implemented with external components. Custom modules allow integrating specific values of passive speed control and current sensing components. These 'turn-key', fully tested hybrids, essentially, constitute a 3θ BLDC motion control 'system' within a single package. They provide the values of performance, reliability, simplicity, and versatility for many fractional horsepower 3-phase motors. Both industrial and hermetic MIL-rated versions are available; and circuitry is electrically isolated from the package.

ABSOLUTE MAXIMUM RATINGS

Motor Supply Voltage Range, V_{SS} OM9313SF .... 10V to 40V
OM9314SF .... 18V to 48V
OM9315SF .... 26V to 56V
Continuous Output Current, I_{OUT} 20A
Pulsed Output Current, I_{DM} 40A
Logic/Control Supply Range, V_{CC} .... 10V to 30V
Digital Inputs (For/Rev, Sensor Inputs, Output Enable, 60°/120°, Brake) .... Vref (+6.2V)
Oscillator Input Current (Source or Sink), I_{OSC} 30mA
Error Amp Input Voltage Range, V_{IR} .... -3.0 to V_{ref}[1]
Error Amp Output Current (Source or Sink), I_{OUT} .... 10mA[2]
Current Sense Input Voltage Range (Non-inverting/Inverting), V_{SENSE} .... -3.0V to 5.0V
Fault Output Voltage, $V_{CE(FAULT)}$ 20V
Fault Output Sink Current, $I_{SINK(FAULT)}$ 20mA
Thermal Resistance, Junction to Case, $R_{\theta JC}$ .... TBD
Operating Ambient Temperature Range, T_A
Industrial Modules .... -40°C to +85°C
MIL-Rated, Hermetic Modules .... -55°C to +125°C
Storage Temperature Range, T_{stg} .... -65°C to +150°C
Isolation Voltage, V_{ISO} 1500V

RECOMMENDED OPERATING CONDITIONS (Over Specified Temperature Range)

Supply Voltage, V_{SS} OM9313SF .... 10V to 30V
OM9314SF .... 18V to 38V
OM9315SF .... 28V to 48V
Continuous Output Current, I_{OUT} 13A
Control/Logic Supply, V_{CC} .... 15V ±10%
Logic Thresholds, V_{INH} (Pins 1, 2, 3, 4, 5, 14, 15, 27) .... 3.0V (min)
V_{INL} .... 0.8V (max)
Junction Temperature, T_J .... + 150°C

ELECTRICAL CHARACTERISTICS (V_{cc} = 20V, R_T/C_T = 4.7k/10nF, T_A = 25° unless otherwise noted.)

Reference and Internal Regulator Section	Min.	Typ.	Max.	Unit
Reference Output Voltage, V_{ref} (I_{ref} = 10mA)	5.9	6.25	6.5	V
T_A = -40°C to +85°C	5.8		6.6	V
T_A = -55°C to +125°C	5.7		6.7	V
Line Regulation, Reg_{line} ($V_{CC} \geq 10V \leq 30V$, I_{ref} = 1.0mA)		1.5	30	mV
Load Regulation, Reg_{load} (I_{ref} = 1.0mA to 20mA)		16	30	mV
Output Short Circuit Current, I_{SC} (Note 3)	40	75		mA
Reference Under voltage Lockout Threshold, V_{th}	4.0	4.5	5.0	V
Single Supply Linear Regulator, V_{REG} ($V_M \geq 20 \leq V_{MAX}$)	12.9	13.9	14.8	V
Single Supply Linear Regulator, I_{OUT} ($V_M \leq V_{MAX}$)	75			mA

NOTES: 1. Input common mode voltage or input signal voltage should not be permitted to exceed -0.3V.
2. Compliance voltage must not exceed the range of -0.3V to Reference Voltage.
3. Limited by maximum power dissipation; V_{ref} can be buffered to provide higher currents @ ≈ 5.6V.

