MOTOROLA
SEMICONDUCTOR
TECHNICAL DATA

TDA4601

Advance Information

Control IC For Line-Isolated Free Running Flyback Converter

FLYBACK CONVERTER CONTROL CIRCUIT

SILICON MONOLITHIC INTEGRATED CIRCUIT

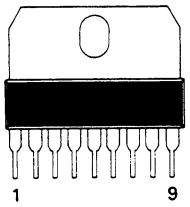
The bipolar integrated circuit TDA4601 drives, regulates and monitors the switching transistor in a power supply based on the ringing choke flyback principle.

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 TDA4601 is available in a 9-pin plastic medium power SIP package. The operating temperature range is −15°C to +85°C.

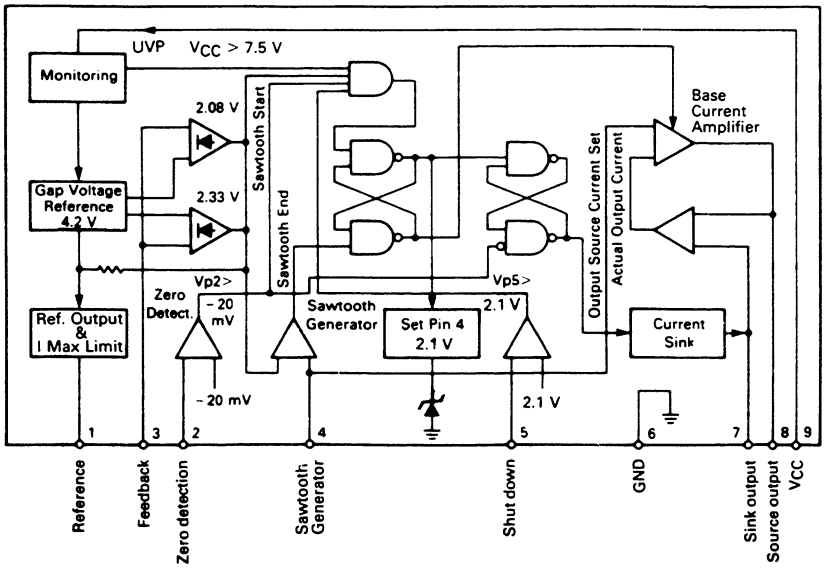
- Wide Operational Range
- High Voltage Stability Even at High Load Changes
- Direct Control of Switching Transistor
- Low Start-Up Current
- Linear Foldback of the Overload Characteristic
- Base Drive Proportional to the Current Through the Power Switching Transistor
- Standby Mode 3.5 W into the External Load
- Inhibit Capability (TTL Compatible)
- Undervoltage Lockout

For Application Details See ANE002

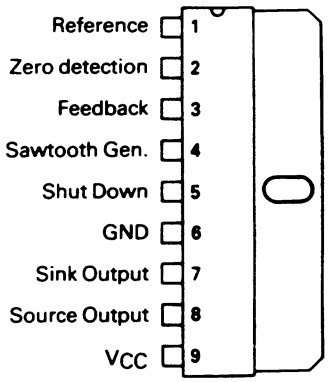


PLASTIC
MEDIUM POWER
PACKAGE
CASE 762

BLOCK DIAGRAM



PIN ASSIGNMENTS



ORDERING INFORMATION

Device	Temperature Range	Package
TDA4601	−15°C to +85°C	Plastic SIP

This document contains information on a new product. Specifications and information herein are subject to change without notice.

