PROMAX-JOHNTON

PJ494

Switchmode Pulse Width Modulation Control Circuit

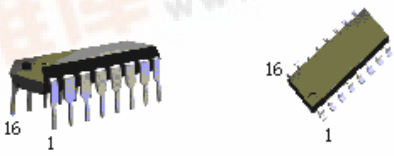
The PJ494 incorporates on a single monolithic chip all the functions required in the construction of a pulse-width-modulation control circuit. Designed primarily for power supply control, these devices offer the systems engineer the flexibility to tailor the power supply control circuitry to his application.

The PJ494 contains an error amplifier, an on-chip adjustable oscillator, a deed-time control comparator, pulse-steering control flip-flop, a 5-volt, 5% precision regulator, and output-control circuits. The error amplifier exhibits a common-mode voltage from –0.3 volts to Vcc –2 volts. The dead-time control comparator has a fixed offset that provides approximately 5% dead time when externally altered. The on-chip oscillatory be bypassed by terminating R_T (pin 6) to the reference output and providing a sawtooth input to C_T (PIN 5), or it may be used to drive the common circuits in synchronous multiple-rail power supplies. The uncommited output transistor provide either common-emitter or emitter-follower output capability. Each device provides for push-pull or single-ended output operation, which may be selected through the output-control function. The architecture of these devices prohibits the possibility of either output being pulsed twice during push-pull operation.

FEATURES

- Complete PWM Power Control Circuitry
- Uncommitted Outputs for 200mA Sink or Source Current
- Output Control Selects Single-Ended or Push –Pull Operation
- Internal Circuitry Prohibits Double Pulse at Either Output
- Variable Dead-Time Provides Control over Total Range
- Internal Regulator Provides a Stable 5-V Reference Supply, 5%

DIP-16 SOP-16



Pin 1.Noninv Input } Error Amp1
2.Inv Input
3.Feedback 4.Dead-Time Control
5.C_T 6.R_T 7.Gnd
8.C1 9.E1 10.E2
11.C2 12.Vcc
13.Output Control 14.Ref Out
15. Inv Input
16. Noninv Input } Error Amp2

ORDERING INFORMATION

Device	OperatingTemperature (Ambient)	Package
PJ494CD	-20℃ to +85℃	DIP-16
PJ494CS		SOP-16

ABSOLUTE MAXIMUM RATINGS OVER OPERATING FREE-AIR TEMPERATURE RANGE

(unless otherwise noted)

Rating	Symbol	Value	Unit
Supply voltage	Vcc	41	V
Amplifier input voltage	Vi	Vcc+0.3	
Collector output voltage	Vo	41	
Collector output current		250	mA
Operating free-air temperature range		-20 to 85	℃
Storage temperature range	T_{stg}	-25 to 125	
Operating Junction Temperature	T_J	125	
Lead temperature 1,6mm from case for 10 seconds		260	
Power Dissipation @T_A≦45℃	P_D	1000	mW

PROMAX-JOHNTON

PJ494

Switchmode Pulse Width Modulation Control Circuit

RECOMMENDED OPERATING CONDITIONS

Parameter	Symbol	Min	Max	Unit
Supply voltage	Vcc	7	40	V
Amplifier input voltage	Vi	-0.3	Vcc-2	
Collector output voltage	Vo		40	
Collector output current(each transistor)			200	mA
Current into feedback terminal			0.3	
Timing capacitor	C_T	0.47	10000	nF
Timing resistor	R_T	1.8	500	KΩ
Oscillator frequency		1	300	KHz
Operating free-air temperature	T_A	0	70	℃

ELECTRICAL CHARACTERISTICS OVER RECOMMENDED OPERATING FREE-AIR TEMPERATURE

Vcc=15V, f=10KHz (unless otherwise noted).

REFERENCE SECTION

Parameter	Test Conditions*	Value			Unit
		Min	Typ	Max	
Output voltage(Vref)	Io=1mA	4.75	5	5.25	V
Line regulation	Vcc=7V to 40V	--	2.0	25	mV
Load regulation	Io=1mA to 10mA	--	3.0	15	
Output voltage change with temperature	ΔT_A=MIN to MAX	--	0.2	1	%
Short-circuit output current***	Vref=0	15	35	75	mA

OSCILLATOR SECTION

Parameter	Test Conditions*	Value			Unit
		Min	Typ	Max	
Frequency	C_T=0.001μF,R_T=30KΩ	--	40	--	KHz
Standard deviation of frequency****	C_T=0.001μF,R_T=30KΩ	--	3.0	--	%
Frequency change with voltage	Vcc=7V to 40V, T_A=25℃	--	0.1	--	
Frequency change with temperature***	C_T=0.001μF,R_T=30KΩ ΔT_A=MIN to MAX	--	--	12	

ERROR AMPLIFIER SECTION

Parameter	Test Conditions*	Value			Unit
		Min	Typ**	Max	
Input offset voltage	Vo=(pin 3)=2.5V	--	2.0	10	mA
Input offset current	Vo=(pin 3)=2.5V	--	5.0	250	nA
Input bias current	Vo=(pin 3)=2.5V	--	-0.1	-1.0	μA
Common-mode input voltage range	Vcc=7V to 40V	-0.3 toV_{cc}-2			V
Open-loop voltage amplification	ΔVo=3V,R_L=2KΩ,Vo=0.5 to 3.5V	70	95	--	dB
Unity-gain bandwidth	R_L=2KΩ,Vo=0.5 to 3.5V	--	800	--	KHz
Common-mode rejection ratio	ΔVo=40V, T_A=25℃	65	90	--	dB
Power Supplu Rejection Ratio	ΔVcc=33V,Vo=2.5V,R_L=2KΩ	--	100	--	dB
Output sink current (pin 3)	V_{ID}=-15mV to -5V,$V_{(PIN3)}$=0.7V	0.3	0.7	--	mA
Output source current (pin 3)	V_{ID}=15mV to 5V,$V_{(PIN3)}$=3.5V	2.0	-4.0	--	mA

