MOTOROLA

TDA4600

Specifications and Applications Information

FLYBACK CONVERTER REGULATOR CONTROL CIRCUIT

SILICON MONOLITHIC INTEGRATED CIRCUIT

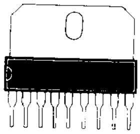
CONTROL IC FOR LINE ISOLATED FREELY OSCILLATING FLYBACK CONVERTER

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.

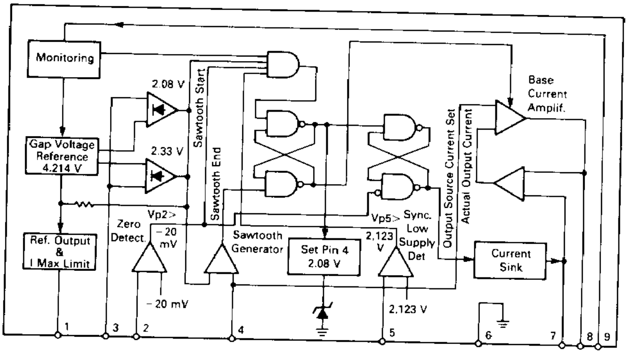
The TDA4600 is available in a 9-pin SIP plastic medium-power package. The ambient temperature during operation can be from −15°C to +85°C.

- 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

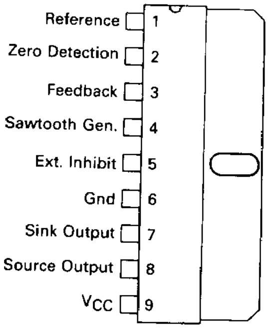


SIP 9
PLASTIC
MEDIUM-POWER PACKAGE
CASE 762-01

BLOCK DIAGRAM



PIN CONNECTIONS



ORDERING INFORMATION

Device	Temperature Range	Package
TDA4600	−15°C to +85°C	Plastic SIP

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Supply Voltage	V_9	20	V
Sink Output Voltage	V_7	0 to V_9	V
Source Output	V_8 V_7-V_8	0 to V_9 ±6.0	V
Reference Output	I_1	−10 to +1.0	mA
Zero Passage	I_2	−3.0 to +3.0	mA
Control Amplifier	I_3	−3.0 to 0	mA
Collector Current Balancing	I_4	−2.0 to +5.0	mA
Trigger Input	I_5	−2.0 to +3.0	mA
Sink Output Current	I_7	−1.5	A
Source Output Current	I_8	1.5	A
Junction Temperature	T_J	+150	°C
Storage Temperature	T_{stg}	−40 to +125	°C
Thermal Resistance (Junction-to-Air)	$R_{\theta JA}$	70	°C/W
Thermal Resistance (Junction-to-Case)	$R_{\theta JC}$	15	°C/W

ELECTRICAL CHARACTERISTICS (T_A = +25°C unless otherwise noted.)

Operating Conditions	Symbol	Fig.	Min	Typ	Max	Unit
Supply Voltage	V_9		—	—	18	V
Ambient Temperature	T_A		−15	—	85	°C

START OPERATION

Current Consumption (V_1 not yet switched)	I_9	1	—	—	0.5	mA
V_9 = 3.0 V	I_9	1	—	1.5	2.0	mA
V_9 = 5.0 V	I_9	1	—	2.4	3.2	mA
V_9 = 10 V	V_9	1	11.3	11.8	12.3	V
Turn-on Point for V_1						

NORMAL OPERATION (V_9 = 10 V; V_{reg} = −10 V; V_{pulse} = ±0.5 V; f = 20 kHz; duty cycle: ½ after the turn-on process is completed.)

Current Consumption V_{reg} = −10 V	I_9	1	110	135	160	mA
V_{reg} = 0	I_9	1	55	85	110	
Reference Voltage V_1 < 0.1 mA	V_1	1	4.0	4.2	4.5	V
V_1 = 5.0 mA	V_1	1	4.0	4.2	4.4	
Reference Voltage Temperature Coefficient	TC_1	1	—	100	—	ppm/°C
Feedback Voltage	V_2*	1	—	0.2	—	V
Regulating Voltage V_{reg} = 0 V	V_3	1	2.3	2.6	2.9	V
Collector Current Balancing Voltage						V
V_{reg} = 0 V	V_4*	1	1.8	2.2	2.5	
V_{reg} = 0 V/−10 V	ΔV_4*	1	0.3	0.4	0.5	
Max Trigger Input Voltages Limitation	V_5	1	5.5	6.3	7.0	V
Output Voltages						V
V_{reg} = 0 V	V_7*	1	2.7	3.3	4.0	
V_{reg} = 0 V	V_8*	1	2.7	3.4	4.0	
V_{reg} = 0 V/−10 V	ΔV_8*	1	1.4	1.8	2.2	

*Only dc portion.

