TL494 脉宽调制控制电路

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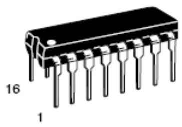
TL494

SWITCHMODE
PULSE WIDTH MODULATION
CONTROL CIRCUIT

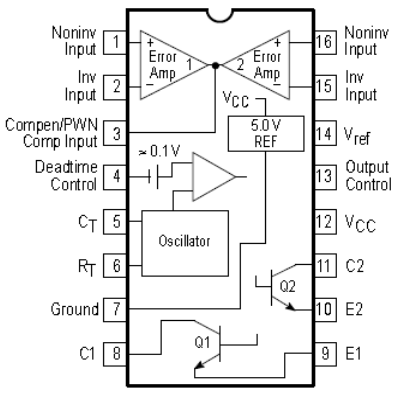
SEMICONDUCTOR
TECHNICAL DATA

D SUFFIX
PLASTIC PACKAGE
CASE 751B
(SO–16)



N SUFFIX
PLASTIC PACKAGE
CASE 648

PIN CONNECTIONS



(Top View)

ORDERING INFORMATION

Device	Operating Temperature Range	Package
TL494CD	T_A = 0° to +70°C	SO–16
TL494CN		Plastic
TL494IN	T_A = – 25° to +85°C	Plastic

 Rev 1

TL494 是一种固定频率脉宽调制电路，它主要为开关电源电路而设计。

- 集成了全部的脉宽调制电路
- 内置主从振荡器
- 内置误差放大器
- 内置 5.0V 参考基准电压源
- 可调整死区时间
- 内置功率晶体管可提供最大 500mA 的驱动能力
- 输出可控制推拉电路或单端电路
- 欠压保护

最大额定值：

unless otherwise noted.)

Rating	Symbol	TL494C	TL494I	Unit
Power Supply Voltage	V_{CC}	42		V
Collector Output Voltage	V_{C1}, V_{C2}	42		V
Collector Output Current (Each transistor) (Note 1)	I_{C1}, I_{C2}	500		mA
Amplifier Input Voltage Range	V_{IR}	–0.3 to +42		V
Power Dissipation @ $T_A \le 45°C$	P_D	1000		mW
Thermal Resistance, Junction–to–Ambient	$R_{\theta JA}$	80		°C/W
Operating Junction Temperature	T_J	125		°C
Storage Temperature Range	T_{stg}	–55 to +125		°C
Operating Ambient Temperature Range TL494C TL494I	T_A	 0 to +70 –25 to +85		°C
Derating Ambient Temperature	T_A	45		°C

注意：必须注意最大发热限制。

Power supply voltage:电源电压

Collector Output Voltage:集电极输出电压

Collector Output Current（Each transistor）：集电极输出电流（每一个管子）

Amplifier Input Voltage Range：输入放大器电压范围

Power Dissipation @ TA < 45°C：45℃下功率损耗

Thermal Resistance,Junction–to–Ambien：结对环境热敏阻抗

Operating Junction Temperature：结点工作温度

Storage Temperature Range：储存温度范围

Operating Ambient Temperature Range：运行环境范围

Derating Ambient Temperature：降额温度

推荐工作条件

Characteristics	Symbol	Min	Typ	Max	Unit
Power Supply Voltage	V_{CC}	7.0	15	40	V
Collector Output Voltage	V_{C1}, V_{C2}	–	30	40	V
Collector Output Current (Each transistor)	I_{C1}, I_{C2}	–	–	200	mA
Amplified Input Voltage	V_{in}	–0.3	–	V_{CC} – 2.0	V
Current Into Feedback Terminal	I_{fb}	–	–	0.3	mA
Reference Output Current	I_{ref}	–	–	10	mA
Timing Resistor	R_T	1.8	30	500	kΩ
Timing Capacitor	C_T	0.0047	0.001	10	μF
Oscillator Frequency	f_{osc}	1.0	40	200	kHz

电特性（VCC = 15 V, CT = 0.01uF, RT = 12 kW，无特殊说明下）

Characteristics	Symbol	Min	Typ	Max	Unit

参考区

Reference Voltage (I_O = 1.0 mA)	V_{ref}	4.75	5.0	5.25	V
Line Regulation (V_{CC} = 7.0 V to 40 V)	Reg_{line}	–	2.0	25	mV
Load Regulation (I_O = 1.0 mA to 10 mA)	Reg_{load}	–	3.0	15	mV
Short Circuit Output Current (V_{ref} = 0 V)	I_{SC}	15	35	75	mA

输出区

Collector Off–State Current (V_{CC} = 40 V, V_{CE} = 40 V)	$I_{C(off)}$	–	2.0	100	μA
Emitter Off–State Current V_{CC} = 40 V, V_C = 40 V, V_E = 0 V)	$I_{E(off)}$	–	–	–100	μA
Collector–Emitter Saturation Voltage (Note 2) Common–Emitter (V_E = 0 V, I_C = 200 mA) Emitter–Follower (V_C = 15 V, I_E = –200 mA)	 $V_{sat(C)}$ $V_{sat(E)}$	 – –	 1.1 1.5	 1.3 2.5	V
Output Control Pin Current Low State (V_{OC} ≤ 0.4 V) High State (V_{OC} = V_{ref})	 I_{OCL} I_{OCH}	 – –	 10 0.2	 – 3.5	 μA mA
Output Voltage Rise Time Common–Emitter (See Figure 12) Emitter–Follower (See Figure 13)	t_r	 – –	 100 100	 200 200	ns
Output Voltage Fall Time Common–Emitter (See Figure 12) Emitter–Follower (See Figure 13)	t_f	 – –	 25 40	 100 100	ns

误差放大区

Input Offset Voltage ($V_{O\ (Pin\ 3)}$ = 2.5 V)	V_{IO}	–	2.0	10	mV
Input Offset Current ($V_{O\ (Pin\ 3)}$ = 2.5 V)	I_{IO}	–	5.0	250	nA
Input Bias Current ($V_{O\ (Pin\ 3)}$ = 2.5 V)	I_{IB}	–	–0.1	–1.0	μA
Input Common Mode Voltage Range (V_{CC} = 40 V, T_A = 25°C)	V_{ICR}		–0.3 to V_{CC}–2.0		V
Open Loop Voltage Gain (ΔV_O = 3.0 V, V_O = 0.5 V to 3.5 V, R_L = 2.0 kΩ)	A_{VOL}	70	95	–	dB
Unity–Gain Crossover Frequency (V_O = 0.5 V to 3.5 V, R_L = 2.0 kΩ)	f_{C-}	–	350	–	kHz
Phase Margin at Unity–Gain (V_O = 0.5 V to 3.5 V, R_L = 2.0 kΩ)	ϕ_m	–	65	–	deg.
Common Mode Rejection Ratio (V_{CC} = 40 V)	CMRR	65	90	–	dB
Power Supply Rejection Ratio (ΔV_{CC} = 33 V, V_O = 2.5 V, R_L = 2.0 kΩ)	PSRR	–	100	–	dB
Output Sink Current ($V_{O\ (Pin\ 3)}$ = 0.7 V)	I_{O-}	0.3	0.7	–	mA
Output Source Current ($V_{O\ (Pin\ 3)}$ = 3.5 V)	I_{O+}	2.0	–4.0	–	mA

