

MITSUBISHI <ANALOG ASSP>
M5T494P, FP, GP

SWITCHING REGULATOR CONTROL

DESCRIPTION

The M5T494 is a monolithic IC designed for a pulse-width-modulation control circuit.

It contains all functions necessary to control single-ended or push-pull switching power supplies. It employs an on-chip 5-volt regulator, two error amplifiers, an adjustable oscillator, a dead-time control comparator, a pulse-steering flip-flop, output-control circuitry and an undervoltage-lockout (UVLO) function.

The UVLO prevents irregular operation at the IC outputs when the IC supply voltage is excessively low.

FEATURES

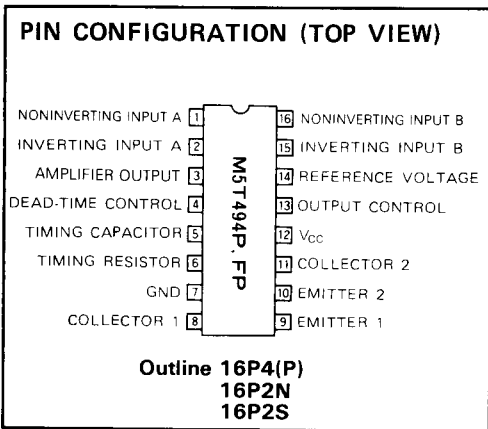
- Undervoltage lockout (inhibits output for low V_{CC})
- Built-in 5-volt reference regulator
 (Reference voltage $5V \pm 5\%$)
- Output control selectable for single-ended or push-pull operation.
- Uncommitted outputs for 200-mA sink or source.

APPLICATION

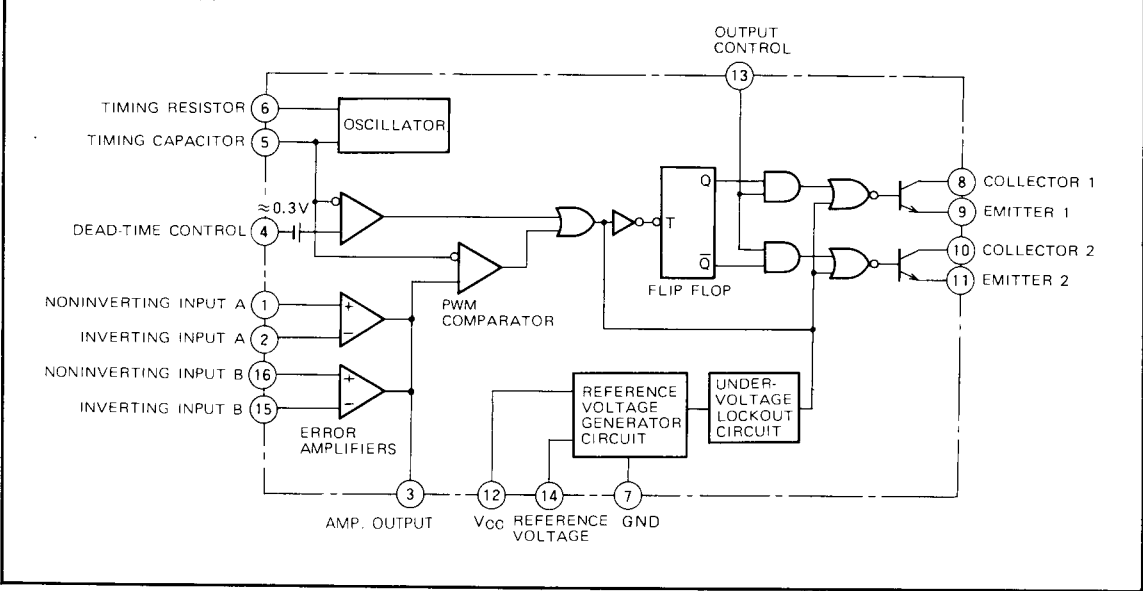
Switching voltage regulators, Step-up step-down regulators, Voltage inversion regulators.

