

# IR9494/IR9494N Switching Regulator Control Circuit

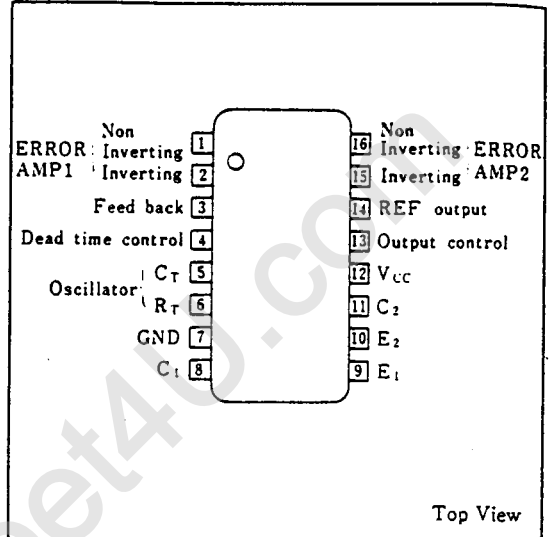
## ■ Description

The IR9494/IR9494N is a fixed frequency Pulse-Width-Modulation control circuit. It includes most functions required for control circuits.

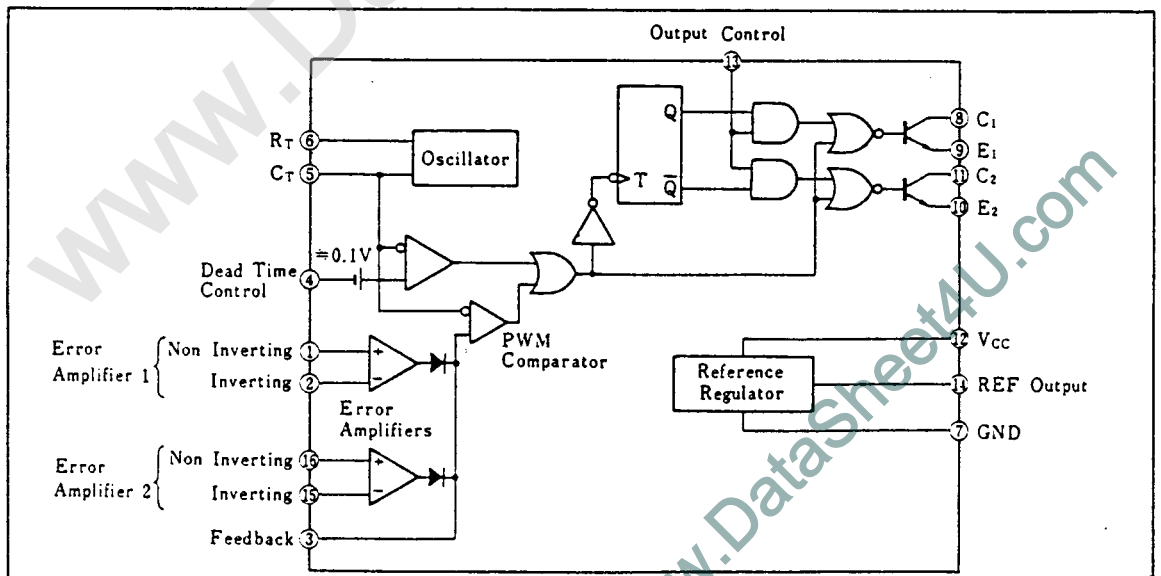
## ■ Features

1. Complete PWM power control circuitry
2. Uncommitted output 200mA sink or source
3. Output control selects single-ended or push-pull operation
4. Internal circuitry prohibits double pulse as either output
5. Wide common-mode input range
6. Variable dead-time provides control over total range
7. Internal regulator provides a stable 5V reference supply
8. Circuit architecture provides easy synchronization
9. 16-pin dual-in-line package(IR9494)  
16-pin small-outline package(IR9494N)

