LINFINITY MICROELECTRONICS

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LIN Doc #: 1825

SG1825C/SG2825C/SG3825C

HIGH-SPEED CURRENT-MODE PWM

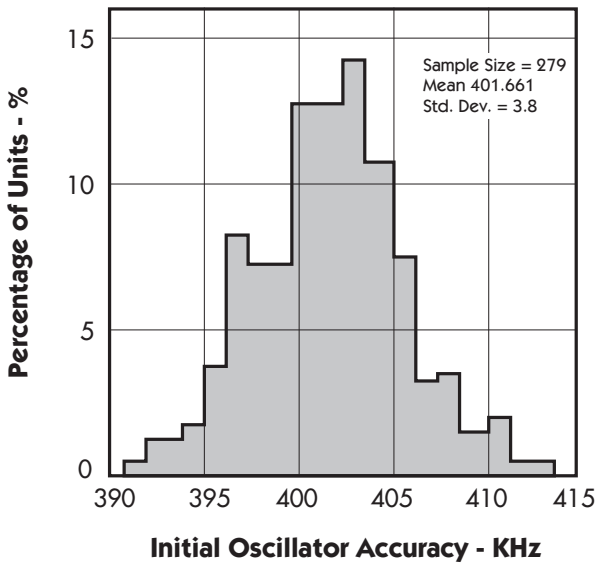
NOT RECOMMENDED FOR NEW DESIGNS

DESCRIPTION

The SG1825C is a high-performance pulse width modulator optimized for high frequency current-mode power supplies. Included in the controller are a precision voltage reference, micropower start-up circuitry, soft-start, high-frequency oscillator, wideband error amplifier, fast current-limit comparator, full double-pulse suppression logic, and dual totem-pole output drivers. Innovative circuit design and an advanced linear Schottky process result in very short propagation delays through the current limit comparator, logic, and output drivers. This device can be used to implement either current-mode or voltage-mode switching power supplies. It also is useful as a series-resonant controller to frequencies beyond 1MHz. The SG1825C is specified for operation over the full military ambient temperature range of -55°C to 125°C. The SG2825C is characterized for the industrial range of -25°C to 85°C, and the SG3825C is selected for the commercial range of 0°C to 70°C.

PRODUCT HIGHLIGHT

INITIAL OSCILLATOR ACCURACY



KEY FEATURES

- **IMPROVED REFERENCE INITIAL TOLERANCE** (±1% max.)
- **IMPROVED OSCILLATOR INITIAL ACCURACY** (±3% typ.)
- **IMPROVED STARTUP CURRENT** (500µA typ.)
- **PROP DELAY TO OUTPUTS** (50ns typ.)
- 10V TO 30V OPERATION
- 5.1V REFERENCE TRIMMED TO ±1%
- 2MHZ OSCILLATOR CAPABILITY
- 1.5A PEAK TOTEM-POLE DRIVERS
- U.V. LOCKOUT WITH HYSTERESIS
- NO OUTPUT DRIVER "FLOAT"
- PROGRAMMABLE SOFTSTART
- DOUBLE-PULSE SUPPRESSION LOGIC
- WIDEBAND LOW-IMPEDANCE ERROR AMPLIFIER
- CURRENT-MODE OR VOLTAGE-MODE CONTROL
- WIDE CHOICE OF HIGH-FREQUENCY PACKAGES

HIGH RELIABILITY FEATURES

- AVAILABLE TO MIL-STD-883B
- LINFINITY LEVEL "S" PROCESSING AVAIL.

PACKAGE ORDER INFORMATION

T_J (°C)	N Plastic DIP 16-pin	DW Plastic Wide SOIC 16-pin	Q Plastic LCC 20-pin	J Ceramic DIP 16-pin	L Ceramic LCC 20-pin
0 to 70	SG3825CN	SG3825CDW	SG3825CQ	SG3825CJ	—
-25 to 85	SG2825CN	SG2825CDW	SG2825CQ	SG2825CJ	—
-55 to 125	—	—	—	SG1825CJ	SG1825CL
MIL-STD-883	—	—	—	SG1825CJ/883B	SG1825CL/883B
DESC	—	—	—	SG1825CJ/DESC	SG1825CL/DESC

