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April 1st, 2010
Renesas Electronics Corporation

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RENESAS

BIPOLAR ANALOG INTEGRATED CIRCUIT
μPC494

SWITCHING REGULATOR CONTROL CIRCUIT

<R> DESCRIPTION

The μPC494 is a PWM type switching regulator control circuit.

Included in this device are a 5 V voltage reference, dual error amplifiers, a variable frequency sawtooth-wave generating oscillator, a comparator for dead-time control, a flip flop, dual alternating output switches, and a buffer to output source and sink currents.

Error amplifiers have wide common mode input voltage capability, and circuits for voltage feedback and over current protection are easy to configure. The μPC494 can be applied to all types of switching regulators, including chopper type regulators.

<R> FEATURES

- 250 mA output buffer to output sink and source currents
- Switchable operation mode between a single-end mode and a push-pull mode
- No double pulsing during transient condition
- Adjustable dead-time (0 to 100%)
- Internal 5 V output voltage reference circuit
- Error amplifiers with phase-compensating function
- Providing master-slave operation (synchronizing multiple ICs)
- With malfunction prevention circuit for low level supply voltage
- Package variations available for different applications

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Printed in Japan

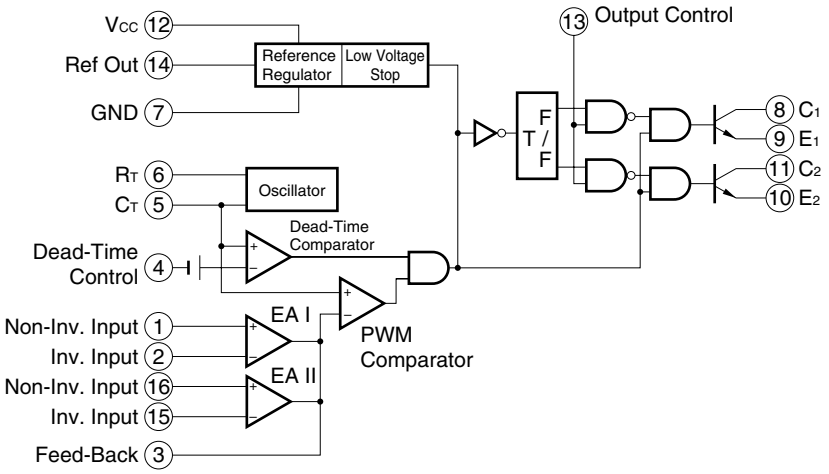
The mark <R> shows major revised points.
The revised points can be easily searched by copying an "<R>" in the PDF file and specifying it in the "Find what:" field.

<R> ORDERING INFORMATION

Part Number	Package	Package Type
μPC494C	16-pin plastic DIP (7.62 mm (300))	• plastic magazine
μPC494GS	16-pin plastic SOP (7.62 mm (300))	• plastic magazine
μPC494GS-E1	16-pin plastic SOP (7.62 mm (300))	• embossed taping • Pin 1 on draw-out side • 2500 pcs/reel
μPC494GS-E2	16-pin plastic SOP (7.62 mm (300))	• embossed taping • Pin 1 at take-up side • 2500 pcs/reel
μPC494GT-A Note	16-pin plastic SOP (9.53 mm (375))	• plastic magazine
μPC494GT-E1-A Note	16-pin plastic SOP (9.53 mm (375))	• embossed taping • Pin 1 on draw-out side • 1500 pcs/reel
μPC494GT-E2-A Note	16-pin plastic SOP (9.53 mm (375))	• embossed taping • Pin 1 at take-up side • 1500 pcs/reel
μPC494GS-A Note	16-pin plastic SOP (7.62 mm (300))	• plastic magazine
μPC494GS-E1-A Note	16-pin plastic SOP (7.62 mm (300))	• embossed taping • Pin 1 on draw-out side • 2500 pcs/reel
μPC494GS-E2-A Note	16-pin plastic SOP (7.62 mm (300))	• embossed taping • Pin 1 at take-up side • 2500 pcs/reel

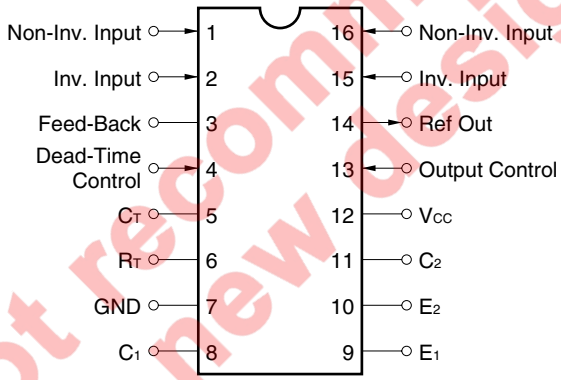
Note Pb-free (This product does not contain Pb in the external electrode and other parts.)

