

SG3525AP013TR-HX/SG2525AP013TR-HX REGULATING PULSE WIDTH MODULATORS

Description

The SG3525AP013TR-HX/SG2525AP013TR-HX series of pulse width modulator integrated circuits are engineered to deliver enhanced performance while reducing the external component count in the design of various types of switching power supplies. The on-chip +5.1 V reference voltage is precisely trimmed to $\pm 1\%$, and the input common-mode range of the error amplifier encompasses the reference voltage, thereby eliminating the need for external resistors. A synchronization input for the oscillator enables multiple units to be slaved together or allows a single unit to synchronize with an external system clock.

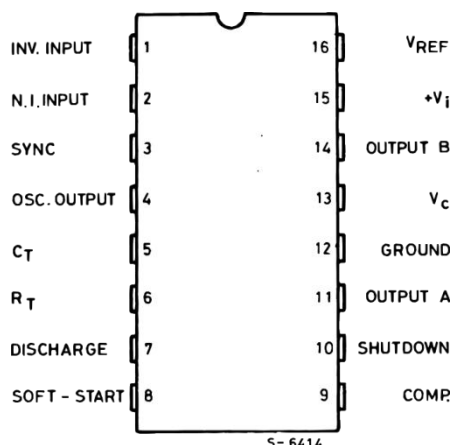
A single resistor connected between the CT and discharge terminals facilitates a broad range of dead time adjustments. Additionally, these devices incorporate built-in soft-start circuitry that requires only an external timing capacitor. A shutdown terminal governs both the soft-start functionality and output stages, enabling instantaneous turn-off through a PWM latch with pulsed shutdown capabilities, as well as facilitating soft-start recycling during extended shutdown commands. These operations are further managed by an undervoltage lockout feature that ensures outputs remain off and discharges the soft-start capacitor under sub-normal input voltage conditions. This lockout mechanism includes approximately 500 mV of hysteresis for jitter-free operation.

Another notable characteristic of these PWM circuits is a latch following the comparator; once a PWM pulse has been terminated for any reason, outputs will remain off throughout that period until reset by each clock pulse. The output stages employ totem-pole designs capable of sourcing or sinking currents exceeding 200 mA. Notably, the SG3525AP013TR-HX output stage utilizes NOR logic, resulting in a LOW output state when turned OFF.

Features

- ★ Operate from 8 to 35v
- ★ Adjust the 5.1v reference to $\pm 1\%$
- ★ Oscillator range from 100 Hz to 500 KHZ
- ★ Independent oscillator synchronization terminal
- ★ Adjustable dead zone control
- ★ Internal soft start
- ★ PULSE-BY-PULSE is off
- ★ Input undervoltage lockout with lag
- ★ Latch PWM to prevent multiple pulses
- ★ Dual-source/receive output driver

Pin connections and ordering numbers (top view)