OUTPUT SECTION

Parameter		Test Conditions	Value			Unit
			Min	Typ	Max	
Collector off-state current		V_{CE}=40V,V_{CC}=40V	--	2.0	100	μA
Emitter off-state current		Vcc=Vc=40V, V_E=0	--	--	-100	
Collector-emitter saturation voltage	Common-emitter	V_E=0, Ic=200mA	--	1.1	1.3	V
	Emitter-follower	Vc=15V, I_E=-200mA	--	1.5	2.5	
Output control input current		V_I=Vref	--	--	3.5	mA

DEAD-TIME CONTROL SECTIONDead-time control-section (See Figure 11)

Parameter	Test Conditions	Value			Unit
		Min	Typ*	Max	
Input bias current (pin 4)	V_I=0 to 5.25V	--	-2.0	-10	μA
Maximum duty cycle, each output	V_I(pin 4)=0,C_T=0.1μF,R_T=12KΩ	--	45	50	%
Input threshold voltage(pin 4)	Zero duty cycle	--	3.0	3.3	V
	Maximum duty cycle	0	--	--	

PWM COMPARATOR SECTION (See Figure11)

Parameter	Test Conditions	Value			Unit
		Min	Typ*	Max	
Input threshold voltage (pin 3)	Zero duty cycle	--	4.0	4.5	V
Input sink current (pin 3)	V(pin 3)=0.7V	0.3	0.7	--	mA

TOTAL DEVICE

Parameter	Test Conditions		Value			Unit
			Min	Typ*	Max	
Standby supply current	Pin 6 at Vref, all other inputs and outputs open	Vcc=15V	--	6.0	10	mA
		Vcc=40V	--	9.0	15	
Average supply current	$V_{I(PIN4)}$=2V, See Figure 1		--	7.5	--	

SWITCHING CHARACTERISTICS, T_A=25℃

Parameter	Test Conditions	Value			Unit
		Min	Typ*	Max	
Output voltage rise time	Common-emitter configuration, See Figure 3	--	100	200	ns
Output voltage fall time		--	25	100	
Output voltage rise time	Emitter-follower configuration, See Figure 4	--	100	200	
Output voltage fall time		--	40	100	

UNDERVOLTAGE LOCKOUT SECTION

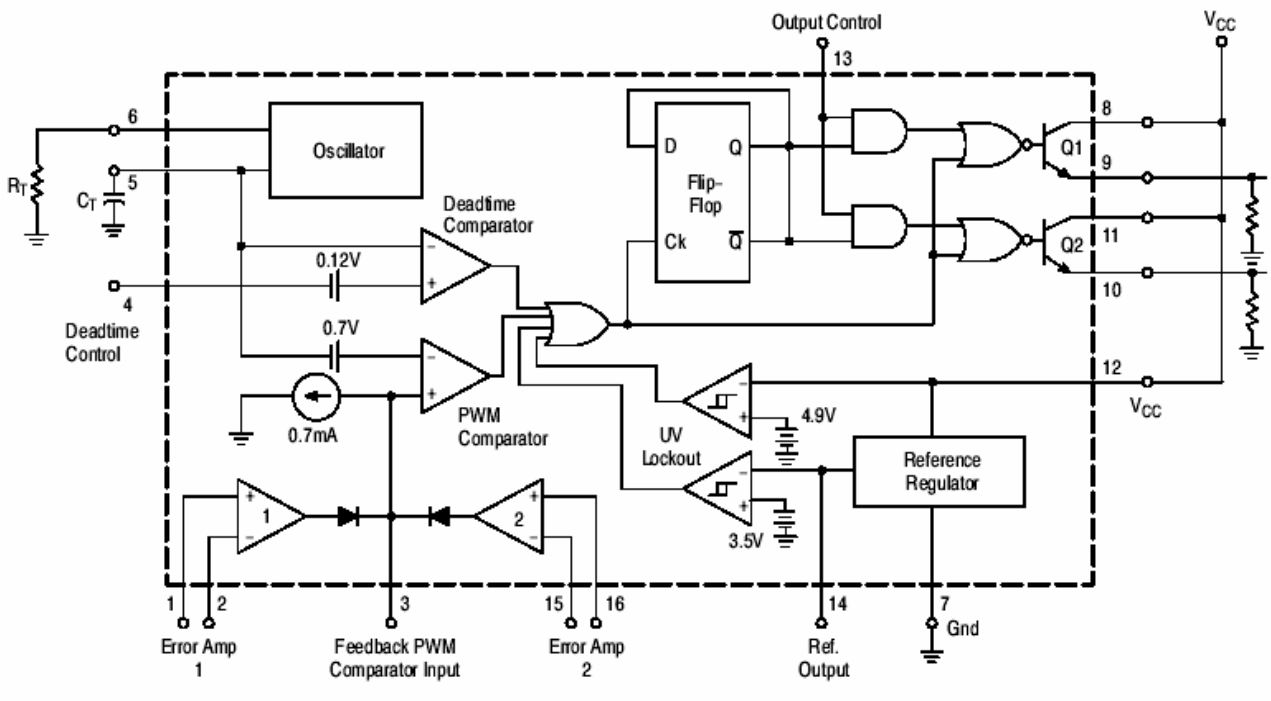
Parameter	Test Conditions	Value			Unit
		Min	Typ*	Max	
Turn-on Threshold	Vcc increasing Iref =1.0mA	5.5	6.43	7.0	V

- All typical value except for temperature coefficient are at T_A=25℃
- For conditions shown as MIN or MAX, use the appropriate value specified under recommended operating conditions.
- All typical values except for parameter changes with temperature are at T_A=25℃
- Duration of the short-circuit should not exceed one second
- Standard deviation is a measure of the statistical distribution about the mean as derived from the formula

$$\sigma = \left[\sum_{n=1}^{N} \frac{(x_n - \overline{x})^2}{N-1} \right]^{1/2}$$