PWM 比较区（图 11 测试电路）

Input Threshold Voltage (Zero Duty Cycle)	V_{TH}	–	2.5	4.5	V
Input Sink Current ($V_{(Pin\ 3)}$ = 0.7 V)	I_{I-}	0.3	0.7	–	mA

死区电压控制区（图 11 测试电路）

Input Bias Current (Pin 4) ($V_{Pin\ 4}$ = 0 V to 5.25 V)	$I_{IB\ (DT)}$	–	–2.0	–10	μA
Maximum Duty Cycle, Each Output, Push–Pull Mode ($V_{Pin\ 4}$ = 0 V, C_T = 0.01 μF, R_T = 12 kΩ) ($V_{Pin\ 4}$ = 0 V, C_T = 0.001 μF, R_T = 30 kΩ)	DC_{max}	 45 –	 48 45	 50 50	%
Input Threshold Voltage (Pin 4) (Zero Duty Cycle) (Maximum Duty Cycle)	V_{th}	 – 0	 2.8 –	 3.3 –	V

振荡区

Frequency (C_T = 0.001 μF, R_T = 30 kΩ)	f_{osc}	–	40	–	kHz
Standard Deviation of Frequency* (C_T = 0.001 μF, R_T = 30 kΩ)	σf_{osc}	–	3.0	–	%
Frequency Change with Voltage (V_{CC} = 7.0 V to 40 V, T_A = 25°C)	Δf_{osc} (ΔV)	–	0.1	–	%
Frequency Change with Temperature (ΔT_A = T_{low} to T_{high}) (C_T = 0.01 μF, R_T = 12 kΩ)	Δf_{osc} (ΔT)	–	–	12	%

欠压保护区

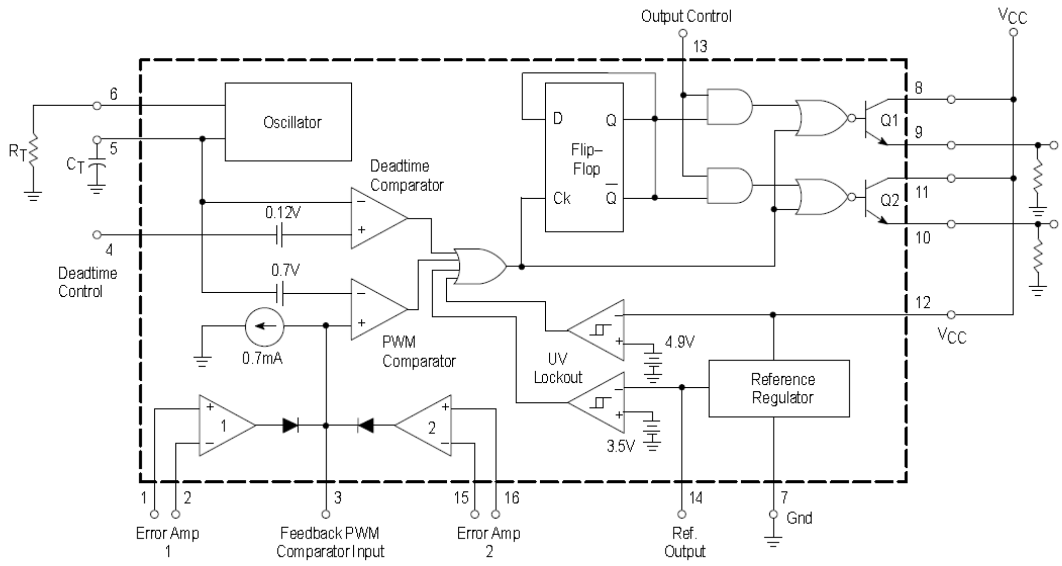
Turn–On Threshold (V_{CC} increasing, I_{ref} = 1.0 mA)	V_{th}	5.5	6.43	7.0	V

整个器件

Standby Supply Current (Pin 6 at V_{ref}, All other inputs and outputs open) (V_{CC} = 15 V) (V_{CC} = 40 V)	I_{CC}	 – –	 5.5 7.0	 10 15	mA
Average Supply Current (C_T = 0.01 μF, R_T = 12 kΩ, $V_{(Pin\ 4)}$ = 2.0 V) (V_{CC} = 15 V) (See Figure 12)		–	7.0	–	mA

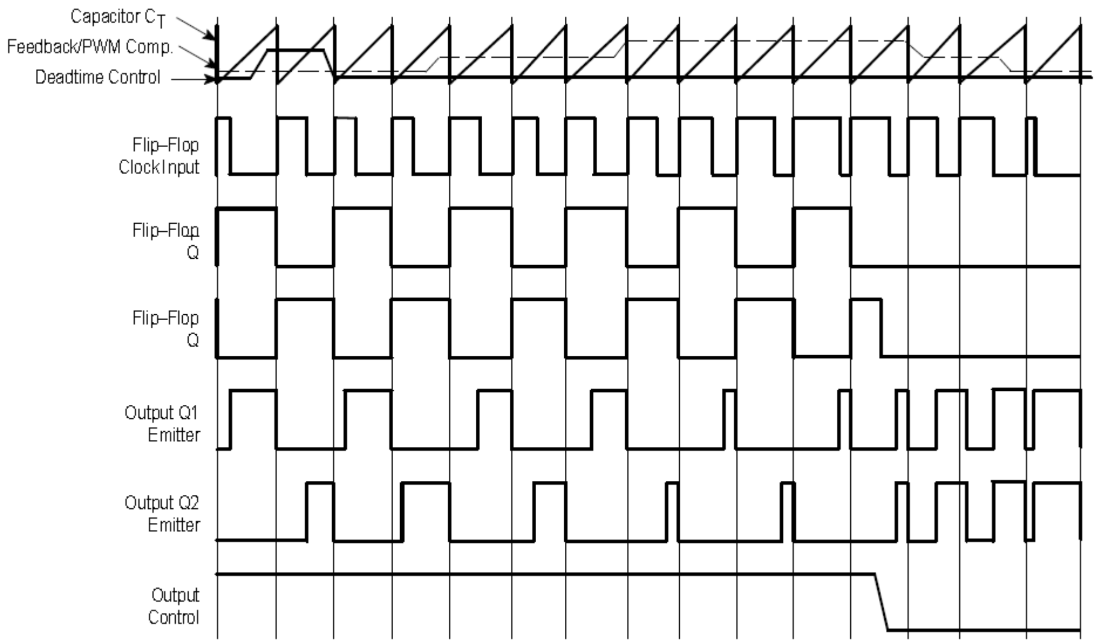
*标准差是一种平均统计分布，从右公式得来：$\sigma \sqrt{\frac{\sum_{n=1}^{N}(x_n-\overline{X})^2}{N-1}}$

