

SWITCHING REGULATOR CONTROL CIRCUIT

■ GENERAL DESCRIPTION

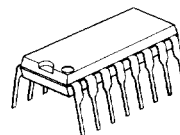
The NJM3524 of regulating pulse width modulators contains all of the control circuitry necessary to implement switching regulators of either polarity, transformer coupled DC to DC converters, transformerless polarity converters and voltage doublers, as well as other power control applications. This device includes a 5V voltage regulator capable of supplying up to 50mA to external circuitry a control amplifier, an oscillator, a pulse width modulator, a phase splitting flip-flop, dual alternating output switch transistors, and current limiting and shut-down circuitry. Both the regulator output transistor and each output switch are internally current limited and, to limit junction temperature, an internal thermal shut-down circuit is employed.

■ FEATURES

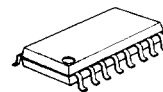
- Operating Voltage (8V~40V)
- Complete PWM Power Control Circuitry
- Uncommitted Outputs for Single-Ended or Push-Pull Applications
- Low Standby Current
- Package Outline
- Bipolar Technology

DIP16, DMP16, SSOP16

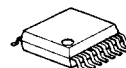
■ PACKAGE OUTLINE



NJM3524D



NJM3524M

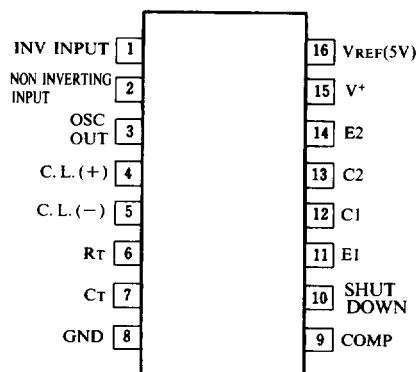


NJM3524V

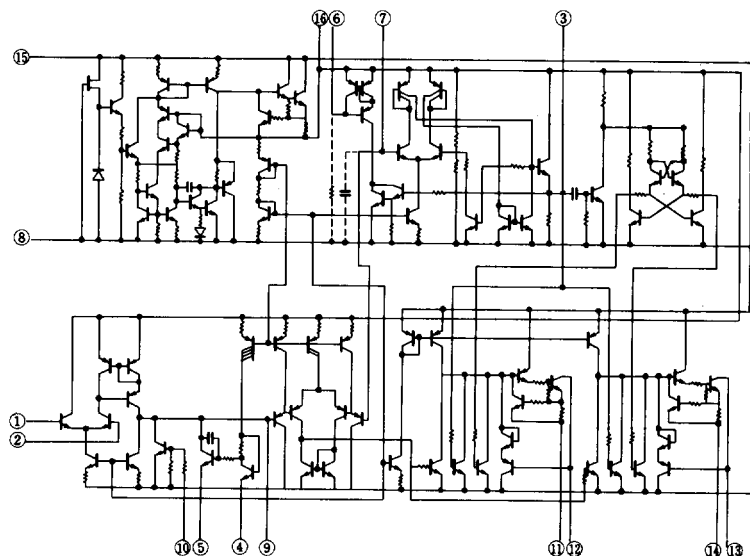
■ RECOMMEND OPERATING CONDITION

Parameter	Symbol	Min.	Typ.	Max.	Unit
Operating Voltage	V^+	8	20	40	V
Output Reference Current	I_{REF}	0	—	50	mA
Timing Resistance	R_T	1.8	—	100	k Ω
Timing Capacitor	C_T	—	—	0.1	μ F
Operating Temperature Range	T_{opr}	-20	25	75	$^{\circ}$ C

■ PIN CONFIGURATION



■ EQUIVALENT CIRCUIT





■ ABSOLUTE MAXIMUM RATINGS

(Ta=25°C)

PARAMETER	SYMBOL	RATINGS	UNIT
Supply Voltage	V ⁺	40	V
Output Current	I _o	100	mA
Output Reference Current	I _{REF}	50	mA
Power Dissipation	P _D	(DIP16) 700 (DMP16) 300	mW
Operating Temperature Range	T _{opr}	-20~+75	°C
Storage Temperature Range	T _{stg}	-40~+125	°C

■ ELECTRICAL CHARACTERISTICS

Electrical characteristics over recommended operating free-air temperature range, V⁺=20V, f=20kHz
(unless otherwise noted).