- Temperature coefficient of timing capacitor and timing resistor not taken into account

FUNCTION BLOCK DIAGRAM



This device contained 46 active transistors

Figure 1. Representative Block Diagram

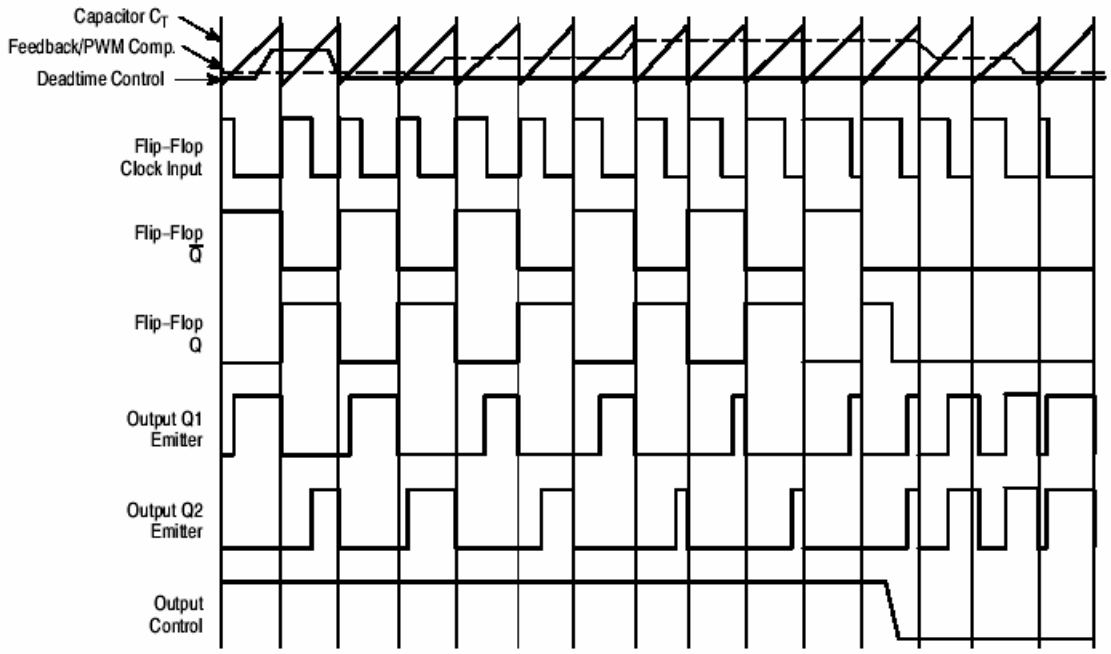


Figure 2. Timing Diagram

Switchmode Pulse Width Modulation Control Circuit

APPLICATIONS INFORMATION

Description

The PJ494 is a fixed-frequency pulse width modulation control circuit, incorporating the primary building blocks required for the control of a switching power supply . (See Figure 1.) An internal-linear sawtooth oscillator is frequescy-programmable by two external components, R_T and C_T. The approximate oscillator frequency is determined by:

$$f_{osc} \approx \frac{1.1}{R_T \bullet C_T}$$ ……. For more information refer to Figure 3.

Output pulse width modulation is accomplished by comparison of the positive sawtooth waveform across capacitor C_T to either of two control signals. The NOR gates, which drive output transistors Q1 and Q2, are enabled only when the flip-flop clock-input line is in its low state. This happens only during that portion of time when the sawtoothvoltage is greater than the control signals. Therefore, an increase in contro-signal amplitude causes a corresponding linear decrease of output pulse width. (Refer to the Timing Diagram shown in Figure 2.)

The control signals are external inputs that can be fed into the deadtime control, the error amplifier inputs, or the feedback input. The deadtime control comparator has an effective 120mV input offset which limits the minimum output deadtime to approximately tge first 4% of the sawtooth-cycle time. This would result in a maximum duty cycle on a given output of 96% with the output control grounded, and 48% with it connected to the reference line. Additional deadtime may be imposed on the output by setting the deadtime-control input to a fixed voltage, ranging between 0V to 3.3V .

Functional Table

Input/Output Controls	Output Function	$\frac{f_{out}}{f_{osc}}$ =
Grounded	Single–ended PWM @ Q1 and Q2	1.0
@ V_{ref}	Push–pull Operation	0.5

The pulse width modulator comparator provides a means for the error amplifiers to adjust the output pulse width from the maximum percent on-time, established by the deadtime control input, down to zero as the voltage at the feedback pin varies from 0.5V to 3.5V. Both error amplifiers have a common mode input range from -0.3C to (Vcc – 2V), and may be ised to sense power-supply output voltage and current. The error –amplifier outputs are active high and are ORed together at the noninverting input of the pulse-width modulator comparator. With this configuration, the amplifier that demands minimum output on time, dominates control of the loop.

When capacitor C_T is discharged, a positive pulse is generated on the output of the deadtime comparator, which clocks the pulse-steering flip=flop and inhibits the output transistors, Q1 and Q2. With the output-control connected to the reference line, the pulse-steering flip-flop directs the modulated pulses to each of the rwo output transistors alternately for push-pull operation. The output frequency is equal to half that of the oscillator. Output drive can also be taken from Q1 and Q2, when single-ended operation with a maximum on-time of less than 50% is required. This is desirable when the output transformer has a ringback winding with a catch diode ised for snubbing. When higher output-drive currents are required for single-ended operation, Q1 and Q2 may be connected in parallel, and the output mode pin must be tied to ground to disable the flip-flop. The output frequency will now be equal to that of the oscillator.