## ■ Pin Connections



## ■ Block Diagram



### Absolute Maximum Ratings

Parameter	Symbol	Condition	Rating	Unit	
Supply voltage	$V_{CC}$		41	V	
Input voltage	$V_{IN}$	Terminals 1, 2, 15 and 16	$V_{CC}+0.3$	V	
Output voltage	$V_{OUT}$	Terminals 8 and 11	41	V	
Output current	$I_{OUT}$	Terminals 8 and 11	250	mA	
Power dissipation	$P_D$	$T_a \leq 25^\circ\text{C}$	IR9494	950	mW
			IR9494N	500	
$P_D$ derating ratio	$\Delta P_D/^\circ\text{C}$	$T_a > 25^\circ\text{C}$	IR9494	9.5	mW/°C
			IR9494N	4	
Operating temperature	$T_{opr}$		-20 ~ +85	°C	
Storage temperature	$T_{stg}$		-55 ~ +150	°C	

### Recommended Operating Conditions

Parameter	Symbol	Condition	MIN.	MAX.	Unit
Supply voltage	$V_{CC}$		7	40	V
Input voltage	$V_{IN}$		-0.3	$V_{CC}-2$	V
Output voltage	$V_{OUT}$			40	V
Output current	$I_{OUT}$	Per circuit		200	mA
	$I_{OA}$	Infollow to terminal 3		0.3	
Timing capacitance	$C_T$		0.47	10,000	nF
Timing resistance	$R_T$		1.8	500	k $\Omega$
Oscillating frequency	$f$		1	300	kHz
Operating temperature	$T_{opr}$		-20	+70	°C

### Electrical Characteristics

 $(V_{CC}=15\text{V}, f=10\text{kHz}, T_a=-20\sim+85^\circ\text{C})$ 

Parameter	Symbol	Condition	MIN.	TYP.	MAX.	Unit
Reference voltage source						
Output voltage	$V_{REF}$	$I_{OUT}=1\text{mA}$	4.75	5.00	5.25	V
Input stability	$\Delta V_{REF}/\Delta V_{IN}$	$V_{CC}=7\sim40\text{V}, T_a=25^\circ\text{C}$		2	25	mV
Output stability	$\Delta V_{REF}/\Delta I_{REF}$	$I_{OUT}=1\sim10\text{mA}, T_a=25^\circ\text{C}$		1	15	mV
Temperature stability	$\Delta V_{REF}/\Delta T$			0.3	1.5	%
Short-circuit output current	$I_{REF}$	$V_{REF}=0\text{V}, T_a=25^\circ\text{C}$	15	25		mA
Oscillating circuit						
Frequency	$f$	$C_T=0.01\ \mu\text{F}, R_T=12\text{k}\Omega$		10		kHz
Frequency setting accuracy	$f_{TOL}$	Fixed $V_{CC}, C_T, R_T$ and $T_a$		10		%
Frequency input stability	$\Delta f/\Delta V_{IN}$	$V_{CC}=7\sim40\text{V}, T_a=25^\circ\text{C}$		0.1		%
Frequency temperature stability	$\Delta f/\Delta T$	$C_T=0.01\ \mu\text{F}, R_T=12\text{k}\Omega$			3	%
Dead time setting circuit						
Input bias current	$I_B$	$V_{IN}=0\sim+5.25\text{V}$		-2	-10	$\mu\text{A}$
Output maximum duty		$V_{IN}$ (terminal 4) = 0V, per output	45			%
Input voltage (Terminal 4)	$V_{IN}$	Output duty 0%		3	3.3	V
		Output duty maximum	0			

Electrical Characteristics (Continued)

