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# SG1525A/2525A/3525A
# SG1527A/2527A/3527A
## Regulating Pulse Width Modulators

PRELIMINARY
Specifications Subject To Change Without Notice

### FEATURES

- 8V to 35V operation
- 5.1V reference trimmed to ±1%
- 100Hz to 500kHz oscillator range
- Separate oscillator sync terminal
- Adjustable Deadtime control
- Internal Softstart
- Input undervoltage lockout
- Latching PWM to prevent multiple pulses
- Dual sink/source output drivers

### GENERAL DESCRIPTION

The SG1525A/1527A series of pulse width modulator integrated circuits is designed to offer improved performance and lowered external parts count when used to implement all types of switching power supplies. The on-chip +5.1V reference is trimmed to ±1% initial accuracy, and the input common-mode range of the error amplifier includes the reference voltage, thereby eliminating external potentiometers and divider resistors. A SYNC input to the oscillator allows multiple units to be slaved together or a single unit to be synchronized to an external system clock. A single resistor between the $C_T$ pin and the DISCHARGE pin provides a wide range of Deadtime adjustments. These devices also feature built-in Softstart circuitry, with only a timing capacitor required externally. A SHUTDOWN pin controls both the Softstart circuitry and the output stages, providing instantaneous turn-off with Softstart recycle for slow turn-on. These functions are also controlled by an undervoltage lockout which keeps the outputs "off" and the Softstart capacitor discharged for input voltages less than that required for normal operation. Another unique feature of these PWM circuits is a latch following the comparator. Once a PWM pulse has been terminated for any reason, the outputs will remain "off" for the duration of the period. The latch is reset with each clock pulse. The output stages are totem-pole designs capable of sourcing or sinking currents in excess of 200mA. The SG1525A output stage features NOR logic, giving a LOW output for an "off" state. The SG1527A utilizes OR logic, which results in a HIGH output level when "off".

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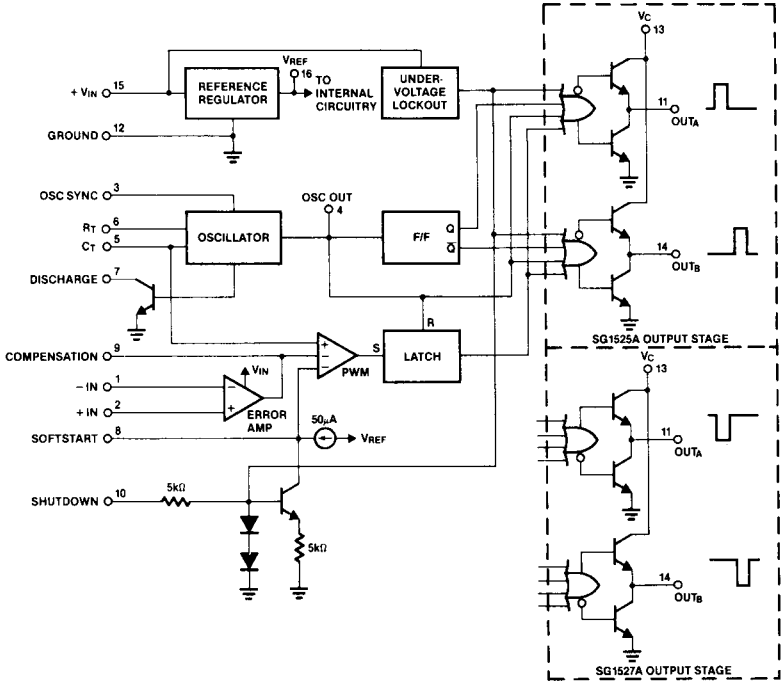
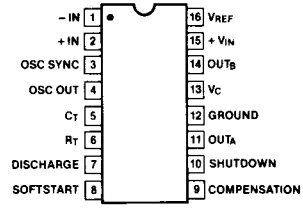
### BLOCK DIAGRAM Note: All component values shown are nominal.