The PJ494 has an internal 5.0V reference capable of sourcing up to 10mA of laod current for external bias circuits. The reference has an internal accuracy of ±5.0% with a typical thermal drift of less than 50mV over an operating temperature range of 0 to 70℃.

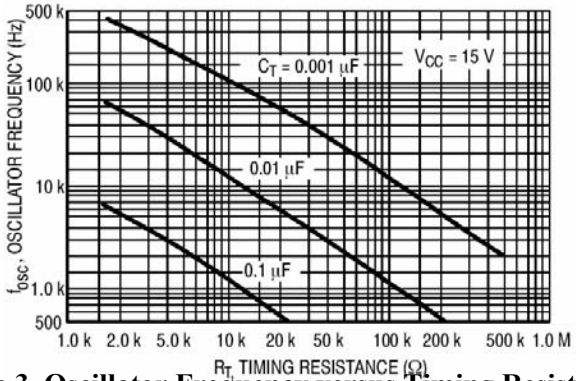


Figure 3. Oscillator Frequency versus Timing Resistance

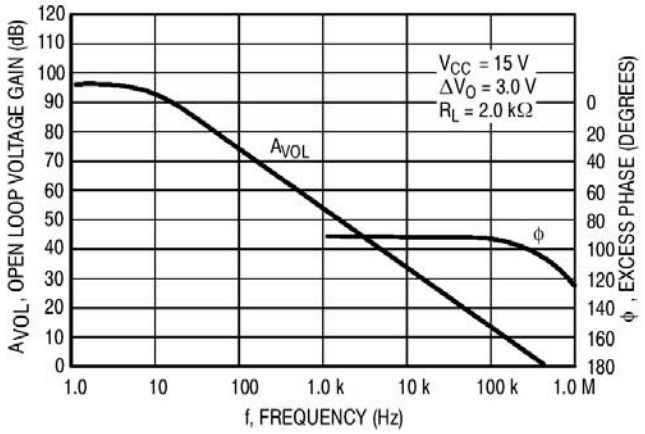


Figure 4. Open Loop Voltage Gain and Phase Versus Frequency

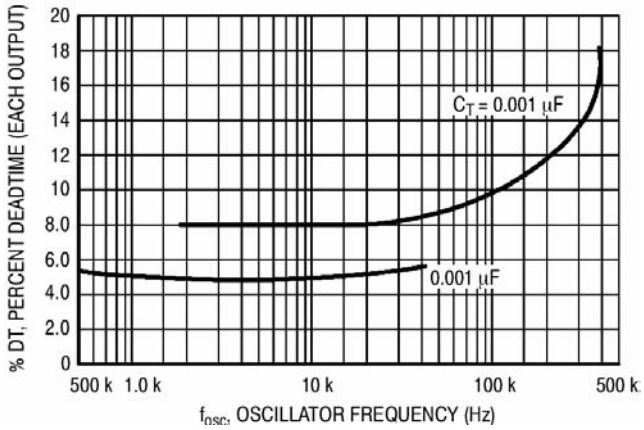


Figure 5. Percent Deadtime versus Oscillator Frequency

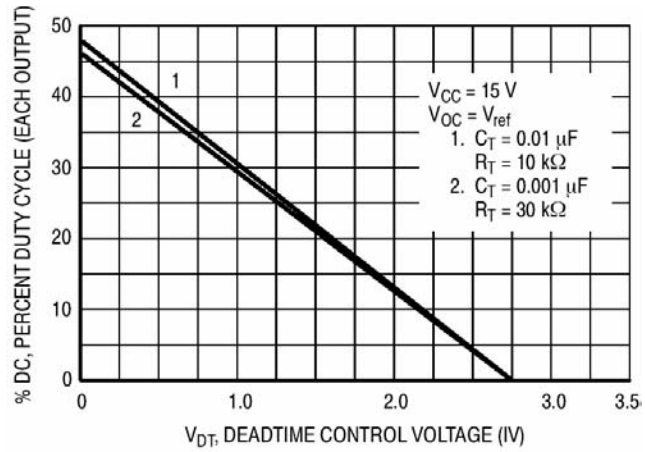


Figure 6. Percent Duty Cycle versus Deadtime Control Voltage

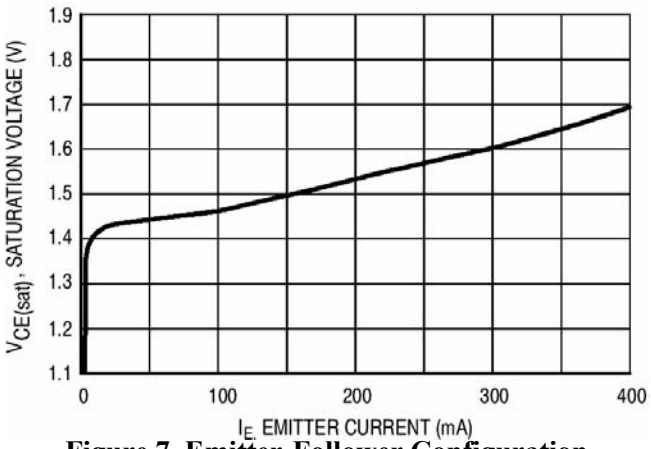


Figure 7. Emitter-Follower Configuration Output Saturation versus Emitter Current

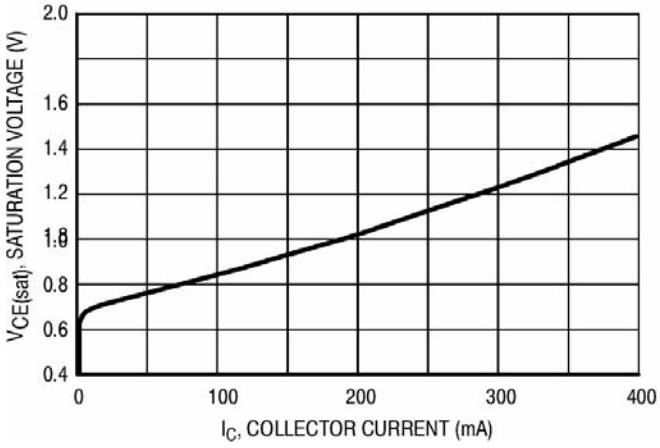


Figure 8. Common-Emitter Configuration Output Saturation Voltage versus Collector Current

