



**MOTOROLA**

**TDA4600**

**Specifications and Applications Information**

**CONTROL IC FOR LINE ISOLATED FREELY OSCILLATING FLYBACK CONVERTER**

The bipolar integrated circuit TDA4600 drives, regulates and monitors the switching transistor in a power supply based on freely oscillating flyback converters.

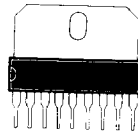
Due to the wide regulating range and the high voltage stability during large load changes, SMPS for Hi-Fi equipment and active loudspeakers can be realized as well as applications in TV receivers and video recorders.

The TDA4600 is available in a 9-pin SIP plastic medium-power package. The ambient temperature during operation can be from  $-15^{\circ}\text{C}$  to  $+85^{\circ}\text{C}$ .

- Wide Operational Range
- High Voltage Stability Even at High Load Changes
- Direct Control of Switching Transistor
- Low Start-Up Current
- Linear Foldback of the Overload Characteristic
- Base Drive Proportional to the Current Through the Power Switching Transistor

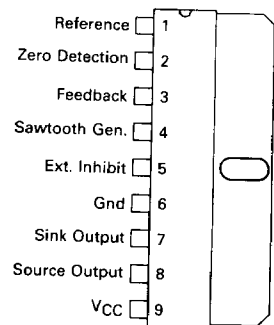
**FLYBACK CONVERTER  
REGULATOR CONTROL  
CIRCUIT**

**SILICON MONOLITHIC  
INTEGRATED CIRCUIT**

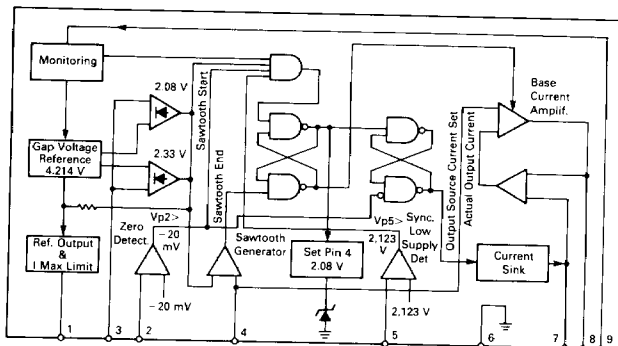


**SIP 9  
PLASTIC  
MEDIUM-POWER PACKAGE  
CASE 762-01**

**PIN CONNECTIONS**



**BLOCK DIAGRAM**



**ORDERING INFORMATION**

| Device  | Temperature Range                              | Package     |
|---------|--|-------------|
| TDA4600 | $-15^{\circ}\text{C}$ to $+85^{\circ}\text{C}$ | Plastic SIP |

**MAXIMUM RATINGS**

| Rating                                   | Symbol   | Value                        | Unit |
|--|--|------------------------------|------|
| Supply Voltage                           | V <sub>g</sub>                                   | 20                           | V    |
| Sink Output Voltage                      | V <sub>7</sub>                                   | 0 to V <sub>g</sub>          | V    |
| Source Output                            | V <sub>8</sub><br>V <sub>7</sub> -V <sub>8</sub> | 0 to V <sub>g</sub><br>± 6.0 | V    |
| Reference Output                         | I <sub>1</sub>                                   | - 10 to + 1.0                | mA   |
| Zero Passage                             | I <sub>2</sub>                                   | - 3.0 to + 3.0               | mA   |
| Control Amplifier                        | I <sub>3</sub>                                   | - 3.0 to 0                   | mA   |
| Collector Current Balancing              | I <sub>4</sub>                                   | - 2.0 to + 5.0               | mA   |
| Trigger Input                            | I <sub>5</sub>                                   | - 2.0 to + 3.0               | mA   |
| Sink Output Current                      | I <sub>7</sub>                                   | - 1.5                        | A    |
| Source Output Current                    | I <sub>8</sub>                                   | 1.5                          | A    |
| Junction Temperature                     | T <sub>J</sub>                                   | + 150                        | °C   |
| Storage Temperature                      | T <sub>stg</sub>                                 | - 40 to + 125                | °C   |
| Thermal Resistance<br>(Junction-to-Air)  | R <sub>θJA</sub>                                 | 70                           | °C/W |
| Thermal Resistance<br>(Junction-to-Case) | R <sub>θJC</sub>                                 | 15                           | °C/W |

**ELECTRICAL CHARACTERISTICS** (T<sub>A</sub> = + 25°C unless otherwise noted.)

| Operating Conditions | Symbol         | Fig. | Min  | Typ | Max | Unit |
|----------------------|----------------|------|------|-----|-----|------|
| Supply Voltage       | V <sub>g</sub> |      | —    | —   | 18  | V    |
| Ambient Temperature  | T <sub>A</sub> |      | - 15 | —   | 85  | °C   |

