

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

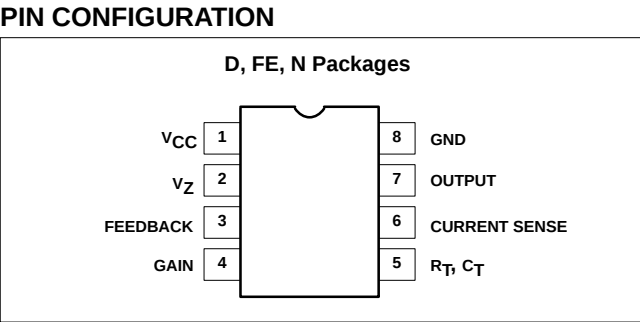


Figure 1. Pin Configuration

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

| 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 |

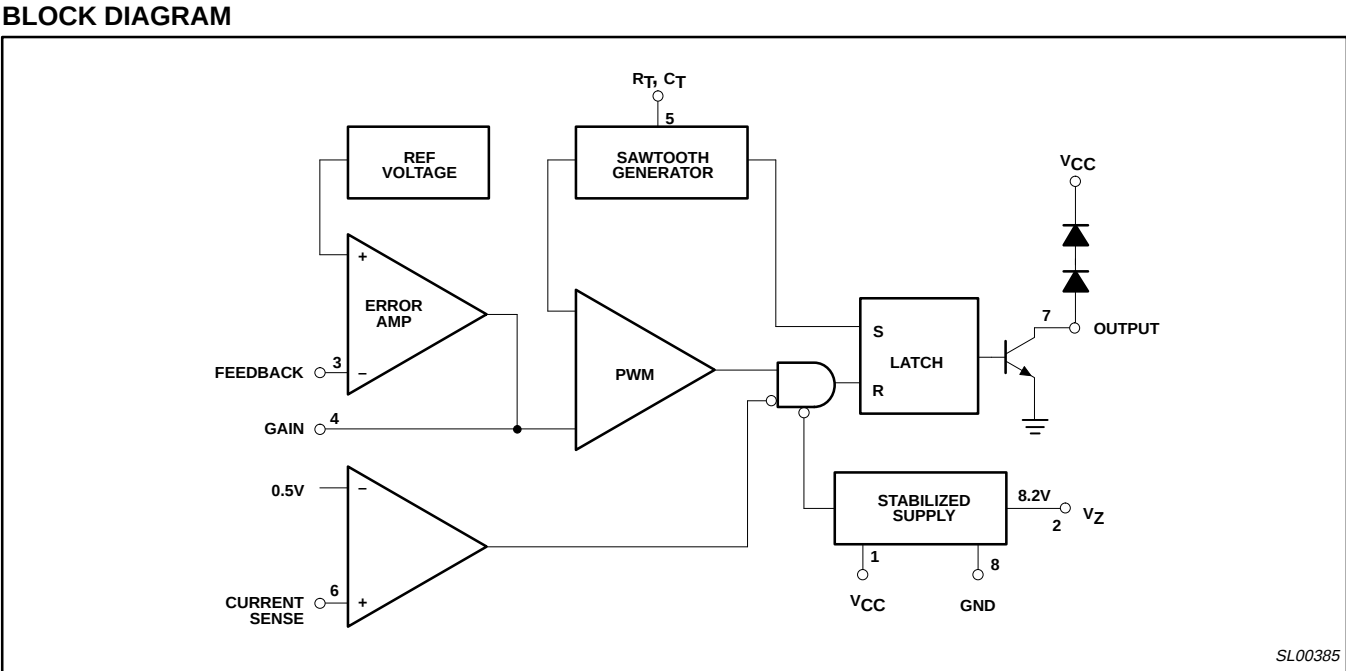


Figure 2. Block Diagram

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## ABSOLUTE MAXIMUM RATINGS

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

## NOTES:

1. See Voltage-Current-fed supply characteristic curve.

## 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  |        |    |
| Reference section  |                                       |                                            |                        |      |      |        |      |      |        |    |
| 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 |    |
| Oscillator section |                                       |                                            |                        |      |      |        |      |      |        |    |