PROTECTIVE OPERATION (V_9 = 10 V; V_{reg} = −10 V; V_{pulse} = ±0.5 V; f = 20 kHz; duty cycle: ½)

Current Consumption ($V_5 < 1.8$ V)	I_9	1	14	20	26	mA
Turn-off Voltage ($V_5 < 1.8$ V)	V_7 V_4	1 1	1.3 1.8	1.5 2.1	1.8 2.5	V
External Trigger Input Enable Voltage (V_{reg} = 0 V) Disabled Voltage (V_{reg} = 0 V)	 V_5 V_5	 1 1	 — 1.8	 2.4 2.2	 2.7 —	V
Supply Voltage Disabling V_8 (V_{reg} = 0 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 When S_3 = Closed (ΔP_3 = 19 W Audio Frequency Output Power) When S_2 = Closed (ΔP_2 = 15 W)	 ΔV_2 ΔV_2	 2 2	 — —	 100 500	 500 1000	mV
Standby Operation (Secondary Useable Power = 3.0 W) When S_1 = Open	ΔV_2 f P_{prim}	2 2 2	— 70 —	20 75 10	30 — 12	V kHz 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

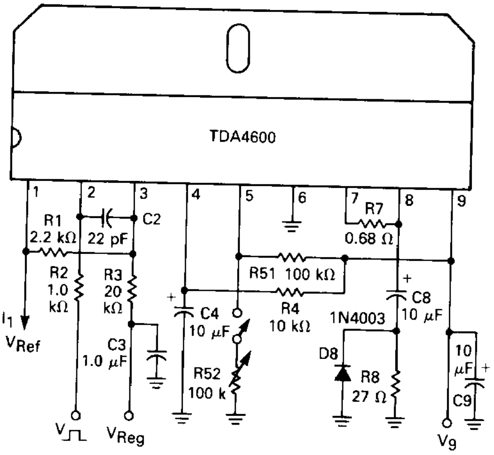
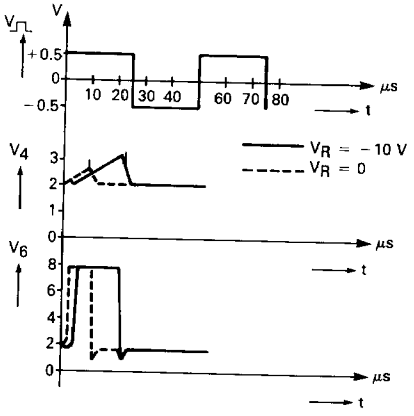


FIGURE 2 — TEST DIAGRAM: NORMAL OPERATION



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_9 = 12 V, the current I_9 is less than 3.2 mA.
2. Release of the internal reference voltage V_1 = 4.0 V. This voltage is available when V_9 = 12 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 thru 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

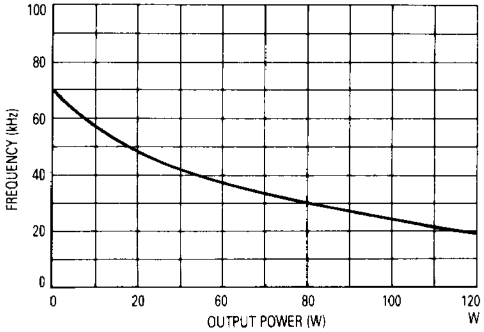
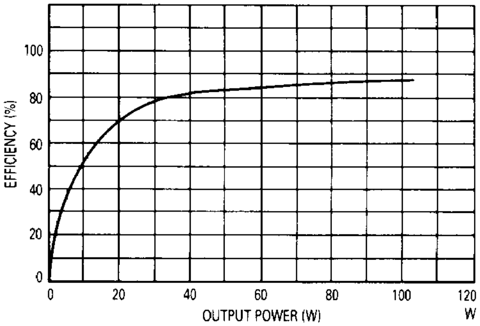


FIGURE 4 — EFFICIENCY versus OUTPUT POWER



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.

