

# Regulating Pulse Width Modulators

SG1525/SG2525/SG3525  
SG1527/SG2527/SG3527

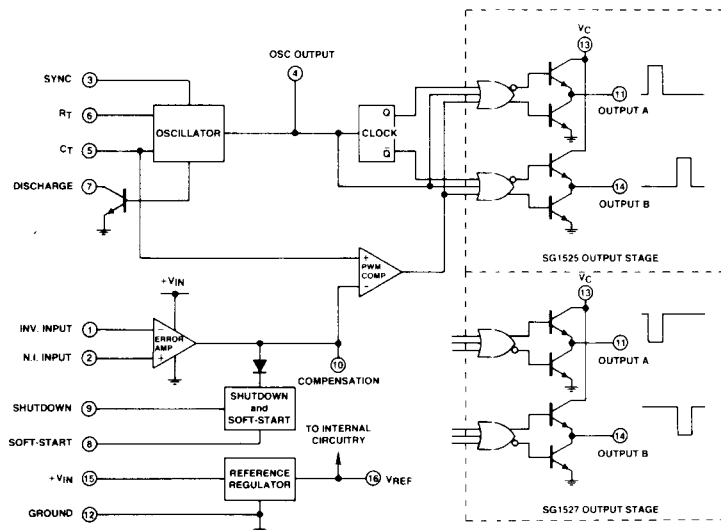
## DESCRIPTION

The SG1525/1527 series of pulse width modulator integrated circuits are designed to offer improved performance and lowered external parts count when used to implement switching power supplies. The on-chip +5.1 volt reference is trimmed to  $\pm 1\%$  initial accuracy and the common mode range of the error amplifier includes the reference voltage, 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 adjustment. These devices also feature internal clamp diodes and current sources for soft-start. A timing capacitor is the only external component required. A Shutdown pin controls the soft-start circuitry, allowing external monitoring devices to initiate soft-start cycles. The output stages are totem-pole designs capable of sourcing or sinking 100 mA. The SG1525 output stage features NOR logic, giving a normally LOW output level. The SG1527 utilizes OR logic, which results in a normally HIGH output level.

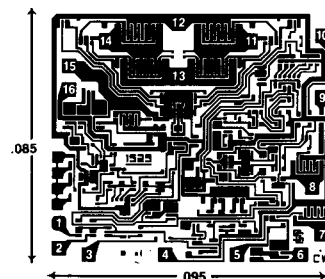
## FEATURES

- 8 to 35 volt operation
- 5.1 volt reference trimmed to  $\pm 1\%$
- 100 Hz to 400 kHz oscillator range
- Oscillator Sync terminal
- Adjustable deadtime
- Internal soft-start
- Error amp input common mode includes reference
- Dual 100 mA source/sink output drivers
- Power FET drive capability

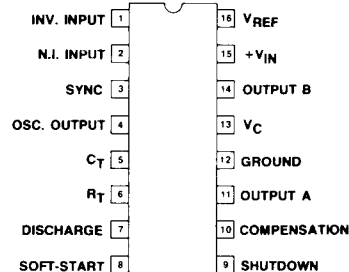
## BLOCK DIAGRAM



## CHIP LAYOUT



## CONNECTION DIAGRAM TOP VIEW



J-PACKAGE  
16 PIN CERDIP

# Regulating Pulse Width Modulators

## SG1525/SG2525/SG3525 SG1527/SG2527/SG3527

### ABSOLUTE MAXIMUM RATINGS (Note 1)

|  |                           |  |                 |
|--|---------------------------|--|-----------------|
| Supply Voltage (+V <sub>IN</sub> )         | -40V                      | Power Dissipation at T <sub>A</sub> = +25°C (Note 2) | 1000 mW         |
| Collector Supply Voltage (V <sub>C</sub> ) | -40V                      | Thermal Resistance: junction to ambient              | 100°C/W         |
| Logic Inputs                               | -0.3 V to +5.5V           | Power Dissipation at T <sub>C</sub> = +25°C (Note 3) | 2000 mW         |
| Analog Inputs                              | -0.1V to -V <sub>IN</sub> | Thermal Resistance: junction to case                 | 60°C/W          |
| Output Current, Source or Sink             | 200 mA                    | Operating Junction Temperature                       | +150°C          |
| Reference Output Current                   | 50 mA                     | Storage Temperature Range                            | -65°C to +150°C |
| Oscillator Charging Current                | 5 mA                      | Lead Temperature (Soldering, 10 seconds)             | +300°C          |

Note 1. Values beyond which damage may occur.

Note 2. Derate at 10 mW/°C for ambient temperatures above +50°C.

Note 3. Derate at 16 mW/°C for case temperatures above +25°C.