Absolute maximum ratings

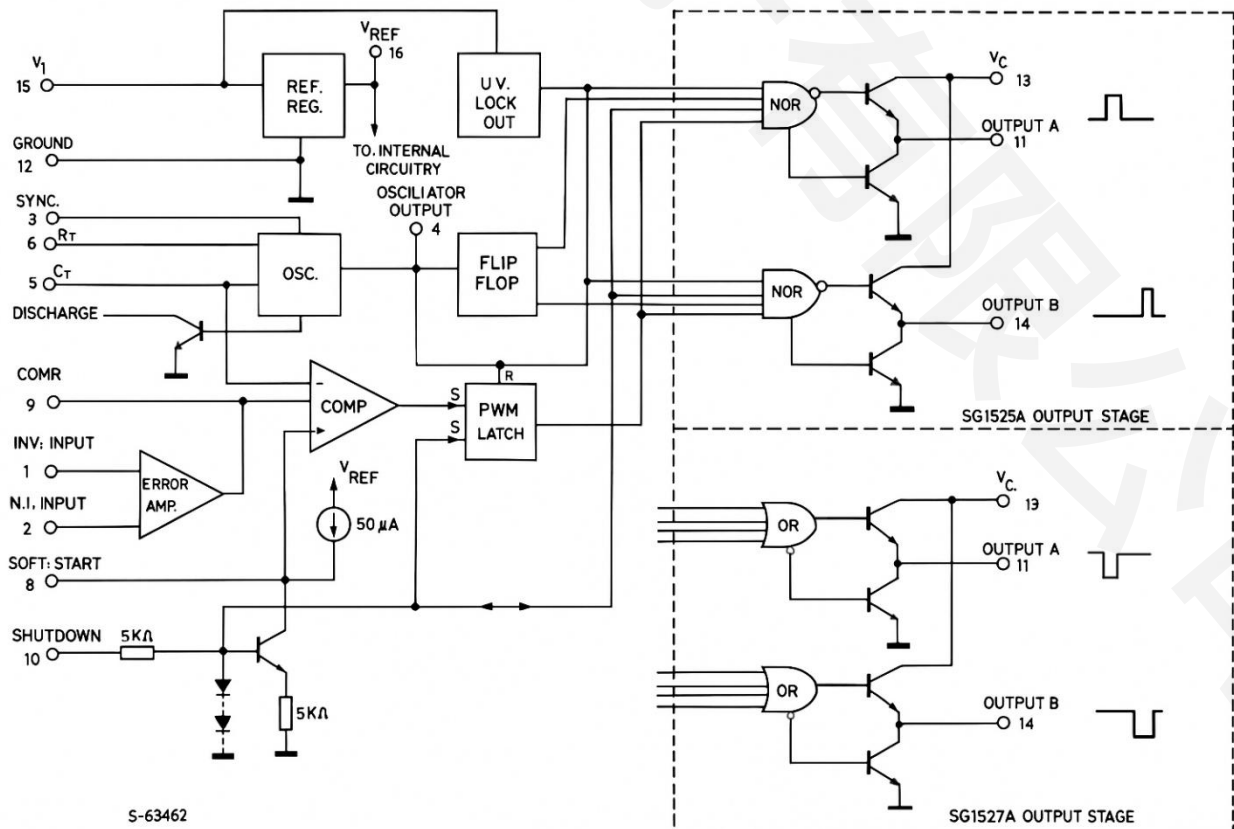
Symbol	Parameter	Value	Unit
V_i	Supply Voltage	40	V
V_c	Collector Supply Voltage	40	V
I_{osc}	Oscillator Charging Current	5	mA
I_o	Output Current, Source or Sink	500	mA
I_R	Reference Output Current	50	mA
I_r	Current through C_T Terminal	5	mA
	Logic Inputs	- 0.3 to + 5.5	V
	Analog Inputs	- 0.3 to V_i	V
P_{tot}	Total Power Dissipation at $T_{amb} = 70\text{ }^{\circ}\text{C}$	1000	mW
T_j	Junction Temperature Range	- 55 to 150	$^{\circ}\text{C}$
T_{stg}	Storage Temperature Range	- 65 to 150	$^{\circ}\text{C}$
T_{op}	Operating Ambient Temperature : SG2525AP013TR-HX SG3525AP013TR-HX	- 25 to 85 0 to 70	$^{\circ}\text{C}$ $^{\circ}\text{C}$

THERMAL DATA

Symbol	Parameter		SO16	DIP16	Unit
$R_{th\ j\text{-pins}}$	Thermal Resistance Junction-pins	Max		50	$^{\circ}\text{C/W}$
$R_{th\ j\text{-amb}}$	Thermal Resistance Junction-ambient	Max		80	$^{\circ}\text{C/W}$
$R_{th\ j\text{-alumina}}$	Thermal Resistance Junction-alumina (*)	Max	50		$^{\circ}\text{C/W}$

* Thermal resistance junction-alumina with the device soldered on the middle of an alumina supporting substrate measuring $15 \times 20\text{ mm}$; 0.65 mm thickness with infinite heatsink.

BLOCK DIAGRAM



Electrical characteristics

(V_i = 20 V, and over operating temperature, unless otherwise specified)