RECOMMENDED OPERATING CONDITIONS

- Supply voltage range 7 ~ 40V
 Pin 3 sink current Less than 0.3mA
 Timing capacitor, C_T 470pF ~ 3.3 μ F
 Timing resistor, R_T 1.8 ~ 500k Ω
 Oscillator frequency Lower than 300kHz



BLOCK DIAGRAM



SWITCHING REGULATOR CONTROL

ABSOLUTE MAXIMUM RATINGS ($T_a = 25^\circ\text{C}$, unless otherwise noted)

Symbol	Parameter	Conditions	Limits	Unit
V_{CC}	Supply voltage		41	V
V_{ICM}	common input voltage		$-0.3 \sim V_{CC}$	V
V_{ID}	Differential input voltage		V_{CC}	V
V_O	Output voltage		41	V
I_O	Output current		200	mA
V_{I3}	Input voltage		$-0.3 \sim V_{I3} + 0.3$	V
P_d	Power dissipation		1000(P)/800(FP)/550(GP)	mW
K_θ	Thermal derating	$T_a \geq 25^\circ\text{C}$	8(P)/6.4(FP)/4.4(GP)	mW/°C
T_{opr}	Operating temperature		$-20 \sim +85$	°C
T_{stg}	Storage temperature		$-40 \sim +125$	°C

ELECTRICAL CHARACTERISTICS ($V_{CC} = 15\text{V}$, $f_{osc} = 40\text{kHz}$, $T_a = -20 \sim +70^\circ\text{C}$, unless otherwise noted)

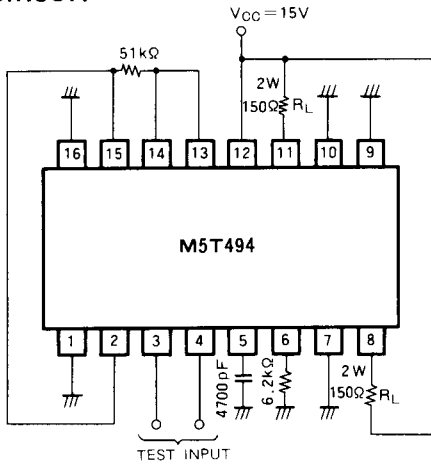
Symbol	Block	Parameter	Test conditions	Limits			Unit
				Min	Typ	Max	
V_{ref}	REFERENCE	Output voltage	$I_{ref} = -1\text{mA}$, $T_j = 25^\circ\text{C}$	4.75	5	5.25	V
ΔV_{refIN}		Input regulation	$V_{CC} = 7 \sim 40\text{V}$, $I_{ref} = -1\text{mA}$, $T_j = 25^\circ\text{C}$		1	10	mV
ΔV_{refL}		Load regulation	$I_{ref} = -1 \sim -10\text{mA}$, $T_j = 25^\circ\text{C}$		2	20	mV
$\Delta V_{ref}/\Delta T_a$		Temperature coefficient output voltage	$T_a = -20 + 85^\circ\text{C}$, $I_{ref} = -1\text{mA}$		0.01	0.03	%/°C
I_s	OSCILLATOR	Short circuit current	$V_{ref} = 0$	-50	-30	-15	mA
f_{osc}		Frequency	$C_T = 4700\text{pF}$, $R_T = 6.2\text{k}\Omega$	37	41	45	kHz
$\Delta f/f_s$		Standard deviation of frequency	$V_{CC} = 7 \sim 40\text{V}$, $T_a = 25^\circ\text{C}$, C_T , R_T		10		%
$\Delta f/f_{IN}$		Frequency change with voltage	$V_{CC} = 7 \sim 40\text{V}$, $T_a = 25^\circ\text{C}$, $C_T = 4700\text{pF}$, $R_T = 6.2\text{k}\Omega$		0.5	1.5	%
$\Delta f/f_{T_a}$	Frequency change with temperature	$T_a = 0 \sim 70^\circ\text{C}$, $C_T = 4700\text{pF}$, $R_T = 6.2\text{k}\Omega$		1	2	%	
I_{I3}	DEAD-TIME CONTROL	Input bias current	$V_{I3} = 0 \sim 5.25\text{V}$	-7	-0.7		μA
D_{MAX}		Maximum duty cycle (each output)	$V_{I3} = 0\text{V}$	42	45	48	%
V_{I3TH1}		Input threshold voltage 1	Zero duty cycle (each output)		2.45	2.80	V
V_{I3TH2}		Input threshold voltage 2	Maximum duty cycle (each output)		0		V
V_{AMPIO}	ERROR AMPLIFIERS	Input offset voltage	$V_{(3)} = 2.5\text{V}$		1	7	mV
I_{AMPIO}		Input offset current	$V_{(3)} = 2.5\text{V}$		5	200	nA
I_{AMPIB}		Input bias current	$V_{(3)} = 2.5\text{V}$	-700	-100		nA
V_{AMPICM}		Common input voltage range	$V_{CC} = 7 \sim 40\text{V}$	-0.3		$V_{CC} - 2$	V
A_V		Open loop voltage gain	$V_{(3)} = 0.5 \sim 3.5\text{V}$, $T_a = 25^\circ\text{C}$	70	110		dB
f_T		Gain bandwidth product	$T_a = 25^\circ\text{C}$	500	900		kHz
$CMRR$		Common mode rejection ratio	$V_{CC} = 40\text{V}$, $T_a = 25^\circ\text{C}$	65	85		dB
I_{I3SINK}		Output sink current	$V_{(3)} = 0.7\text{V}$	0.3	0.7		mA
$I_{I3SOURCE}$		Output source current	$V_{(3)} = 3.5\text{V}$		-10	-2	mA
$V_{I3RANGE}$		Output voltage range	"L" level		0.1	0.3	V
	"H" level		$I_{(3)} = 0$	4.2	4.9	V	
V_{I3TH}	PWM COMPARATOR	Input threshold voltage	Zero duty cycle (each output)		3.4	3.8	V
I_{I3SINK}		Input sink current	$V_{(3)} = 0.7\text{V}$	0.3	0.7	mA	