BLOCK DIAGRAM



PIN CONFIGURATION (Top View)

<R> • μPC494C, 494GS, 494GT-A, 494GS-A



<R> ABSOLUTE MAXIMUM RATINGS (T_A = 25°C, unless otherwise noted)

Characteristics	Symbol	μPC494C	μPC494GS	μPC494GT-A	μPC494GS-A	Unit
Supply Voltage	V_{CC}	−0.3 to +41				V
Error Amplifier Input Voltage	V_{ICM}	−0.3 to V_{CC} +0.3				V
Dead-time Comparator Input Voltage	V_{DTC}	−0.3 to +5.25				V
Output Voltage	V_{CER}	−0.3 to +41				V
Output Current	I_C	250				mA
Total Power Dissipation	P_T	1000	650 Note	780 Note	650 Note	mW
Operating Ambient Temperature	T_A	−20 to +85				°C
Storage Temperature	T_{stg}	−65 to +150				°C

Note With 5 cm x 5 cm x 1.6 mmt glass-epoxy substrate.

Caution Product quality may suffer if the absolute maximum rating is exceeded even momentarily for any parameter. That is, the absolute maximum ratings are rated values at which the product is on the verge of suffering physical damage, and therefore the product must be used under conditions that ensure that the absolute maximum ratings are not exceeded.

RECOMMENDED OPERATING CONDITIONS

Characteristics	Symbol	MIN.	TYP.	MAX.	Unit
Supply Voltage	V_{CC}	7		40	V
Output Voltage	V_{CER}	−0.3		+40	V
<R> Output Current (per output stage)	I_C			200	mA
Error Amplifier Sink Current	I_{OAMP}			−0.3	mA
Timing Capacitor	C_T	0.47		10000	nF
Timing Resistance	R_T	1.8		500	kΩ
Oscillation Frequency	f_{OSC}	1		300	kHz
Operating Ambient Temperature	T_A	−20		+70	°C

Caution The recommended operating range may be exceeded without causing any problems provided that the absolute maximum ratings are not exceeded. However, if the device is operated in a way that exceeds the recommended operating conditions, the margin between the actual conditions of use and the absolute maximum ratings is small, and therefore thorough evaluation is necessary. The recommended operating conditions do not imply that the device can be used with all values at their maximum values.

ELECTRICAL SPECIFICATIONS (V_{CC} = 15 V, f = 10 kHz, –20°C ≤ T_A ≤ +70°C, unless otherwise noted)

Block	Characteristics	Symbol	Conditions	MIN.	TYP. Note1	MAX.	Unit
Reference Section	Output Voltage	V_{REF}	I_{REF} = 1 mA, T_A = 25°C	4.75	5	5.25	V
	Line Regulation	REG_{IN}	7 V ≤ V_{CC} ≤ 40 V, I_{REF} = 1 mA, T_A = 25°C		8	25	mV
	Load Regulation	REG_L	1 mA ≤ I_{REF} ≤ 10 mA, T_A = 25°C		1	15	mV
	Temperature Coefficient	$\Delta V_{REF}/\Delta T$	–20°C ≤ T_A ≤ +85°C, I_{REF} = 1 mA		0.01	0.03	%/°C
	Short Circuit Output Current Note2	I_{SHORT}	V_{REF} = 0 V		50		mA
Oscillator Section	Frequency	f_{OSC}	C_T = 0.01 μF, R_T = 12 kΩ		10		kHz
	Standard Deviation of Frequency Note3		7 V ≤ V_{CC} ≤ 40 V, T_A = 25°C, under recommended operating conditions of C_T and R_T constants.		10		%
	Frequency Change with Voltage		7 V ≤ V_{CC} ≤ 40 V, T_A = 25°C, C_T = 0.01 μF, R_T = 12 kΩ		1		%
	Frequency Change with Temperature		0°C ≤ T_A ≤ 70°C, C_T = 0.01 μF, R_T = 12 kΩ		1	2	%
Dead- Time Control Section	Input Bias Current		0 V ≤ V_{DTC} ≤ 5.25 V		–2	–10	μA
	Maximum Duty Cycle (Each Output)		V_{DTC} = 0 V	45	49		%
	Input Threshold Voltage 1	V_{TH1}	Output pulse 0% duty cycle		3	3.3	V
	Input Threshold Voltage 2	V_{TH2}	Output pulse maximum duty cycle	0			V
Error Amplifier 1, 2 Section	Input Offset Voltage	V_{IO}	V_{OAMP} = 2.5 V		2	10	mV
	Input Offset Current	I_{IO}	V_{OAMP} = 2.5 V		25	250	nA
	Input Bias Current		V_{OAMP} = 2.5 V		0.2	1	μA
	Common Mode Input Voltage Low level	V_{ICM}	7 V ≤ V_{CC} ≤ 40 V	–0.3			V
	Common Mode Input Voltage High level			V_{CC} – 2			
	Open Loop Voltage Gain	A_V	V_{OAMP} = 0.5 to 3.5 V, T_A = 25°C	60	80		dB
	Unity Gain Bandwidth		T_A = 25°C	500	830		kHz
	Common Mode Rejection Ratio	CMR	V_{CC} = 40 V, T_A = 25°C	65	80		dB
	Output Sink Current		V_{OAMP} = 0.7 V	0.3	0.7		mA
	Output Source Current		V_{OAMP} = 3.5 V	–2	–10		mA
PWM Section	Input Threshold Voltage (Pin 3)		Output pulse 0% duty cycle, see **Figure 1**.		4	4.5	V
	Input Sink Current		$V_{(Pin\ 3)}$ = 0.7 V	0.3	0.7		mA

Notes 1. The TYP. values are values at T_A = 25°C, except for the characteristics of temperature.