图 1.典型代表方框图



此器件包含 46 个有效晶体管

图 2.时序图



应用资料

TL494 是一个固定频率的脉冲宽度调制电路，内置线性锯齿波振荡器，振荡频率可通过外部的电阻 R_T 和电容 C_T 来进行调节，其振荡频率为：

$$f_{osc} \approx \frac{1.1}{R_T \cdot C_T}$$

输出脉冲的宽度是通过电容 C_T 上的正极性锯齿波电压与另外两个控制信号进行比较来实现。功率输出管 Q1 和 Q2 受或非门控制，仅当双稳触发器的时钟信号为低电平时才工作，亦即锯齿波电压大于控制信号期间工作。因此，当控制信号增大时，输出的脉冲宽度将减小（参见图 2）。

控制信号由集成电路外部输入，一路送至死区电压比较器，一路送往误差放大器输入端。死区电压比较器具有 120mv 的输入补偿电压，它限制了最小输出死区时间约等于锯齿波周期的 4%。当输出控制端接地，最大输出占空比为 96%，接参考电压时，占空比为 48%。当把死区时间控制输入端接上固定电压（范围在 0~3.3V 之间）时，即能在输出脉冲上产生附加的死区时间。

脉冲宽度比较器为误差放大器调节输出宽度提供了一种手段。当反馈电压从 0.5V 变化到 3.5V 时，输出的脉冲宽度从被死区确定的最大导通百分比下降到 0。两个误差放大器有相同的电压输入范围，从-0.3 到 V_{CC}-2，这可被用于检测电源的输出电压和电流。误差放大器的输出端常处于高电平，它与脉冲宽度调制器的反相输入端进行或运算。使用这种结构，放大器只需最小的输出即可支配控制回路。

当电容 C_T 放电，一个正脉冲出现在死区比较器的输出端，受脉冲约束的双稳触发器进行计时，同时停止输出管 Q1 和 Q2 的工作。若输出控制端连接到参考电压源，那么脉冲交替输至两个输出晶体管，输出频率等于脉冲振荡器的频率的一半。如果工作在单端状态，且最大占空比为 50%时，输出驱动信号分别从晶体管 Q1 和 Q2 取得，输出变压器一个反馈绕组及二极管提供反馈电压。在单端工作模式下，当需要更高的驱动电流输出，亦可将 Q1 和 Q2 并联使用，这时，需要将输出模式控制脚接地以关闭双稳触发器，此状态下，输出频率等于振荡器的频率。

TL494 内置一个 5.0V 的基准电压源，使用外置偏置电路时，可提供高达 10mA 的负载电流。在典型的 0~70℃温度条件下，该基准电源能提供±5%的精确度。