### PIN CONFIGURATION




(outline dwg JE)

## ABSOLUTE MAXIMUM RATINGS

($T_A$ = 25°C unless otherwise specified)

Supply Voltage ($+V_{IN}$) ..... +40V
Collector Supply Voltage ($V_C$) ..... +40V
Logic Inputs ..... −0.3V to +5.5V
Analog Inputs ..... −0.3V to $+V_{IN}$
Output Current, Source or Sink ..... 500mA
Reference Output Current ..... 50mA
Oscillator Charging Current ..... 5mA
Power Dissipation (Note 1) ..... 1000mW
Thermal Resistance: junction to ambient ..... 100°C/W
Power Dissipation ($T_C$ = 25°C) (Note 2) ..... 2000mW
Thermal Resistance: junction to case ..... 60°C/W
Operating Junction Temperature ..... +150°C
Storage Temperature Range ..... −65°C to +150°C
Lead Temperature (soldering, 10 seconds) ..... +300°C

**Note 1:** Derate at 10mW/°C for ambient temperatures above +50°C.

**Note 2:** Derate at 16mW/°C for case temperatures above +25°C.

## RECOMMENDED OPERATING CONDITIONS

(Note 3)

Input Voltage ($+V_{IN}$) ..... +8V to +35V
Collector Supply Voltage ($V_C$) ..... +4.5V to +35V
Sink/Source Load Current (steady state) ..... 0mA to 100mA
Sink/Source Load Current (peak) ..... 0mA to 400mA
Reference Load Current ..... 0mA to 20mA
Oscillator Frequency Range ..... 100Hz to 400kHz
Oscillator Timing Resistor ..... 2kΩ to 150kΩ
Oscillator Timing Capacitor ..... 0.001μF to 0.1μF
Deadtime Resistor Range ..... 0Ω to 500Ω
Operating Ambient Temperature Range
SG1525A, SG1527A ..... −55°C to +125°C
SG2525A, SG2527A ..... −25°C to +85°C
SG3525A, SG3527A ..... 0°C to +70°C

**Note 3:** Range over which the device is functional and parameter limits are guaranteed.

*Stresses above those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. These are stress ratings only and functional operation of the device at these or any other conditions above those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.*

## OPERATING CHARACTERISTICS

$+V_{IN}$ = +20V; $T_A$ = operating temperature range, unless otherwise specified

| PARAMETER | SYMBOL | TEST CONDITIONS | SG1525A/2525A SG1527A/2527A | | | SG3525A SG3527A | | | UNITS |
|---|---|---|---|---|---|---|---|---|---|
| | | | MIN | TYP | MAX | MIN | TYP | MAX | |
| **ERROR AMPLIFIER SECTION** ($V_{CM}$ = 5.1V) | | | | | | | | | |
| Input Offset Voltage | $V_{OS}$ | | | 0.5 | 5 | | 2 | 10 | mV |
| Input Bias Current | $I_{BIAS}$ | | | 1 | 10 | | 1 | 10 | μA |
| Input Offset Current | $I_{OS}$ | | | | 1 | | | 1 | |
| DC Open Loop Gain | $A_{VOL}$ | $R_L \geq 10M\Omega$ | 60 | 75 | | 60 | 75 | | dB |
| Gain Bandwidth Product (Note 4) | GBW | $A_V$ = 0dB, $T_J$ = 25°C | 1 | 2 | | 1 | 2 | | MHz |
| Output Low Level | $V_{OL}$ | | | 0.2 | 0.5 | | 0.2 | 0.5 | V |
| Output High Level | $V_{OH}$ | | 3.8 | 5.6 | | | 3.8 | 5.6 | |
| Common-Mode Rejection Ratio | CMRR | $V_{CM}$ = 1.5V–5.2V | 60 | 75 | | | 60 | 75 | dB |
| Power Supply Rejection Ratio | PSRR | $V_{IN}$ = 8V–35V | 50 | 60 | | | 50 | 60 | |
| **OSCILLATOR SECTION** (Note 5) | | | | | | | | | |
| Initial Accuracy (Notes 4 and 5) | | $T_J$ = 25°C | | ±2 | ±6 | | ±2 | ±6 | % |
| Voltage Stability (Notes 4 and 5) | | $V_{IN}$ = 8V–35V | | ±0.3 | ±1 | | ±1 | ±2 | |
| Temperature Stability (Note 4) | | $T_A$ = Operating Temperature Range | | ±3 | ±6 | | ±3 | ±6 | |
| Frequency Min | $f_{min}$ | $R_T$ = 150kΩ, $C_T$ = 0.1μF | | | 100 | | | 100 | Hz |
| Frequency Max | $f_{max}$ | $R_T$ = 2kΩ, $C_T$ = 1000pF | 400 | | | 400 | | | kHz |
| Current Mirror | | $I_{RT}$ = 2mA | 1.7 | 2.0 | 2.2 | 1.7 | 2.0 | 2.2 | mA |
| Clock Amplitude (Notes 4 and 5) | $V_{CLK}$ | | 3.0 | 3.5 | | 3.0 | 3.5 | | V |
| Clock Pulse Width (Notes 4 and 5) | $t_{CLK}$ | $T_J$ = 25°C | 0.3 | 0.5 | 1.0 | 0.3 | 0.5 | 1.0 | μs |
| Sync Threshold | $V_{SYNC}$ | | 1.2 | 2.0 | 2.8 | 1.2 | 2.0 | 2.8 | V |
| Sync Input Current | $I_{SYNC}$ | $V_{SYNC}$ = 3.5V | | 1.0 | 2.5 | | 1.0 | 2.5 | mA |