2. The short circuit output current flow must be terminated within 1 second.
Repeated operations are allowed while internal heat accumulation is within a safe range.

3. Standard deviation is a measure of the statistical distribution about the mean as derived from the formula;

$$\sigma = \sqrt{\frac{\sum_{n=1}^{N} (X_n - \overline{X})^2}{N-1}}$$

Calculation expression of frequency f_{OSC} is as follows ;

$$f_{OSC} \cong \frac{1}{0.817\ R_T \bullet C_T + 1.42 \bullet 10^{-6}}\ (Hz) \qquad [R_T] = \Omega,\ [C_T] = F$$

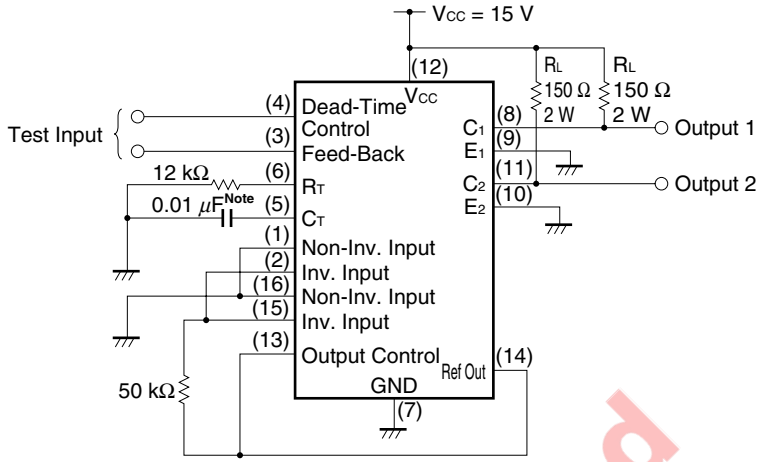
(2/2)

Block	Characteristics		Symbol	Conditions	MIN.	TYP. Note	MAX.	Unit
Output Section	Collector Cut-off Current		I_{CER}	V_{CE} = 40 V, V_{CC} = 40 V, Common Emitter			100	μA
	Emitter Cut-off Current			V_{CC} = V_C = 40 V, V_E = 0 V, Emitter Follower			–100	μA
	Collector Saturation Voltage	Common Emitter	$V_{CE(sat)}$	I_C = 200 mA, V_E = 0 V		0.95	1.3	V
		Emitter Follower	$V_{CE(ON)}$	I_E = –200 mA, V_C = 15 V		1.6	2.5	V
	Output Voltage Rise Time	Common Emitter	t_{r1}	V_{CC} = 15 V, R_L = 150 Ω, I_C ≅ 100 mA, T_A = 25°C, see **Figure 1**.		100	200	ns
	Output Voltage Fall Time		t_{f1}			70	200	ns
	Output Voltage Rise Time	Emitter Follower	t_{r2}	V_C = 15 V, R_L = 150 Ω, I_E ≅ 100 mA, T_A = 25°C, see **Figure 1**.		100	200	ns
	Output Voltage Fall Time		t_{f2}			70	200	ns
Total Device	Standby Current		$I_{CC(S.B)}$	V_{CC} = 15 V, all other pins open.		8	12.5	mA
	Bias Current		$I_{CC(BI)}$	$V_{(Pin\ 4)}$ = 2 V, see **Figure 1**.		10		mA

Note The TYP. values are values at T_A = 25°C, except for the characteristics of temperature.

TEST CIRCUIT AND WAVEFORM CHARACTERISTICS

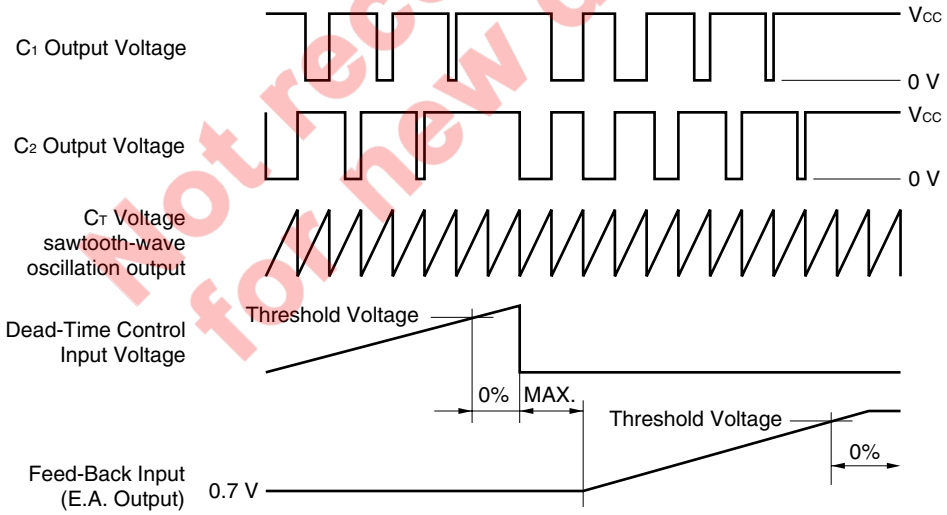
Figure1. Test Circuit



Note Recommend film capacitor.

Caution When the emitter follower is output, connect C_1 and C_2 to V_{CC} and E_1 and E_2 to GND via R_L.