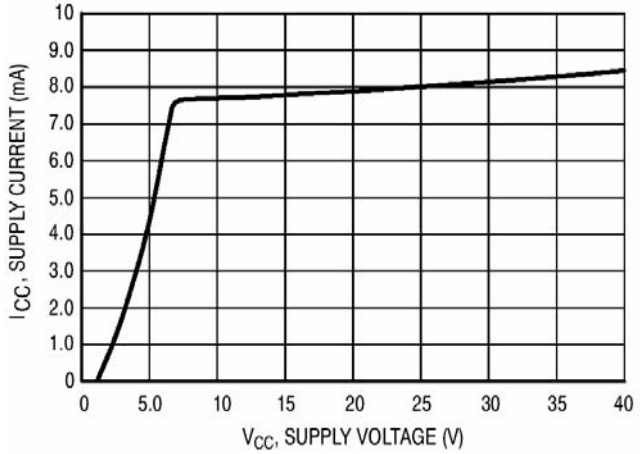


Figure 9. Standby Supply Current versus Supply Voltage

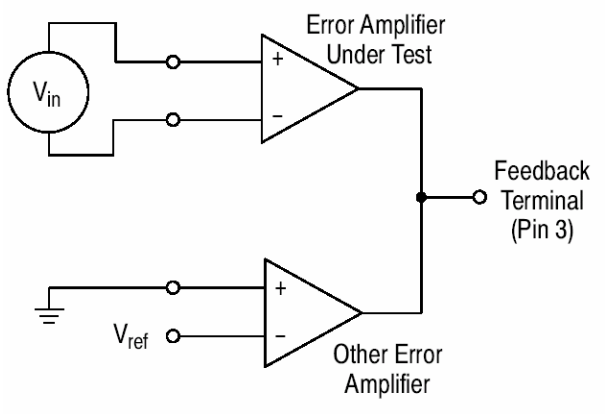


Figure 10. Error-Amplifier Characteristics

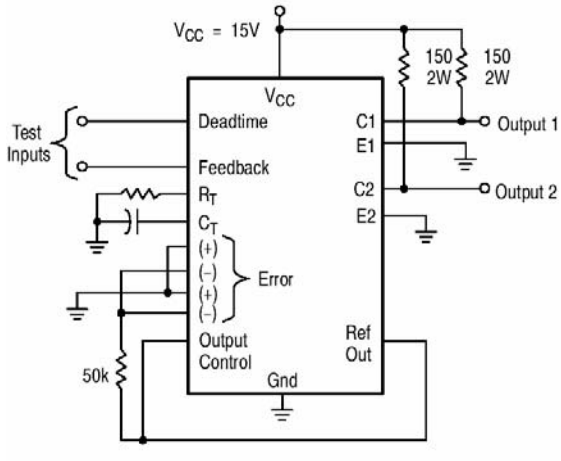


Figure 11. Deadtime and Feedback Control Circuit

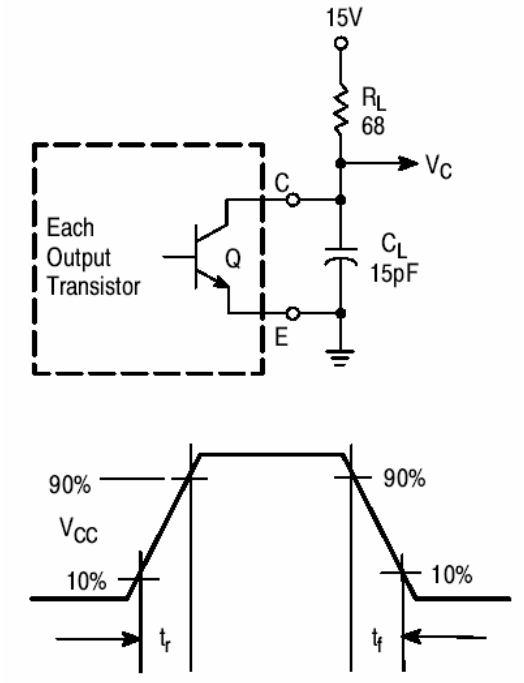


Figure 12. Common –Emitter Configuration
Test Circuit and Waveform

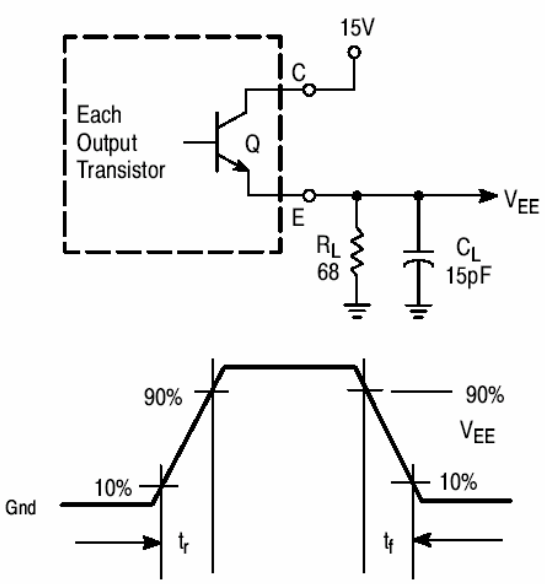
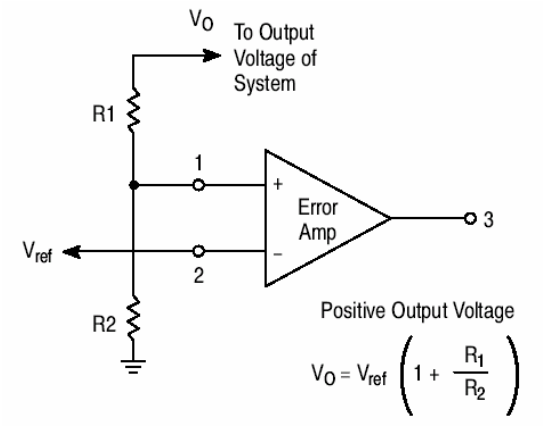