**START OPERATION**

|   |                |   |      |      |      |    |
|---|----------------|---|------|------|------|----|
| Current Consumption (V <sub>1</sub> not yet switched) | I <sub>g</sub> | 1 | —    | —    | 0.5  | mA |
| V <sub>g</sub> = 3.0 V                                | I <sub>g</sub> | 1 | —    | 1.5  | 2.0  | mA |
| V <sub>g</sub> = 5.0 V                                | I <sub>g</sub> | 1 | —    | 2.4  | 3.2  | mA |
| V <sub>g</sub> = 10 V                                 | V <sub>g</sub> | 1 | 11.3 | 11.8 | 12.3 | V  |
| Turn-on Point for V <sub>1</sub>                      |                |   |      |      |      |    |

**NORMAL OPERATION** (V<sub>g</sub> = 10 V; V<sub>reg</sub> = - 10 V; V<sub>pulse</sub> = ± 0.5 V; f = 20 kHz; duty cycle: ½ after the turn-on process is completed.)

|  |   |             |                   |                   |                   |        |
|--|---|-------------|-------------------|-------------------|-------------------|--------|
| Current Consumption V <sub>reg</sub> = - 10 V<br>V <sub>reg</sub> = 0                                  | I <sub>g</sub><br>I <sub>g</sub>                          | 1<br>1      | 110<br>55         | 135<br>85         | 160<br>110        | mA     |
| Reference Voltage V <sub>1</sub> < 0.1 mA<br>V <sub>1</sub> = 5.0 mA                                   | V <sub>1</sub><br>V <sub>1</sub>                          | 1<br>1      | 4.0<br>4.0        | 4.2<br>4.2        | 4.5<br>4.4        | V      |
| Reference Voltage Temperature Coefficient  | TC <sub>1</sub>   | 1           | —                 | 100               | —                 | ppm/°C |
| Feedback Voltage   | V <sub>2</sub> *  | 1           | —                 | 0.2               | —                 | V      |
| Regulating Voltage V <sub>reg</sub> = 0 V  | V <sub>3</sub>  | 1           | 2.3               | 2.6               | 2.9               | V      |
| Collector Current Balancing<br>V <sub>reg</sub> = 0 V<br>V <sub>reg</sub> = 0 V / - 10 V               | V <sub>4</sub> *<br>ΔV <sub>4</sub> *                     | 1<br>1      | 1.8<br>0.3        | 2.2<br>0.4        | 2.5<br>0.5        | V      |
| Max Trigger Input Voltages Limitation  | V <sub>5</sub>  | 1           | 5.5               | 6.3               | 7.0               | V      |
| Output Voltages<br>V <sub>reg</sub> = 0 V<br>V <sub>reg</sub> = 0 V<br>V <sub>reg</sub> = 0 V / - 10 V | V <sub>7</sub> *<br>V <sub>8</sub> *<br>ΔV <sub>8</sub> * | 1<br>1<br>1 | 2.7<br>2.7<br>1.4 | 3.3<br>3.4<br>1.8 | 4.0<br>4.0<br>2.2 | V      |

\*Only dc portion.

**PROTECTIVE OPERATION** ( $V_g = 10\text{ V}$ ;  $V_{reg} = -10\text{ V}$ ;  $V_{pulse} = \pm 0.5\text{ V}$ ;  $f = 20\text{ kHz}$ ; duty cycle:  $\frac{1}{2}$ )

|  |       |   |     |     |     |    |
|--|-------|---|-----|-----|-----|----|
| Current Consumption ( $V_5 < 1.8\text{ V}$ )   | $I_g$ | 1 | 14  | 20  | 26  | mA |
| Turn-off Voltage ( $V_5 < 1.8\text{ V}$ )  | $V_7$ | 1 | 1.3 | 1.5 | 1.8 | V  |
|  | $V_4$ | 1 | 1.8 | 2.1 | 2.5 | V  |
| External Trigger Input<br>Enable Voltage ( $V_{reg} = 0\text{ V}$ )<br>Disabled Voltage ( $V_{reg} = 0\text{ V}$ ) | $V_5$ | 1 | —   | 2.4 | 2.7 | V  |
|  | $V_5$ | 1 | 1.8 | 2.2 | —   | V  |
| Supply Voltage Disabling $V_8$ ( $V_{reg} = 0\text{ V}$ )  | $V_9$ | 1 | 6.7 | 7.4 | 7.8 | V  |