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**OPERATING CHARACTERISTICS** (Continued) + $V_{IN}$ = +20V; $T_A$ = operating temperature range, unless otherwise specified

| PARAMETER | SYMBOL | TEST CONDITIONS | SG1525A/2525A SG1527A/2527A | | | SG3525A SG3527A | | | UNITS |
|---|---|---|---|---|---|---|---|---|---|
| | | | MIN | TYP | MAX | MIN | TYP | MAX | |
| **REFERENCE SECTION** | | | | | | | | | |
| Output Voltage | $V_O$ | $T_J$ = 25°C | 5.05 | 5.10 | 5.15 | 5.00 | 5.10 | 5.20 | V |
| Line Regulation | $\Delta V_O \mid \Delta V_{IN}$ | $V_{IN}$ = 8V-35V | | 10 | 20 | | 10 | 20 | mV |
| Load Regulation | $\Delta V_O \mid \Delta I_L$ | $I_L$ = 0mA-20mA | | 20 | 50 | | 20 | 50 | mV |
| Temperature Stability (Note 4) | $\Delta V_O \mid \Delta T_A$ | $T_A$ = Operating Temperature Range | | 20 | 50 | | 20 | 50 | mV |
| Total Output Variation (Note 4) | $V_O \mid \Delta$ | Line, Load, and Temperature | 5.00 | | 5.20 | 4.95 | | 5.25 | V |
| Short Circuit Current | $I_{SC}$ | $V_{REF}$ = 0V, $T_J$ = 25°C | | 80 | 100 | | 80 | 100 | mA |
| Output Noise Voltage (Note 4) | $\bar{e}_n$ | f = 10Hz-10kHz, $T_J$ = 25°C | | 40 | 200 | | 40 | 200 | μVrms |
| Long Term Stability (Note 4) | | $T_J$ = 125°C | | 20 | 50 | | 20 | 50 | mV / 1000hr |
| **PWM COMPARATOR** | | | | | | | | | |
| Duty Cycle Min | | | | | 0 | | | 0 | % |
| Duty Cycle Max | | | 45 | 49 | | 45 | 49 | | % |
| Input Threshold (Note 5) | $V_{IN}$ | Zero Duty Cycle | 0.6 | 0.9 | | 0.6 | 0.9 | | V |
| | | Max Duty Cycle | | 3.3 | 3.6 | | 3.3 | 3.6 | V |
| Input Bias Current (Note 4) | $I_{BIAS}$ | | | 0.05 | 1.0 | | 0.05 | 1.0 | μA |
| **SOFTSTART SECTION** | | | | | | | | | |
| Softstart Current | $I_{SFT}$ | $V_{SHDN}$ = 0V | 25 | 50 | 80 | 25 | 50 | 80 | μA |
| Softstart Voltage | $V_{SFT}$ | $V_{SHDN}$ = 2V | | 0.4 | 0.6 | | 0.4 | 0.6 | V |
| Shutdown Input Current | $I_{SHDN}$ | $V_{SHDN}$ = 2.5V | | 0.4 | 1.0 | | 0.4 | 1.0 | mA |
| **OUTPUT DRIVERS** (Each Output; $V_C$ = 20V) | | | | | | | | | |
| Output Low Level | $V_{OL}$ | $I_{SINK}$ = 20mA | | 0.2 | 0.4 | | 0.2 | 0.4 | V |
| | | $I_{SINK}$ = 100mA | | 1.0 | 2.0 | | 1.0 | 2.0 | V |
| Output High Level | $V_{OH}$ | $I_{SOURCE}$ = 20mA | 18 | 19 | | 18 | 19 | | V |
| | | $I_{SOURCE}$ = 100mA | 17 | 18 | | 17 | 18 | | V |
| Undervoltage Lockout | | $V_{COMP}$ and $V_{SFT}$ = HIGH | 6 | 7 | 8 | 6 | 7 | 8 | V |
| Collector Leakage (Note 6) | | $V_C$ = 35V | | | 200 | | | 200 | μA |
| Rise Time (Note 4) | $t_r$ | $C_L$ = 1000pF, $T_J$ = 25°C | | 100 | 600 | | 100 | 600 | ns |
| Fall Time (Note 4) | $t_f$ | | | 50 | 300 | | 50 | 300 | ns |
| Shutdown Delay (Note 4) | | $V_{SHDN}$ = 3V, $C_S$ = 0, $T_J$ = 25°C | | 0.2 | 0.5 | | 0.2 | 0.5 | μs |
| **TOTAL STANDBY CURRENT** | | | | | | | | | |
| Supply Current | $I^+$ | $V_{IN}$ = 35V | | 14 | 20 | | 14 | 20 | mA |