图 3.振荡器频率与定时电阻关系

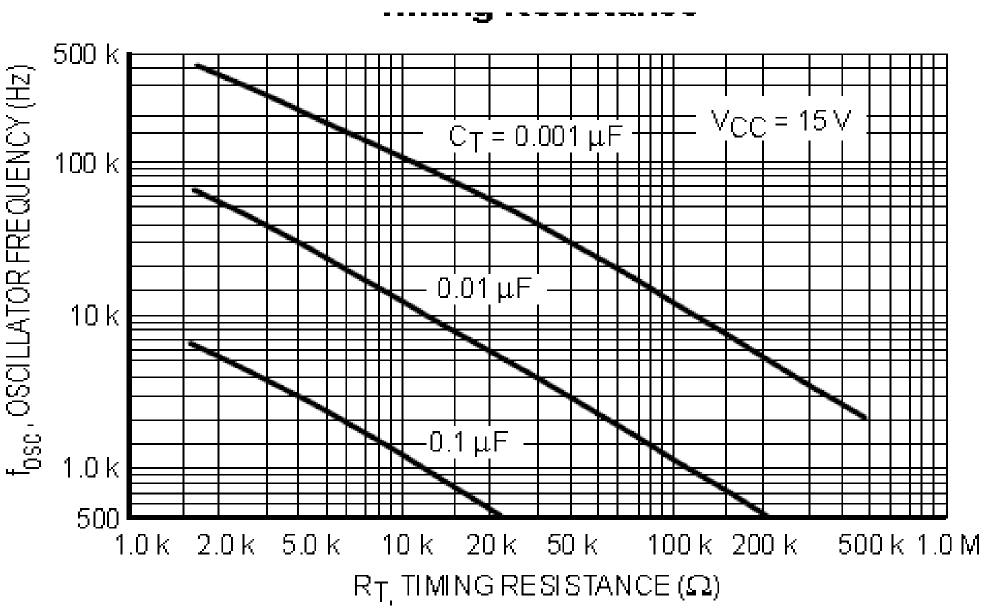


图 4.开环电压增益、相位与频率关系

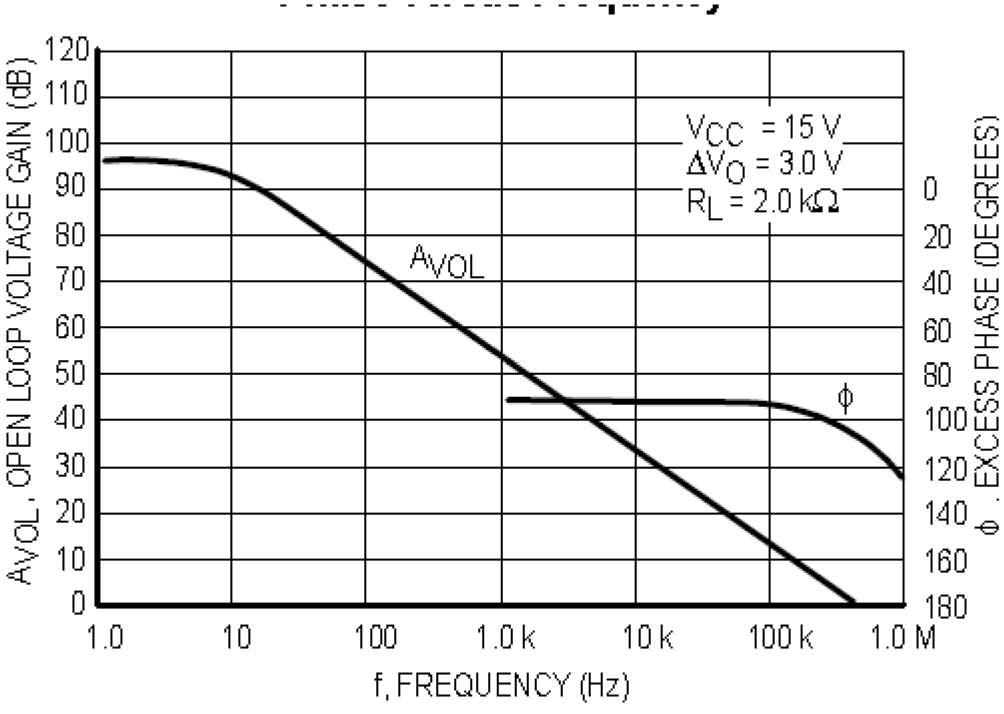


图 5.死区时间百分比与振荡频率关系

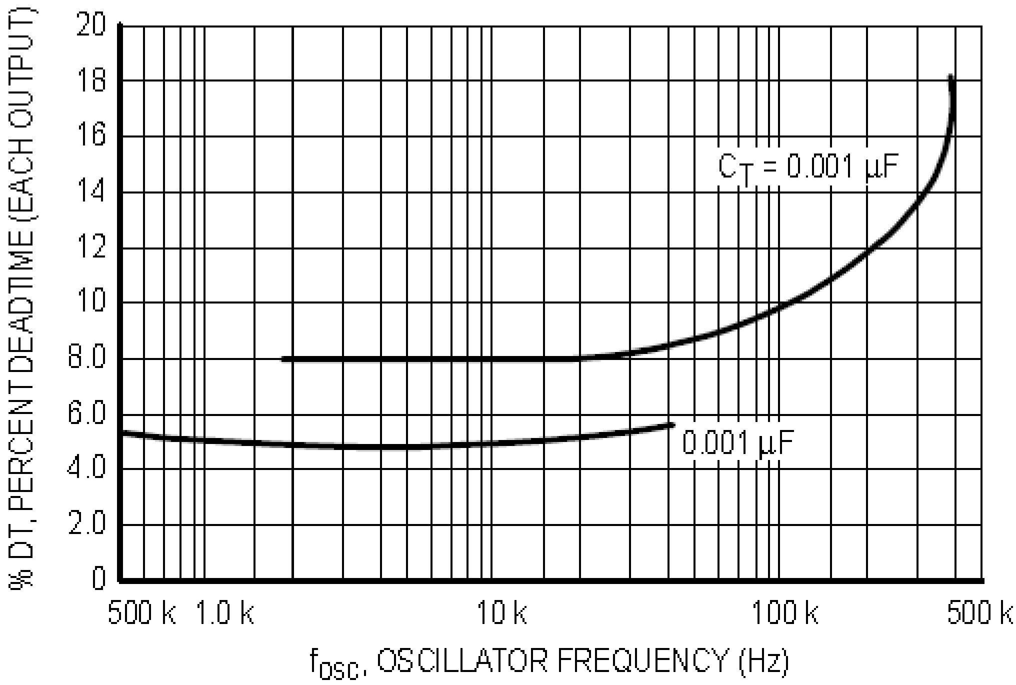


图 6.占空比和死区时间控制电压关系

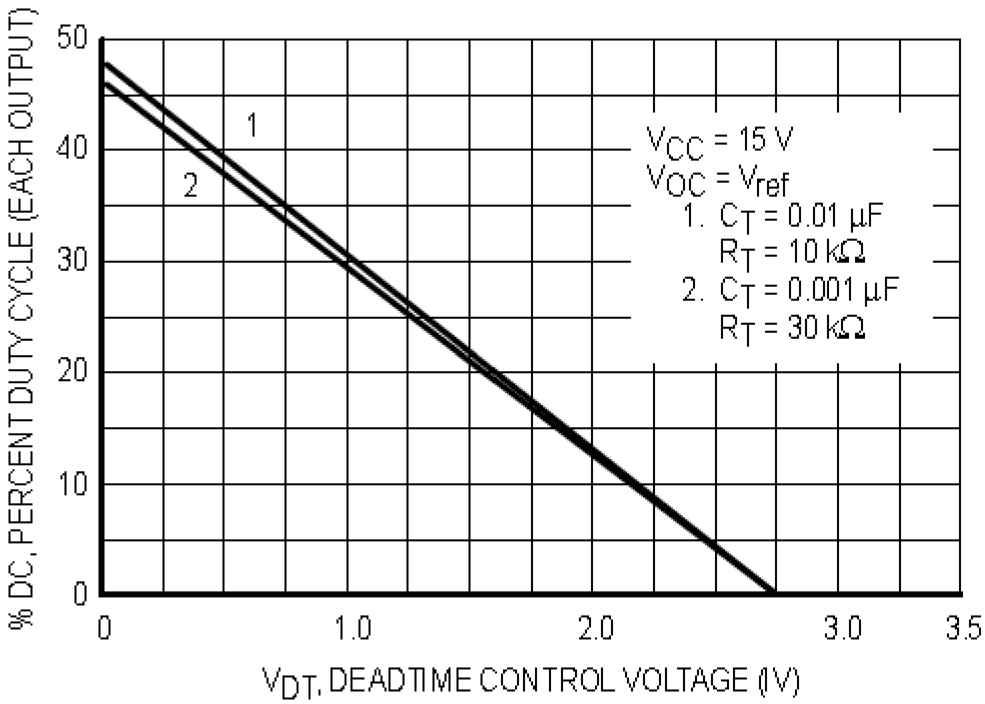