SWITCHING REGULATOR CONTROL

ELECTRICAL CHARACTERISTICS

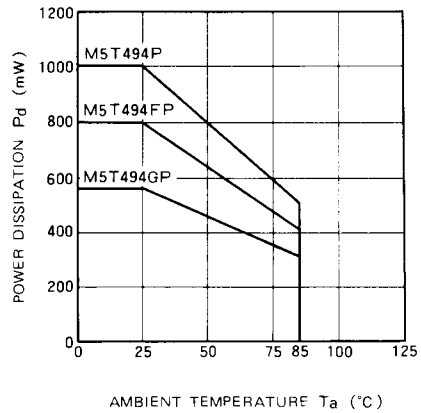
Symbol	Section	Parameter	Test conditions	Limits			Unit
				Min	Typ	Max	
I_{CL}	OUTPUT	Collector leak current	$V_{CE} = 40V, V_{CC} = 40V$ (Common-emitter)		0.01	100	μA
I_{EL}		Emitter leak current	$V_{CC} = V_C = 40V, V_E = 0$ (Emitter follower)	-100	-0.01		μA
V_{CESAT}		Output saturation voltage (Common-emitter)	$I_C = 200mA, V_E = 0$		0.95	1.3	V
V_{CEON}		Output saturation voltage (Emitter follower)	$I_E = -200mA, V_C = 15V$		1.6	2.5	V
t_{r1}		Output-voltage rise time	$V_{CC} = 15V, R_L = 150\Omega, I_C = 100mA,$ $T_a = 25^\circ C$ (Common-emitter)		80	200	ns
t_{f1}		Output-voltage fall time			30	100	ns
t_{r2}		Output-voltage rise time	$V_{CC} = V_C = 15V, R_L = 150\Omega, I_E =$ $-100mA, T_a = 25^\circ C$ (Emitter follower)		200	400	ns
t_{f2}		Output-voltage fall time			30	100	ns
I_{i3}		Output-control input current	$V_{i3} = V_{ref}$		270	550	1000
V_{CCLO}	UNDER VOLTAGE LOCK-OUT	Lockout voltage	Supply voltage at output cut-off	3.8	5	5.7	V
ΔV_{CCLO}		Hysteresis		100	200	380	mV
I_{CCSB}	CIRCUIT CURRENT	Standby supply current	$V_{CC} = 15V$ All other inputs and outputs open		6.7	11.5	mA
I_{CCBI}		Average bias current	$V_{i4} = 2V,$		7.3	13	mA

TEST CIRCUIT

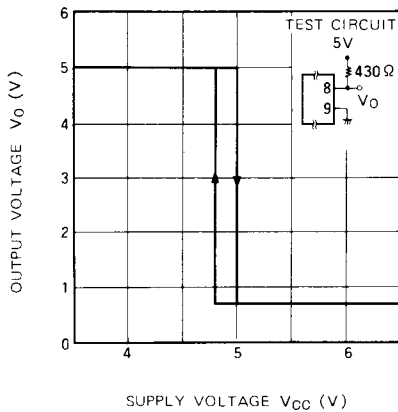


Note: To obtain output voltage from the emitter follower, connect pins ⑧ and ⑩ to V_{CC} , and connect each of pins ⑨ and ⑪ to ground through resistor R_L .