Note: All surface-mount packages are available in Tape & Reel. Append the letter "T" to part number. (i.e. SG3825CDWT)

FOR FURTHER INFORMATION CALL (714) 898-8121

Rev. 1.3 6/96

11861 WESTERN AVENUE, GARDEN GROVE, CA. 92841

ABSOLUTE MAXIMUM RATINGS (Note 1)

Input Voltage (V_{IN} and V_C) 30V
Analog Inputs:
  Error Amplifier and Ramp ..... -0.3V to 7.0V
  Softstart and I_{LIM}/S.D. ..... -0.3V to 6.0V
Digital Input (Clock) ..... 1.5V to 6.0V
Driver Outputs ..... -0.3V to V_C+1.5V
Source / Sink Output Current (each output):
  Continuous 0.5A
  Pulse, 500ns 2.0A
Softstart Sink Current 20mA
Clock Output Current 5mA
Error Amplifier Output Current 5mA
Oscillator Charging Current 5mA
Operating Junction Temperature:
  Hermetic (J, L Package) ..... 150°C
  Plastic (DW, N, Q Packages) ..... 150°C
Storage Temperature Range ..... -65°C to 150°C
Lead Temperature (soldering, 10 seconds) ..... 300°C

Note 1. Exceeding these ratings could cause damage to the device.

THERMAL DATA

N PACKAGE:

THERMAL RESISTANCE-JUNCTION TO AMBIENT, θ_{JA}	65°C/W

DW PACKAGE:

THERMAL RESISTANCE-JUNCTION TO AMBIENT, θ_{JA}	95°C/W

Q PACKAGE:

THERMAL RESISTANCE-JUNCTION TO AMBIENT, θ_{JA}	80°C/W

J PACKAGE:

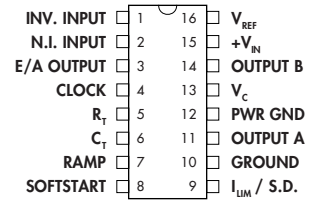
THERMAL RESISTANCE-JUNCTION TO AMBIENT, θ_{JA}	80°C/W

L PACKAGE:

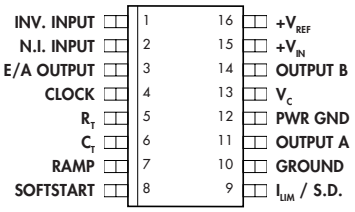
THERMAL RESISTANCE-JUNCTION TO CASE, θ_{JC}	35°C/W
THERMAL RESISTANCE-JUNCTION TO AMBIENT, θ_{JA}	120°C/W

Junction Temperature Calculation: $T_J = T_A + (P_D \times \theta_{JA})$.
The θ_{JA} numbers are guidelines for the thermal performance of the device/pc-board system. All of the above assume no ambient airflow.

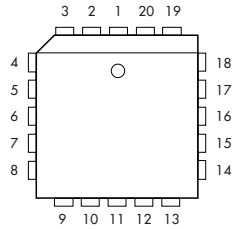
PACKAGE PIN OUTS



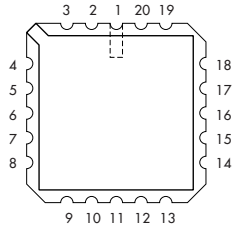
J & N PACKAGE
(Top View)



DW PACKAGE
(Top View)



Q PACKAGE
(Top View)



L PACKAGE
(Top View)

1. N.C.	11. N.C.
2. INV. INPUT	12. I_{LIM} / S.D.
3. N.I. INPUT	13. GROUND
4. E/A OUTPUT	14. OUTPUT A
5. CLOCK	15. PWR GND
6. N.C.	16. N.C.
7. R_T	17. V_C
8. C_T	18. OUTPUT B
9. RAMP	19. $+V_{IN}$
10. SOFTSTART	20. V_{REF}

LINFINITY MICROELECTRONICS

RECOMMENDED OPERATING CONDITIONS (Note 2)

Parameter	Symbol	Recommended Operating Conditions			Units
		Min.	Typ.	Max.	
Supply Voltage Range		10		30	V
Voltage Amp Common Mode Range		1.5		5.5	V
Ramp Input Voltage Range		0		5.0	V
Current Limit / Shutdown Voltage Range		0		4.0	V
Source / Sink Output Current					
Continuous			200		mA
Pulse, 500ns			1.0		A
Voltage Reference Output Current		1		10	mA
Oscillator Frequency Range		4		1500	kHz
Oscillator Charging Current		0.030		3	mA
Oscillator Timing Resistor	R_T	1		100	kΩ
Oscillator Timing Capacitor	C_T	0.470		10	nF
Operating Ambient Temperature Range:					
SG1825C	T_A	0		70	°C
SG2825C	T_A	-25		85	°C
SG3825C	T_A	-55		125	°C

Note 2. Range over which the device is functional.