Symbol	Parameter	Test Conditions	SG2525AP013TR-HX			SG3525AP013TR-HX			Unit
			Min	Typ	Max	Min	Typ	Max	
REFERENCE SECTION									
V _{REF}	Output Voltage	T _j = 25 °C	5.05	5.1	5.15	5	5.1	5.2	V
ΔV _{REF}	Line Regulation	V _i = 8 to 35 V		10	20		10	20	mV
ΔV _{REF}	Load Regulation	I _L = 0 to 20 mA		20	50		20	50	mV
ΔV _{REF} /ΔT*	Temp. Stability	Over Operating Range		20	50		20	50	mV
*	Total Output Variation	Line, Load and Temperature	5		5.2	4.95		5.25	V
	Short Circuit Current	V _{REF} = 0 T _j = 25 °C		80	100		80	100	mA
*	Output Noise Voltage	10 Hz ≤ f ≤ 10 kHz, T _j = 25 °C		40	200		40	200	μVrms
ΔV _{REF} *	Long Term Stability	T _j = 125 °C, 1000 hrs		20	50		20	50	mV
OSCILLATOR SECTION **									
*, •	Initial Accuracy	T _j = 25 °C		± 2	± 6		± 2	± 6	%
*, •	Voltage Stability	V _i = 8 to 35 V		± 0.3	± 1		± 1	± 2	%
Δf/ΔT*	Temperature Stability	Over Operating Range		± 3	± 6		± 3	± 6	%
f _{MIN}	Minimum Frequency	R _T = 200 KΩ C _T = 0.1 μF			120			120	Hz
f _{MAX}	Maximum Frequency	R _T = 2 KΩ C _T = 470 pF	400			400			KHz
	Current Mirror	I _{RT} = 2 mA	1.7	2	2.2	1.7	2	2.2	mA
*, •	Clock Amplitude		3	3.5		3	3.5		V
*, •	Clock Width	T _j = 25 °C	0.3	0.5	1	0.3	0.5	1	μs
	Sync Threshold		1.2	2	2.8	1.2	2	2.8	V
	Sync Input Current	Sync Voltage = 3.5 V		1	2.5		1	2.5	mA
ERROR AMPLIFIER SECTION (V _{CM} = 5.1 V)									
V _{OS}	Input Offset Voltage			0.5	5		2	10	mV
I _b	Input Bias Current			1	10		1	10	μA
I _{OS}	Input Offset Current				1			1	μA
	DC Open Loop Gain	R _L ≥ 10 MΩ	60	75		60	75		dB
*	Gain Bandwidth Product	G _v = 0 dB T _j = 25 °C	1	2		1	2		MHz
*, ■	DC Transconduct.	30 KΩ ≤ R _L ≤ 1 MΩ T _j = 25 °C	1.1	1.5		1.1	1.5		ms
	Output Low Level			0.2	0.5		0.2	0.5	V
	Output High Level		3.8	5.6		3.8	5.6		V
CMR	Comm. Mode Reject.	V _{CM} = 1.5 to 5.2 V	60	75		60	75		dB
PSR	Supply Voltage Rejection	V _i = 8 to 35 V	50	60		50	60		dB

ELECTRICAL CHARACTERISTICS (continued)

Symbol	Parameter	Test Conditions	SG2525AP013TR-HX			SG3525AP013TR-HX			Unit
			Min	Typ	Max	Min	Typ	Max	
PWM COMPARATOR									
	Minimum Duty-cycle				0			0	%
•	Maximum Duty-cycle		45	49		45	49		%
•	Input Threshold	Zero Duty-cycle	0.7	0.9		0.7	0.9		V
		Maximum Duty-cycle		3.3	3.6		3.3	3.6	V
*	Input Bias Current			0.05	1		0.05	1	μA
SHUTDOWN SECTION									
	Soft Start Current	VSD = 0 V, VSS = 0 V	25	50	80	25	50	80	μA
	Soft Start Low Level	VSD = 2.5 V		0.4	0.7		0.4	0.7	V
	Shutdown Threshold	To outputs, VSS = 5.1 V Tj = 25 °C	0.6	0.8	1	0.6	0.8	1	V
	Shutdown Input Current	VSD = 2.5 V		0.4	1		0.4	1	mA
*	Shutdown Delay	VSD = 2.5 V Tj = 25 °C		0.2	0.5		0.2	0.5	μs
OUTPUT DRIVERS (each output) (VC = 20 V)									
	Output Low Level	Isink = 20 mA		0.2	0.4		0.2	0.4	V
		Isink = 100 mA		1	2		1	2	V
	Output High Level	Isource = 20 mA	18	19		18	19		V
		Isource = 100 mA	17	18		17	18		V
	Under-Voltage Lockout	Vcomp and Vss = High	6	7	8	6	7	8	V
Ic	Collector Leakage	Vc = 35 V			200			200	μA
tr*	Rise Time	CL = 1 nF, Tj = 25 °C		100	600		100	600	ns
tf*	Fall Time	CL = 1 nF, Tj = 25 °C		50	300		50	300	ns
TOTAL STANDBY CURRENT									
Is	Supply Current	Vi = 35 V		14	20		14	20	mA