Oscillator Section	Min.	Typ.	Max.	Unit
Oscillator Frequency, f_{OSC}	22	25	28	kHz
Frequency to Voltage Dependency, $\Delta f_{OSC}/\Delta V$ (V_{CC} = 10V to 30V)		0.01	5	%
Sawtooth Peak Voltage, $V_{OSC(P)}$		4.1	4.5	V
Sawtooth Valley Voltage, $V_{OSC(V)}$	1.2	1.5		V

Tachometer Output	Min.	Typ.	Max.	Unit
Output Voltage, High State, V_{OH}, I_{SOURCE} = 5mA	3.60	3.95	4.20	V
Low State, V_{OL}, I_{SINK} = 10mA		0.25	0.50	V
Output Pulse Width (Pin 6), t_{PW}, R_T = 10k, C_T = 22nF	205	225	245	μs
Capacitor C_T Discharge Current, I_{DISCHG}	20	35	60	mA

Current Limit Comparator	Min.	Typ.	Max.	Unit
Threshold Voltage, V_{th}	85	101	115	mV
Input Common Mode Voltage Range, V_{ICR}		3.0		V
Input Bias Current, I_{IB}		-0.9	-5.0	μA

2.1

ELECTRICAL CHARACTERISTICS (V_{cc} = 20V, R_T/C_T = 4.7k/10nF, T_A = 25° unless otherwise noted.)

Error Amplifier Section	Min.	Typ.	Max.	Unit
Input Offset Voltage, V_{IO} (T_A = -40°C to +85°C)		0.4	10	mV
Input Offset Current, I_{IO} (T_A = -40°C to +85°C)		8.0	500	nA
Input Bias Current, I_{IB} (T_A = -40°C to +85°C)		-50nA	-1.0µA	
Input Common Mode Voltage Range, V_{ICR}	0		V_{REF}	V
Open-Loop Voltage Gain, A_{VOL} (V_O = 3.0V, R_L = 15k)	70	80		dB
Input Common Mode Rejection Ratio, CMRR	55	86		
Power Supply Rejection Ratio, PSRR ($V_{CC} \geq 10V \leq 30V$)	65	105		
Output Voltage Swing, V_{OH} (High: R_L = 15k to Gnd)	4.6	5.3		V
V_{OL} (Low: R_L =15k to V_{ref})		0.5	1.0	

Logic Inputs	Min.	Typ.	Max.	Unit
High State Voltage, V_{INH} (Pins 1, 2, 3, 4, 14, 15, 27)	3.0	2.2		V
Low State Voltage, V_{INL}		1.7	0.8	
Sensor Inputs: High State Current, I_{IH} (V_{IH} = 5.0V)	-150	-70	-20	µA
(Pins 2, 3, 4) Low State Current, I_{IL} (V_{IL} = 0V)	-600	-330	-150	
For/Rev, 60°/120° Select, Brake (Pins 1, 14, 15)				
High State Current, I_{IH} (V_{IH} = 5.0V)	-75	-35	-10	µA
Low State Current, I_{IL} (V_{IL} = 0V)	-300	-175	-75	
Output Enable (Pin 27)				
High State Current, I_{IH} (V_{IH} = 5.0V)	-60	-30	-10	µA
Low State Current, I_{IL} (V_{IL} = 0V)	-60	-30	-10	