Figure2. Voltage Waveform



Connection of Output Control Pin (Pin 13)

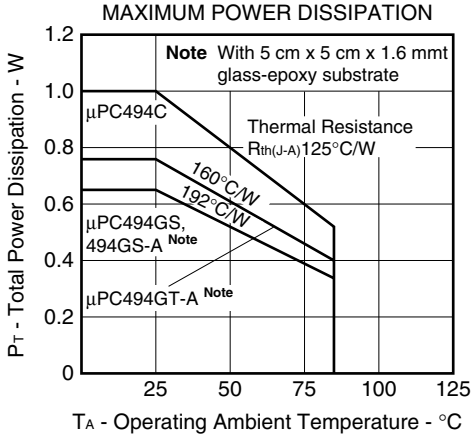
Output Control Input (Pin 13)	Operation Mode
Ref Out	push-pull
GND	Single-ended operation (common-mode output of C1, C2)

TYPICAL PERFORMANCE CHARACTERISTICS

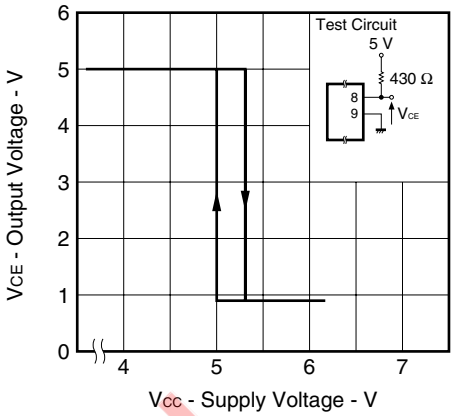
(Unless otherwise specified, T_A = 25°C, V_{CC} = 15 V, Reference)

<R>

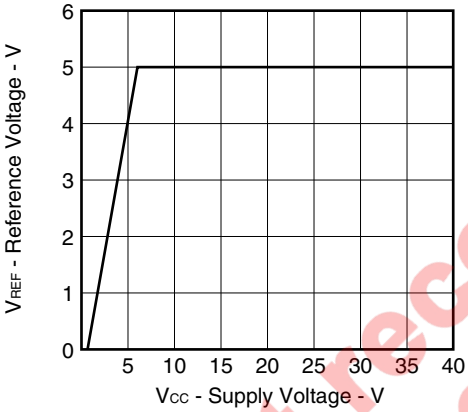
MAXIMUM POWER DISSIPATION



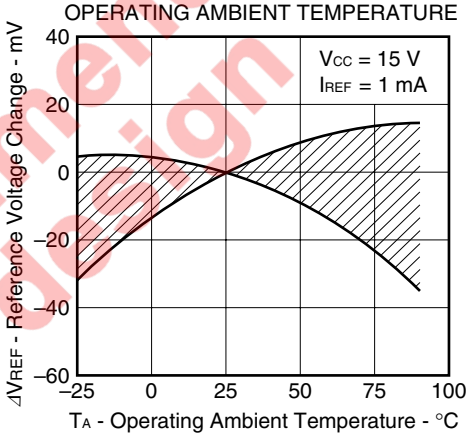
MISS-OPERATION PREVENTION CIRCUIT CHARACTERISTICS



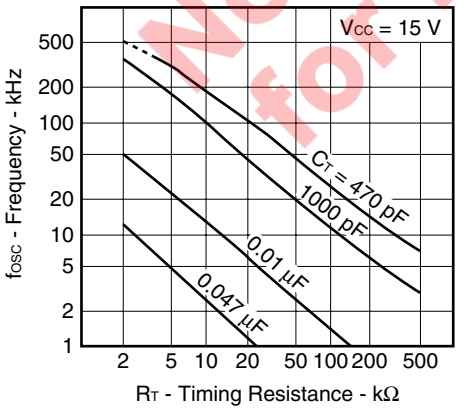
REFERENCE VOLTAGE vs. SUPPLY VOLTAGE



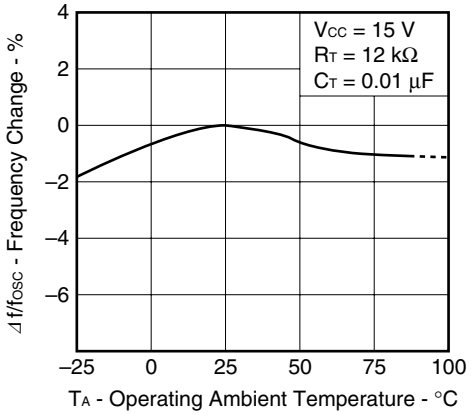
REFERENCE VOLTAGE vs. OPERATING AMBIENT TEMPERATURE