MAXIMUM RATINGS

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

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

Range of Operation	Symbol	Fig. No.	Min	Typ	Max	Unit
Supply Voltage	V_9		—	15	18	V
Ambient Temperature	T_A		−15	—	85	°C
START OPERATION T_A = 25°C						
Current Consumption (V_1 Not Yet Switched)	I_9	1				mA
V_9 = 3.0 V			—	—	0.5	
V_9 = 5.0 V			—	1.5	2.0	
V_9 = 10 V			—	2.0	3.2	
Turn-On Point for V_1	V_9	1	11.3	11.8	12.3	V
V_4 Before Start-Up (V_9 < 11.8 V)	V_4	1	6.0	6.7	—	V
REGULATION MODE V_9 = 15 V T_A = 25°C						
Current Consumption V_{reg} = −10 V	I_9	1	110	135	160	mA
V_{reg} = 0			55	85	110	
Reference Voltage I_1 < 0.1 mA	V_1	1	4.0	4.2	4.5	V
I_1 = 5.0 mA			4.0	4.2	4.4	
Reference Voltage Temperature Coefficient	TC_1	1	—	100	—	ppm/°C
$V_{Pin\ 4}$ Low Static Voltage	V_4	1	1.8	2.08	2.5	V
$V_{Pin\ 4}$ Regulation Peak Voltage	$V_{4\ peak}$	1				V
$I_{Pin\ 3}$ = 5.0 μA			4.0	4.2	4.5	
$I_{Pin\ 3}$ = 1.3 mA			—	2.4	3.0	
$V_{Pin\ 3}$	V_3	1				V
Full Fold Back $I_{Pin\ 3}$ = 1.3 mA			—	3.7	4.0	
Fold Back $I_{Pin\ 3}$ = 0.5 mA			—	2.5	3.0	
Overload Decision $I_{Pin\ 3}$ = 1.0 μA			—	2.4	2.9	
$V_{Pin\ 3}$ Regulation			—	2.11	—	
$I_{Pin\ 3}$ Regulation	I_3	1	—	1.0	—	μA
$I_{Pin\ 3}$ Leakage at $V_{Pin\ 3}$ = 1.5 V			—	0.4	—	
$V_{Pin\ 7}$ Peak High	$V_{7\ peak}$	1				V
V_R = 0 V (Full Fold Back)			—	3.5	—	
V_R = −10 V (Regulation)			—	4.0	—	
V_R = −15 V (Standby)			—	5.0	—	
$V_{Pin\ 7}$ Peak Low	$V_{7\ peak}$	1				V
V_R = 0 V			—	1.4	—	
V_R = −10 V			—	1.45	—	
V_R = −15 V			—	1.57	—	

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

Range of Operation	Symbol	Fig. No.	Min	Typ	Max	Unit
REGULATION MODE (continued) V_9 = 15 V T_A = 25°C						
$I_{Pin\ 7}$ Sink Peak V_R = −15 V	$I_{7\ peak}$	1	—	+0.7	—	A
$I_{Pin\ 8}$ Source Peak V_R = −15 V	$I_{8\ peak}$	1	—	−0.8	—	A
$V_{Pin\ 2}$	V_2	1				V
$I_{Pin\ 2}$ = −3.0 mA			—	−0.3	—	
= −0.3 mA			—	−0.2	—	
+3.0 mA			—	+0.7	—	
+0.3 mA			—	+0.8	—	
PROTECTIVE OPERATION V_9 = 15 V T_A = 25°C						
Current Consumption (V_5 < 1.8 V)	I_9	1	14	20	26	mA
Turn-Off Voltage (V_5 < 1.8 V)	V_7	1	1.3	1.5	1.8	V
	V_4	1	1.8	2.1	2.5	
External Trigger Input	V_5	1				V
Enable Voltage (V_{reg} = 0 V)			—	2.2	2.4	
Disabled Voltage (V_{reg} = 0 V)			2.0	2.2	—	
Supply Voltage Disabling V_8 and V_1	V_9	1	6.7	7.4	7.8	V
$V_{Pin\ 5}$ Zener Voltage (Pin 5 Open)	V_5	1	6.5	7.3	7.8	V
$I_{Pin\ 5}$ $V_{Pin\ 5}$ = 3.0 V	I_5	1	—	1.4	—	μA
$V_{Pin\ 5}$ = 0 V			—	−11	—	
Turn-On Time (Secondary Voltages)	t_{on}	2	—	350	450	ms
Voltage Change	ΔV_2	2				mV
When S_3 = Closed (ΔP_3 = 19 W)			—	100	500	
When S_2 = Closed (ΔP_2 = 15 W)			—	500	1000	
Standby Operation (Minimum Secondary Power: 3.0 Watts) When S_1 = Open	ΔV_2	2	—	20	30	V
Switching Frequency During Standby Mode	f	2	70	75	—	kHz
Primary Power Consumption During Standby Mode The heatsink must be optimized, taking the maximum data (T_J, θ_{JC}, T_A) into consideration	P_{prim}	2	—	10	15	VA