|                    | 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   | %      |    |
| Current limiting   |                                       |                                            |                        |      |      |        |      |      |        |    |
| 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      |    |
| Error amplifier    |                                       |                                            |                        |      |      |        |      |      |        |    |
|                    | 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      |    |
| Output stage       |                                       |                                            |                        |      |      |        |      |      |        |    |
| 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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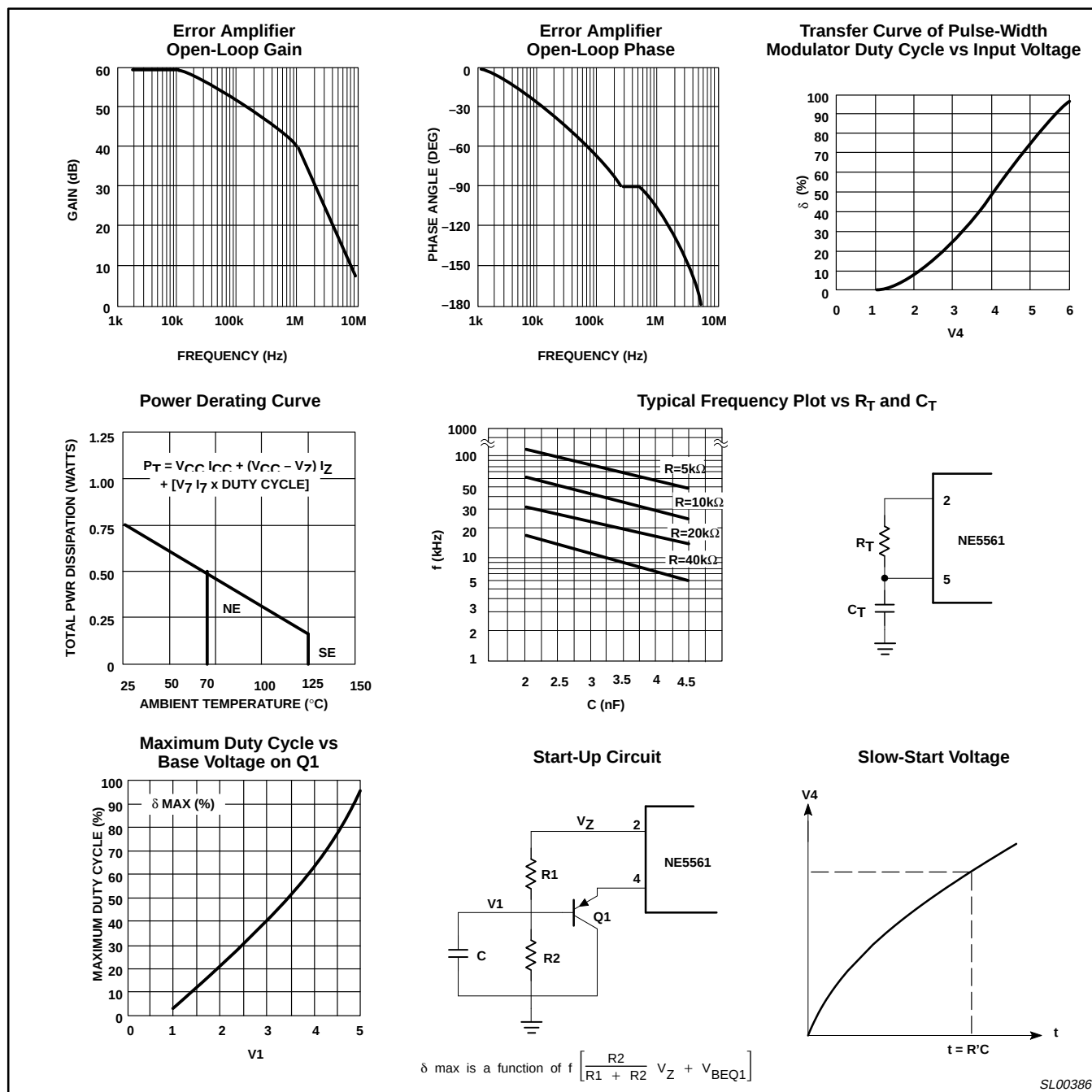
**DC ELECTRICAL CHARACTERISTICS** $V_{CC}=12V$ ,  $T_A=25^{\circ}C$ , unless otherwise specified.