图 7.射极跟随器输出饱和电压和射极电流关系

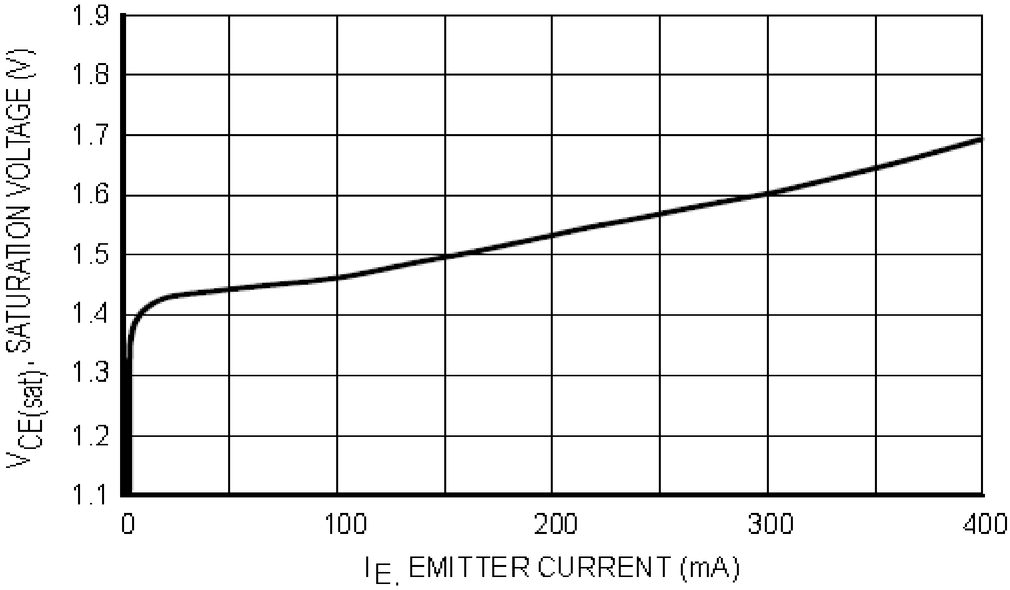


图 8.共射极结构输出饱和电压和集电极电流关系

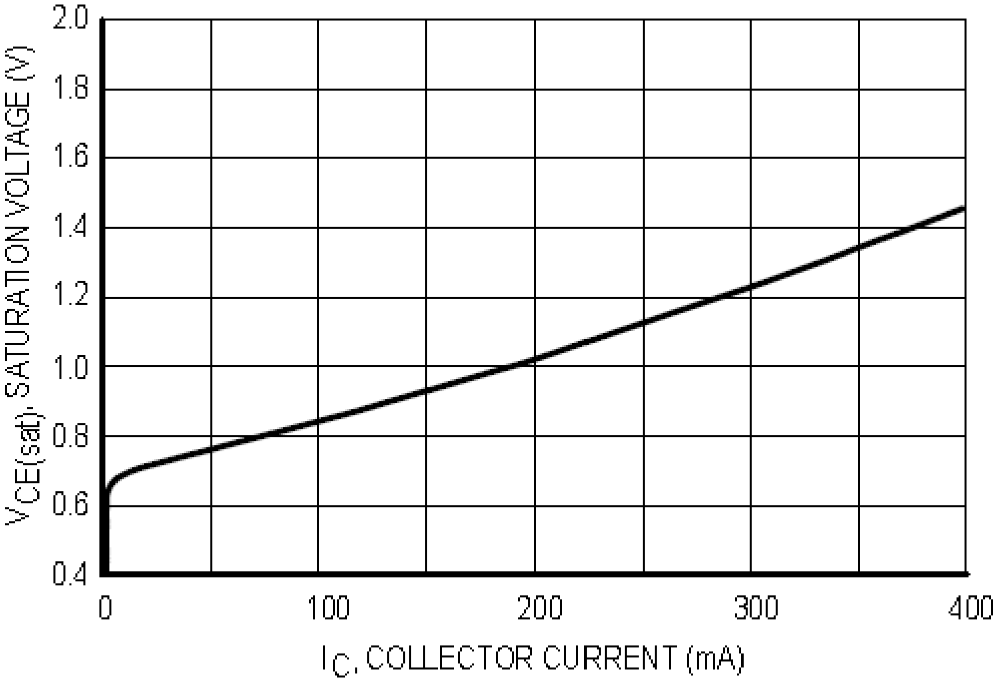


图 9 待机电源电源电流和电源电压关系

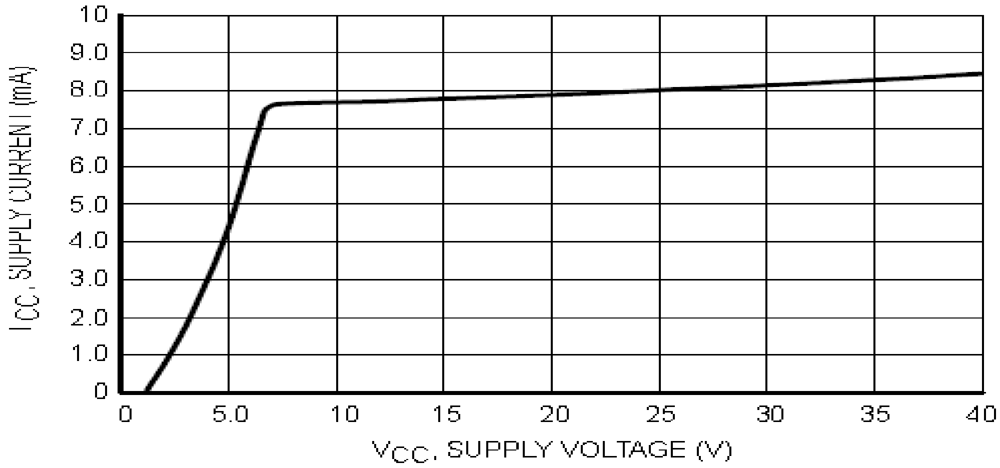


图 10.误差放大器特性

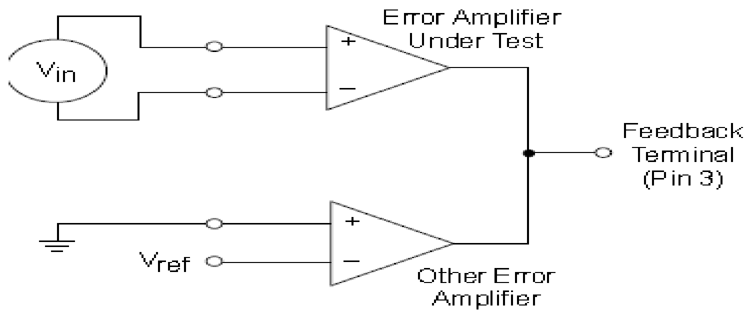