**RANGE OF OPERATION**

|  |              |   |    |     |      |     |
|--|--------------|---|----|-----|------|-----|
| Turn-on Time (Secondary Voltages)  | + on         | 2 | —  | 350 | 450  | ms  |
| Voltage Change<br>When $S_3 = \text{Closed}$ ( $\Delta P_3 = 19\text{ W}$ Audio Frequency Output Power)<br>When $S_2 = \text{Closed}$ ( $\Delta P_2 = 15\text{ W}$ ) | $\Delta V_2$ | 2 | —  | 100 | 500  | mV  |
|  | $\Delta V_2$ | 2 | —  | 500 | 1000 | mV  |
| Standby Operation (Secondary Useable Power = $3.0\text{ W}$ )<br>When $S_1 = \text{Open}$  | $\Delta V_2$ | 2 | —  | 20  | 30   | V   |
|  | $f$          | 2 | 70 | 75  | —    | kHz |
|  | $P_{prim}$   | 2 | —  | 10  | 12   | VA  |

The heat sink must be optimized, taking the maximum data ( $T_J, R_{\theta JC}, R_{\theta JA}, T_A$ ) into consideration.

FIGURE 1 — MEASURING CIRCUIT

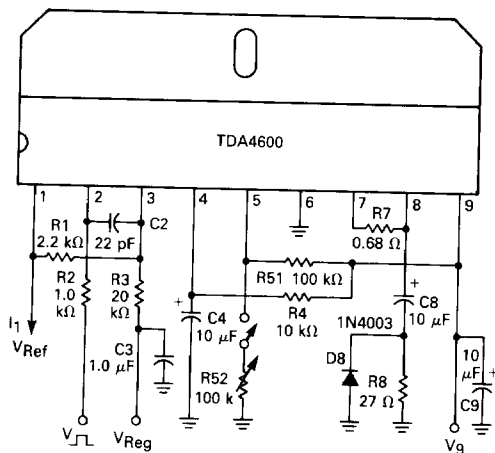
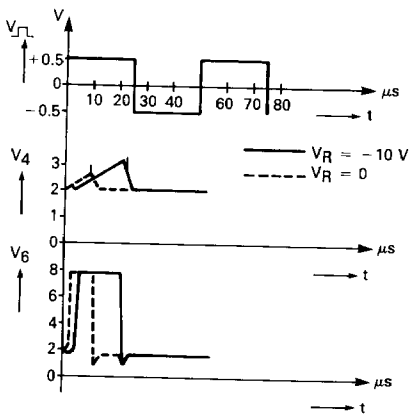


FIGURE 2 — TEST DIAGRAM: NORMAL OPERATION



**CIRCUIT DESCRIPTION**

The TDA4600 regulates, controls, and protects the switching transistor in flyback converter power supplies at starting, normal and overload operation.

**A. Starting Behavior**

At the start-up there are three consecutive operation states.

1. An internal reference voltage is created. It supplies the voltage regulator and enables the supply to the coupling electrolytic capacitor and the switching transistor. For a supply voltage of  $V_g = 12\text{ V}$ , the current  $I_g$  is less than  $3.2\text{ mA}$ .
2. Release of the internal reference voltage  $V_1 = 4.0\text{ V}$ . This voltage is available when  $V_g = 12\text{ V}$  and

enables all parts of the IC to be supplied from the control logic with thermal and overload protection.

3. Release of control logic — As soon as the reference voltage is available, the control is switched on through an additional stabilization circuit.

This start-up sequence is necessary for driving the switching transistor through the coupling electrolytic capacitor.

#### B. Normal Operation

Zero crossing detection is sensed on Pin 2 and linked to the control logic.

The signal picked up on the feedback winding is applied, after filtering, to Pin 3 (used for input regulation and for overload protection). The regulating section works with an input voltage of about 2.0 V for normal regulation and a current of about 1.4 mA for foldback operation. Together with the collector current simulation Pin 4, the overload recognition defines the operating region of the regulating amplifier depending on the internal reference voltage. The simulation of the collector current is generated by an external RC network at Pin 4 and an internally set voltage level.

For a constant line and for a given output power on the load ( $t_{ON}$  fixed) less than the maximum output power, a decrease of C Pin 4 produces an increase of

the current sent to the base of the power switching transistor. So the foldback point is reached earlier. The regulation range starts from a 2.0 Vdc level which is the bottom of a sawtooth waveform whose top is limited at 4.0 V (reference voltage).

A secondary load of 19 W produces a switching frequency of about 50 kHz at an almost constant duty cycle. Furthermore, when the switchmode power supply delivers approximately 3.0 W, the switching frequency jumps to about 70 kHz. At the same time, the collector peak current falls below 1.0 A.

The comparison of the output level of the regulating amplifier, the overload detection and the collector current simulation drives the control logic. An additional steering control and blocking possibility is offered through Pin 5. When the voltage applied on Pin 5 falls below 2.2 V, the source output (Pin 8) is blocked.