Figure 13. Emitter-Follower Configuration
Test Circuit and Waveform



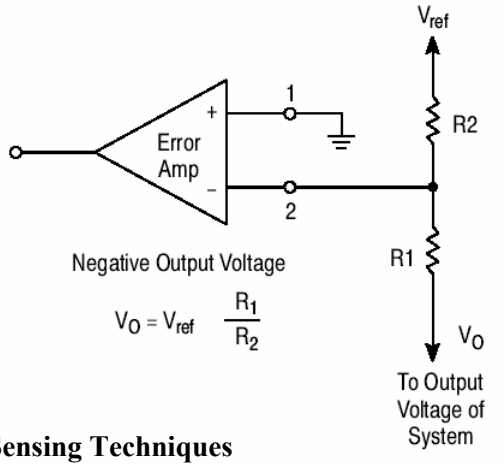


Figure 14. Error-Amplifier Sensing Techniques

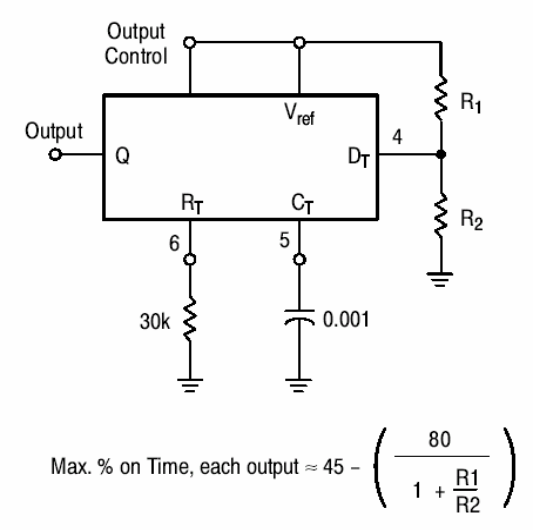


Figure 15. Deadtime Control Circuit

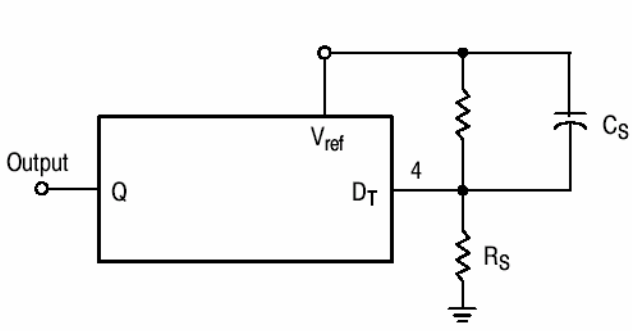


Figure 16. Soft-Start Citcuit

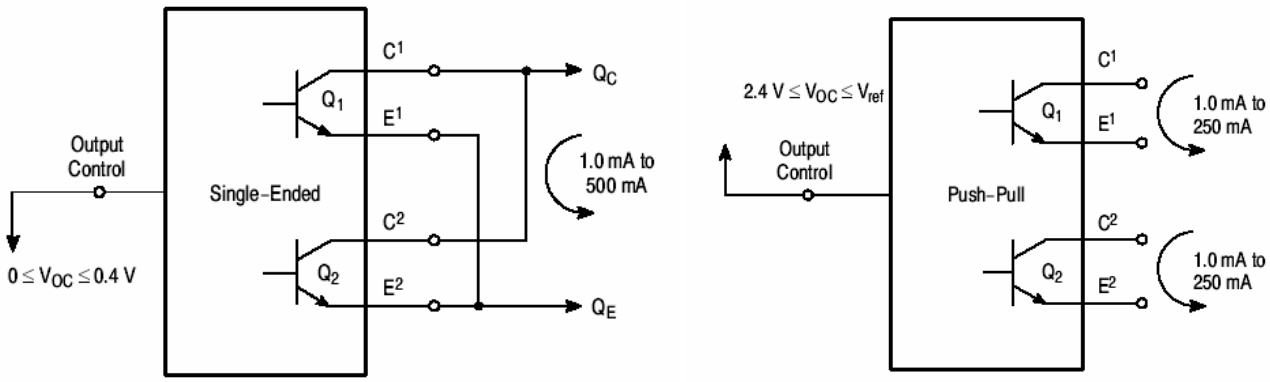


Figure 17. Output Connections for Single-Ended and Push-Pull Configurations

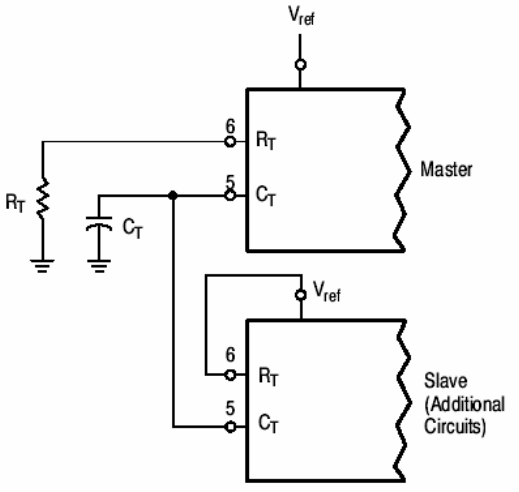


Figure 18. Slaving Two or More Control Circuit

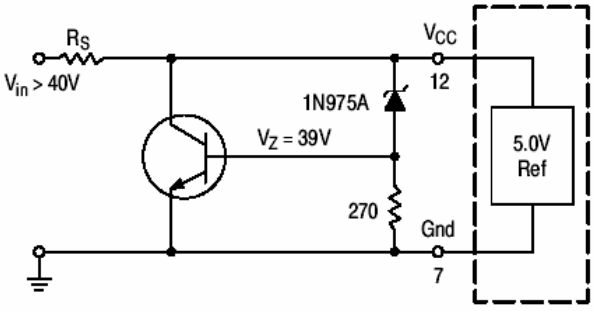