### RECOMMENDED OPERATING CONDITIONS (Note 4)

|  |                   |                                     |                    |
|--|-------------------|-------------------------------------|--------------------|
| Input Voltage (+V <sub>IN</sub> )          | +1.5V to +35V     | Oscillator Timing Capacitor         | 0.001 μF to 0.1 μF |
| Collector Supply Voltage (V <sub>C</sub> ) | +4.5V to +35V     | Deadtime Resistor Range             | 0 to 500 Ω         |
| Sink/Source Load Current (each output)     | 0 to 100 mA       | Operating Ambient Temperature Range |                    |
| Reference Load Current                     | 0 to 20 mA        | SG1525, SG1527                      | -55°C to +125°C    |
| Oscillator Frequency Range                 | 100 Hz to 400 kHz | SG2525, SG2527                      | -25°C to +85°C     |
| Oscillator Timing Resistor                 | 2kΩ to 150kΩ      | SG3525, SG3527                      | 0°C to +70°C       |

Note 4. Range over which the device is functional and parameter limits are guaranteed.

### ELECTRICAL CHARACTERISTICS (+V<sub>IN</sub> = 20V, and over operating temperature, unless otherwise specified)

| PARAMETER                                 | CONDITIONS                                       | SG1525/2525/1527/2527 |       |      | SG3525/3527 |      |      | UNITS  |  |
|---|--|-----------------------|-------|------|-------------|------|------|--------|--|
|   |  | MIN                   | TYP   | MAX  | MIN         | TYP  | MAX  |        |  |
| REFERENCE SECTION (I <sub>L</sub> = 1 mA) |  |                       |       |      |             |      |      |        |  |
| Output Voltage                            | T <sub>j</sub> = 25°C                            | 5.05                  | 5.10  | 5.15 | 5.00        | 5.10 | 5.20 | V      |  |
| Line Regulation                           | V <sub>IN</sub> = 8 to 35V                       |                       | 10    | 20   |             | 10   | 20   | mV     |  |
| Load Regulation                           | I <sub>L</sub> = 0 to 20 mA                      |                       | 20    | 50   |             | 20   | 50   | mV     |  |
| Temperature Stability <sup>5</sup>        | Over Operating Range                             |                       | 20    | 50   |             | 20   | 50   | mV     |  |
| Total Output Variation                    | Line, Load, and Temp                             | 5.00                  |       | 5.20 | 4.95        |      | 5.25 | V      |  |
| Short Circuit Current                     | V <sub>REF</sub> = 0, T <sub>j</sub> = 25°C      |                       | 80    | 100  |             | 80   | 100  | mA     |  |
| Output Noise Voltage <sup>5</sup>         | 10 Hz ≤ f ≤ 10 kHz, T <sub>j</sub> = 25°C        |                       | 40    | 200  |             | 40   | 200  | μVrms  |  |
| Long Term Stability <sup>5</sup>          | T <sub>j</sub> = 125°C                           |                       | 20    | 50   |             | 20   | 50   | mV/khr |  |
| OSCILLATOR SECTION (Note 6)               |  |                       |       |      |             |      |      |        |  |
| Initial Accuracy <sup>5</sup>             | T <sub>j</sub> = 25°C                            |                       | ± 2   | ± 6  |             | ± 2  | ± 6  | %      |  |
| Voltage Stability <sup>5</sup>            | V <sub>IN</sub> = 8 to 35V                       |                       | ± 0.3 | ± 1  |             | ± 1  | ± 2  | %      |  |
| Temperature Stability <sup>5</sup>        | Over Operating Range                             |                       | ± 3   | ± 6  |             | ± 3  | ± 5  | %      |  |
| Minimum Frequency                         | R <sub>T</sub> = 150 kΩ, C <sub>T</sub> = 0.1 μF |                       |       | 100  |             |      | 100  | Hz     |  |
| Maximum Frequency                         | R <sub>T</sub> = 2 kΩ, C <sub>T</sub> = 1 nF     | 400                   |       |      | 400         |      |      | kHz    |  |
| Current Mirror                            | I <sub>RT</sub> = 2 mA                           | 1.8                   | 2.0   | 2.2  | 1.8         | 2.0  | 2.2  | mA     |  |
| Clock Amplitude                           |  | 3.0                   | 3.5   |      | 3.0         | 3.5  |      | V      |  |
| Clock Width <sup>5</sup>                  | T <sub>j</sub> = 25°C                            | 0.3                   | 0.5   | 2.0  | 0.3         | 0.5  | 2.0  | μ sec  |  |
| Sync Threshold                            |  |                       | 1.0   | 2.0  |             | 1.0  | 2.0  | V      |  |
| Sync Input Current                        | Sync Voltage = 3.5V                              |                       | 0.2   | 0.4  |             | 0.2  | 0.4  | mA     |  |