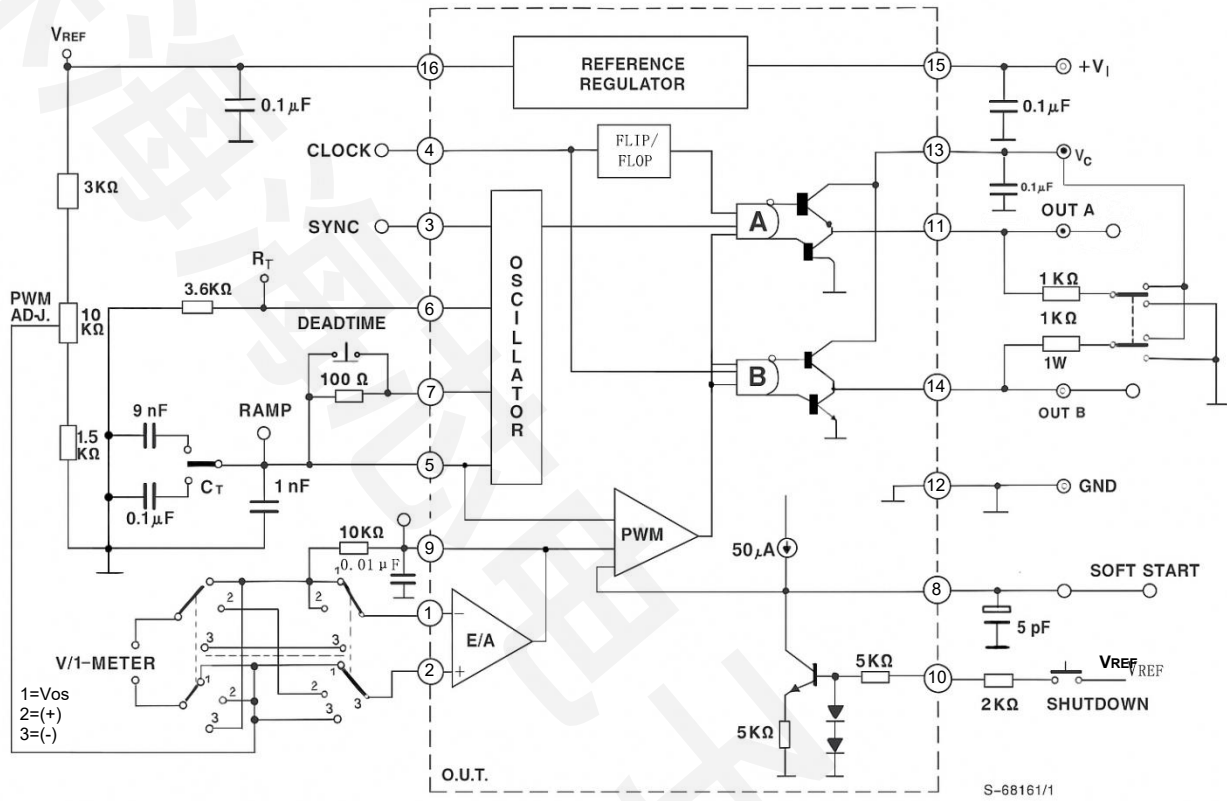
* These parameters, although guaranteed over the recommended operating conditions, are not 100 % tested in production.

• Tested at f_{osc} = 40 KHz (R_T = 3.6 KΩ, C_T = 10nF, R_D = 0 Ω). Approximate oscillator frequency is defined by :

$$f = \frac{1}{C_T(0.7 R_T + 3 R_D)}$$

es to DC open-loop voltage gain (G_V) according to the following equation : G_V = g_M R_L where R_L is the resistance from pin 9 to ground. The minimum g_M specification is used to calculate minimum G_V when the error amplifier output is loaded.

TEST CIRCUIT



RECOMMENDED OPERATING CONDITIONS (°)

Parameter	Value
Input Voltage (V_i)	8 to 35 V
Collector Supply Voltage (V_c)	4.5 to 35 V
Sink/Source Load Current (steady state)	0 to 100 mA
Sink/Source Load Current (peak)	0 to 400 mA
Reference Load Current	0 to 20 mA
Oscillator Frequency Range	100 Hz to 400 KHz
Oscillator Timing Resistor	2 KΩ to 150 KΩ
Oscillator Timing Capacitor	0.001 μF to 0.1 μF
Dead Time Resistor Range	0 to 500 Ω

(°) Range over which the device is functional and parameter limits are guaranteed.

Figure 1 : Oscillator Charge Time vs. R_T and C_T .

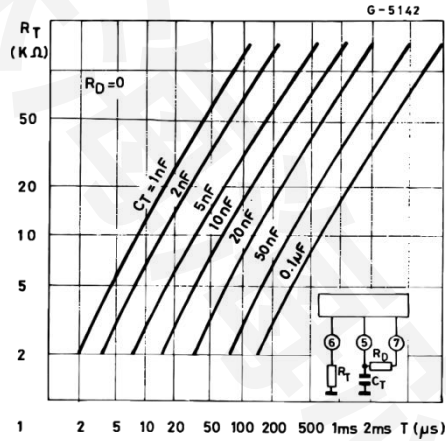


Figure 2 : Oscillator Discharge Time vs. R_D and C_T .