Outputs and Power Section (T_C = 25° unless otherwise noted)	Min.	Typ.	Max.	Unit
NMOS Leakage Current, $I_{DS(OFF)}$				
(V_M = Rated Max, Brake = High)			20	µA
@ T_C = +125°C			200	
PMOS Leakage Current, $I_{DS(OFF)}$				
(V_M = Rated Max, Brake = High)			-20	µA
@ T_C = +125°C			-200	
NMOS Output ON Voltage, $V_{DS(ON)}$				
I_{OUT} = 20A (per truth table)			1.6	V
I_{OUT} = 13A, @ T_C = +100°C			1.9	
NMOS Output ON Resistance, $R_{DS(ON)}$ I_D = 10A			75	mΩ
PMOS Output ON Voltage, $V_{DS(ON)}$				
I_{OUT} = 20A (per truth table)		3.3		V
I_{OUT} = 13A, @ T_C = +100°C			3.9	
PMOS Output ON Resistance, $R_{DS(ON)}$ I_D = 10A			150	mΩ
Turn-On Delay, $t_{d(on)}$*			TBD	
Turn-Off Delay, $t_{d(off)}$*			TBD	
Source-Drain Diode Characteristics (I_S = Rated I_D)*				
NMOS Forward ON Voltage, V_{SD}		1.5	1.8	V
PMOS Forward ON Voltage, V_{SD}		2.8	4.0	
Forward Turn-On Time, t_{on}*		100		ns
Reverse Recovery Time, t_{rr}* NMOS Body Diodes		450		ns
PMOS Body Diodes		350		
Fault Output Off-State Leakage, $I_{FLT(OFF)}$				
(V_{CE} = 20V)		1.0	100	µA
Fault Output Saturation Voltage, $V_{CE(sat)}$				
(I_{sink} = 16mA)		225	500	mV
Under voltage Lockout				
Drive Output Enabled, $V_{th(on)}$ (V_{CC} Rising)	8.2	8.9	10	V
Hysteresis, V_H	0.1	0.2	0.3	
Power Supply Current, I_{CC}				
(V_{CC} = 20V, Inputs/Outputs = Open)		≤20	TBD	mA

* Pulse Test: Pulse width ≤ 300µs, Duty cycle ≤ 2%, V_{GS} = 0V

2.1

THREE PHASE, SIX STEP COMMUTATION TRUTH TABLE (NOTE 1)

Inputs (Note 2)										Outputs (Note 3)							
Sensor Electrical Phasing (Note 4)										Source Outputs			Sink Outputs				
60°			120°														
S_A	S_B	S_C	S_A	S_B	S_C	F/R	Enable	Brake	Current Sense	A_T	B_T	C_T	A_B	B_B	C_B	$\overline{Fault}$	
1	0	0	1	0	0	1	1	0	0	ON	OFF	OFF	OFF	OFF	ON	1	Forward
1	1	0	1	1	0	1	1	0	0	OFF	ON	OFF	OFF	OFF	ON	1	(Note 5)
1	1	1	0	1	0	1	1	0	0	OFF	ON	OFF	ON	OFF	OFF	1	F/R = 1
0	1	1	0	1	1	1	1	0	0	OFF	OFF	ON	ON	OFF	OFF	1	
0	0	1	0	0	1	1	1	0	0	OFF	OFF	ON	OFF	ON	OFF	1	
0	0	0	1	0	1	1	1	0	0	ON	OFF	OFF	OFF	ON	OFF	1	
1	0	0	1	0	0	0	1	0	0	OFF	OFF	ON	ON	OFF	OFF	1	Reverse
1	1	0	1	1	0	0	1	0	0	OFF	OFF	ON	OFF	ON	OFF	1	(Note 5)
1	1	1	0	1	0	0	1	0	0	ON	OFF	OFF	OFF	ON	OFF	1	F/R = 0
0	1	1	0	1	1	0	1	0	0	ON	OFF	OFF	OFF	OFF	ON	1	
0	0	1	0	0	1	0	1	0	0	OFF	ON	OFF	OFF	OFF	ON	1	
0	0	0	1	0	1	0	1	0	0	OFF	ON	OFF	ON	OFF	OFF	1	
1	0	1	1	1	1	X	X	0	X	OFF	OFF	OFF	OFF	OFF	OFF	0	(Note 6)
0	1	0	0	0	0	X	X	0	X	OFF	OFF	OFF	OFF	OFF	OFF	0	Brake = 0
1	0	1	1	1	1	X	X	1	X	OFF	OFF	OFF	ON	ON	ON	0	(Note 7)
0	1	0	0	0	0	X	X	1	X	OFF	OFF	OFF	ON	ON	ON	0	Brake = 1
V	V	V	V	V	V	X	1	1	X	OFF	OFF	OFF	ON	ON	ON	1	Brake/Inhibit (Note 8)
V	V	V	V	V	V	X	0	1	X	OFF	OFF	OFF	ON	ON	ON		Brake (Note 9)
V	V	V	V	V	V	X	0	0	X	OFF	OFF	OFF	OFF	OFF	OFF		Coast (Note 10)
V	V	V	V	V	V	X	1	0	1	OFF	OFF	OFF	OFF	OFF	OFF		Overcurrent (Note 11)