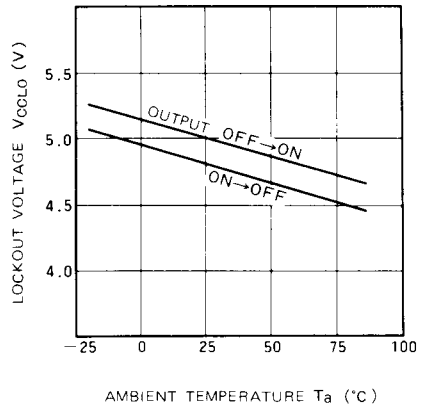
THERMAL DERATING (MAXIMUM RATING)



UNDERVOLTAGE LOCKOUT CHARACTERISTICS

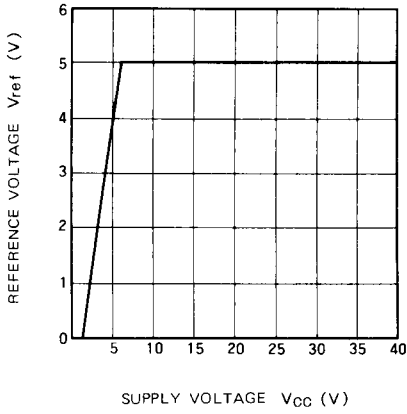


LOCKOUT VOLTAGE VS AMBIENT TEMPERATURE

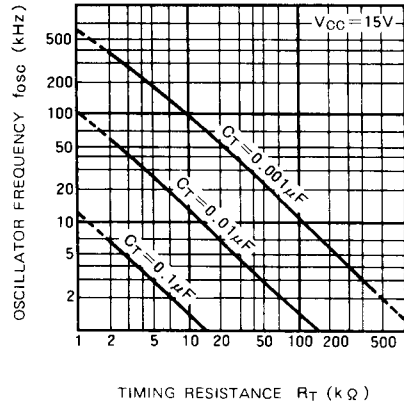


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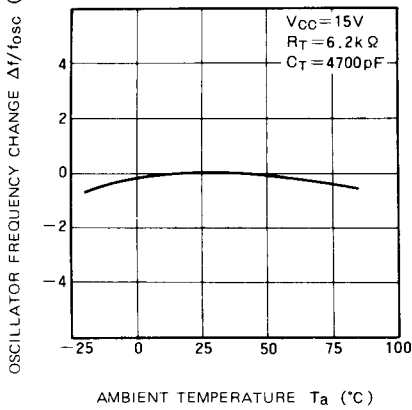
REFERENCE VOLTAGE VS SUPPLY VOLTAGE



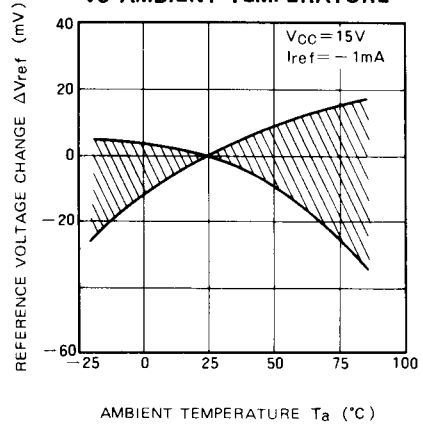
OSCILLATOR FREQUENCY VS TIMING RESISTANCE