CIRCUIT DESCRIPTION

The TDA4601 regulates, controls and protects the switching transistor in flyback converter power supplies at starting-up, normal, and overload operation.

Start-Up Sequence

During start-up there are three consecutive operations:

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 (V_9) of 12 V, the current is less than 3.2 mA.
2. Activation of the internal reference voltage V_1 = 4.0 V. This voltage is suddenly available when V_9 reaches 12 V and enables all parts of the IC to be supplied from the control logic including thermal and overload protection.
3. Activation of the 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 smoothly driving the switching transistor through the coupling electrolytic capacitor.

FIGURE 1 — TEST CONFIGURATION

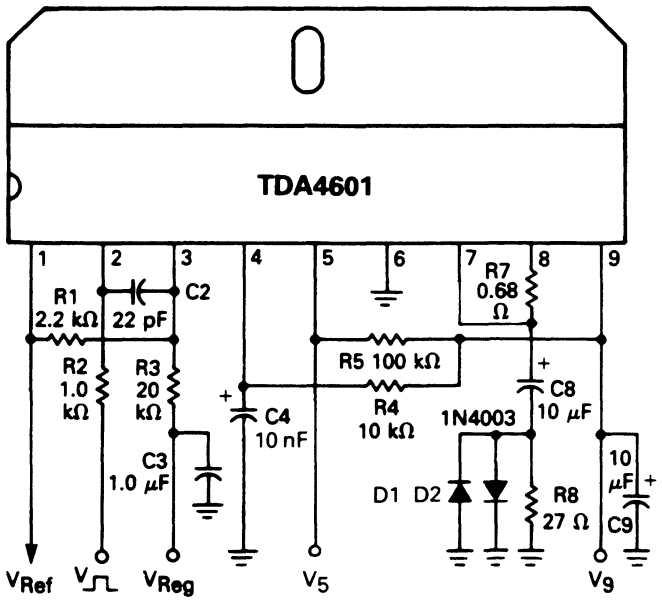
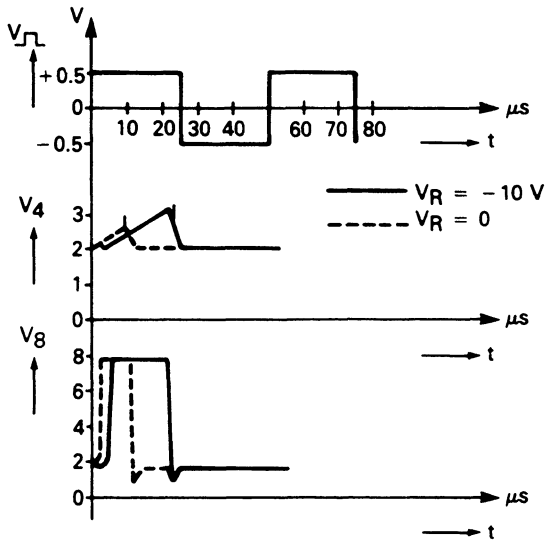


FIGURE 2 — TEST DIAGRAM: NORMAL OPERATION



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 voltage and for a given output power on the load (t on fixed) less than the maximum output power, a decrease of C4 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; the maximum 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 (approximately 3). Furthermore, when the switchmode power supply delivers approximately 3.0 W, the switching frequency jumps to about 70 kHz at a duty cycle of approximately 11. 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 then 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 enabling. 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 resistor determines the maximum amplitude of the base current drive.