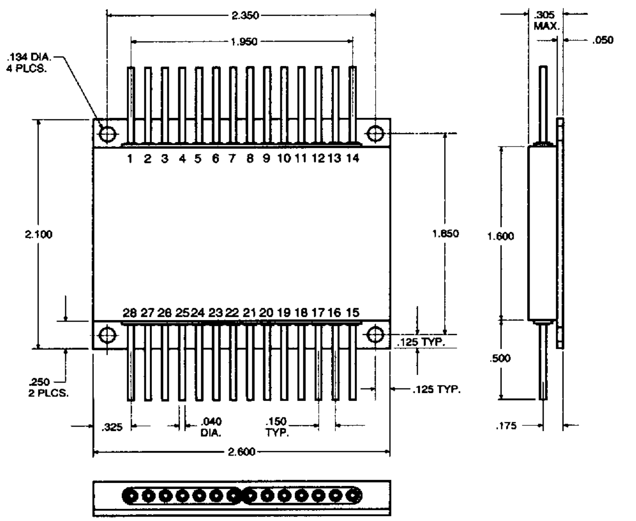
INVALID INPUTS $\overline{FAULT}$ CONDITION

NOTES:

1. V = Any one of six valid sensor or drive combinations X = Don't care.
2. The digital inputs (Pins 1, 2, 3, 4, 5, 13, 14) are all TTL compatible. The current sense input (Pin 8) has a 100 mV threshold with respect to Pin 28. A logic 0 for this input is defined as <85 mV, and a logic 1 is >115 mV.
3. The fault and top drive outputs are open collector design and active in the low (0) state.
4. With 60°/120° select (Pin 13) in the high (1) state, configuration is for 60° sensor electrical phasing inputs. With Pin 13 in low (0) state, configuration is for 120° sensor electrical phasing inputs.
5. Valid 60° or 120° sensor combinations for corresponding valid top and bottom drive outputs.
6. Invalid sensor inputs with brake = 0; All top and bottom drives off, $\overline{Fault}$ low.
7. Invalid sensor inputs with brake = 1; All top drives off, all bottom drives on, $\overline{Fault}$ low.
8. Valid 60° or 120° sensor inputs with brake = 1; All top drives off, all bottom drives on, $\overline{Fault}$ high.
9. Valid sensor inputs with brake = 1 and enable = 0; All top drives off, all bottom drives on, $\overline{Fault}$ low.
10. Valid sensor inputs with brake = 0 and enable = 0; All top and bottom drives off, $\overline{Fault}$ low.
11. All bottom drives off, $\overline{Fault}$ low.

