

# Switched-mode power supply control circuit

# NE/SE5561

## DESCRIPTION

The NE5561/SE5561 is a control circuit for use in switched-mode power supplies. It contains an internal temperature-compensated supply, PWM, sawtooth oscillator, overcurrent sense latch, and output stage. The device is intended for low cost SMPS applications where extensive housekeeping functions are not required.

## FEATURES

- Micro-miniature (D) package
- Pulse-width modulator
- Current limiting (cycle-by-cycle)
- Sawtooth generator
- Stabilized power supply
- Double pulse protection
- Internal temperature-compensated reference

## PIN CONFIGURATION

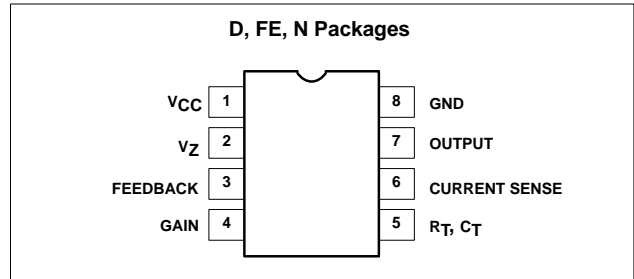


Figure 1. Pin Configuration

## APPLICATIONS

- Switched-mode power supplies
- DC motor controller inverter
- DC/DC converter

## ORDERING INFORMATION

| DESCRIPTION                                 | TEMPERATURE RANGE | ORDER CODE | DWG #   |
|---|-------------------|------------|---------|
| 8-Pin Plastic Dual In-Line Package (DIP)    | 0 to +70°C        | NE5561N    | SOT97-1 |
| 8-Pin Plastic Dual In-Line Package (DIP)    | -55 to +125°C     | SE5561N    | SOT97-1 |
| 8-Pin Ceramic Dual In-Line Package (CERDIP) | -55 to +125°C     | SE5561FE   | 0580A   |
| 8-Pin Small Outline (SO) Package            | 0 to +70°C        | NE5561D    | SOT96-1 |