图 11.死区时间和反馈控制电路

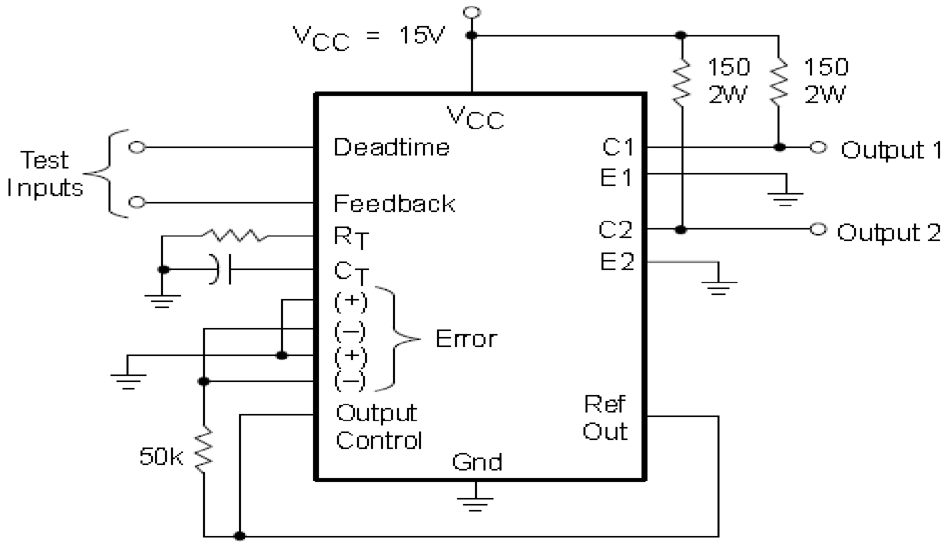


图 12.共射极电路结构测试电路和波形

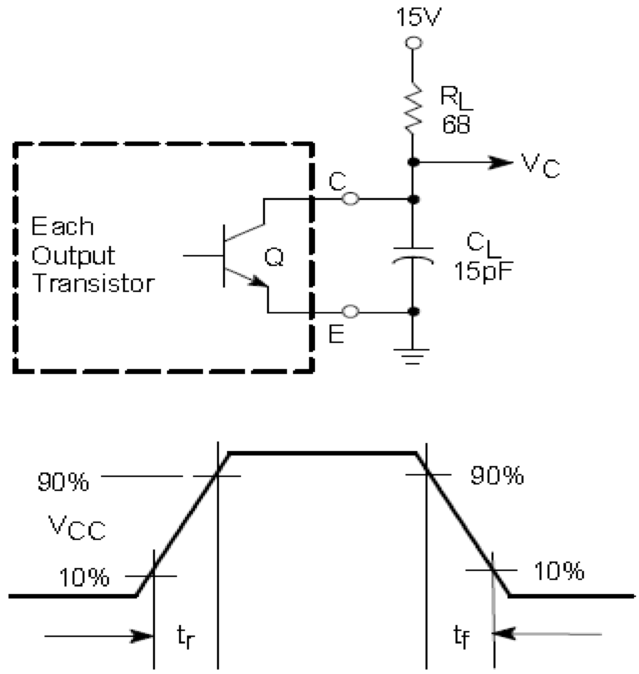


图 13.射极跟随器结构测试电路和波形

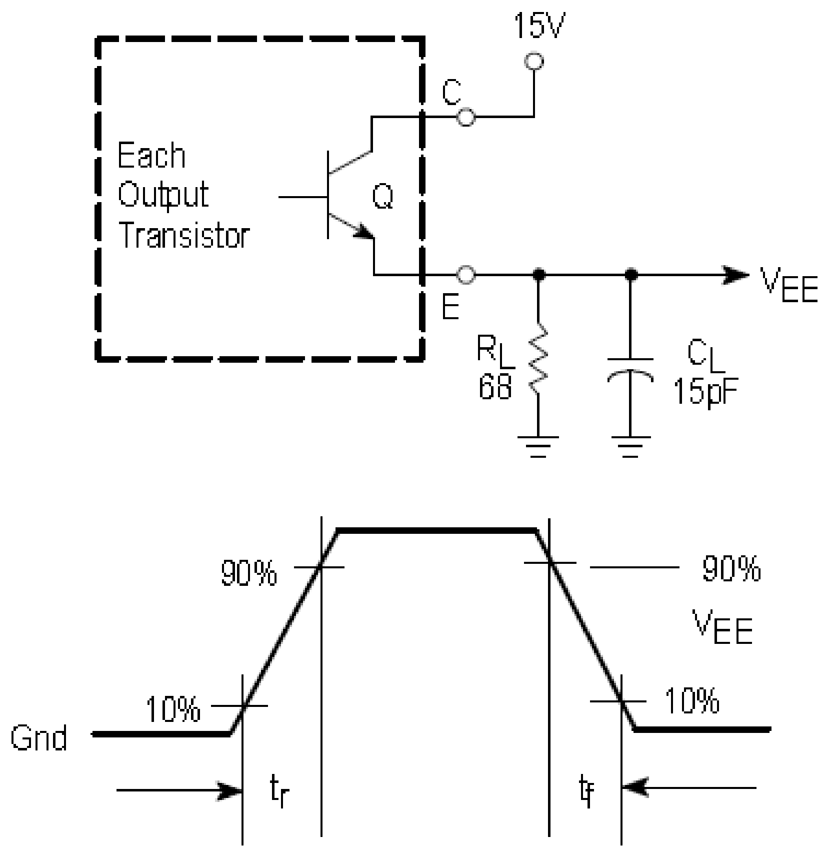
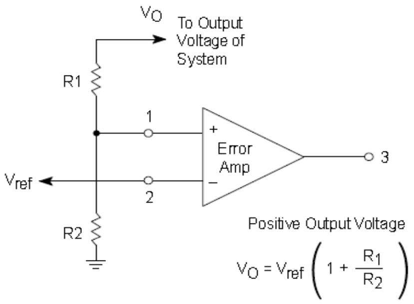