| SYMBOL                 | PARAMETER       | TEST CONDITIONS                      |                      | SE5561 |      |      | NE5561 |      |      | UNIT |
|------------------------|-----------------|--------------------------------------|----------------------|--------|------|------|--------|------|------|------|
|                        |                 |                                      |                      | Min    | Typ  | Max  | Min    | Typ  | Max  |      |
| Supply voltage/current |                 |                                      |                      |        |      |      |        |      |      |      |
| I <sub>CC</sub>        | Supply current  | I <sub>Z</sub> =0,<br>voltage-forced | T <sub>A</sub> =25°C |        |      | 10.0 |        |      | 10.0 | mA   |
|                        |                 |                                      | Over temp.           |        |      | 13.0 |        |      | 13.0 |      |
| V <sub>CC</sub>        | Supply voltage  | I <sub>CC</sub> =10mA, current-fed   |                      | 20.0   | 21.0 | 22.0 | 19.0   | 21.0 | 24.0 | V    |
|                        |                 | I <sub>CC</sub> =30mA current        |                      | 20.0   |      | 30.0 | 20.0   |      | 30.0 |      |
| Low supply protection  |                 |                                      |                      |        |      |      |        |      |      |      |
|                        | Pin 1 threshold |                                      |                      | 8      | 9    | 10.5 | 8      | 9    | 10.5 | V    |

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## TYPICAL PERFORMANCE CHARACTERISTICS



SL00386

Figure 3. Typical Performance Characteristics

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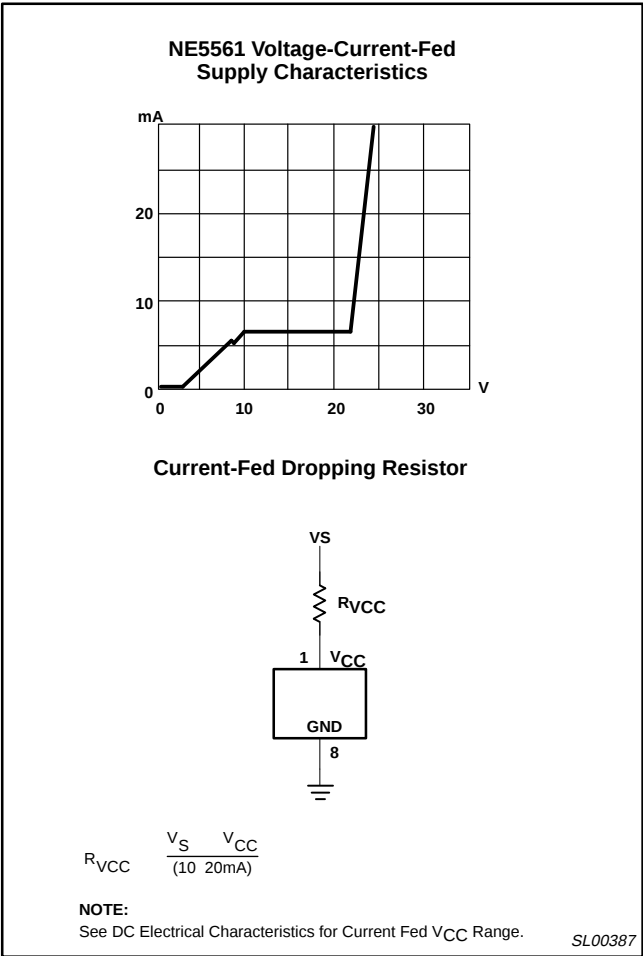


Figure 4. NE5561 Voltage-Current-Fed Supply Characteristics

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 ( $< 10\text{mV}$ ) 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:

$$\frac{R_2}{R_1 + R_2} (8.2\text{V}) = V_{\delta_{MAX}}$$

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