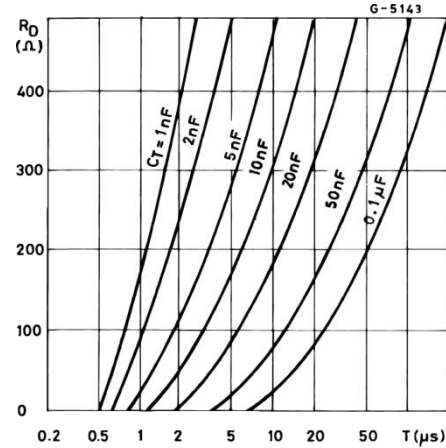


Figure 3 : Output Saturation Characteristics.

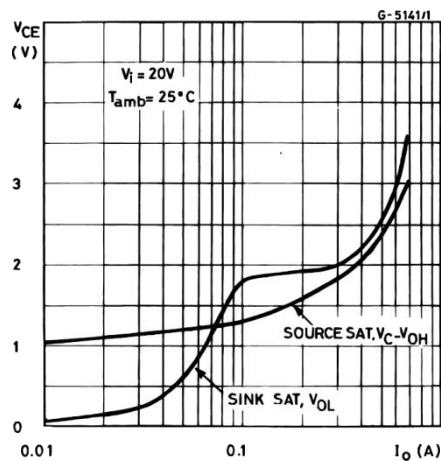


Figure 4 : Error Amplifier Voltage Gain and Phase vs. Frequency.

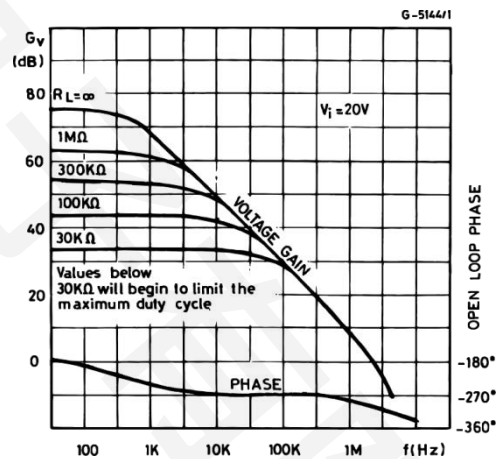
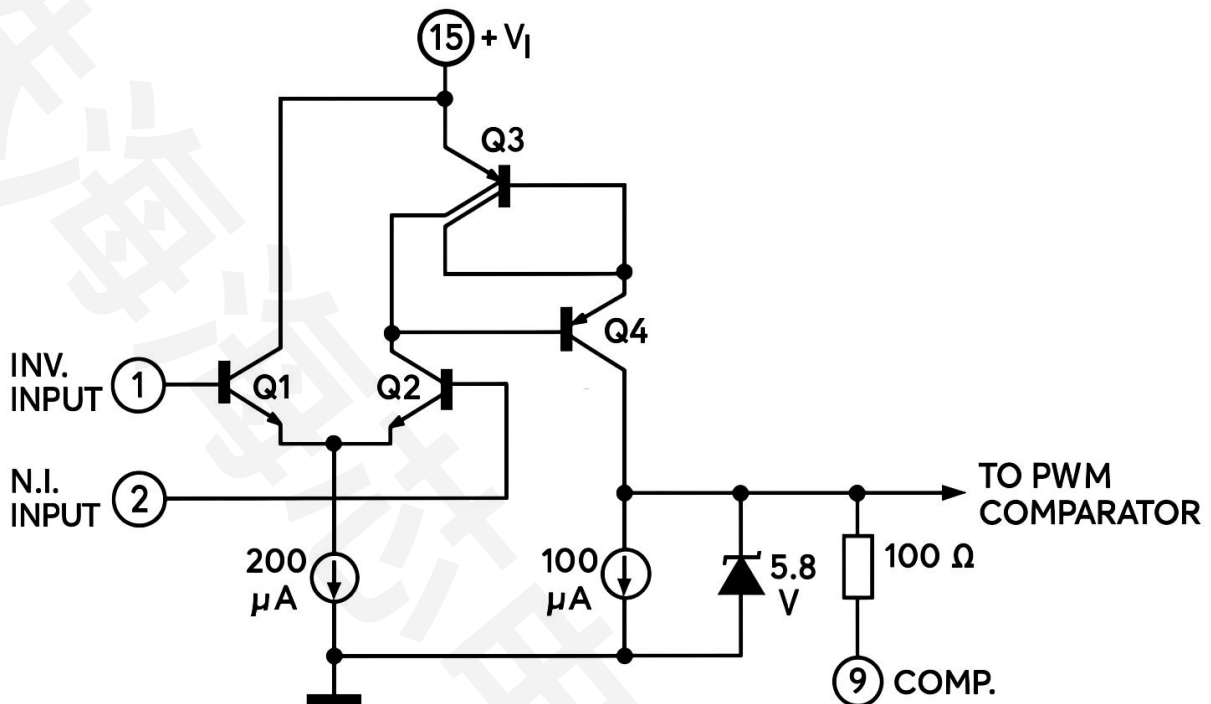


Figure 5 : Error Amplifier.