Figure 19. Operation With VIN >40V Using External Zener

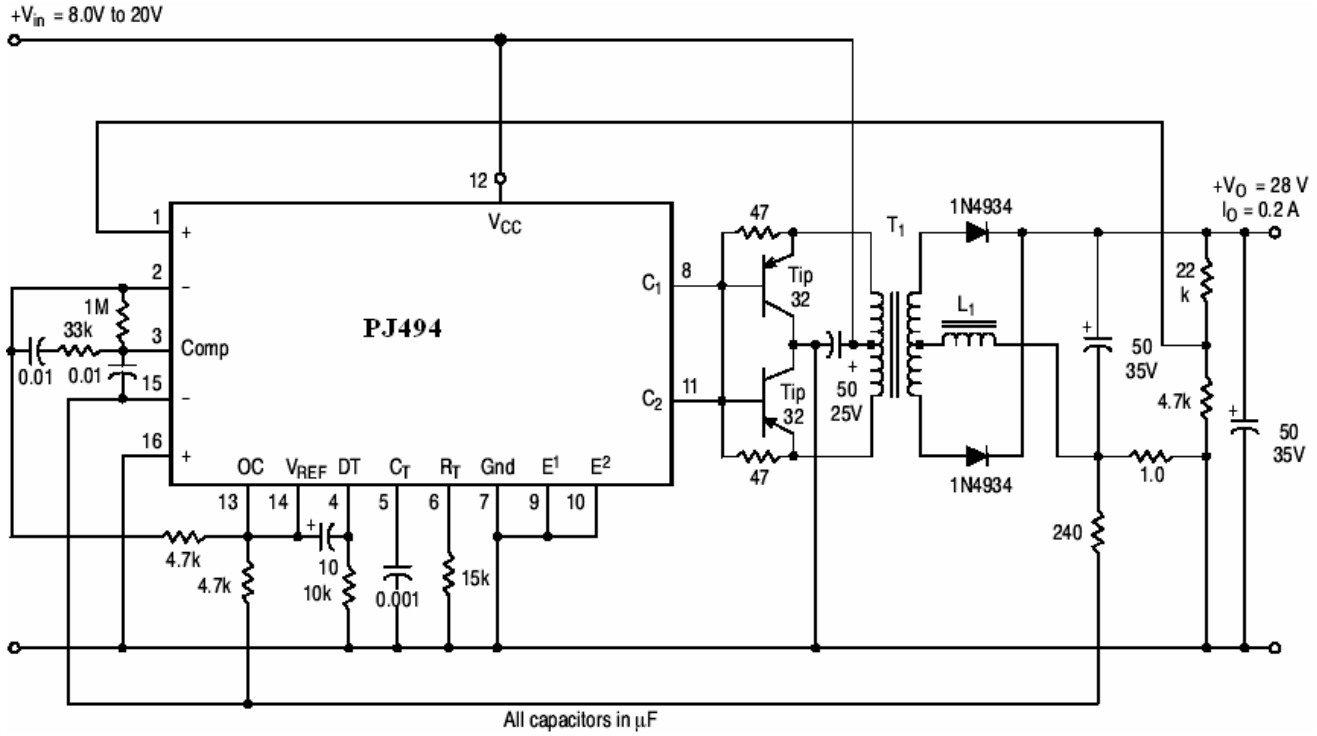


Figure 20. Pulse Width Modulated Push-Pull Converter

Test	Condition	Result
Line Regilation	V_{IN} = 10V to 40V	14mV 0.28%
Load Regilation	V_{IN} = 28V, Io =1.0mA to 10A	3.0mV 0.06%
Output Ripple	V_{IN} = 28V, Io =1.0A	65mV pp P.A.R.D
Short Circuit Current	V_{IN} = 29V, R_L=0.1Ω	1.6A
Efficiency	V_{IN} = 28V, Io =1.0A	71%

L1 – 3.5mH @ 0.3A
T1 – Primary : 20T C.T. #28 AWG
Secondary : 120T C.T. #36 AWG
Core : Ferroxcube 1408P-L00-3CB