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 TDA4601 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.

FIGURE 3 — FREQUENCY versus OUTPUT POWER

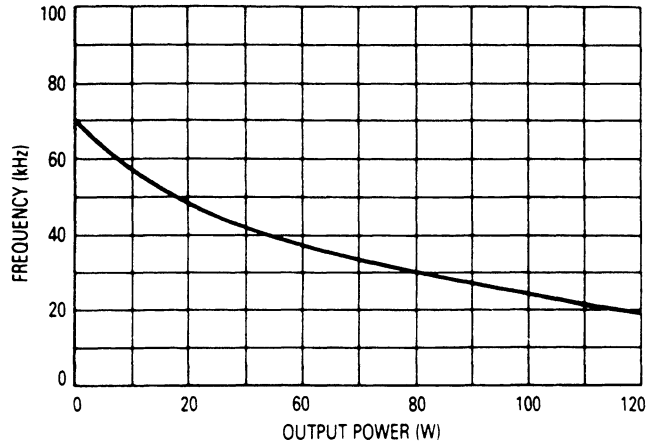


FIGURE 4 — EFFICIENCY versus OUTPUT POWER

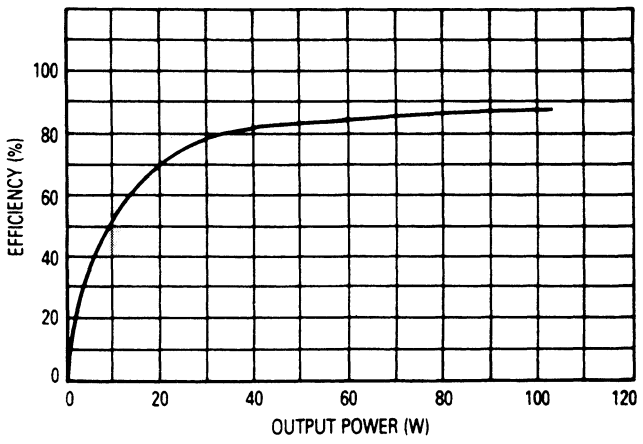


FIGURE 5 — OUTPUT VOLTAGE (V_2) versus OUTPUT CURRENT (I_{q2})

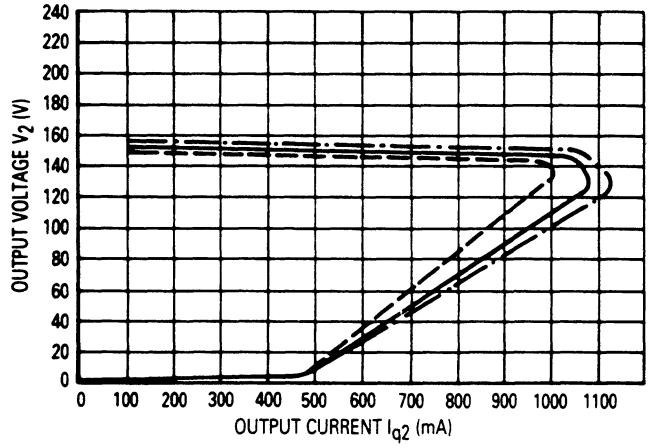
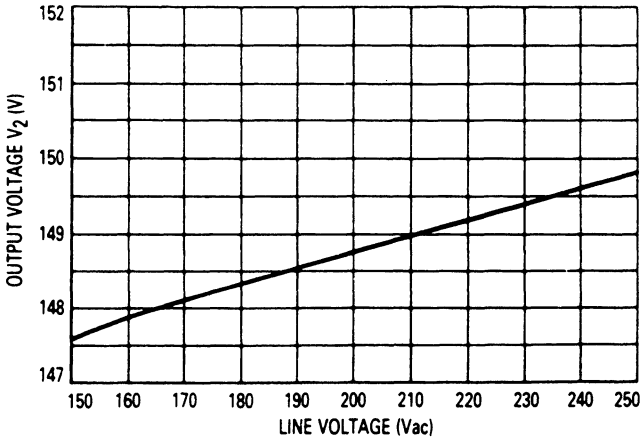