PRINCIPLES OF OPERATION

SHUTDOWN OPTIONS (see Block Diagram)

Since both the compensation and soft-start terminals (Pins 9 and 8) have current source pull-ups, either can readily accept a pull-down signal which only has to sink a maximum of 100 μA to turn off the outputs. This is subject to the added requirement of discharging whatever external capacitance may be attached to these pins.

An alternate approach is the use of the shutdown circuitry of Pin 10 which has been improved to enhance the available shutdown options. Activating this circuit by applying a positive signal on Pin 10 performs two functions : the PWM latch is immediately set providing the fastest turn-off signal to the outputs ; and a 150 μA current sink begins to discharge the external soft-start capacitor. If the shutdown command is short, the PWM signal is terminated without significant discharge of the soft-start capacitor, thus, allowing, for example, a convenient implementation of pulse-by-pulse current limiting. Holding Pin 10 high for a longer duration, however, will ultimately discharge this external capacitor, recycling slow turn-on upon release.

Pin 10 should not be left floating as noise pickup could conceivably interrupt normal operation.

Figure 6 : Oscillator Schematic.

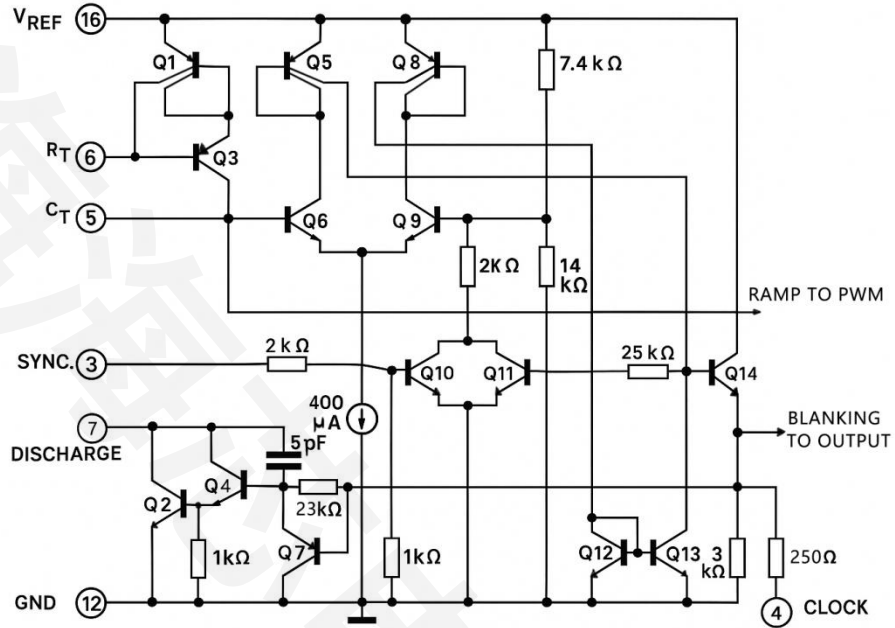


Figure 7 : Output Circuit (1/2 circuit shown).