Parameter	Symbol	Condition	MIN.	TYP.	MAX.	Unit
<b>Error amplifier</b>						
Input offset voltage	$V_{IO}$	$V_{OUT}$ (terminal 3)=2.5V		2	10	mV
Input offset current	$I_{IO}$	$V_{OUT}$ (terminal 3)=2.5V		25	250	nA
Input bias current	$I_B$	$V_{OUT}$ (terminal 3)=2.5V		0.2	1	$\mu$ A
In-phase input voltage range	$V_{ICM}$	$V_{CC}=7\sim 40V$	-0.3- $V_{CC}-2$			V
Open loop voltage gain	$A_{VO}$	$\Delta V_{OUT}=3V, V_{OUT}=0.5\sim 3.5V$	70	95		dB
Gain bandwidth product	G.B.			800		kHz
In-phase signal rejection ratio	CMR	$V_{CC}=40V, T_a=25^\circ C$	65	80		dB
Output sink current	$I_{sink}$	$V_{ID}=-15mV\sim -5V, V_{IN}=0.7V$	0.3	0.7		mA
Output source current	$I_{source}$	$V_{ID}=15mV\sim 5V, V_{IN}=3.5V$	-2			mA
<b>Output circuit</b>						
OFF-state collector current	$I_C$	$V_{CE}=40V, V_{CC}=40V$		3	100	$\mu$ A
OFF-state emitter current	$I_E$	$V_{CC}=V_C=40V, V_E=0V$			-100	$\mu$ A
Output saturation voltage	Emitter ground	$V_{CE SAT}$	$V_E=0V, I_C=200mA$	1.1	1.3	V
	Collector ground	$V_{CE SAT}$	$V_C=15V, I_E=-200mA$	1.5	2.5	
Output control input current	$I_{IC}$	$V_{IN}=V_{REF}$		1.3	3.5	mA
<b>PWB Comparator</b>						
Input voltage	$V_{IN}$	Output duty 0%		4	4.5	V
Input current	$I_{IN}$	$V_{IN}=0.7V$	0.3	0.7		mA
<b>All circuit</b>						
Circuit current	$I_{CC1}$	$V_{CC}=15V$	Terminals 6 and 14 common I/O terminal open	7	12	mA
		$V_{CC}=40V$		9	15	
Circuit current	$I_{CC2}$	Terminal 4=2V, Fig. 1		8		mA
<b>Output switching characteristics</b>						
Rise time	$t_r$	$T_a=25^\circ C$ , emitter ground Fig. 2		100	200	ns
Fall time	$t_f$			25	100	
Rise time	$t_r$	$T_a=25^\circ C$ , collector ground Fig. 3		100	200	ns
Fall time	$t_f$			40	100	