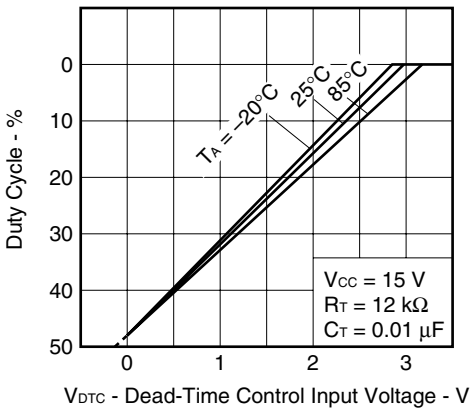
FREQUENCY vs. R_T AND C_T



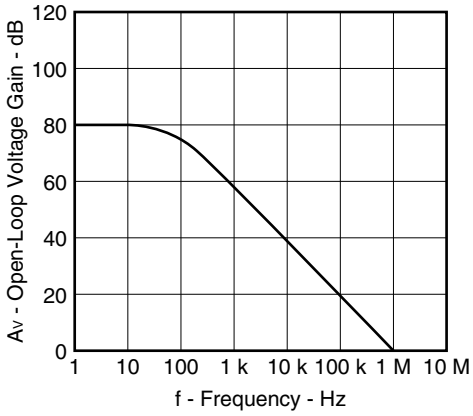
FREQUENCY vs. OPERATING AMBIENT TEMPERATURE



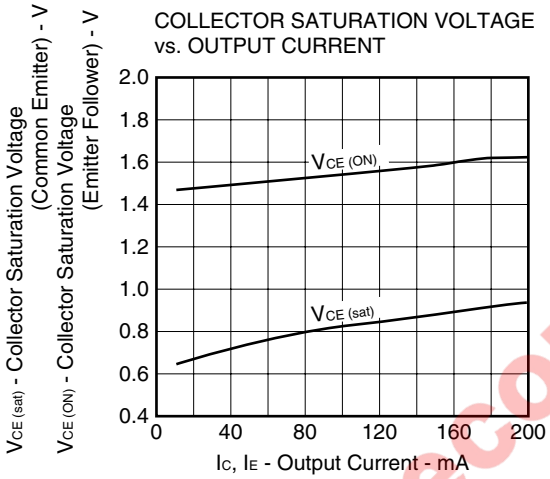
DUTY CYCLE vs. DEAD-TIME CONTROL INPUT VOLTAGE



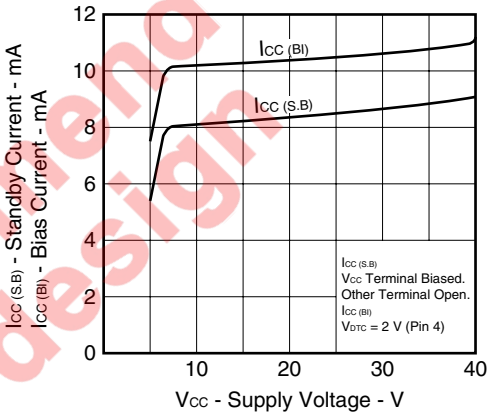
OPEN-LOOP VOLTAGE GAIN vs. FREQUENCY



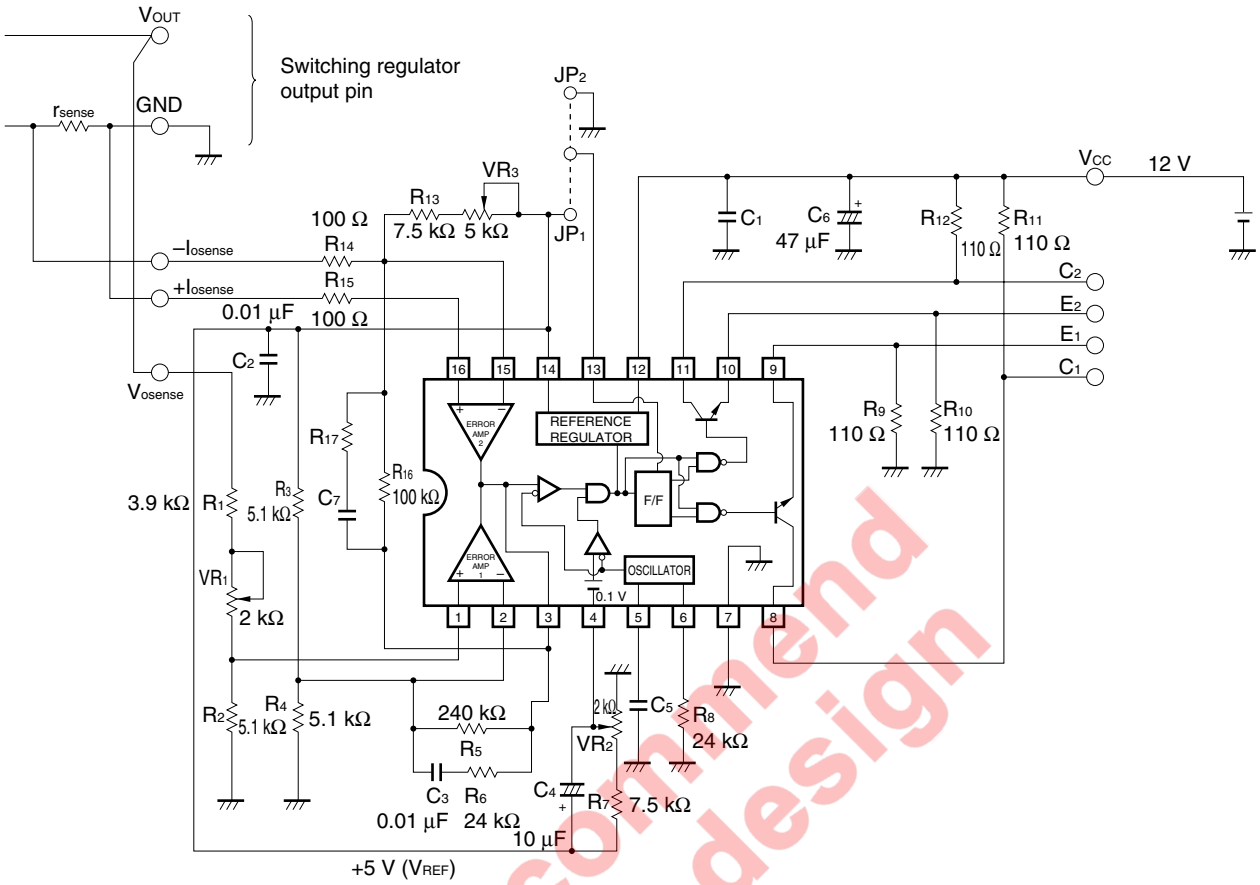
COLLECTOR SATURATION VOLTAGE vs. OUTPUT CURRENT