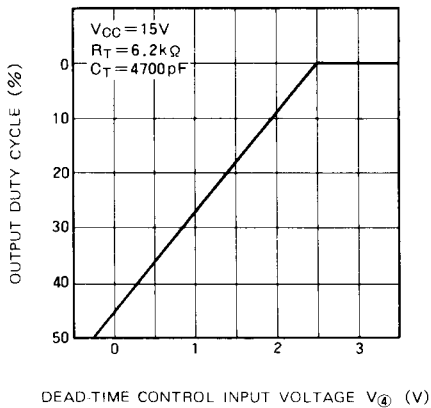
OSCILLATOR FREQUENCY CHANGE VS AMBIENT TEMPERATURE



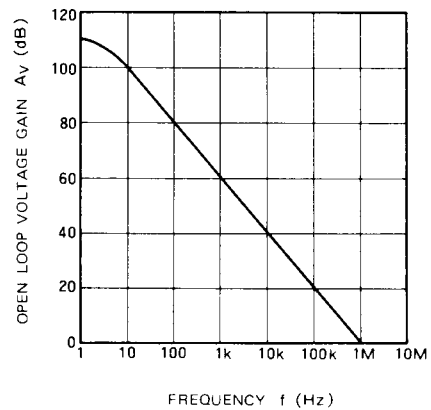
REFERENCE VOLTAGE CHANGE VS AMBIENT TEMPERATURE



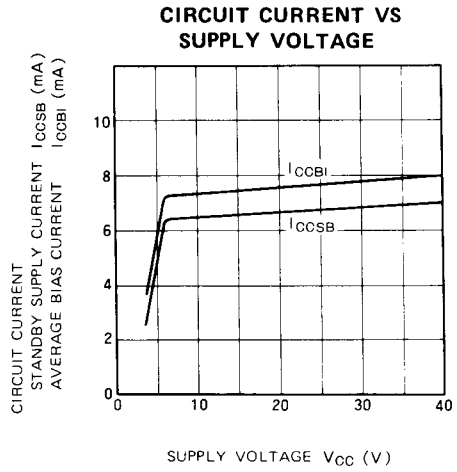
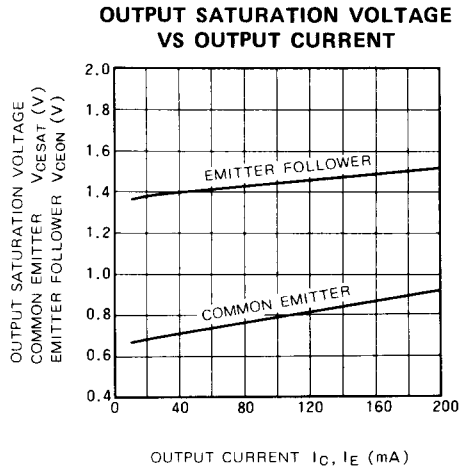
OUTPUT DUTY CYCLE VS DEAD-TIME CONTROL INPUT VOLTAGE



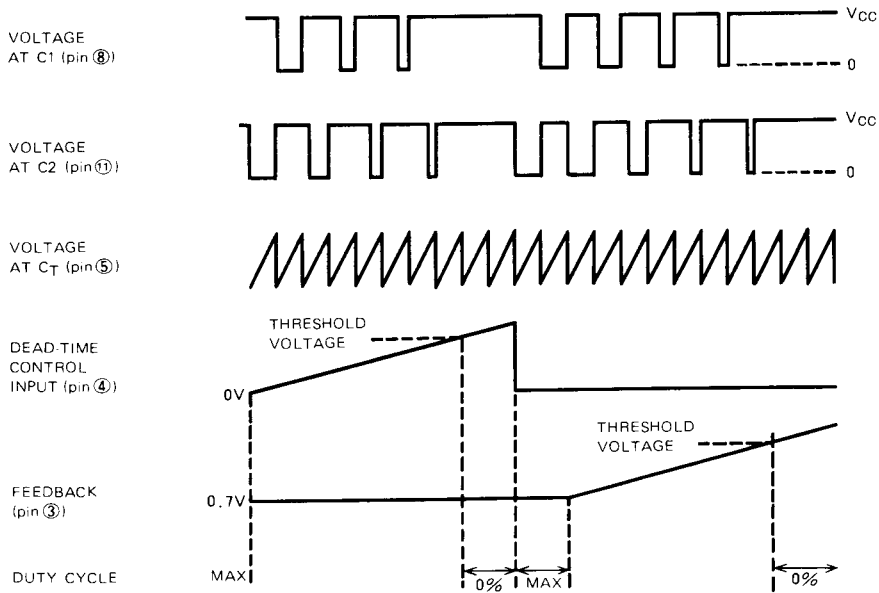
ERROR AMP OPEN LOOP VOLTAGE GAIN VS FREQUENCY



SWITCHING REGULATOR CONTROL



VOLTAGE WAVEFORMS



FUNCTION TABLE

OUTPUT CONTROL (pin 13)	OUTPUT FUNCTION
V_{ref}	Push-pull operation
GND	Single-ended or parallel operation