2.1

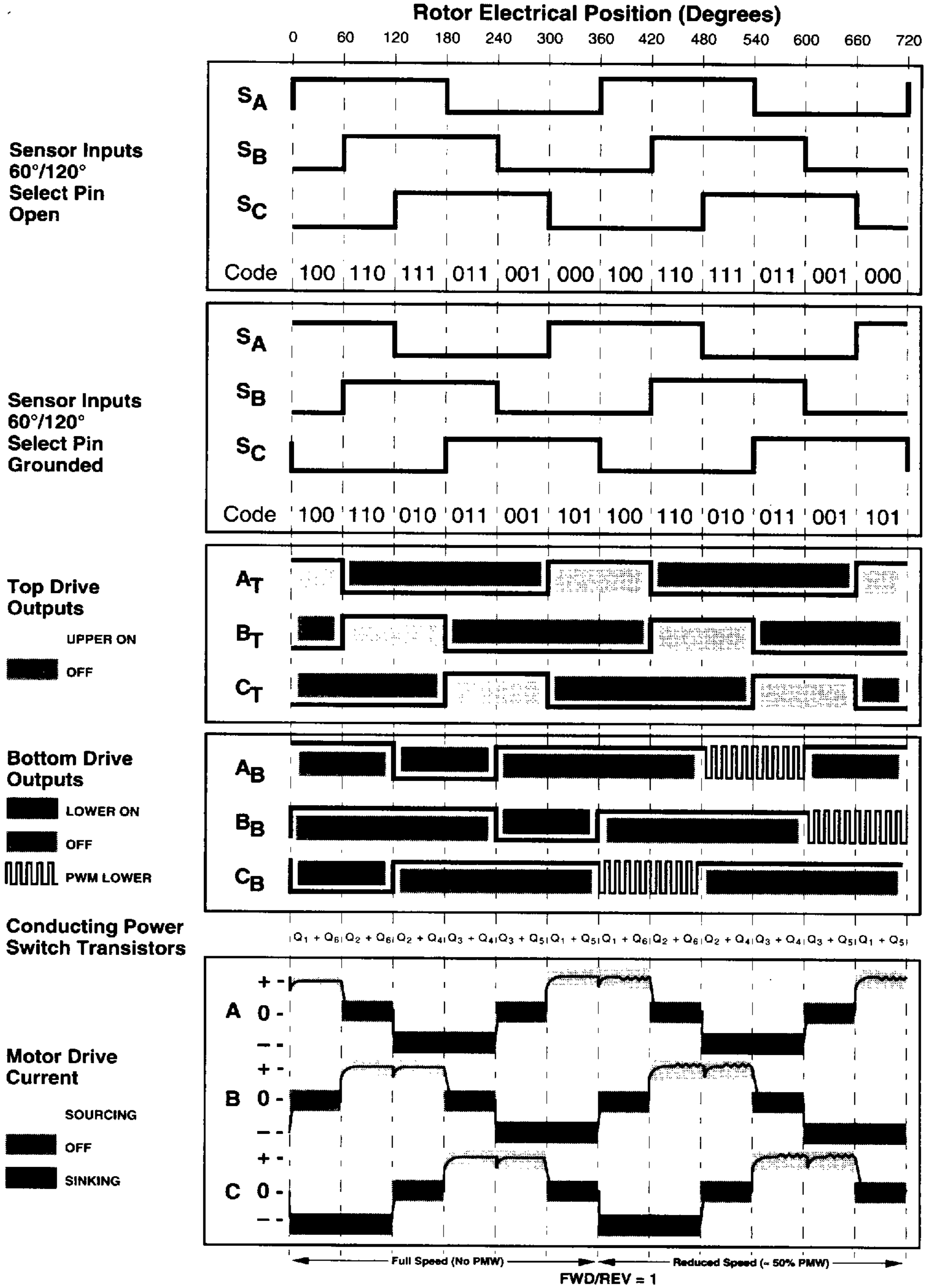
PIN CONNECTION and MECHANICAL OUTLINE



Pin 1: Forward/Reverse
Pin 2: Sensor A Input
Pin 3: Sensor B Input
Pin 4: Sensor C Input
Pin 5: Error Amp (Inverting Input)
Pin 6: f_{OUT} (Tachometer)
Pin 7: Signal Ground
Pin 8: R_T/C_T (Osc Timing)
Pin 9: Current Sense (Non-Inverting)
Pin 10: Oscillator Input
Pin 11: Error Amp Output/PWM Input
Pin 12: Speed Control Input
Pin 13: V_{CC} (Controller Supply)
Pin 14: 60°/120° Select
Pin 28: Fault Output
Pin 27: Output Enable
Pin 26: Power Ground 1
Pin 25: Power Ground 2
Pin 24: V_{ref} (+6.2V Sensor Power)
Pin 23: V_{reg} Out (Internal +15V)
Pin 22: Power Output C
Pin 21: V_M (Motor Supply Voltage)
Pin 20: Common Source (Output FETs)
Pin 19: Power Output B
Pin 18: V_M (Motor Supply Voltage)
Pin 17: Common Source (Output FETs)
Pin 16: Power Output A
Pin 15: Brake Input