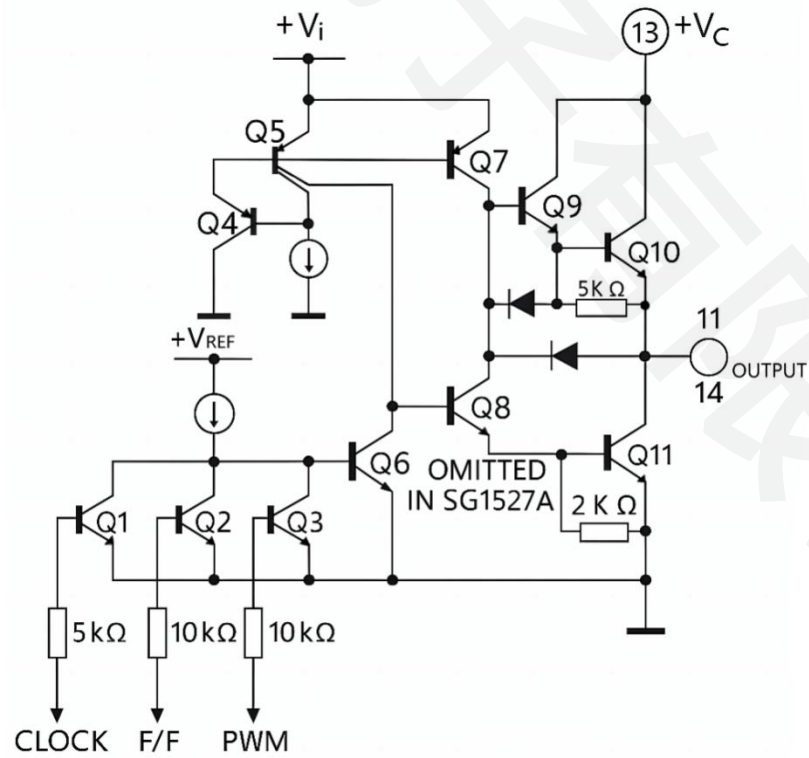
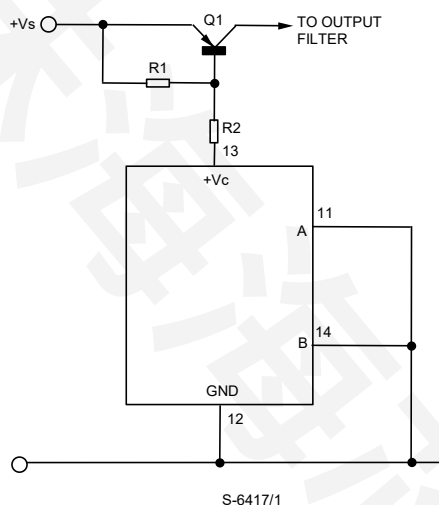
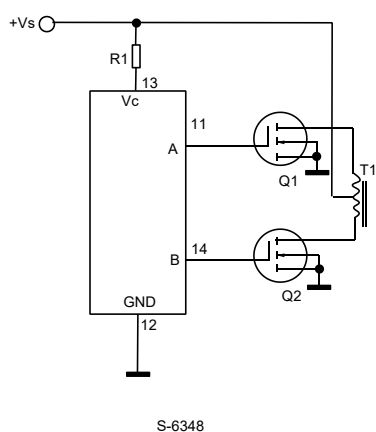


Figure 8.



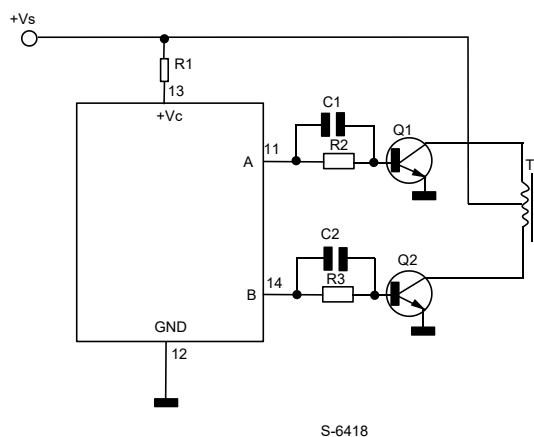
For single-ended supplies, the driver outputs are grounded. The V_c terminal is switched to ground by the totem-pole source transistors on alternate oscillator cycles.

Figure 10.



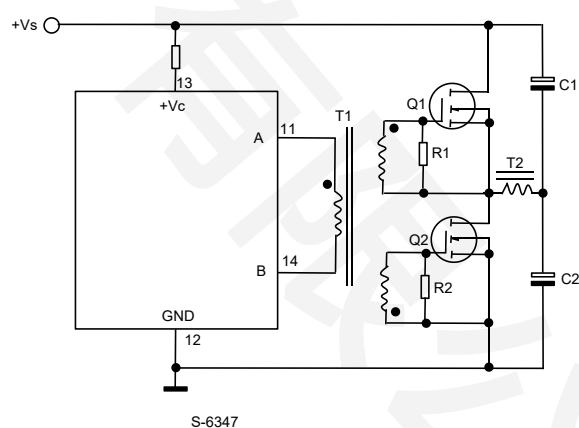
The low source impedance of the output drivers provides rapid charging of Power Mos input capacitance while minimizing external components.

Figure 9.



In conventional push-pull bipolar designs, forward base drive is controlled by $R_1 - R_3$. Rapid turn-off times for the power devices are achieved with speed-up capacitors C_1 and C_2 .