FIGURE 6 — OUTPUT VOLTAGE (V_2) versus LINE VOLTAGE



TEST CIRCUIT AND TYPICAL APPLICATION (See Figure 7)

This application circuit shown in Figure 2 represents a blocking converter for color TV sets with 30 W to 120 W of output power and line voltages from 160 to 270 V.

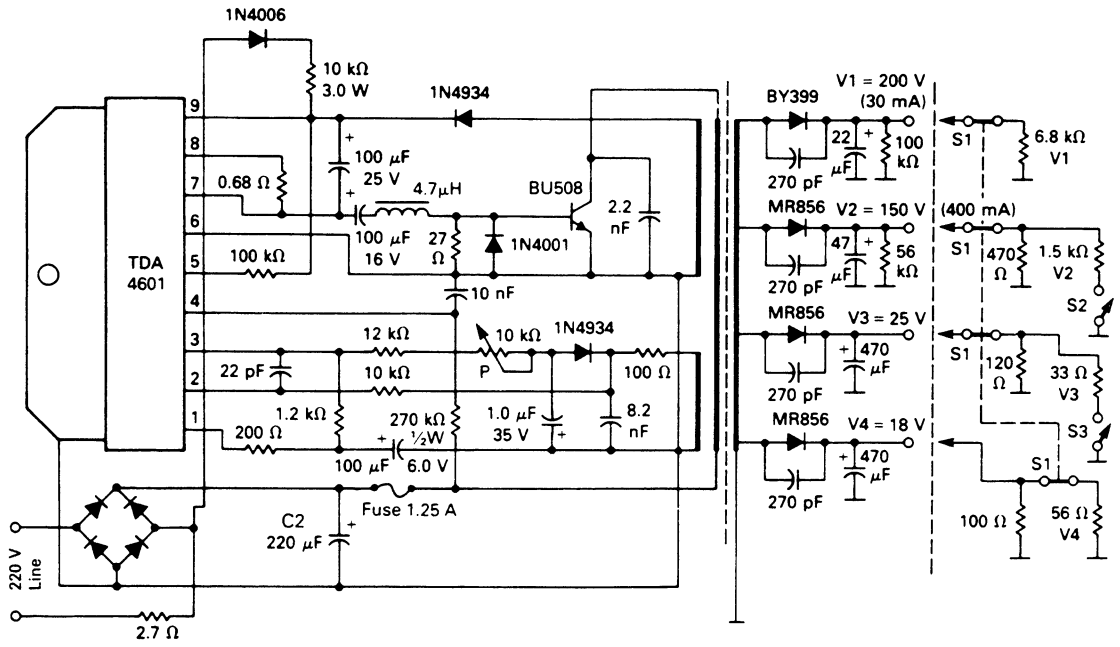
In spite of regulation on the primary side, good voltage stability of the various secondary voltages is achieved even with large load changes.

For line voltage 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 TDA4601

- Direct driving of the power switching transistor
- Low starting current, defined starting behavior also 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 RF1 suppression
- Good regulation of load current and line voltage variations. At a line voltage variation between 170 and 240 V the output voltage of 150 V will change approximately 2.0 V.