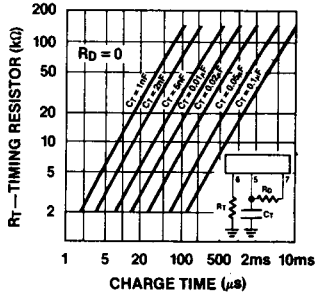
**Note 4:** These parameters, although guaranteed over the recommended operating conditions, are not 100% tested in production.

**Note 5:** Tested at $f_{osc}$ = 40kHz ($R_T$ = 3.6kΩ, $C_T$ = 0.01μF, $R_D$ = 0Ω).

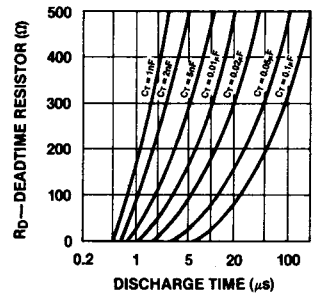
**Note 6:** Applies to SG1525A/2525A/3525A only, due to polarity of output pulses.

## TYPICAL OPERATING CHARACTERISTICS

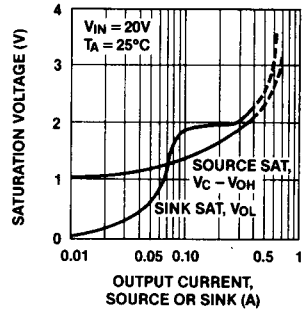
Oscillator Charge Time vs $R_T$ and $C_T$