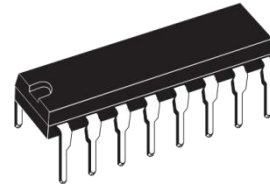
Figure 11.



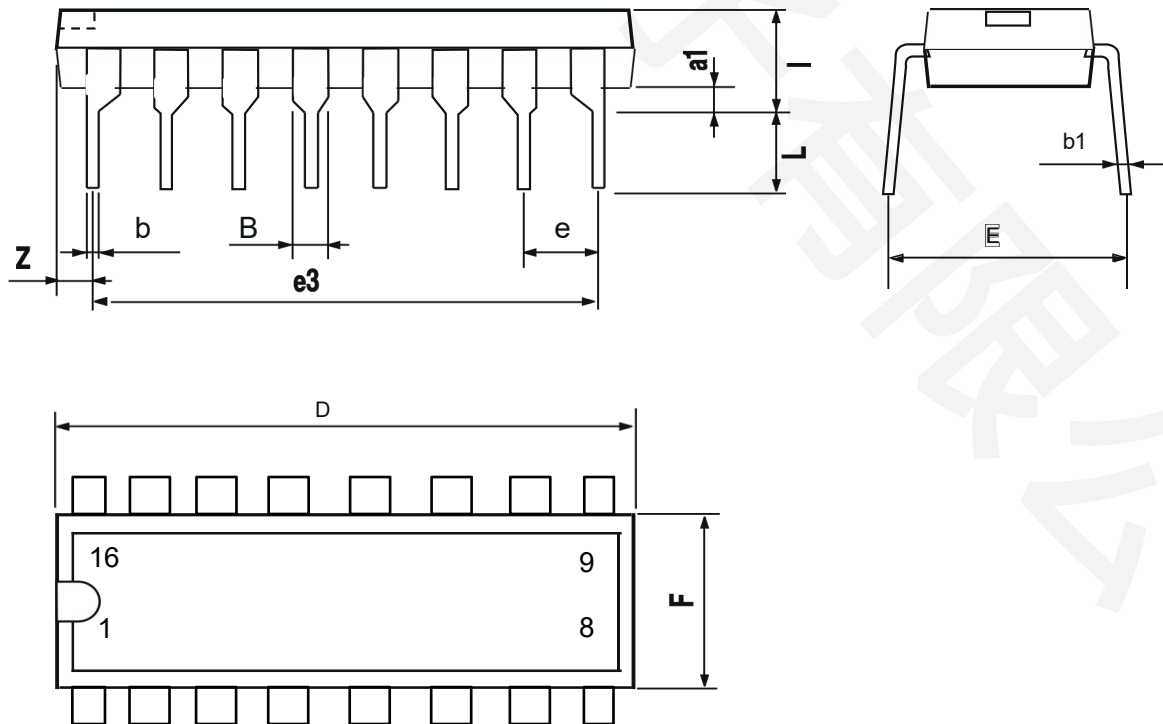
Low power transformers can be driven directly. Automatic reset occurs during dead time, when both ends of the primary winding are switched to ground.

DIM	mm			inch		
	MIN	TYP	MAX	MIN	TYP	MAX
a1	0.51			0.020		
B	0.77		1.65	0.030		0.065
b		0.5		0.020		
b1		0.25		0.010		
D			20			0.787
E		8.5		0.335		
e		2.54		0.100		
e3		17.78		0.700		
F			7.1			0.280
I			5.1			0.201
L		3.3		0.130		
Z			1.27			0.050

OUTLINE AND MECHANICAL DATA

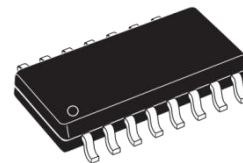


DIP-16



DIM	mm			inch		
	MIN	TYP	MAX	MIN	TYP	MAX
A			1.75			0.069
a1	0.1		0.25	0.004		0.009
a2			1.6			0.063
b	0.35		0.46	0.014		0.018
b1	0.19		0.25	0.007		0.010
C		0.5			0.020	
c1	45° (typ.)					
D (1)	9.8		10	0.386		0.394
E	5.8		6.2	0.228		0.244
e		1.27			0.050	
e3		8.89			0.350	
F (1)	3.8		4	0.150		0.157
G	4.6		5.3	0.181		0.209
L	0.4		1.27	0.016		0.050
M			0.62			0.024
S	8°(max.)					

OUTLINE AND MECHANICAL DATA



SO16 Narrow

(1) D and F do not include mold flash or protrusions. Mold flash or protrusions shall not exceed 0.15mm (.006inch).