The control logic is set according to the start-up circuit, the zero crossing detection and the trigger enable. This logic drives the base current amplifier and the base current shutdown. The base current amplifier drives the source output (Pin 8) proportionally to the sawtooth voltage (Pin 4). A current feedback is performed by an external shunt inserted between Pin 8 and the base of the switching power transistor. This shunt value determines the maximum amplitude of the base current drive.

FIGURE 3 — FREQUENCY versus OUTPUT POWER

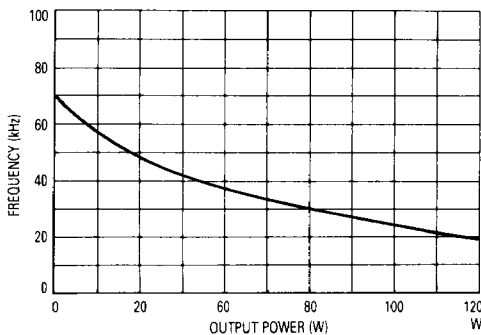
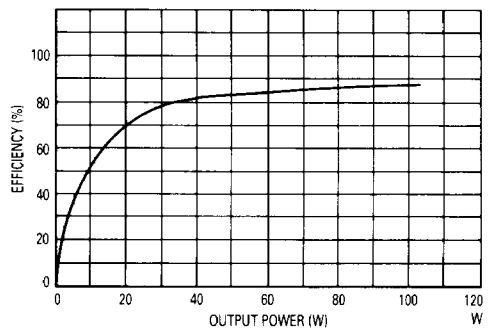


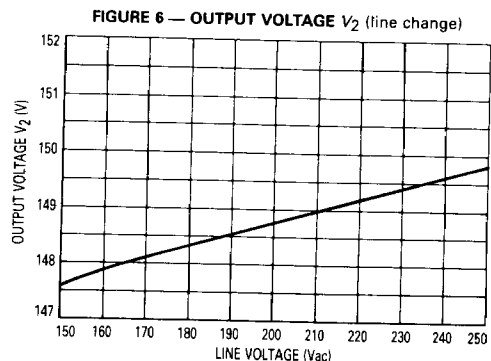
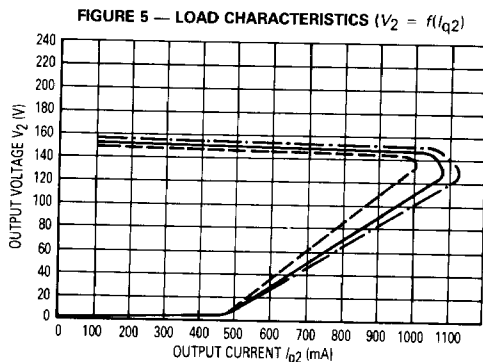
FIGURE 4 — EFFICIENCY versus OUTPUT POWER



### C. Protective Features

The base current shutdown, released by the control logic, clamps the sink output (Pin 7) at 1.6 V, turning off the switching transistor. This feature will be released if the voltage on Pin 9 is less than 7.4 V, or if the applied voltage on Pin 5 is less than 2.2 V. In case of a short circuit of the secondary windings, the TDA4600 continuously monitors the fault condition.

In standby operation the circuit is set to a high duty cycle. The total power consumption of the power supply is held below 6.0 to 10 W. Once the output is blocked (due to the supply voltage coming down to 7.4 V), a further voltage reduction to 6.0 V switches off the reference voltage.



### TEST CIRCUIT AND TYPICAL APPLICATION (see Figure 7 on the next page)

This application circuit shown in Figure 7 represents a blocking converter for color TV sets with 30 W to 120 W of output power and line voltages from 160 V to 270 V.

This circuit shows the low number of external components. In spite of regulation on the primary side, high voltage stability of the various secondary voltages is achieved even with large load changes.

For line isolation and transformation to the desired secondary voltages, a transformer with ferrite core is used.

#### SPECIAL FEATURES OF THE FLYBACK CONVERTER POWER SUPPLY USING THE TDA4600

- Direct driving of the power switching transistor
- Low starting current, defines starting behavior even at slowly rising line voltage
- Short-circuit proof and open-loop resistant circuit. In both cases a power of only 6.0 to 10 W is consumed. Linear foldback characteristic at overload
- Automatic restart after elimination of the overload
- Efficiency of more than 80% at an output power of 40 to 100 W
- Frequency of oscillation between 20 kHz (100 W) and 70 kHz (without load)
- Simple RF I suppression
- Good regulation of load current and line voltage variations. At a line voltage variation between 170 and 240 Vac the output voltage of 150 V will change only by about 2.0 V

FIGURE 7 — TYPICAL APPLICATION