STANDBY AND BIAS CURRENT vs. SUPPLY VOLTAGE

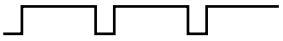
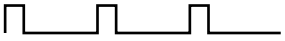


BASIC APPLICATION CIRCUIT



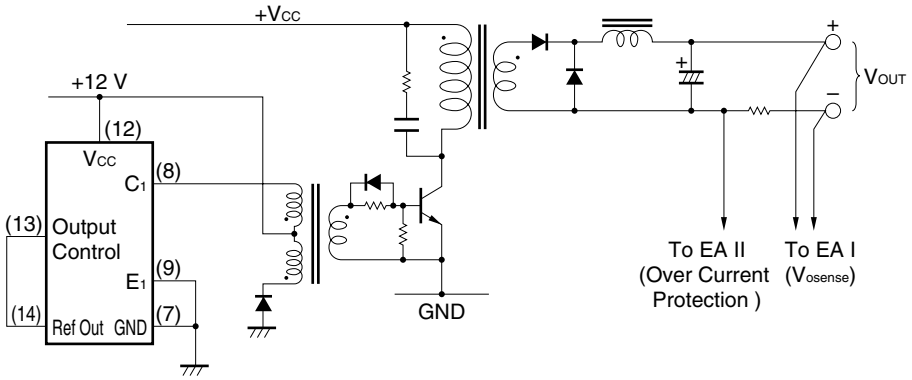
Remark fosc ≅ 40 kHz, C5 = 1000 pF (Recommend film capacitor)

CONNECTION DIAGRAM

Operation Mode	Output Control Input (Pin 13)	Output Mode	Output Voltage Waveform
Push-pull	Ref Out (Pin 14) (JP1 Wired)	Sink (R_9, R_{10} short)	C_1  C_2 
		Source (R_{11}, R_{12} short)	E_1  E_2 
Single-ended operation	GND (Pin 7) (JP2 Wired)	Sink (R_9, R_{10} short)	C_1, C_2 
		Source (R_{11}, R_{12} short)	E_1, E_2 