Test Circuit

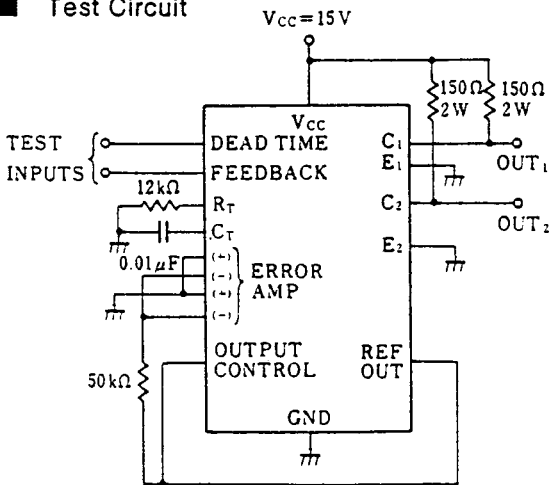


Fig. 1

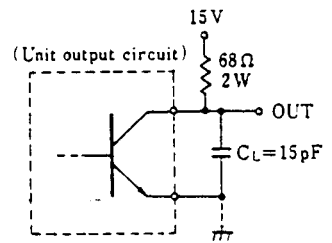


Fig. 2

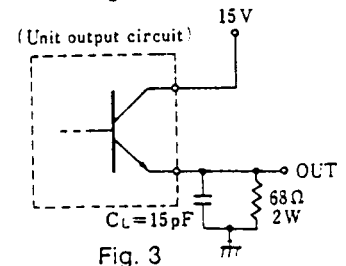
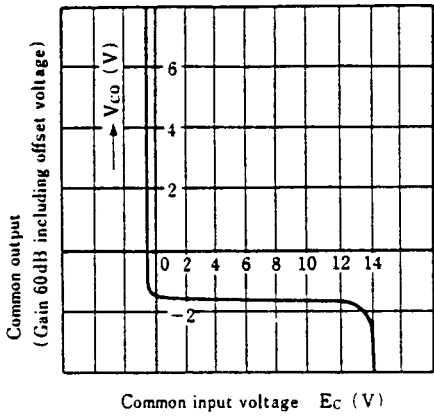


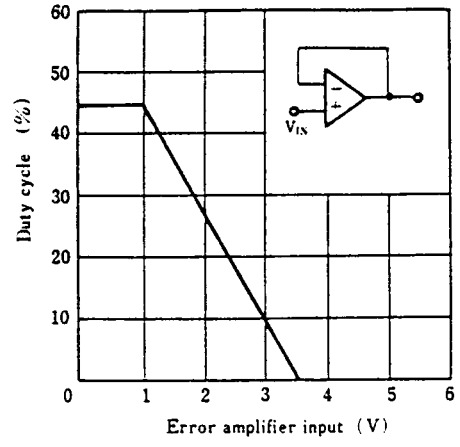
Fig. 3

Electrical Characteristic Curves (Unless otherwise specified,  $V_{CC} = 15V$ ,  $T_a = 25^\circ C$ )

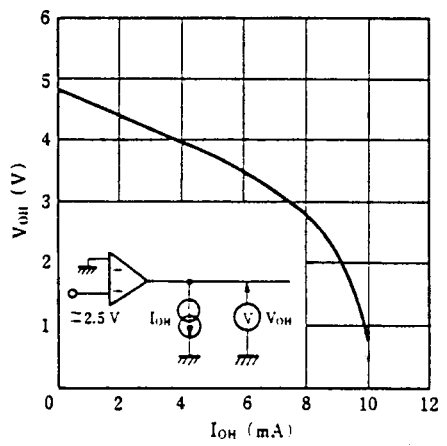
Error amplifier in-phase signal rejection Characteristics



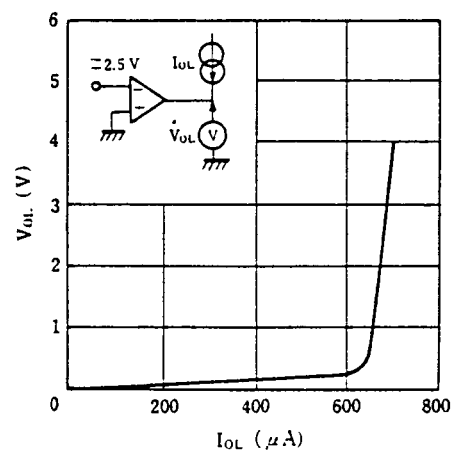
Duty cycle Characteristics



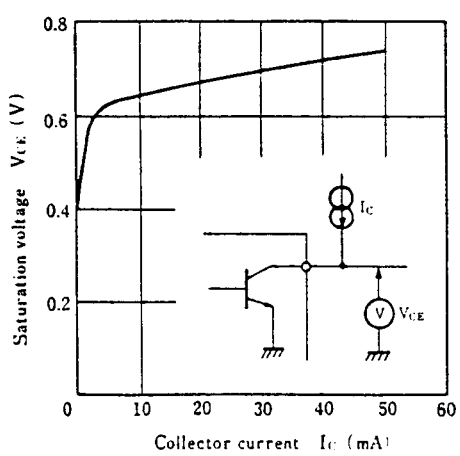
Error amplifier  $V_{OH} - I_{OH}$  Characteristics