ELECTRICAL CHARACTERISTICS (Note 3)

(Unless otherwise specified, these specifications apply over the operating ambient temperatures for SG3825C with 0°C ≤ T_A ≤ 70°C, SG2825C with -25°C ≤ T_A ≤ 85°C, SG1825C with -55°C ≤ T_A ≤ 125°C, and V_{IN}=V_C=15V. Low duty cycle pulse testing techniques are used which maintains junction and case temperatures equal to the ambient temperature.)

Parameter	Symbol	Test Conditions	SG1825C/2825C			SG3825C			Units
			Min.	Typ.	Max.	Min.	Typ.	Max.	
Reference Section									
Output Voltage		T_J = 25°C, I_L = 1mA	5.05	5.10	5.15	5.05	5.10	5.15	V
Line Regulation		V_{IN} = 10 to 30V		2	15		2	15	mV
Load Regulation		I_L = 1 to 10mA		5	15		5	15	mV
Temperature Stability (Note 3)		Over Operating Temperature		0.2	0.4		0.2	0.4	mV/°C
Total Output Range (Note 3)		Over Line, Load, and Temperature	5.00		5.20	5.00		5.20	V
Output Noise Voltage (Note 3)		f = 10Hz to 10kHz, I_L = 0mA		50	200		50		μV_{RMS}
Long Term Stability (Notes 3 &4)		T_J = 125°C, t = 1000hrs		5	25		5	25	mV
Short Circuit Current		V_{REF} = 0V	-15	-50	-100	-15	-50	-100	mA
Oscillator Section (Note 5)									
Initial Accuracy		T_J = 25°C, C_{CLK} ≤ 10pF	370	400	430	370	400	430	kHz
Voltage Stability		V_{IN} = 10 to 30V		0.2	2		0.2	2	%
Temperature Stability (Note 3)		Over Rated Operating Temperature		5	8		5	8	%
Total Frequency Limits (Note 3)		Over Line and Temperature	350		450	350		450	kHz
Minimum Frequency		R_T = 100KΩ, C_T = 0.01µF			4			4	kHz
Maximum Frequency		R_T = 1KΩ, C_T = 470pF	1.5			1.5			MHz
Clock High Level		I_{CLK} = -1mA	3.9	4.5		3.9	4.5		V
Clock Low Level		I_{CLK} = -1mA		2.3	2.9		2.3	2.9	V
Ramp Peak Voltage			2.6	2.8	3.0	2.6	2.8	3.0	V
Ramp Valley Voltage			0.7	1.0	1.25	0.7	1.0	1.25	V
Valley-to-Peak Amplitude			1.6	1.8	2.0	1.6	1.8	2.0	V

Note 3. This parameter is guaranteed by design and process control, but is not 100% tested in production.

Note 4. This parameter is non-accumulative, and represents the random fluctuation of the reference voltage within some error band when observed over any 1000 hour period of time.

ELECTRICAL CHARACTERISTICS (Cont'd.)