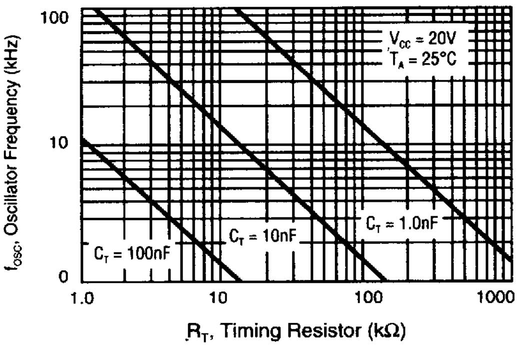
NOTE: Multiple connections are essential for all high-current/power leads. These include Common Source, Power Ground, and V_M (Motor Supply).

THREE PHASE, SIX STEP, FULL WAVE COMMUTATION WAVEFORMS

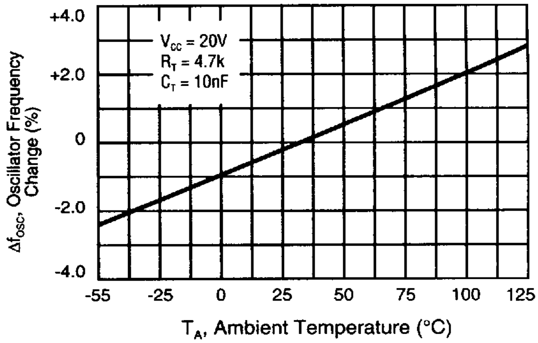


FOR FURTHER INFORMATION, CONTACT FACTORY DIRECT OR YOUR LOCAL SALES REPRESENTATIVE.
This document contains information on a new product. Specifications and information herein are subject to change without notice.

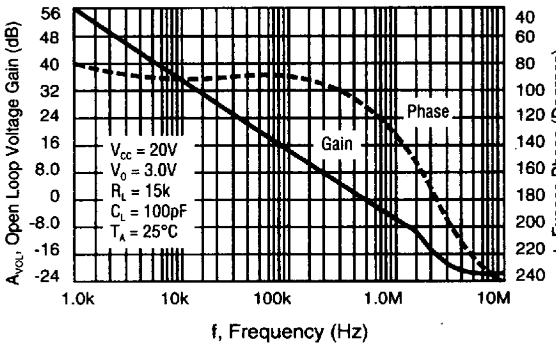
OSCILLATOR FREQUENCY versus TIMING RESISTOR



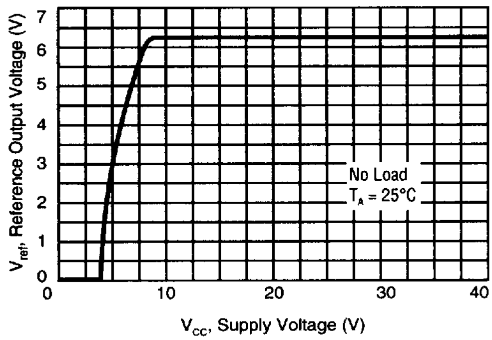
OSCILLATOR FREQUENCY CHANGE versus TEMPERATURE



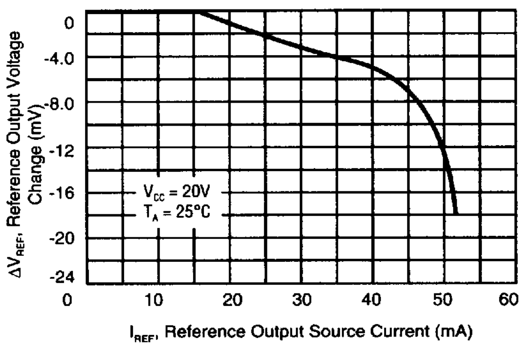
ERROR AMP OPEN LOOP GAIN AND PHASE versus FREQUENCY