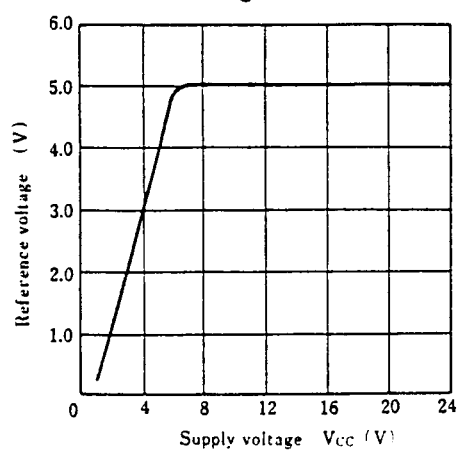
Error amplifier  $V_{OL} - I_{OL}$  Characteristics



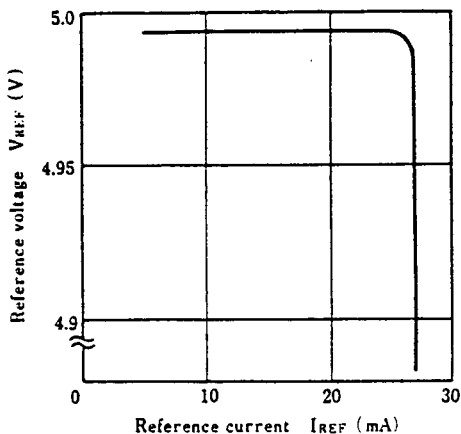
Output transistor  $V_{CE} - I_C$  Characteristics



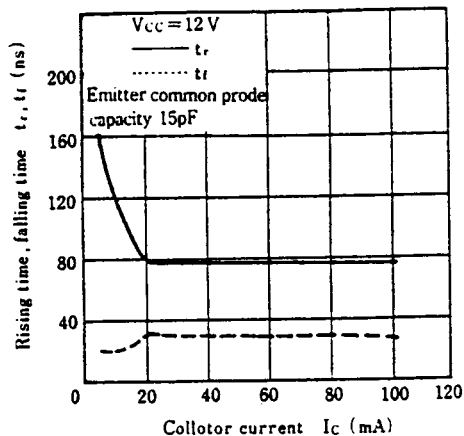
Reference voltage Characteristics



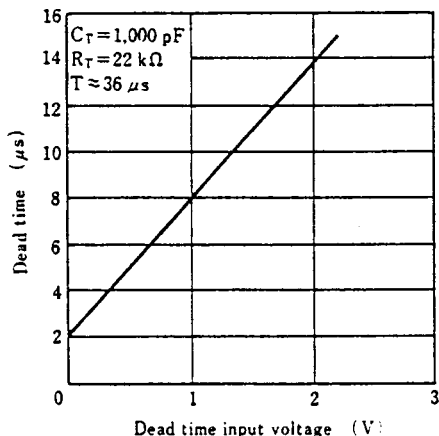
Reference output Characteristics



Rise time, fall time Characteristics



Dead time Characteristics



■ Description of Operation

The IR9494 consists of basic circuits required to control the power supply for switching regulator. It represents an improvement on conventional control ICs that present problems inherent in them. It is also designed to minimize the number of components necessary for power supply designing. Fig. 1 shows its block diagram.

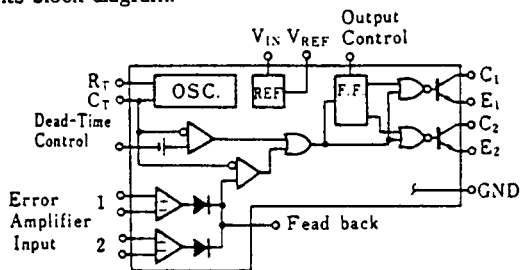


Fig. 1 IR9494 Block diagram

The IR9494 that uses frequency-fix pulse-width modulation system modulates the output by comparing either of the 2 control signals with the saw-tooth wave that appears on the timing capacitor  $C_T$  of the oscillator.