Parameter	Symbol	Test Conditions	SG1825C/2825C			SG3825C			Units
			Min.	Typ.	Max.	Min.	Typ.	Max.	
Error Amplifier Section (Note 6)									
Input Offset Voltage		$R_S \leq 2K\Omega$, V_{ERROR} = 2.5V			15			15	mV
Input Bias Current		V_{ERROR} = 2.5V		0.6	3		0.6	3	µA
Input Offset Current		V_{ERROR} = 2.5V		0.1	1		0.1	1	µA
DC Open Loop Gain	A_{VOL}	V_{ERROR} = 1 to 4V	60	95		60	95		dB
Common Mode Rejection		Over Rated Voltage Range, V_{ERROR} = 2.5V	75	95		75	95		dB
Power Supply Rejection		V_{IN} = 10V to 30V, V_{ERROR} = 2.5V	85	110		85	110		dB
Output Sink Current		V_{ERROR} = 1V	1	2.5		1	2.5		mA
Output Source Current		V_{ERROR} = 4V	-0.5	-1.3		-0.5	-1.3		mA
Output High Voltage		I_{ERROR} = -0.5mA	4.0	4.7	5.0	4.0	4.7	5.0	V
Output Low Voltage		I_{ERROR} = 1mA	0	0.5	1.0	0	0.5	1.0	V
Unity Gain Bandwidth (Note 3)		A_{VOL} = 0dB	3	5.5		3	5.5		MHz
Slew Rate (Note 3)			6			6			V/µsec
PWM Comparator Section (Note 5 & 7)									
Ramp Input Bias Current				-1	-5		-1	-5	µA
Minimum Duty Cycle		V_{ERROR} = 1V			0			0	%
Maximum Duty Cycle (Note 8)		V_{ERROR} = 4V	85			85			%
Zero Duty Cycle Threshold			1.1	1.25		1.1	1.25		V
Delay to Driver Output (Note 3)		V_{RAMP} = 0V to 2V, V_{ERROR}= 2V		50	80		50	80	ns
Softstart Section									
C_{SS} Charge Current		$V_{SOFTSTART}$ = 0.5V	3	9	20	3	9	20	µA
C_{SS} Discharge Current		$V_{SOFTSTART}$ = 1.0V	1			1			mA
Current Limit / Shutdown Section (Note 9)									
I_{LIM} Input Bias Current					±15			±10	µA
Current Limit Threshold			0.9	1.0	1.1	0.9	1.0	1.1	V
Shutdown Threshold			1.25	1.40	1.55	1.20	1.40	1.55	V
Delay to Driver Output (Note 3)		$V_{SHUTDOWN}$ = 0V to 1.2V		50	80		50	80	ns
Output Drivers Section (each output)									
Output Low Level		I_{SINK} = 20mA		0.25	0.40		0.25	0.40	V
		I_{SINK} = 200mA		1.2	2.0		1.2	2.0	V
Output High Level		I_{SOURCE} = 20mA	13.0	13.5		13.0	13.5		V
		I_{SOURCE} = 200mA	12.0	13.0		12.0	13.0		V
V_C Standby Current		V_C = 30V		150	500		150	500	µA
Output Rise / Fall Time (Note 3)		C_L = 1000pF		30	60		30	60	ns
Undervoltage Lockout Section									
Start Threshold Voltage			8.8	9.2	9.7	8.8	9.2	9.7	V
UV Lockout Hysteresis			0.4	0.8	1.2	0.4	0.8	1.2	V
Supply Current Section (Note 5)									
Start Up Current		V_{IN} = 8V		0.5	1.2		0.5	1.2	mA
Operating Current		V_{INV}, V_{RAMP}, $V(I_{LIM}/S.D.)$ = 0V, $V_{N.I.}$ = 1V		22	33		22	33	mA

Note 5. F_{OSC} = 400kHz (R_T = 3.65kΩ, C_T = 1.0nF).
Note 6. V_{CM} = 1.5V to 5.5V.
Note 7. V_{RAMP} = 0V, unless otherwise specified.
Note 8. 100% duty cycle is defined as a pulsewidth equal to one oscillator period.
Note 9. $V(I_{LIM}/S.D.)$ = 0V to 4.0V, unless otherwise specified.