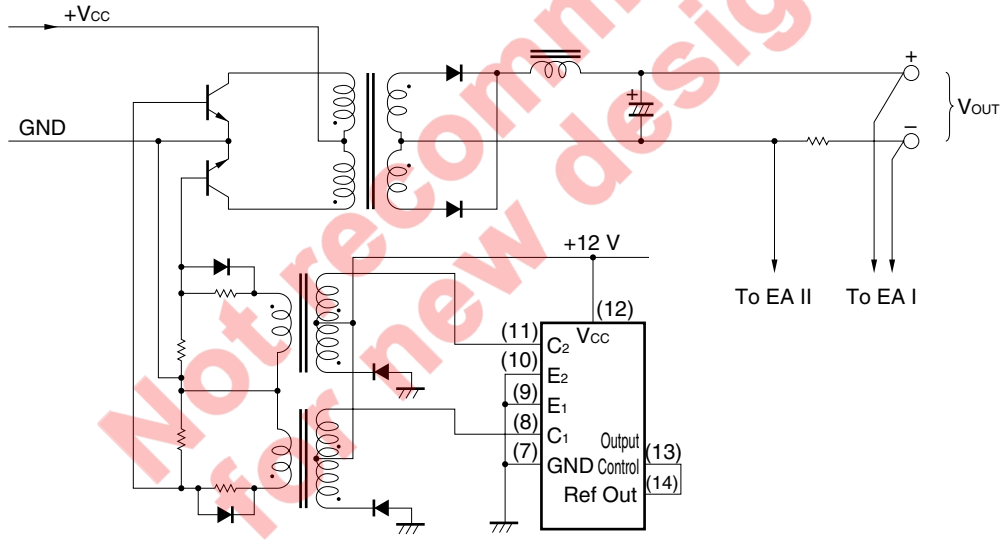
TYPICAL EXAMPLE OF APPLICATION CIRCUITS

1) Forward Type

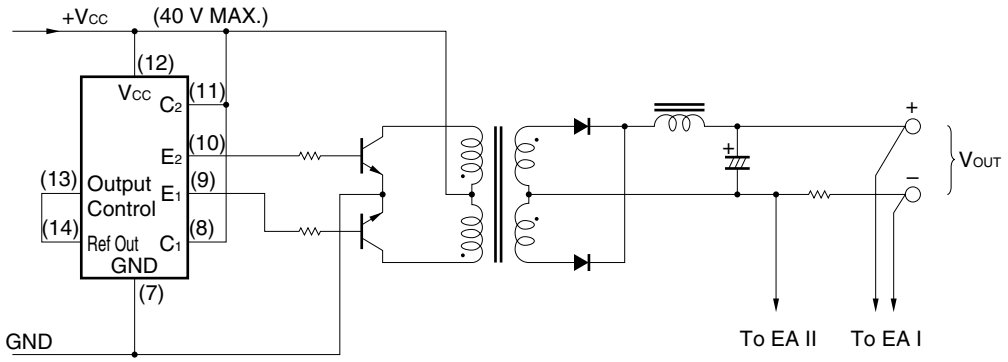


2) Push-pull Type

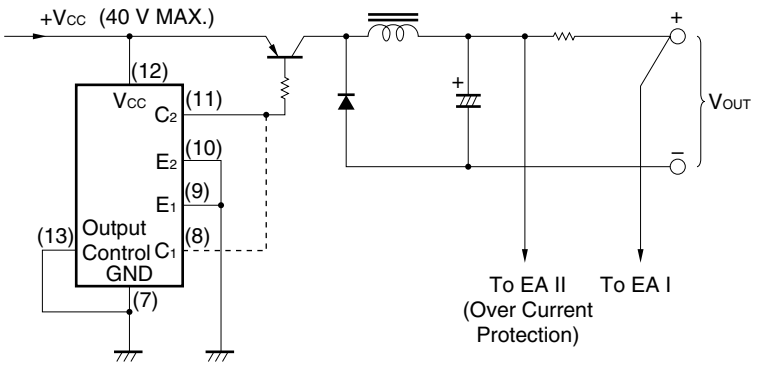
(Isolated)



(Non Isolated)



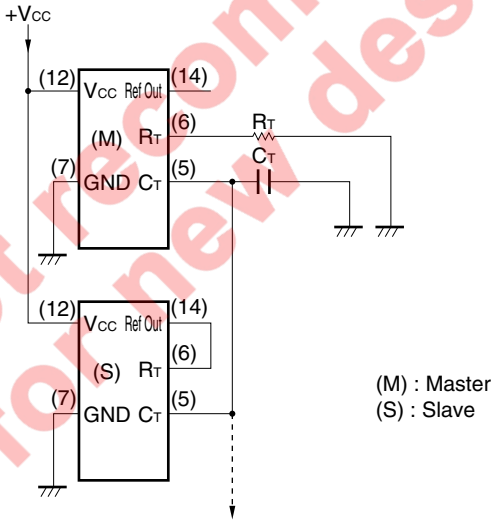
3) Step-down Chopper



Remark The dotted line indicates the connection in case of large current.

EXAMPLE OF MASTER-SLAVE CONNECTION

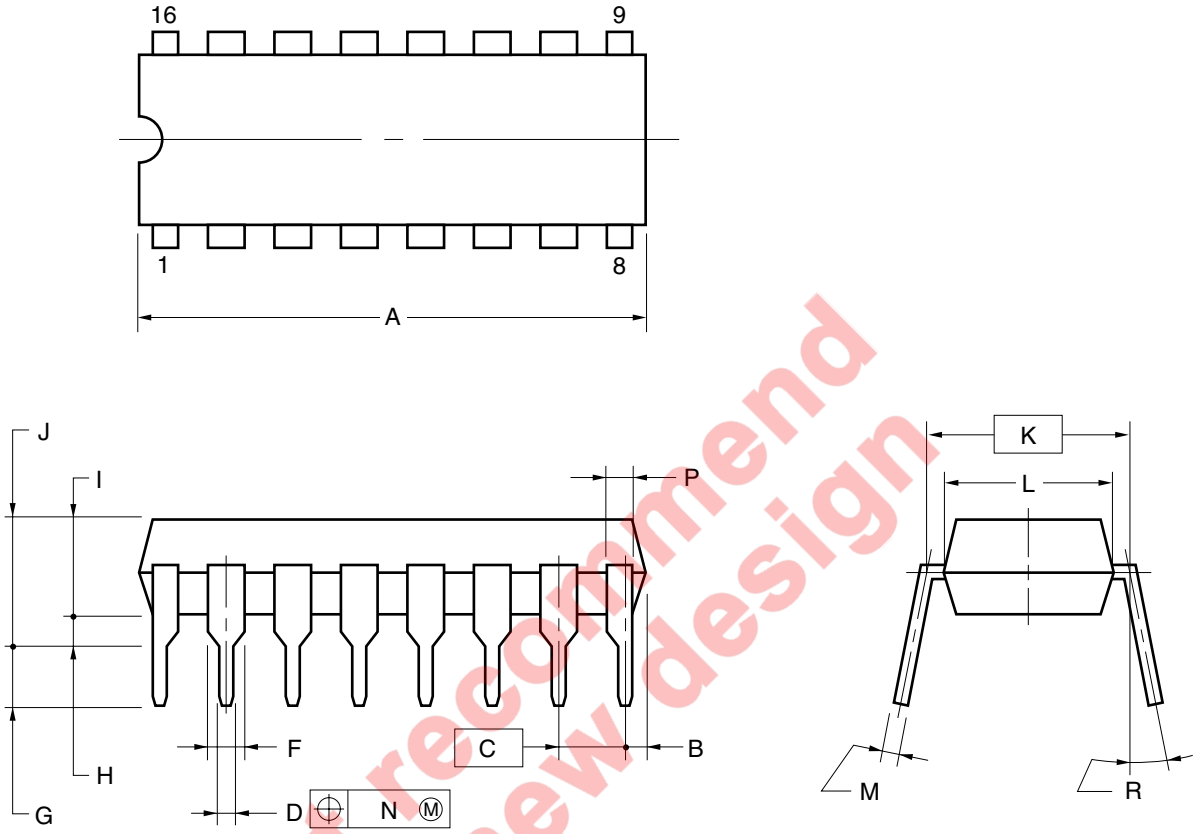
To synchronize μPC494 ICs, connect the pin 6 (R_T) of a slave IC to pin 14 (Ref Out) of the same IC, and connect both C_T pins of master and slave ICs after confirming oscillator of slave IC is stopped.