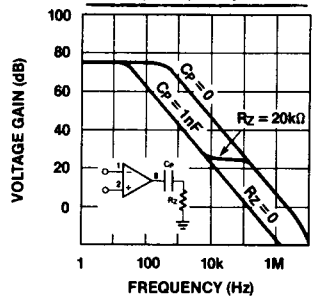

Oscillator Discharge Time vs $R_D$ and $C_T$




SG1525A Output Saturation Characteristics




Error Amplifier Open-Loop Frequency Response

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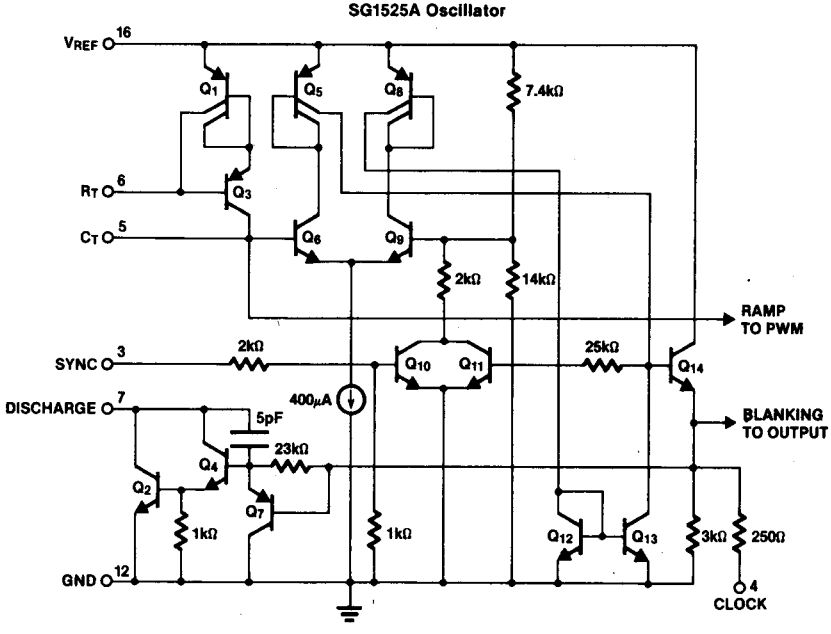
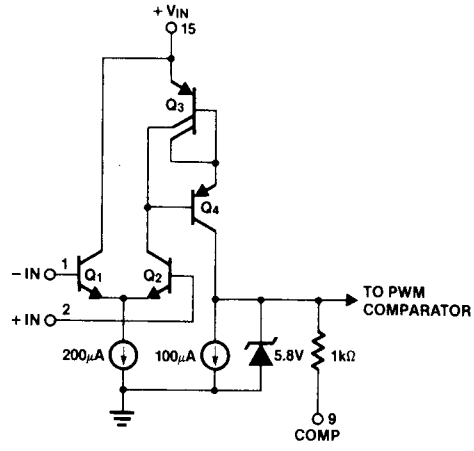
## DETAILED EQUIVALENT SCHEMATICS Note: All component values shown are nominal.

SG1525A Oscillator

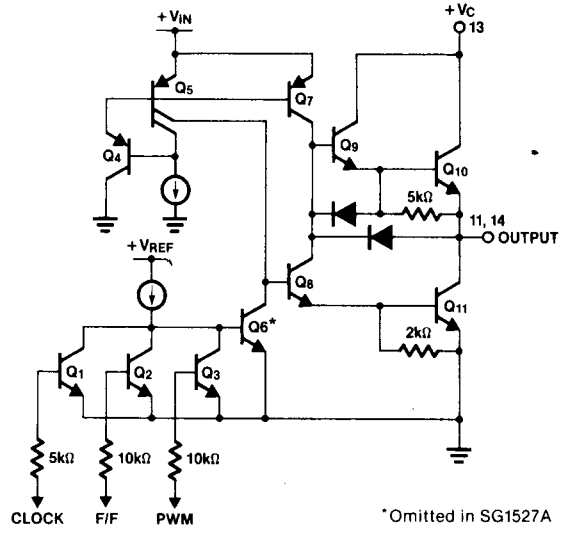


## DETAILED EQUIVALENT SCHEMATICS (Continued) Note: All component values shown are nominal.

SG1525A Error Amplifier




SG1525A Output Circuit (½ Circuit Shown)




*Omitted in SG1527A

## SHUTDOWN OPTIONS (see Block Diagram)

1. Use an external transistor or open-collector comparator to pull down the COMP terminal (pin 9). This will set the PWM latch, turning off both outputs. If the Shutdown signal is momentary, pulse-by-pulse protection can be accomplished, as the PWM latch will be reset with each clock pulse.

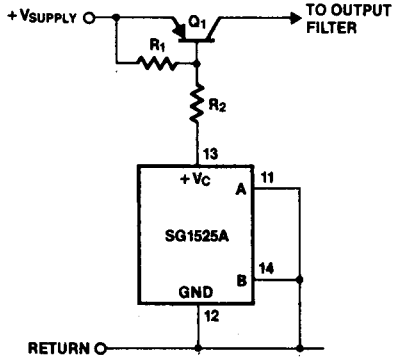
2. The same results can be accomplished by pulling down the SOFTSTART terminal (pin 8), with the difference that Shutdown will not affect the amplifier compensation network but must discharge any Softstart capacitor.

3. Apply a positive-going signal to the SHUTDOWN terminal (pin 10). This will provide most rapid Shutdown of the outputs but will not immediately set the PWM latch if there is a Softstart capacitor. This capacitor will discharge, but with a current of approximately twice the charging current.