BLOCK DIAGRAM

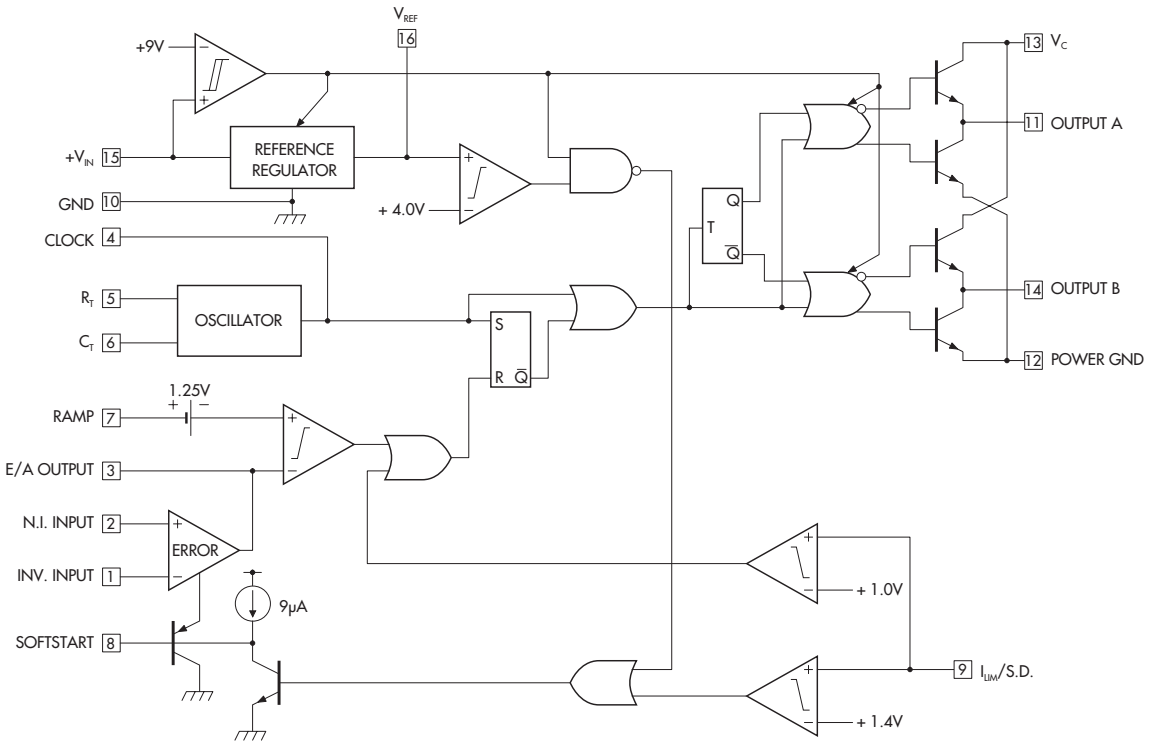


FIGURE INDEX

Application Circuits

FIGURE #

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2. MICROPOWER STARTUP
3. SOFTSTART FAST RESET
4. OSCILLATOR SYCHRONIZATION
5. OSCILLATOR FUNCTIONAL DIAGRAM
6. VOLTAGE AMPLIFIER CONNECTIONS
7. DRIVING SHIELDED CABLE

APPLICATION INFORMATION

HIGH-SPEED LAYOUT AND BYPASSING

The SG1825C, like all high-speed circuits, requires extra attention to external conductor and component layout to minimize undesired inductive and capacitive effects. All lead lengths must be as short as possible. The best printed circuit board choice would be a four-layer design, with the two internal planes supplying power and ground. Signal interconnects should be placed on the outside, giving a conductor-over-ground-plane (microstrip) configuration. A two-sided printed circuit board with one side dedicated as a ground plane is next best, and requires careful component placement by a skilled pc designer.

Two supply bypass capacitors should be employed: a low-inductance 0.1µF ceramic within 0.25 inches of the $+V_{IN}$ pin for high frequencies, and a 1 to 5µF solid tantalum within 0.5 inches of the V_C pin to provide an energy reservoir for the high-peak output currents. A low-inductance .01µF bypass for the reference output is also recommended.

MICROPOWER STARTUP

Since the SG1825C typically draws 700µA of supply current before turning on, a low power bleeder resistor from the rectified AC line supply is all that is required for startup. A start capacitor, C_S, is charged with the excess current from the bleeder resistor. When the turn-on threshold voltage is reached, the PWM circuit becomes active, energizing the power transistors. The additional operating current required by the PWM is then provided by a bootstrap winding on the main high-frequency power transformer.

SOFTSTART CIRCUIT / OUTPUT DUTY CYCLE LIMIT

The softstart pin of the SG1825C is held low when either the chip is in the micropower mode, or when a voltage greater than +1.4 volts is present at the $I_{LIM/S.D.}$ pin. The maximum positive swing of the voltage error amplifier is clamped to the Softstart pin voltage, providing a ramp-up of peak charging currents in the power semiconductors at turn-on.