FIGURE 5 — LOAD CHARACTERISTICS ($V_2 = f(I_{q2})$)

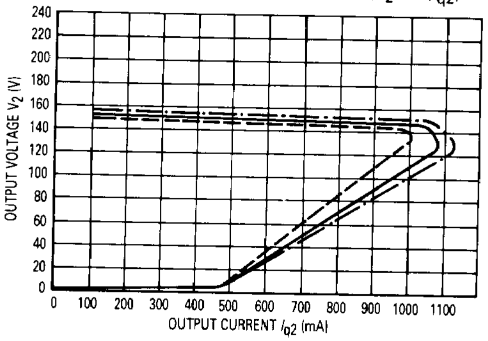
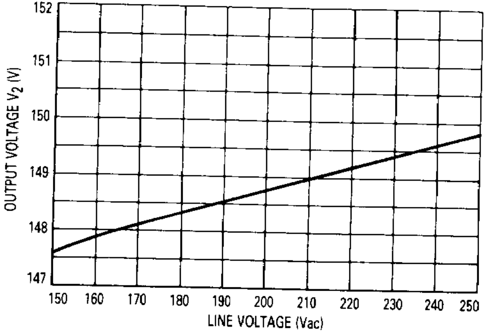


FIGURE 6 — OUTPUT VOLTAGE V_2 (line change)



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.

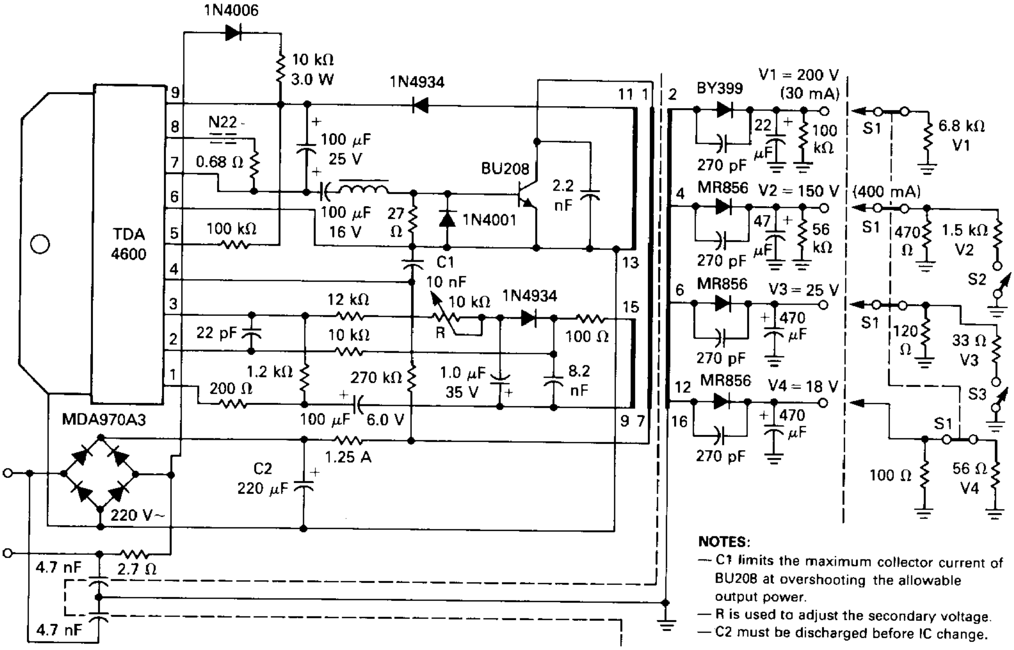
This circuit shows the low number of external components. Inspite of regulation on the primary side, high voltage stability of the various secondary voltages is achieved even with large load changes.

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 ocillation 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



NOTES:

- — C1 limits the maximum collector current of BU208 at overshooting the allowable output power.
- — R is used to adjust the secondary voltage.
- — C2 must be discharged before IC change.