## BLOCK DIAGRAM

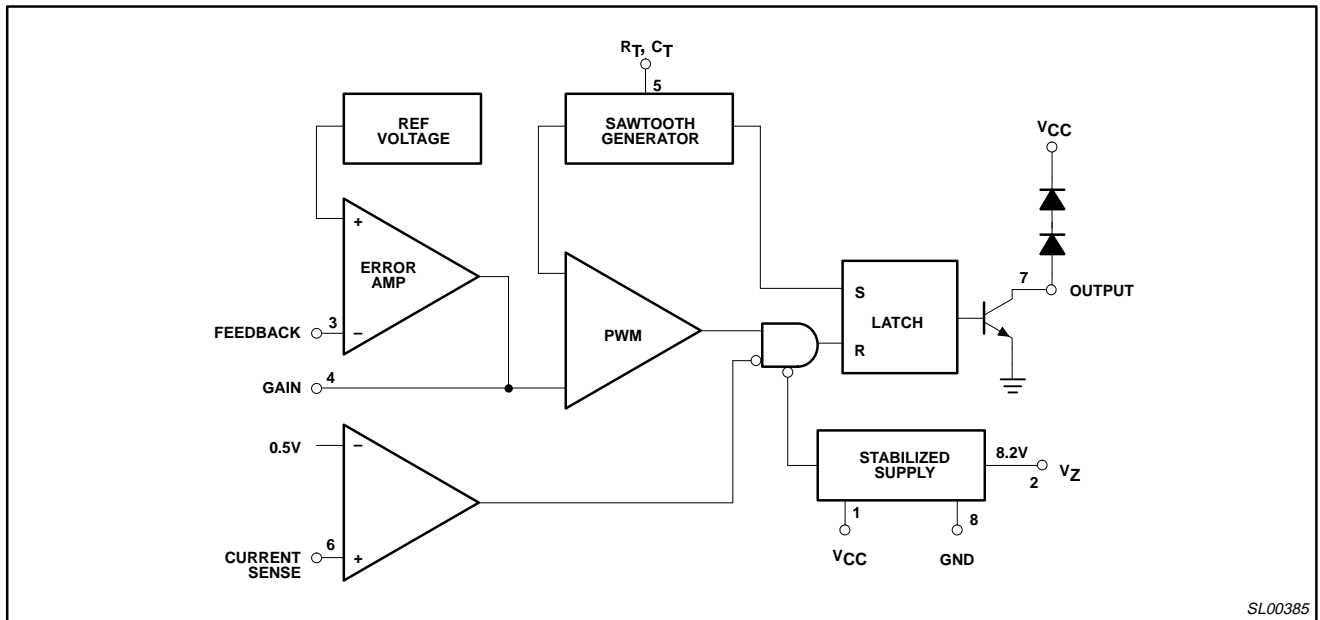


Figure 2. Block Diagram

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## ABSOLUTE MAXIMUM RATINGS

| SYMBOL           | PARAMETER                         | RATING                | UNIT |
|------------------|-----------------------------------|-----------------------|------|
| V <sub>CC</sub>  | Supply <sup>1</sup>               |                       |      |
|                  | Voltage-forced mode               | +18                   | V    |
|                  | Current-fed mode                  | 30                    | mA   |
| I <sub>OUT</sub> | Output transistor (at 20-30V max) |                       |      |
|                  | Output current                    | 40                    | mA   |
| V <sub>OUT</sub> | Output voltage                    | V <sub>CC</sub> +1.4V | V    |
|                  | Output duty cycle                 | 98                    | %    |
| P <sub>D</sub>   | Maximum total power dissipation   | 0.75                  | W    |
| T <sub>A</sub>   | Operating temperature range       |                       |      |
|                  | SE5561                            | -55 to +125           | °C   |
|                  | NE5561                            | 0 to 70               | °C   |

## NOTES:

- See Voltage-Current-fed supply characteristic curve.

## DC ELECTRICAL CHARACTERISTICS

V<sub>CC</sub>=12V, T<sub>A</sub>=25°C, unless otherwise specified.

| SYMBOL                    | PARAMETER                             | TEST CONDITIONS                            | SE5561                 |      |      | NE5561 |      |      | UNIT   |    |
|---------------------------|---------------------------------------|--|------------------------|------|------|--------|------|------|--------|----|
|                           |                                       |  | Min                    | Typ  | Max  | Min    | Typ  | Max  |        |    |
| <b>Reference section</b>  |                                       |  |                        |      |      |        |      |      |        |    |
| V <sub>REF</sub>          | Internal ref voltage                  | T <sub>A</sub> =25°C                       | 3.69                   | 3.75 | 3.84 | 3.57   | 3.75 | 3.96 | V      |    |
|                           |                                       | Over temperature                           | 3.65                   |      | 3.88 | 3.55   |      | 3.98 | V      |    |
| V <sub>Z</sub>            | Internal zener ref                    | *I <sub>L</sub> =7mA                       | 7.8                    | 8.2  | 8.8  | 7.8    | 8.2  | 8.8  | V      |    |
|                           | Temp. coefficient of V <sub>REF</sub> |  |                        | ±100 |      |        | ±100 |      | ppm/°C |    |
|                           | Temp. coefficient of V <sub>Z</sub>   |  |                        | ±200 |      |        | ±200 |      | ppm/°C |    |
| <b>Oscillator section</b> |                                       |  |                        |      |      |        |      |      |        |    |
|                           | Frequency range                       | Over temperature                           | 50                     |      | 100k | 50     |      | 100k | Hz     |    |
|                           | Initial accuracy                      | R <sub>T</sub> and C <sub>T</sub> constant |                        | 5    |      |        | 5    |      | %      |    |
|                           | Duty cycle range                      | f <sub>O</sub> =20kHz                      | 0                      |      | 98   | 0      |      | 98   | %      |    |
| <b>Current limiting</b>   |                                       |  |                        |      |      |        |      |      |        |    |
| I <sub>IN</sub>           | Input current                         | Pin 6=250mV                                | T <sub>A</sub> =25°C   |      | -2   | -10    |      | -2   | -10    | μA |
|                           |                                       |  | Over temp.             |      |      | -20    |      |      | -20    | μA |
|                           | Single pulse inhibit delay            | Inhibit delay time for 20% overdrive at    | I <sub>OUT</sub> =20mA |      | 0.88 | 1.10   |      | 0.88 | 1.10   | μs |
|                           |                                       |  | I <sub>OUT</sub> =40mA |      | 0.7  | 0.8    |      | 0.7  | 0.8    | μs |
|                           | Current limit trip level              |  | .400                   | .500 | .600 | .400   | .500 | .600 | V      |    |
| <b>Error amplifier</b>    |                                       |  |                        |      |      |        |      |      |        |    |
|                           | Open-loop gain                        |  |                        | 60   |      |        | 60   |      | dB     |    |
|                           | Feedback resistor                     |  | 10k                    |      |      | 10k    |      |      | Ω      |    |
| BW                        | Small-signal bandwidth                |  |                        | 3    |      |        | 3    |      | MHz    |    |
| V <sub>OH</sub>           | Output voltage swing                  |  | 6.2                    |      |      | 6.2    |      |      | V      |    |
| V <sub>OL</sub>           | Output voltage swing                  |  |                        |      | 0.7  |        |      | 0.7  | V      |    |
| <b>Output stage</b>       |                                       |  |                        |      |      |        |      |      |        |    |
| I <sub>OUT</sub>          | Output current                        | Over temperature                           | 20                     |      |      | 20     |      |      | mA     |    |
| V <sub>CE</sub>           | Sat                                   | I <sub>C</sub> =20mA, Over temp.           |                        |      | 0.4  |        |      | 0.4  | V      |    |