In some cases, the duration of the Shutdown signal can be too short to fully discharge the softstart capacitor. The illustrated resistor/discrete PNP transistor configuration can be used to shorten the discharge time by a factor of 50 or more. When the internal discharge transistor in the SG1825C turns on, current will flow through surge limit resistor R1. As the resistor drop approaches 0.6 volts, the external PNP turns on, providing a low resistance discharge path for the energy in the softstart capacitor. The capacitor will be rapidly discharged to +0.7 volts, which corresponds to zero duty cycle in the pulse width modulator.

FREQUENCY SYNCHRONIZATION

Two or three SG1825C oscillators may be locked together with the interconnection scheme shown, if the devices are within an inch or so of each other. A master unit is programmed for desired frequency with R_T and C_T as usual. The oscillators in the slave units are disabled by grounding C_T and by connecting R_T to V_{REF}. The logic in the slave units is locked to the clock of the master with the wire-OR connection shown.

Many SG1825Cs can be locked to a master system clock by wiring the oscillators as slave units, and distributing the master clock to each using a tree-fanout geometry.

APPLICATION FIGURES

FIGURE 1. — HIGH-SPEED LAYOUT and BYPASSING

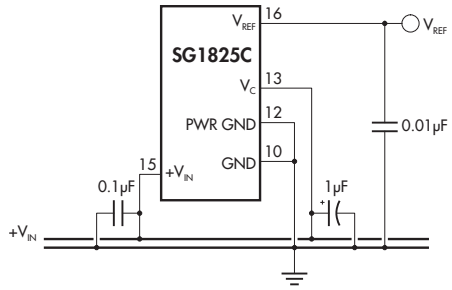


FIGURE 2. — MICROPOWER STARTUP

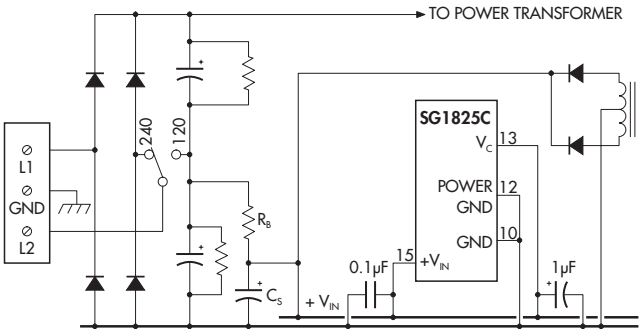


FIGURE 3. — SOFTSTART FAST RESET

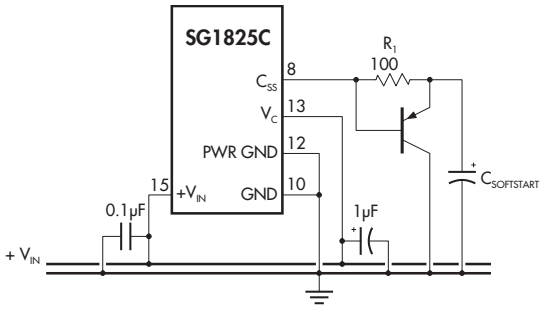
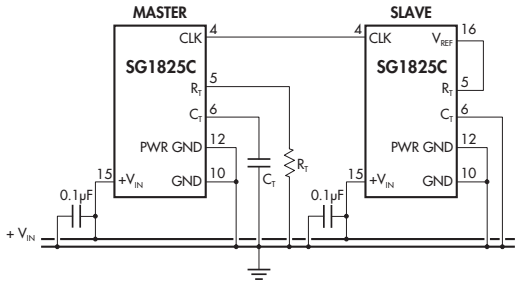


FIGURE 4. — OSCILLATOR SYCHRONIZATION



LINFINITY MICROELECTRONICS

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APPLICATION INFORMATION

OSCILLATOR

The oscillator frequency is programmed by external timing components R_T and C_T. A nominal +3.0 volts appears at the R_T pin. The current flowing through R_T is mirrored internally with a 1:1 ratio. This causes an identical current to flow out the C_T pin, charging the timing capacitor and generating a linear ramp. When the upper threshold of +2.8 volts is reached, a discharge network reduces the ramp voltage to +1.0, where a new charge cycle begins.