Reference Section

PARAMETER	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Output Voltage	V _{REF}	V ⁺ =20V	4.6	5.0	5.4	V
Line Regulation	ΔV _{REF} -V ⁺	V ⁺ =8~40V	—	10	30	mV
Load Regulation	ΔV _{REF} -I _{REF}	V ⁺ =10V, I _{REF} =0~20mA	—	20	50	mV
Ripple Rejection	RR	V ⁺ =20V, f=120Hz	—	66	—	dB
Temperature Coefficient	T.C.	Ta=-20~+75°C	—	-1	—	mV/°C
Short Circuit Output Current	I _{REF S}		—	100	—	mA

Error Amplifier Section

Input Offset Voltage	V _{IO}	V _{IC} =2.5V	—	2	10	mV
Input Bias Current	I _B (1)	V _{IC} =2.5V	—	2	10	μA
Open Loop Voltage Gain	A _V		60	80	—	dB
Input Common Mode Voltage Range	V _{CM}	Ta=25°C	1.8	—	3.4	V
Common Mode Rejection Ratio	CMR		—	70	—	dB
Unity Gain Bandwidth	—		—	3	—	MHz
Output Voltage Swing	—		0.5	—	3.8	V

Oscillator Section

Frequency	f _{osc}	C _T =0.01μF, R _T =2kΩ	—	30	—	kHz
Frequency Change with Voltage	—	V ⁺ =8~40V	—	—	1	%
Frequency Change with Temperature	—	Ta=-20~+75°C	—	—	3	%
Output Pulse Width(Pin 3)	—	C _T =0.01μF	—	0.5	—	μS
Output Amplitude(Pin 3)	—		—	3.5	—	V

6

Maximum Duty Cycle	—		0	—	45	%
Input Threshold (Pin 9)	V _{IH}	“0” duty cycle	—	1.0	—	V
Input Threshold (Pin 9)	V _{IH}	“Max” duty cycle	—	3.5	—	V
Input Bias Current	I _B (2)		—	1	—	μA

Input Voltage Range	—	—0.7	—	+1.0	V
Sense Voltage	—	180	200	220	mV
Sense Voltage Temperature Coefficient	—	—	0.2	—	mV/°C

Collector-Emitter Breakdown Voltage	V_{CE}		40	—	—	V
Collector Leakage Current	I_{CE}	$V_{CE}=40V$	—	0.1	50	μA
Collector-Emitter Saturation Voltage	$V_{CE(SAT)}$	$I_Q=50mA$	—	1	2	V
Emitter Output Voltage	—	$V^+=20V, I_F=-250\mu A$	17	18	—	V
Turn-off Voltage Rise Time	T_r	$R_C=2k\Omega$	—	0.2	—	μS
Turn-on Voltage Fall Time	T_f	$R_C=2k\Omega$	—	0.1	—	μS

Standby Current	I_Q	$V^+ = 40V$, $P_{in(2)} = 2V$ 1,4,7,8,9,11,14=GND All Other Inputs and Outputs Open	—	8	10	mA
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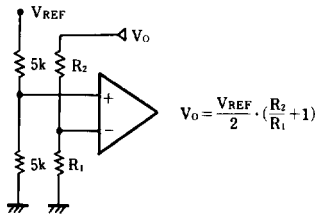
The block diagram illustrates the internal components of a precision current source circuit, enclosed in a dashed rectangular box. The circuit includes the following blocks and connections:

- Reference Regulator:** Receives input from pin 15 and provides a reference voltage to the non-inverting input of the Error Amp. and the inverting input of the Comparator.
- Oscillator:** Receives inputs from pins 3 and 7 and provides a clock signal to the Flip-Flop.
- Flip-Flop:** Receives the clock signal from the Oscillator and provides control signals to the NOR gates.
- Comparator:** Receives inputs from the Reference Regulator and the Error Amp. Its output is connected to the inverting input of the NOR gates.
- Error Amp. (Error Amplifier):** Receives inputs from pins 1 and 2. Its output is connected to the inverting input of the Comparator and the inverting input of the Current Limit block.
- Current Limit:** Receives inputs from the Error Amp. and the inverting input of the NOR gates. Its output is connected to pin 4.
- NOR Gates:** Two NOR gates are used. The first NOR gate has inputs from the Flip-Flop and the Comparator. Its output is connected to pin 12. The second NOR gate has inputs from the Flip-Flop and the Comparator. Its output is connected to pin 13.
- Output Stages:** Two transistors are shown. The first transistor's base is connected to the output of the first NOR gate (pin 12) and its emitter is connected to pin 11. The second transistor's base is connected to the output of the second NOR gate (pin 13) and its emitter is connected to pin 14.
- Other Connections:** Pin 6 is connected to the non-inverting input of the Error Amp. and the inverting input of the Comparator. Pin 7 is connected to the Oscillator. Pin 8 is connected to ground. Pin 9 is connected to the non-inverting input of the Error Amp. and the inverting input of the Comparator. Pin 10 is connected to the base of the first transistor. Pin 11 is connected to the emitter of the first transistor. Pin 12 is connected to the base of the second transistor. Pin 13 is connected to the base of the second transistor. Pin 14 is connected to the emitter of the second transistor. Pin 15 is connected to the Reference Regulator.

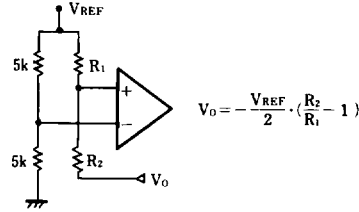


■ ERROR AMPLIFIER BIAS CIRCUITS

(A) Positive Output

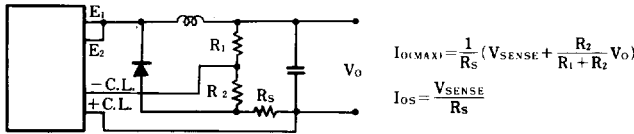


(B) Negative Output



■ CURRENT LIMIT

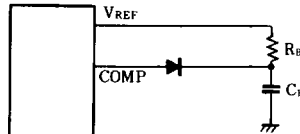
- Take the detection output from the ground line side, because the input voltage range is $-0.7V \sim +1.0V$.
- The sensing voltage is 200mV typical.



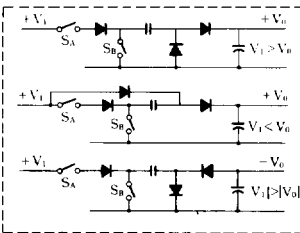
■ SOFT START METHOD

It is possible that the output stage is broken due to a wrong operation of circuits simultaneously when supply voltage was applied. This failure can be prevented by setting the error amplifier output to a low level for a certain time as shown in the right figure.

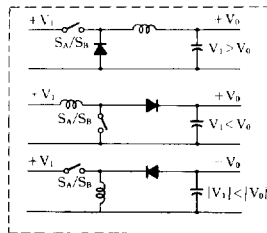
In this case, the soft start time is determined by the time constant of R_B and C_B .