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**DC ELECTRICAL CHARACTERISTICS** $V_{CC}=12V$ ,  $T_A=25^{\circ}C$ , unless otherwise specified.

| SYMBOL                        | PARAMETER       | TEST CONDITIONS             | SE5561            |      |      | NE5561 |      |      | UNIT |    |
|-------------------------------|-----------------|-----------------------------|-------------------|------|------|--------|------|------|------|----|
|                               |                 |                             | Min               | Typ  | Max  | Min    | Typ  | Max  |      |    |
| <b>Supply voltage/current</b> |                 |                             |                   |      |      |        |      |      |      |    |
| $I_{CC}$                      | Supply current  | $I_Z=0$ ,<br>voltage-forced | $T_A=25^{\circ}C$ |      |      | 10.0   |      |      | 10.0 | mA |
|                               |                 |                             | Over temp.        |      |      | 13.0   |      |      | 13.0 |    |
| $V_{CC}$                      | Supply voltage  | $I_{CC}=10mA$ , current-fed |                   | 20.0 | 21.0 | 22.0   | 19.0 | 21.0 | 24.0 | V  |
|                               |                 | $I_{CC}=30mA$ current       |                   | 20.0 |      | 30.0   | 20.0 |      | 30.0 |    |
| <b>Low supply protection</b>  |                 |                             |                   |      |      |        |      |      |      |    |
|                               | Pin 1 threshold |                             |                   | 8    | 9    | 10.5   | 8    | 9    | 10.5 | V  |

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TYPICAL PERFORMANCE CHARACTERISTICS