图 14.误差放大器检测技术



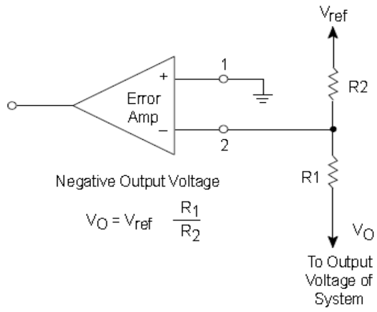


图 15.死区时间控制电路

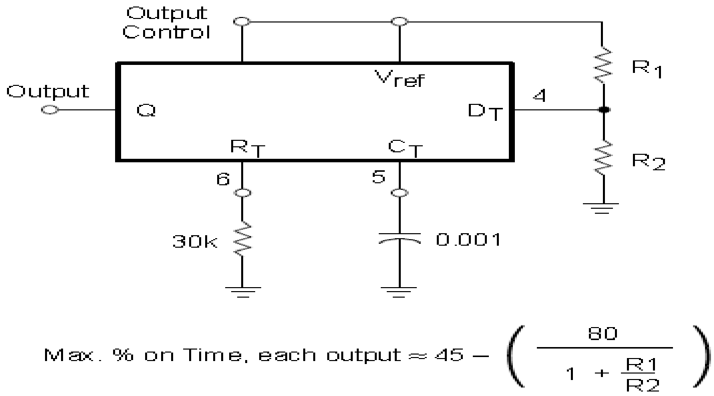


图 16.软启动电路

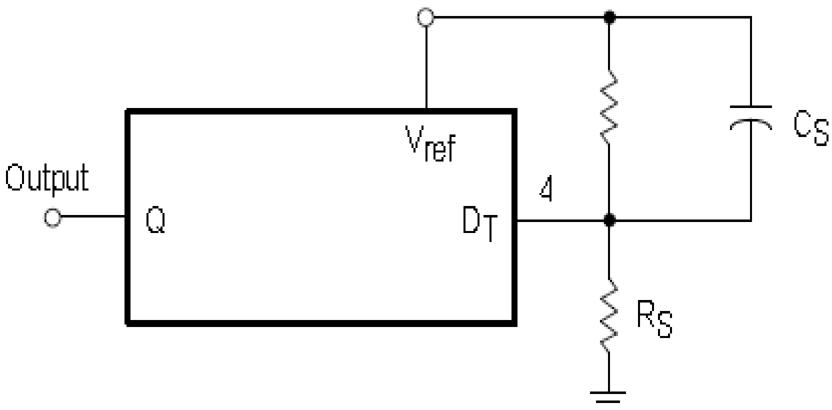


图 17.单端输出连接和推拉结构

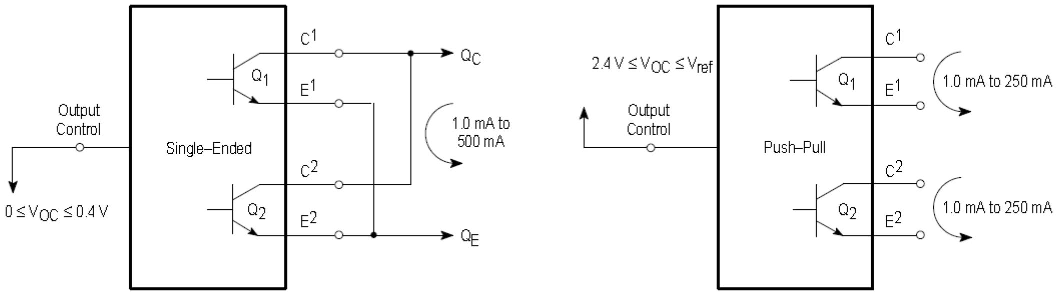


图 18.驱动两个或者多个控制电路

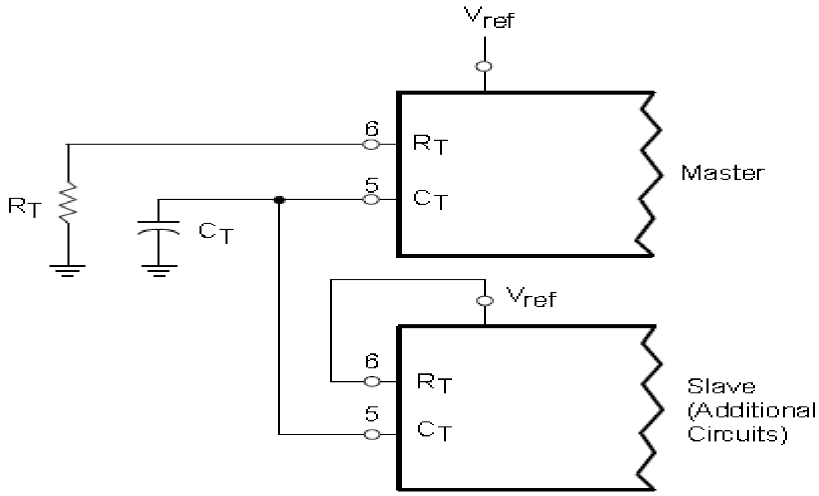


图 19.在电压>40V 时使用齐纳二极管工作

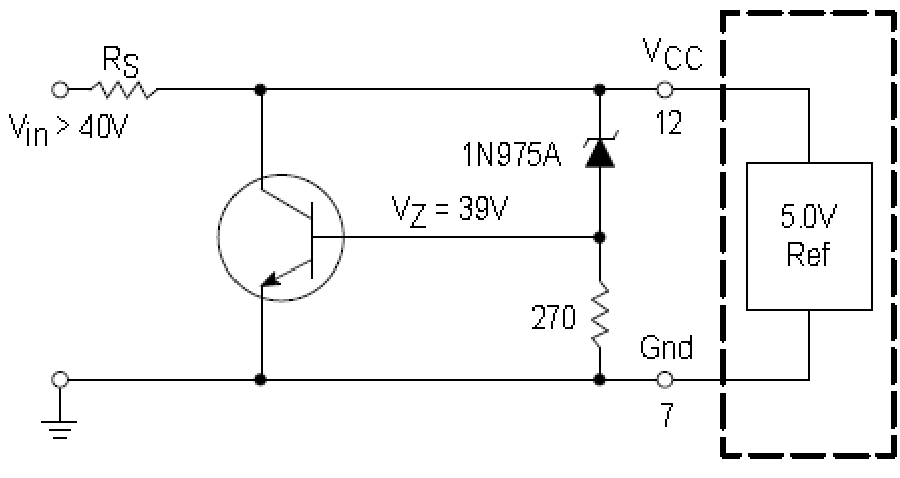
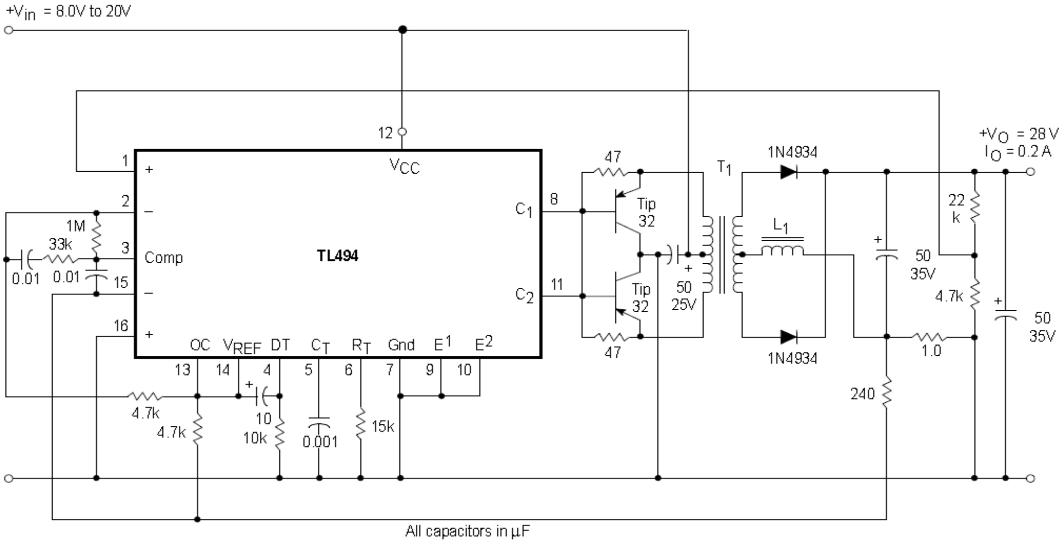