# Regulating Pulse Width Modulators

SG1525/SG2525/SG3525

SG1527/SG2527/SG3527

| PARAMETER  | CONDITIONS  | SG1525/2525/1527/2527 |     |     | SG3525/3527 |     |     | UNITS |
|--|---|-----------------------|-----|-----|-------------|-----|-----|-------|
|  |   | MIN                   | TYP | MAX | MIN         | TYP | MAX |       |
| ERROR AMPLIFIER SECTION (V <sub>CM</sub> = 5.2 Volts)    |   |                       |     |     |             |     |     |       |
| Input Offset Voltage                                     |   |                       | 0.5 | 5   |             | 2   | 10  | mV    |
| Input Bias Current                                       |   |                       | 1   | 10  |             | 1   | 10  | μA    |
| Input Offset Current                                     |   |                       |     | 1   |             |     | 1   | μA    |
| DC Open Loop Gain  | R <sub>L</sub> ≥ 10 Meg Ω                                       | 60                    | 75  |     | 60          | 75  |     | dB    |
| Gain-Bandwidth Product <sup>5</sup>                      | A <sub>V</sub> = 0 dB, T <sub>j</sub> = 25°C                    | 1                     | 2   |     | 1           | 2   |     | MHz   |
| Output Low Level   |   |                       | 0.2 | 0.5 |             | 0.2 | 0.5 | V     |
| Output High Level  |   | 3.8                   | 5.6 |     | 3.8         | 5.6 |     | V     |
| Common Mode Rejection                                    | V <sub>CM</sub> = 1.5 to 5.2V                                   | 60                    | 75  |     | 60          | 75  |     | dB    |
| Supply Voltage Rejection                                 | V <sub>IN</sub> = 8 to 35V                                      | 50                    | 60  |     | 50          | 60  |     | dB    |
| P.W.M. COMPARATOR  |   |                       |     |     |             |     |     |       |
| Minimum Duty Cycle                                       |   |                       |     | 0   |             |     | 0   | %     |
| Maximum Duty Cycle                                       |   | 45                    | 49  |     | 45          | 49  |     | %     |
| Input Threshold <sup>6</sup>                             | Zero Duty Cycle   | 0.6                   | 0.9 |     | 0.6         | 0.9 |     | V     |
| Input Threshold <sup>6</sup>                             | Max Duty Cycle  |                       | 3.3 | 3.5 |             | 3.3 | 3.5 | V     |
| Input Bias Current <sup>5</sup>                          |   |                       | .05 | 1.0 |             | .05 | 1.0 | μA    |
| SOFT—START SECTION                                       |   |                       |     |     |             |     |     |       |
| Soft Start Current                                       | V <sub>SHUTDOWN</sub> = 0V                                      | 50                    | 100 | 175 | 50          | 100 | 175 | μA    |
| Soft Start Voltage                                       | V <sub>SHUTDOWN</sub> = 2V                                      |                       | 0.2 | 0.4 |             | 0.2 | 0.4 | V     |
| Error Clamp Voltage                                      | V <sub>SHUTDOWN</sub> = 2V                                      |                       | 0.2 | 0.4 |             | 0.2 | 0.4 | V     |
| Input Current  | V <sub>SHUTDOWN</sub> = 2V                                      |                       | 1.6 | 3   |             | 1.6 | 3   | mA    |
| OUTPUT DRIVERS (Each Output) (V <sub>C</sub> = 20 Volts) |   |                       |     |     |             |     |     |       |
| Output Low Level   | I <sub>SINK</sub> = 20 mA                                       |                       | 0.2 | 0.4 |             | 0.2 | 0.4 | V     |
|  | I <sub>SINK</sub> = 100 mA                                      |                       | 1.0 | 2.0 |             | 1.0 | 2.0 | V     |
| Output High Level  | I <sub>SOURCE</sub> = 20 mA                                     | 18                    | 19  |     | 18          | 19  |     | V     |
|  | I <sub>SOURCE</sub> = 100 mA                                    | 17                    | 18  |     | 17          | 18  |     | V     |
| Collector Leakage <sup>7</sup>                           | V <sub>C</sub> = 35V  |                       |     | 100 |             |     | 100 | μA    |
| Rise Time <sup>5</sup>                                   | C <sub>L</sub> = 1 nF, T <sub>j</sub> = 25°C                    |                       | 100 | 600 |             | 100 | 600 | nsec  |
| Fall Time <sup>5</sup>                                   | C <sub>L</sub> = 1 nF, T <sub>j</sub> = 25°C                    |                       | 50  | 300 |             | 50  | 300 | nsec  |
| Shutdown Delay <sup>5</sup>                              | V <sub>SH</sub> = 2V, C <sub>S</sub> = 0, T <sub>j</sub> = 25°C |                       | 0.5 | 1.5 |             | 0.5 | 1.5 | μsec  |
| TOTAL STANDBY CURRENT                                    |   |                       |     |     |             |     |     |       |
| Supply Current   | V <sub>IN</sub> = 35V, V <sub>SHUTDOWN</sub> = 2V               |                       | 14  | 20  |             | 14  | 20  | mA    |

Note 5. These parameters, although guaranteed over the recommended operating conditions, are not 100% tested in production.