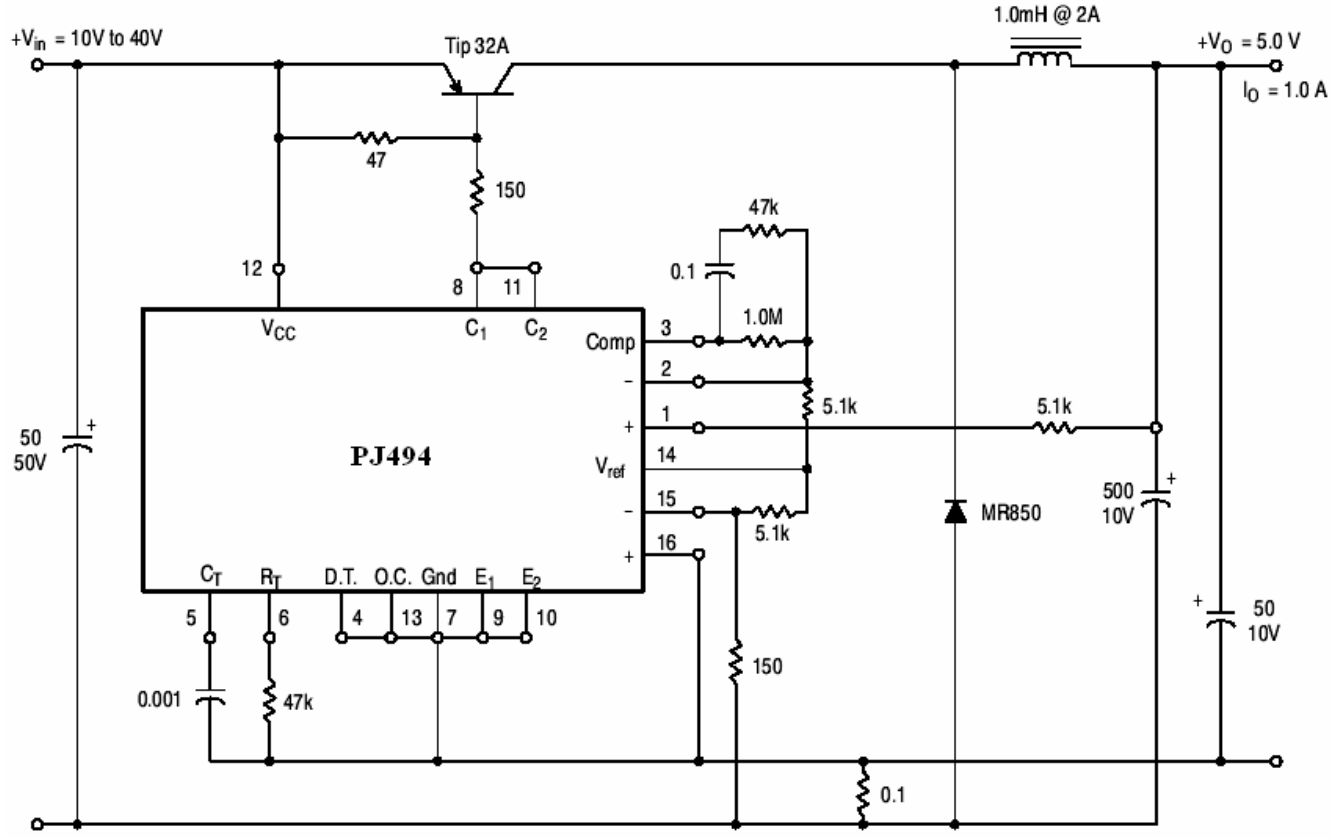
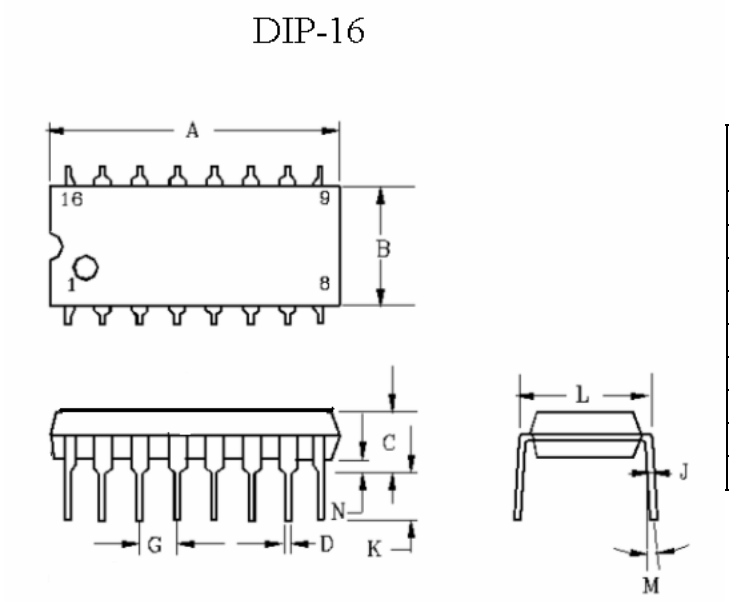


Figure 21. Pulse Width Modulated Step-Down Converter

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

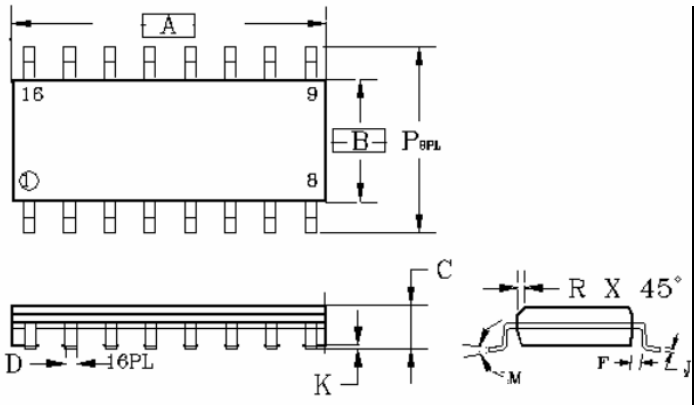
Switchmode Pulse Width Modulation Control Circuit

DIP-16



DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	17.80	18.05	0.701	0.710
B	6.25	6.45	0.292	0.299
C	2.35	2.65	0.093	0.104
D	0.35	0.49	0.014	0.019
G	1.27BSC		0.05BSC	
J	0.25	0.32	0.010	0.012
K	0.10	0.25	0.004	0.009
L	0°	7°	0°	7°
M	-	10°	0.395	0.415

SOP-16



DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	9.80	10.00	0.386	0.393
B	7.40	7.60	0.292	0.299
C	2.35	2.65	0.093	0.104
D	0.35	0.49	0.014	0.019
F	0.50	0.90	0.020	0.035
G	1.27BSC		0.05BSC	
K	0.10	0.25	0.004	0.009
M	0°	7°	0°	7°
P	10.05	10.55	0.395	0.415
R	0.25	0.75	0.010	0.029