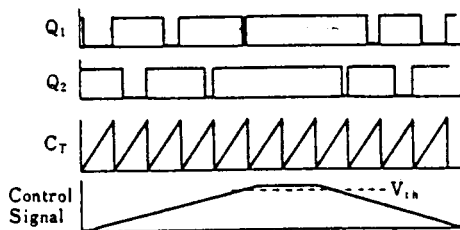


Fig. 2 LR9494 modulation system

The output transistor is only in ON state during the period when the saw-tooth wave, as a result of the comparison, is found to be higher than the con-

control signal. Increasing height of saw-tooth wave reduces the length of the period in which the saw-tooth wave is higher than the control wave resulting in a reduced output pulse-width. Fig. 2 shows this relationship.

The control signal is supplied from a dead-time circuit and 2 error-amplifiers with the control signal inputted by dead-time control to be compared as it is with the dead-time comparator. With its offset voltage set at 110mV, this comparator, when the input is grounded, goes into "OFF" state during the period when the saw-tooth wave is lower than 110mV. This indicates that the minimum programmable dead time is about 3% of it.

The pulse-width modulation comparator compares the control signal from the error amplifier. The error amplifier, which does the output monitoring as one of its functions, has a sufficient gain to be able to convert the error at the input into a control signal that can be 100% modulated. The error amplifier is used to monitor the output current and to regulate the current to the load. Steering flip-flop is responsible for a modulated output that appears at one cycle interval on the output transistor. As explained above it comes equipped with basic functions required for pulsewidth modulation control circuit.

Application Circuit Example

- (1) Inverter system (Input 30V, Output 5V, 5A)

$$\text{Frequency } f = \frac{1}{2RC} = 16.7\text{kHz}$$

(frequency T = 60 μs)

The number of winding turns of the primary winding of EI core.

$$N = \frac{V_{IN} \times 10^8}{4fBA_e} = \frac{30 \times 10^8}{4 \times 16.7 \times 10^3 \times 1.700 \times 1.48} = 18 \text{ turns}$$

Beware that too great a value of this will cause the output voltage to go higher than 5V when it changes over from heavy-load to light-load condition.

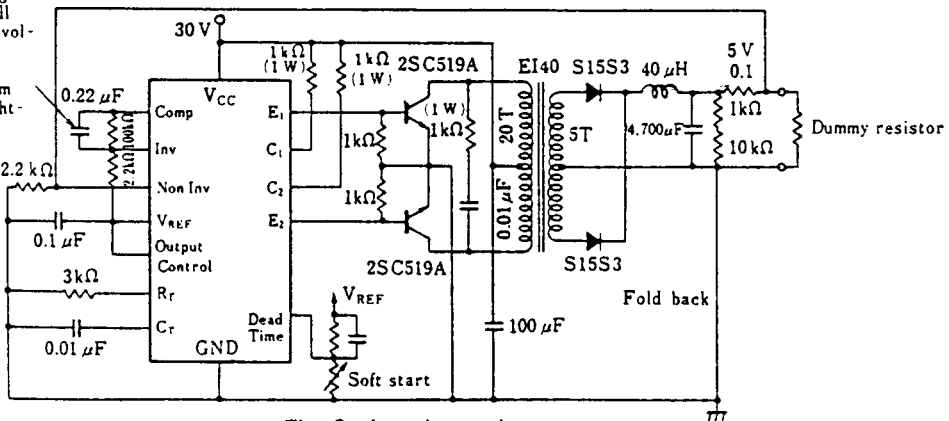


Fig. 3 Inverter system

Suppose the loss by those components like shot-key diode or chokecoil is 1.8V.

The voltage to be induced on the secondary winding of the transformer:

$$V_{N2} = (5 + 1.8) \times \frac{T/2}{T/2 \times 90\%} = 6.8 \times \frac{30}{27} = 7.5V$$

The turn ratio is 4 : 1.

Suppose 20 turns on the primary and 5 turns on the secondary of winding.