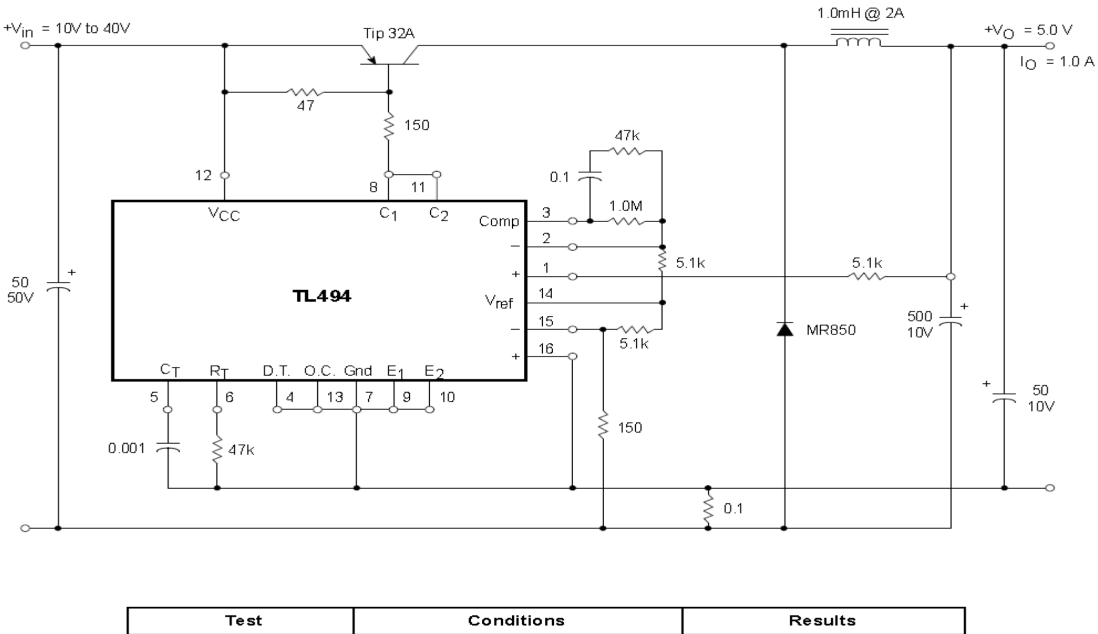
图 20.脉宽调制式推拉转换器



Test	Conditions	Results
Line Regulation	V_{in} = 10 V to 40 V	14 mV 0.28%
Load Regulation	V_{in} = 28 V, I_O = 1.0 mA to 1.0 A	3.0 mV 0.06%
Output Ripple	V_{in} = 28 V, I_O = 1.0 A	65 mV pp P.A.R.D.
Short Circuit Current	V_{in} = 28 V, R_L = 0.1 Ω	1.6 A
Efficiency	V_{in} = 28 V, I_O = 1.0 A	71%

L1 – 3.5 mH @ 0.3 A
T1 – Primary: 20T C.T. #28 AWG
Secondary: 12OT C.T. #36 AWG
Core: Ferroxcube 1408P–L00–3CB

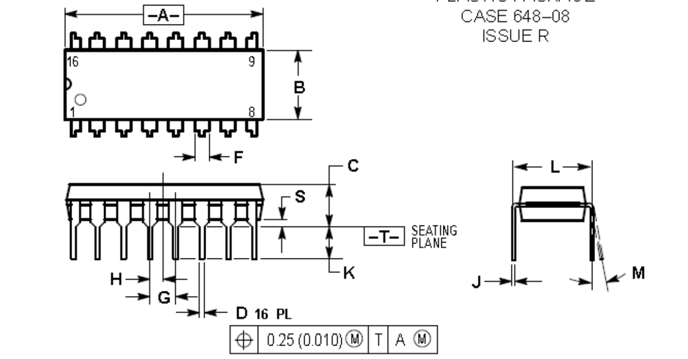
图 21.PWM 降压电路



Test	Conditions	Results
Line Regulation	V_{in} = 8.0 V to 40 V	3.0 mV 0.01%
Load Regulation	V_{in} = 12.6 V, I_O = 0.2 mA to 200 mA	5.0 mV 0.02%
Output Ripple	V_{in} = 12.6 V, I_O = 200 mA	40 mV pp P.A.R.D.
Short Circuit Current	V_{in} = 12.6 V, R_L = 0.1 Ω	250 mA
Efficiency	V_{in} = 12.6 V, I_O = 200 mA	72%

外形尺寸

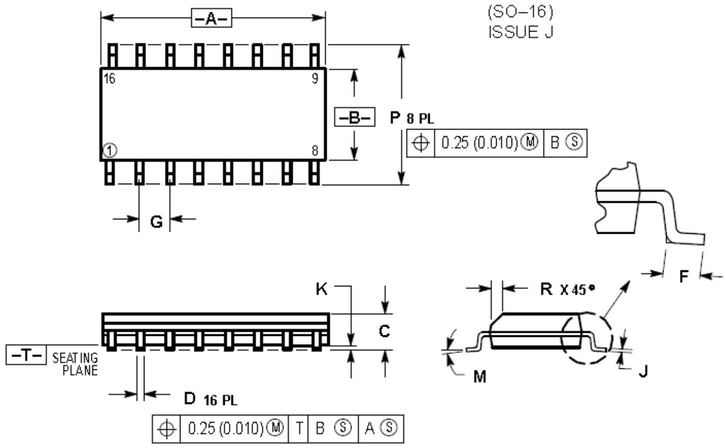
N SUFFIX
PLASTIC PACKAGE
CASE 648–08
ISSUE R



NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: INCH.
3. DIMENSION L TO CENTER OF LEADS WHEN FORMED PARALLEL.
4. DIMENSION B DOES NOT INCLUDE MOLD FLASH.
5. ROUNDED CORNERS OPTIONAL.

	INCHES		MILLIMETERS	
DIM	MIN	MAX	MIN	MAX
A	0.740	0.770	18.80	19.55
B	0.250	0.270	6.35	6.85
C	0.145	0.175	3.69	4.44
D	0.015	0.021	0.39	0.53
F	0.040	0.70	1.02	1.77
G	0.100 BSC		2.54 BSC	
H	0.050 BSC		1.27 BSC	
J	0.008	0.015	0.21	0.38
K	0.110	0.130	2.80	3.30
L	0.295	0.305	7.50	7.74
M	0°	10°	0°	10°
S	0.020	0.040	0.51	1.01

D SUFFIX
PLASTIC PACKAGE
CASE 751B–05
(SO–16)
ISSUE J



NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: MILLIMETER.
3. DIMENSIONS A AND B DO NOT INCLUDE MOLD PROTRUSION.
4. MAXIMUM MOLD PROTRUSION 0.15 (0.006) PER SIDE.
5. DIMENSION D DOES NOT INCLUDE DAMBAR PROTRUSION. ALLOWABLE DAMBAR PROTRUSION SHALL BE 0.127 (0.005) TOTAL IN EXCESS OF THE D DIMENSION AT MAXIMUM MATERIAL CONDITION.

	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	9.80	10.00	0.386	0.393
B	3.80	4.00	0.150	0.157
C	1.35	1.75	0.054	0.068
D	0.35	0.49	0.014	0.019
F	0.40	1.25	0.016	0.049
G	1.27 BSC		0.050 BSC	
J	0.19	0.25	0.008	0.009
K	0.10	0.25	0.004	0.009
M	0°	7°	0°	7°
P	5.80	6.20	0.229	0.244
R	0.25	0.50	0.010	0.019