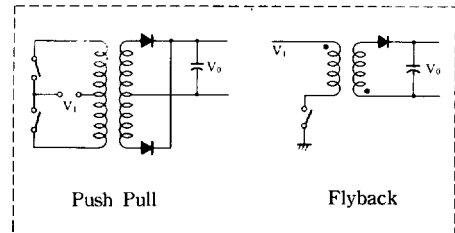
■ OUTPUT CONFIGURATIONS



Capacitor-Diode-Coupled Voltage Multiplier Output stage



Single-Ended Inductor Circuit



Push Pull

Flyback

Transformer-Coupled Outputs

■ TYPICAL APPLICATIONS

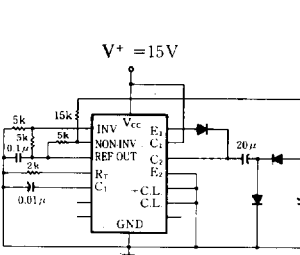


Fig. 1 Capacitor-Diode Output Circuit

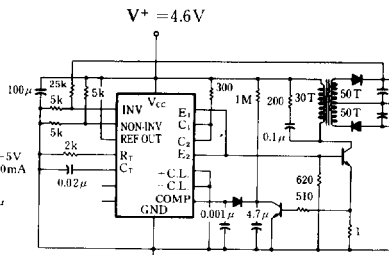


Fig. 2 Flyback Converter Circuit

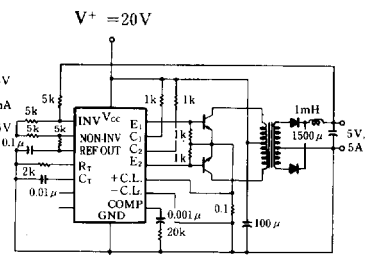
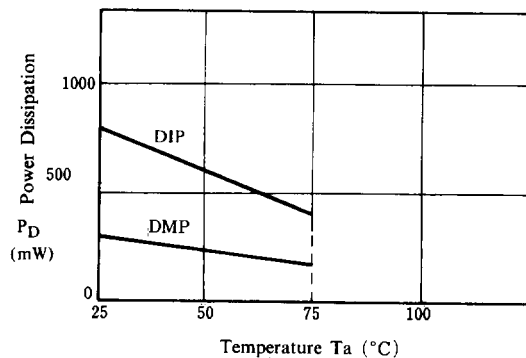


Fig. 3 Push-Pull Transformer-Coupled Circuit

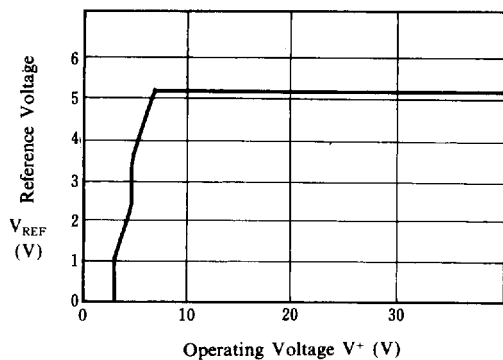


■ POWER DISSIPATION VS. AMBIENT TEMPERATURE

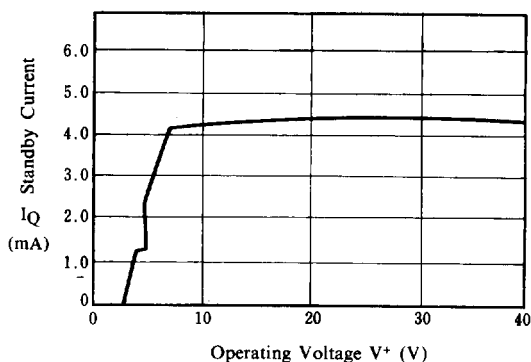


■ TYPICAL CHARACTERISTICS

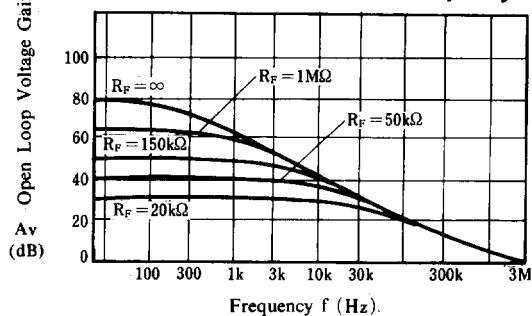
Reference Voltage vs. Operating Voltage



Standby Current vs. Operating Voltage



Open Loop Voltage Gain vs. Frequency



R_T, C_T vs. Frequency