Note 6. Tested at  $f_{OSC} = 40$  kHz ( $R_T = 3.6$  k $\Omega$ ,  $C_T = .01$   $\mu$ F,  $R_D = 0$   $\Omega$ ).

Note 7. Applies to SG1525/2525/3525 only, due to polarity of output pulses.

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SG1525/SG2525/SG3525/SG1527/SG2527/SG3527

## CHARACTERISTIC CURVES

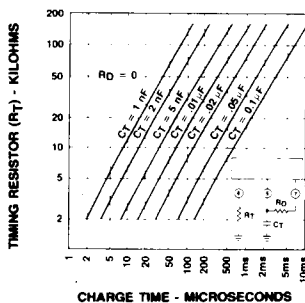


Figure 1. SG1525/1527 Oscillator Charge Time as a Function of  $R_T$  and  $C_T$ .

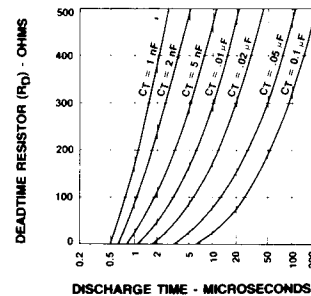


Figure 2. SG1525/1527 Oscillator Discharge Time as a Function of  $R_D$  and  $C_T$ .

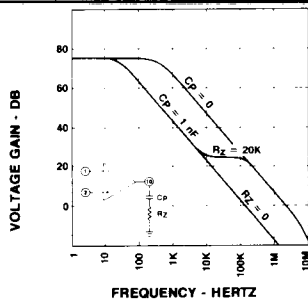


Figure 3. The error amplifier open-loop frequency response may be easily modified by shunt reactance to ground.

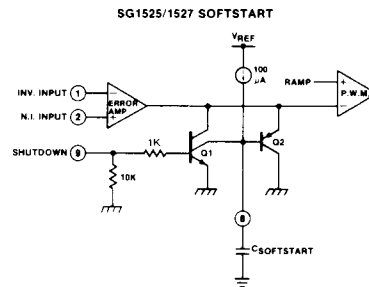


Figure 4. A soft-start cycle begins when the SHUTDOWN pin is low. Turn-on delay to 100% duty cycle is determined by the time required to charge  $C_S$  to +2.7 volts with 100  $\mu A$ .

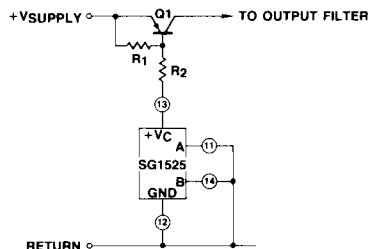


Figure 5. For single-ended supplies, the driver outputs are grounded. The  $V_C$  terminal is switched to ground by the totem-pole source transistors on alternate oscillator cycles.

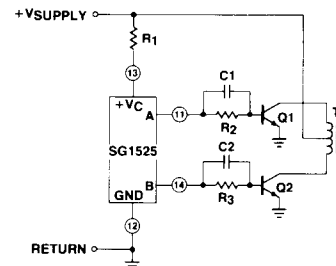


Figure 6. In conventional push-pull bipolar designs, forward base drive is controlled by  $R_1$ - $R_3$ . Rapid turn-off times for the power devices are achieved with speed-up capacitors  $C_1$  and  $C_2$ .

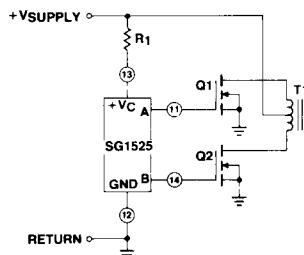


Figure 7. The low source impedance of the output drivers provides rapid charging of power FET input capacitance while minimizing external components.

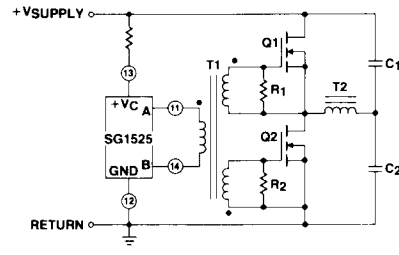


Figure 8. Low power transformers can be driven directly by the SG1525. Automatic flux reset to zero occurs during deadtime, when both ends of the primary winding are switched to ground.