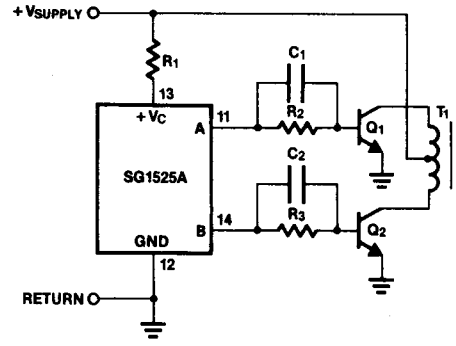
4. The SHUTDOWN terminal (pin 10) can be used to set the PWM latch on a pulse-by-pulse basis if there is no external capacitance on pin 8. Slow turn-on may still be accomplished by applying an external capacitor, blocking diode, and charging resistor to the COMP terminal (pin 9).

5. If the SHUTDOWN pin is not used, ensure that it is tied to GROUND. If it is used with a high impedance drive source, minimize the stray capacitance between it and the (adjacent) OUTput pin, since excessive coupling here can cause problems.

## TYPICAL APPLICATIONS




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.




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 $C_2$.

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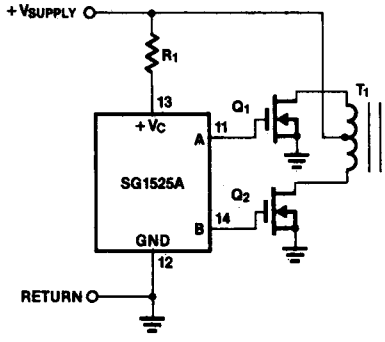
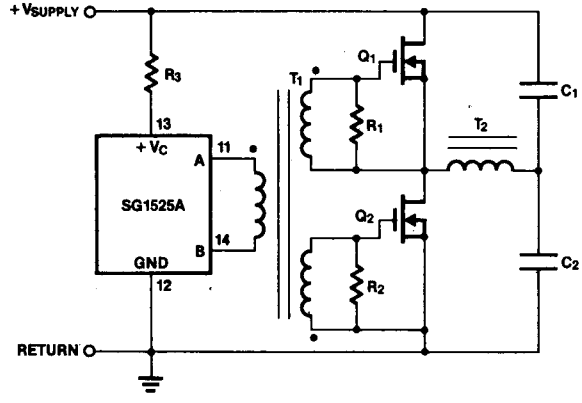


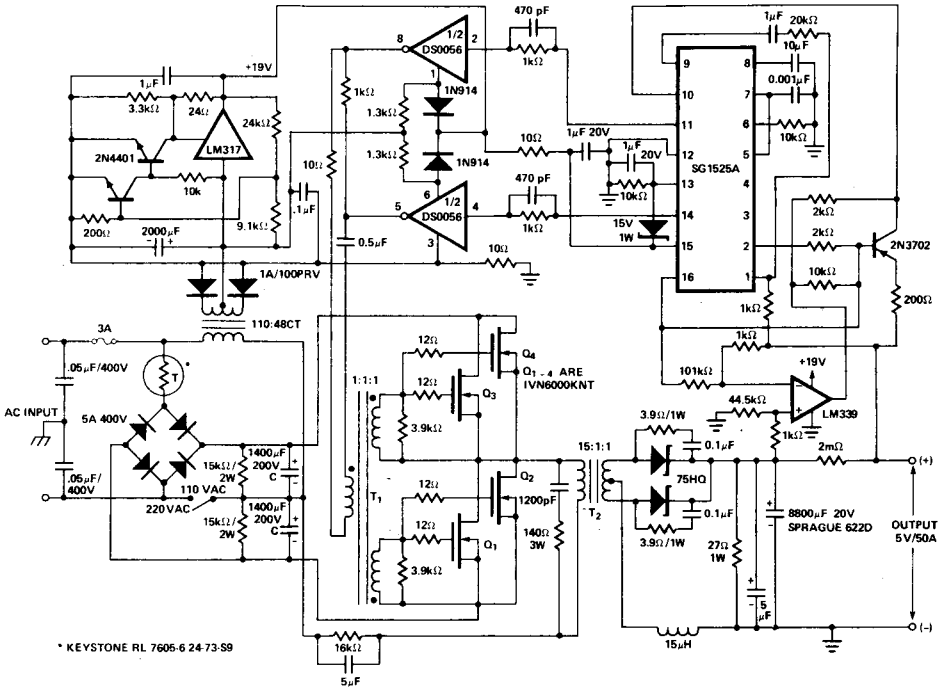

The low source impedance of the output drivers provides rapid charging of power FET input capacitance while minimizing external components.