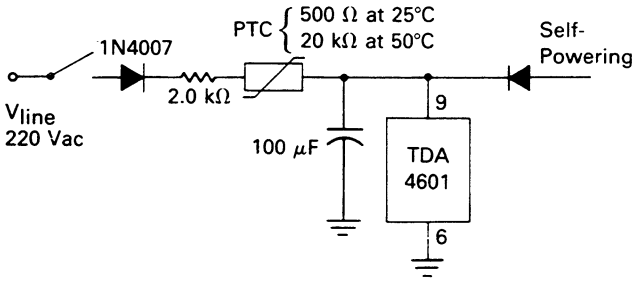
FIGURE 7 — TYPICAL APPLICATION



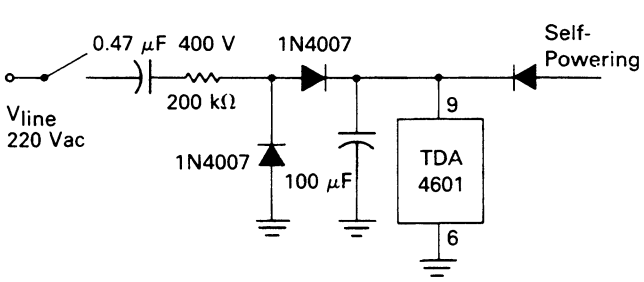
Note:
P is used to adjust the secondary voltage
C2 must be discharged before IC change

FIGURE 8 — ALTERNATIVE START-UP CIRCUIT

A. Thermal Kick Starter



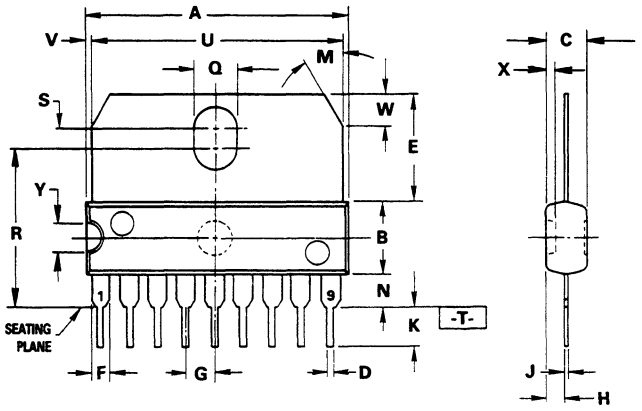
B. Lossless Start-Up Pump



Note: For more application information refer to ANE002

OUTLINE DIMENSIONS

PLASTIC,
MEDIUM POWER PACKAGE
CASE 762-01



NOTES:
1. DIMENSIONS A, AND C ARE DATUMS. AND -T- IS A DATUM PLANE.
2. POSITIONAL TOLERANCE FOR LEAD DIMENSION D:
   ⌖ | ϕ 0.25 (0.010) Ⓜ | -T- | A Ⓜ
3. POSITIONAL TOLERANCE FOR LEAD DIMENSION J:
   ⌖ | ϕ 0.25 (0.010) Ⓜ | -T- | C Ⓜ
4. POSITIONAL TOLERANCE FOR LEAD DIMENSION Q:
   ⌖ | ϕ 0.25 (0.010) Ⓜ | -T- | A Ⓜ
5. DIMENSIONING AND TOLERANCING PER ANSI Y14.5, 1982.
6. CONTROLLING DIMENSION: MILLIMETER.

	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	22.40	23.00	0.873	0.897
B	6.40	6.60	0.252	0.260
C	3.45	3.65	0.135	1.143
D	0.40	0.55	0.015	0.021
E	9.35	9.60	0.368	0.377
F	1.40	1.60	0.055	0.062
G	2.54 BSC		0.100BSC	
H	1.51	1.71	0.059	0.067
J	0.360	0.400	0.014	0.015
K	3.95	4.20	0.155	0.165
M	30° BSC		30° BSC	
N	2.50	2.70	0.099	0.106
Q	3.15	3.45	0.124	0.135
R	13.60	13.90	0.535	0.547
S	1.65	1.95	0.064	0.076
U	22.00	22.20	0.866	0.874
V	0.55	0.75	0.021	0.029
W	2.89 BSC		0.113 BSC	
X	0.65	0.75	0.025	0.029
Y	2.70	2.80	0.106	0.110

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