The Clock output pin is LOW (+2.3 volts) during the charge cycle, and HIGH (+4.5 volts) during the discharge cycle. The Clock pin is driven by an NPN emitter follower, and so can be wire-ORed. Each Clock pin can drive a 1mA load. Since the internal current-source pulldown is approximately 400µA, the DC fan-out to other SG1825C Clock pins is at least two.

The type of capacitor selected for C_T is very important. At high frequencies, non-ideal characteristics such as effective series resistance (ESR), effective series inductance (ESL), dielectric loss and dielectric absorption all affect frequency accuracy and stability. RF capacitors such as silver mica, glass, polystrene, or COG ceramics are recommended. Avoid high-K ceramics, which work best in DC bypass applications.

ERROR AMPLIFIER

The voltage error amplifier is a true operational amplifier with low-impedance output, and can be gain-stabilized using conventional feedback techniques. The typical DC open-loop gain is 95dB, with a single low-frequency pole at 100Hz.

The input connections to the error amplifier are determined by the polarity of the power supply output voltage. For positive supplies, the common-mode voltage is +5.1 volts and the feedback connections in Figure A are used. With negative outputs, the common-mode voltage is half the reference, and the feedback divider is connected between the negative output and the +5.1 volt reference as shown in Figure B.

OUTPUT DRIVER

The output drivers are designed to provide up to 1.5 Amps peak output current. To minimize ringing on the output waveform, which can be destructive to both the power MOSFET and the PWM chip, the series inductance seen by the drivers should be as low as possible.

One solution is to keep the distance between the PWM and MOSFET gate as short as possible, and to use carbon composition series damping resistors. A Faraday shield to intercept radiated EMI from the power transistors is usually required with its choice.

A second approach is to place the MOSFETs some distance from the PWM chip, and use a series-terminated transmission line to preserve drive pulse fidelity. This will minimize noise radiated back to the sensitive analog circuitry of the SG1825C. A Faraday shield may also be required.

If the drivers are connected to an isolation transformer, or if kickback through C_{GD} of the MOSFET is severe, clamp diodes may be required. 1 Amp peak Schottky diodes will limit undershoot to less than -0.3 volts.

APPLICATION FIGURES

FIGURE 5. — OSCILLATOR FUNCTIONAL DIAGRAM

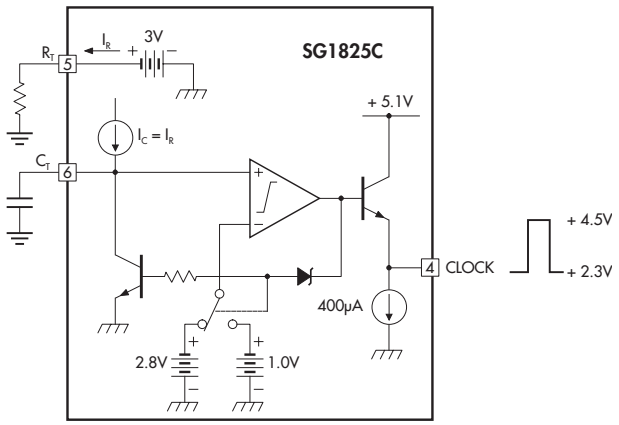

FIGURE 6. — VOLTAGE AMPLIFIER CONNECTIONS

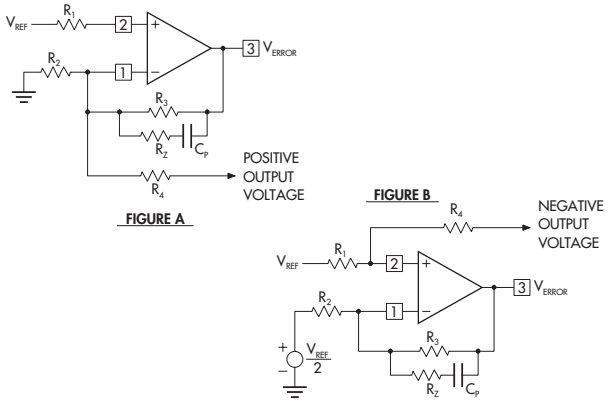

FIGURE 7. — DRIVING SHIELDED CABLE