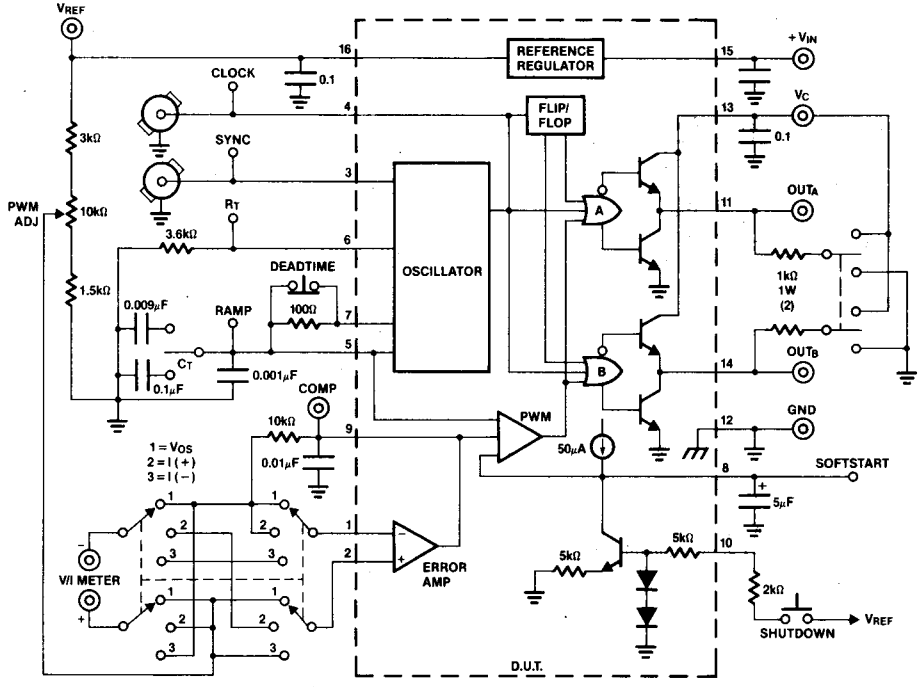

Low power transformers can be driven directly by the SG1525A. Automatic flux reset occurs during Deadtime, when both ends of the primary winding are switched to ground.

## TYPICAL APPLICATIONS (Continued)

**Power MOSFET Switch Mode Power Supply** (see A037 for details)




## SG1525A/1527A TEST CIRCUIT



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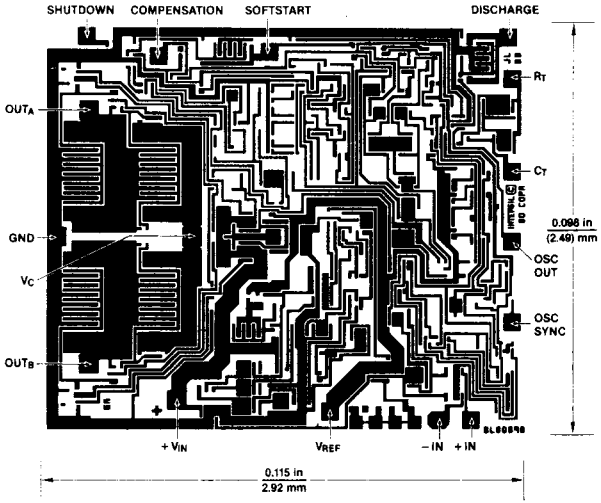
## CHIP TOPOGRAPHY




## ORDERING INFORMATION

| PART TYPE | OUTPUT LEVEL WHEN DEVICE IS OFF | TEMPERATURE RANGE | 16 PIN CERDIP | DICE |
|---|---|---|---|---|
| SG1525A | LOW | −55°C to +125°C | SG1525AJ | — |
| SG1527A | HIGH | −55°C to +125°C | SG1527AJ | — |
| SG2525A | LOW | −25°C to +85°C | SG2525AJ | — |
| SG2527A | HIGH | −25°C to +85°C | SG2527AJ | — |
| SG3525A | LOW | 0°C to +70°C | SG3525AJ | SG3525A/D |
| SG3527A | HIGH | 0°C to +70°C | SG3527AJ | SG3527A/D |

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