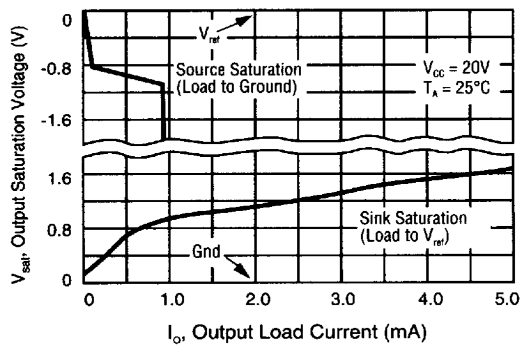
REFERENCE OUTPUT VOLTAGE versus SUPPLY VOLTAGE



REFERENCE OUTPUT VOLTAGE CHANGE versus OUTPUT SOURCE CURRENT



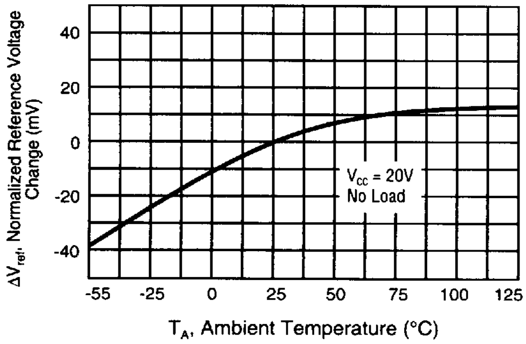
ERROR AMP OUTPUT SATURATION VOLTAGE versus LOAD CURRENT



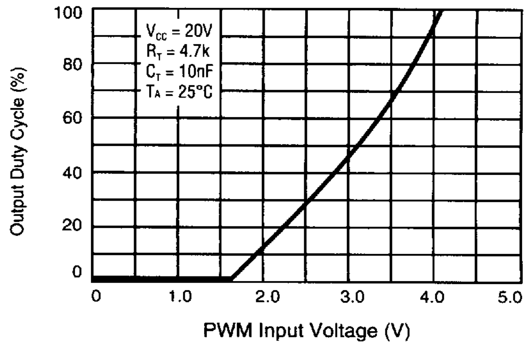
2.1

6789073 0001195 T59

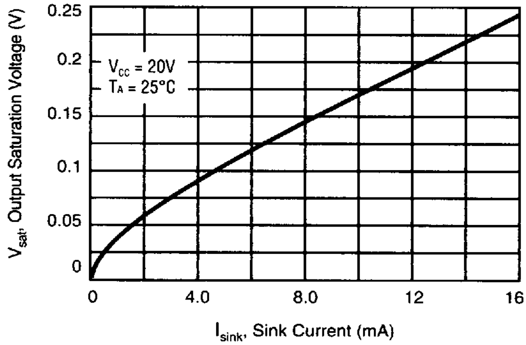
REFERENCE OUTPUT VOLTAGE versus TEMPERATURE



OUTPUT DUTY CYCLE versus PWM INPUT VOLTAGE

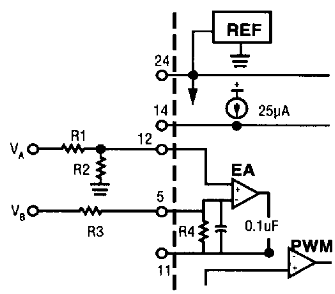


FAULT OUTPUT SATURATION versus SINK CURRENT



2.1

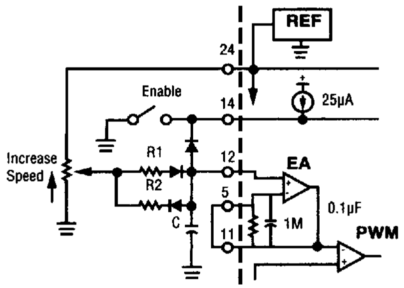
DIFFERENTIAL INPUT SPEED CONTROLLER



$$V_{pin}13 = V_A\left(\frac{R3 + R4}{R1 + R2}\right)\frac{R2}{R3} - \left(\frac{R4}{R3}V_B\right)$$