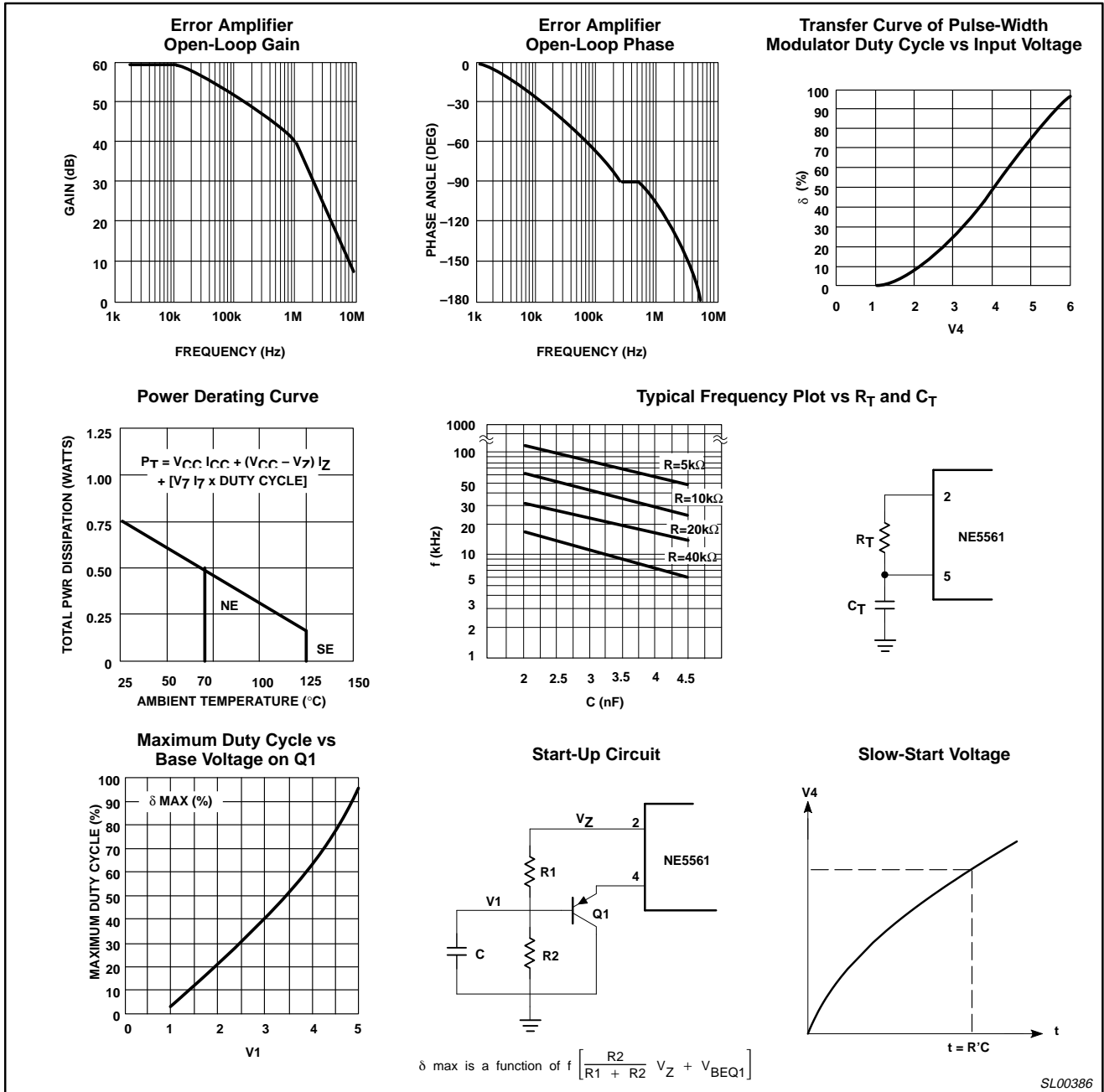


Figure 3. Typical Performance Characteristics

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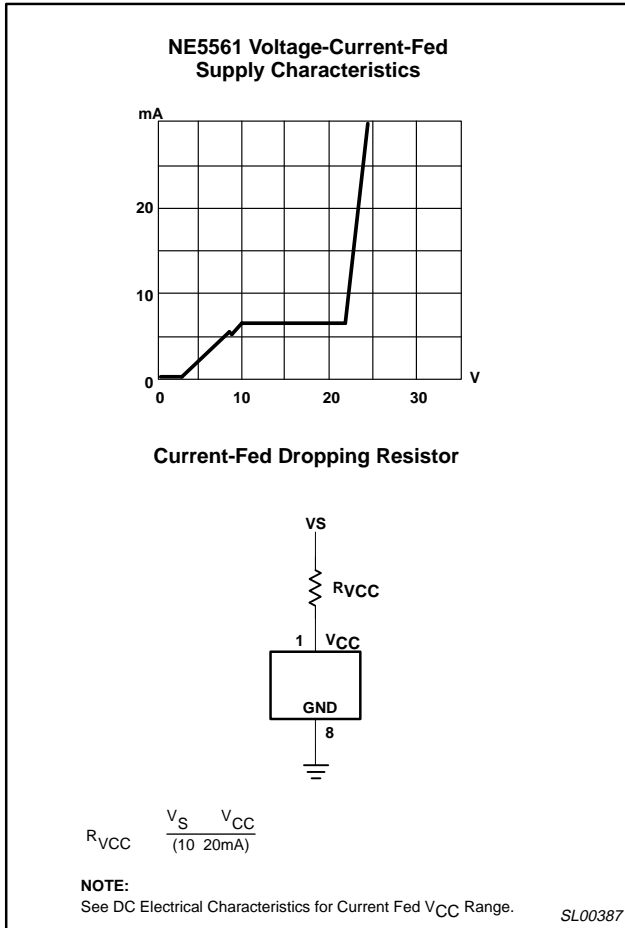


Figure 4. NE5561 Voltage-Current-Fed Supply Characteristics

**NE5561 START-UP**

The start-up, or initial turn-on, of this device requires some degree of external protective duty cycle limiting to prevent the duty cycle from

initially going to the extreme maximum ( $\delta > 90\%$ ). Either overcurrent limit or slow-start circuitry must be employed to limit duty cycle to a safe value during start-up. Both may be used, if desired.

To implement slow-start, the start-up circuit can be used. The divider R1 and R2 sets a voltage, buffered by Q1, such that the output of the error amplifier is clamped to a maximum output voltage, thereby limiting the maximum duty cycle. The addition of capacitor C will cause this voltage to ramp-up slowly when power is applied, causing the duty cycle to ramp-up simultaneously.

Overcurrent limit may be used also. To limit duty cycle in this mode, the switch current is monitored at Pin 6 and the output of the 5561 is disabled on a cycle-by-cycle basis when current reaches the programmed limit. With current limit control of slow-start, the duty cycle is limited to that value, just allowing maximum switch current to flow. (Approximately 0.50V measured at Pin 6.)

**APPLICATIONS**

**5V, 0.5A Buck Regulator Operates from 15V**

The converter design shows how simple it is to derive a TTL supply from a system supply of 15V (see Figure 1). The NE5561 drives a 2N4920 PNP transistor directly to provide switching current to the inductor.

Overall line regulation is excellent and covers a range of 12V to 18V with minimal change (<10mV) in the output operating at full load.

As with all NE5561 circuits, the auxiliary slow start and  $\delta_{MAX}$  circuit is required, as evidenced by Q1. The  $\delta_{MAX}$  limit may be calculated by using the relationship:

$$\frac{R2}{R1 + R2} (8.2V) = V_{\delta_{MAX}}$$

The maximum duty cycle is then determined from the pulse-width modulator transfer graph, with R1 and R2 being defined from the desired conditions.