To obtain up to 5A of output current, the switching transistor is required to have h<sub>FE</sub> as high as 50. (Fig. 3 C<sub>1</sub>, C<sub>2</sub> 1kΩ pull-up)

For the current flowing into the choke coil of the output circuit not to be discontinuous, it is required:

$$L > \frac{2.5(7.5-5)}{I_a(\text{MAX})} \frac{5}{7.5} \times \frac{1}{2 \times 16.7 \times 10^3} = 25 \mu H$$

And from the ripple condition (with dummy current), it is required of the output capacitor to have:

$$C > \frac{7.5-5}{4\Delta V_O} \frac{1}{f^2} = 1,500 \mu F$$

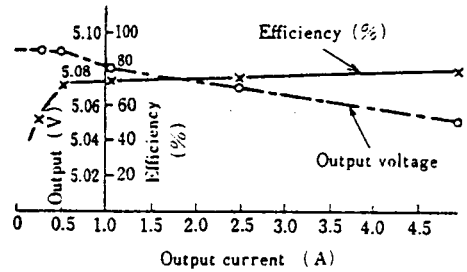


Fig. 4 Output voltage, efficiency—output current (Input 30V, output 5V, inverter system)

(2) Flyback system (Input 28V, output 5V, 10A)

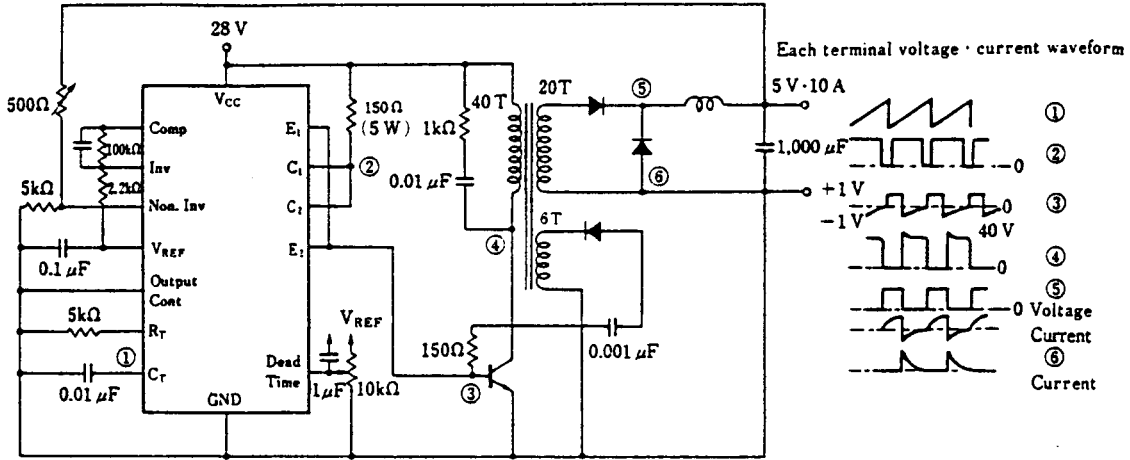


Fig. 5 Flyback system

(3) Photo isolation output voltage control by the IR9494

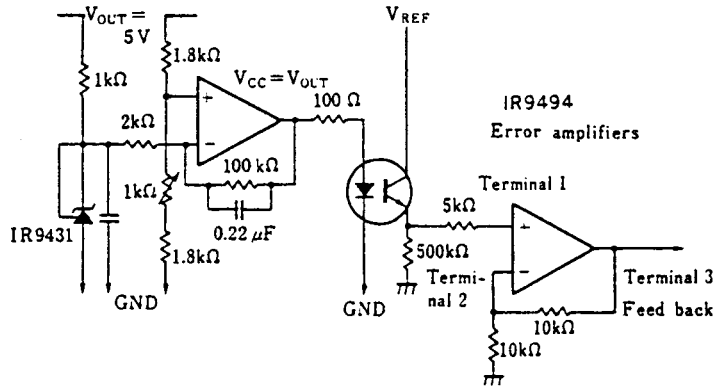


Fig.6 Photo isolation output voltage control circuit