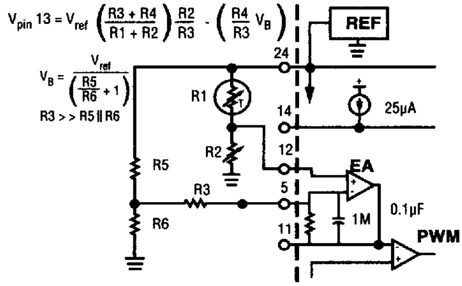
$R_4 = 1M\Omega$

CONTROLLED ACCELERATION/DECELERATION



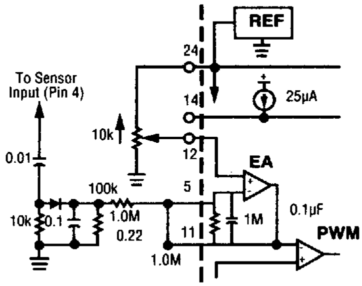
Resistor R1 with capacitor C sets the acceleration time constant while R2 controls the deceleration. The values of R1 and R2 should be at least ten times greater than the speed set potentiometer to minimize time constant variations with different speed settings.

CLOSED LOOP TEMPERATURE CONTROL



This circuit can control the speed of a cooling fan proportional to the difference between the sensor and set temperatures. The control loop is closed as the forced air cools the NTC thermistor. For controlled heating applications, exchange the positions of R1 and R2.

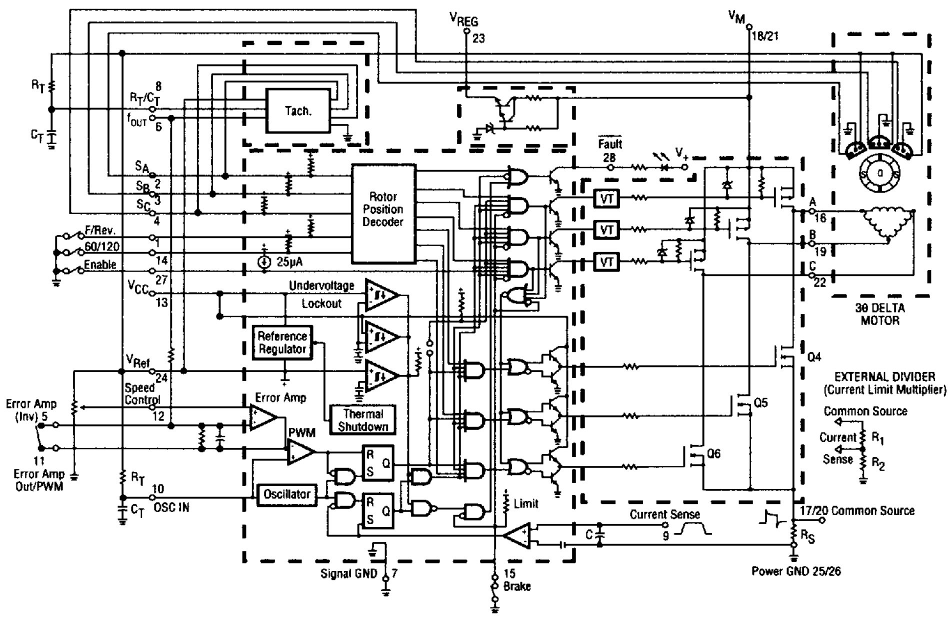
CLOSED LOOP SPEED CONTROL



The rotor position sensors can be used as a tachometer. By differentiating the positive-going edges and then integrating them over time, a voltage proportional to speed can be generated. The error amp compares this voltage to that of the speed set to control the PWM.

REPRESENTATIVE BLOCK DIAGRAM

2.1



6789073 0001197 821

Omnirel 205 Crawford Street, Leominster, MA 01453 USA (508) 534-5776 FAX (508) 537-4246