PACKAGE DRAWINGS (Unit : mm)

μPC494C

16-PIN PLASTIC DIP (7.62mm(300))



NOTES

1. Each lead centerline is located within 0.25 mm of its true position (T.P.) at maximum material condition.

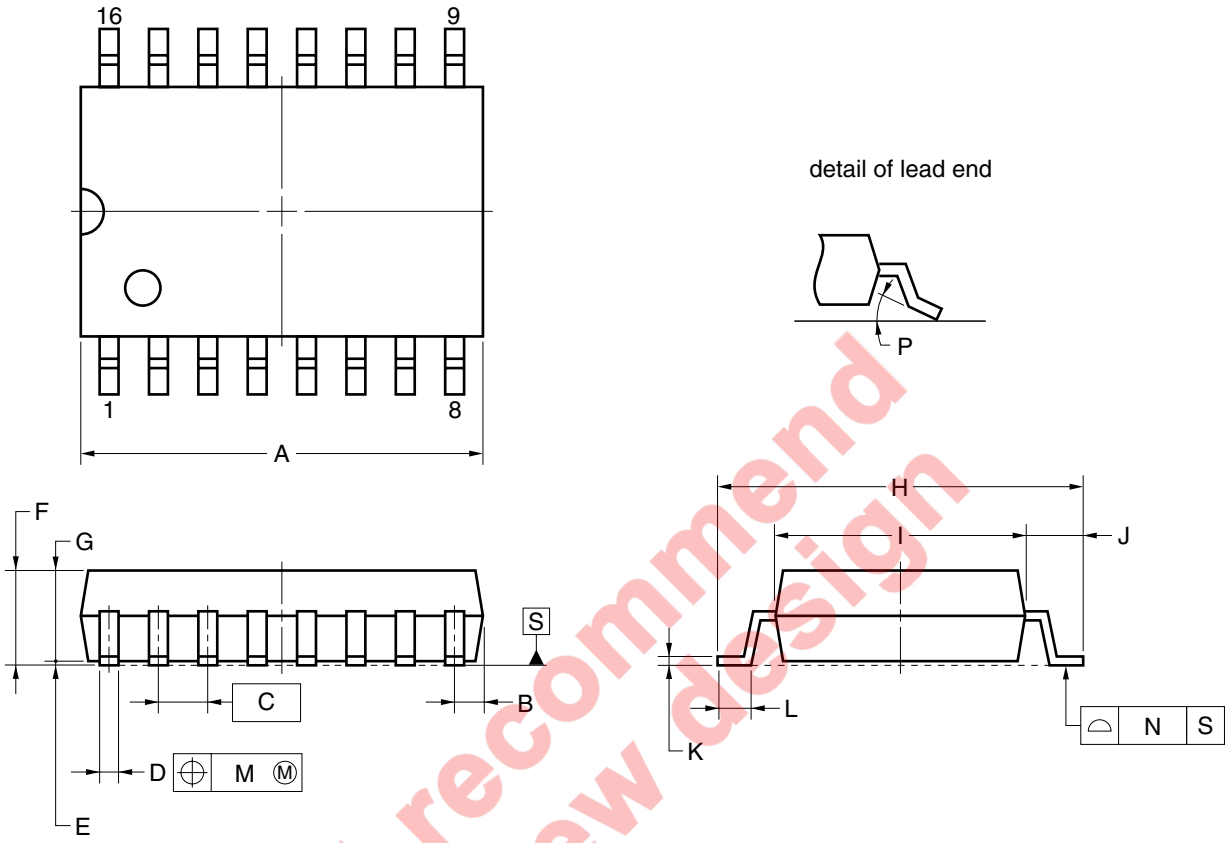
2. Item "K" to center of leads when formed parallel.

ITEM	MILLIMETERS
A	20.32 MAX.
B	1.27 MAX.
C	2.54 (T.P.)
D	0.50±0.10
F	1.1 MIN.
G	3.5±0.3
H	0.51 MIN.
I	4.31 MAX.
J	5.08 MAX.
K	7.62 (T.P.)
L	6.5
M	$0.25^{+0.10}_{-0.05}$
N	0.25
P	1.1 MIN.
R	0~15°

P16C-100-300B-2

<R> **μPC494GT-A**

16-PIN PLASTIC SOP (9.53 mm (375))



NOTE

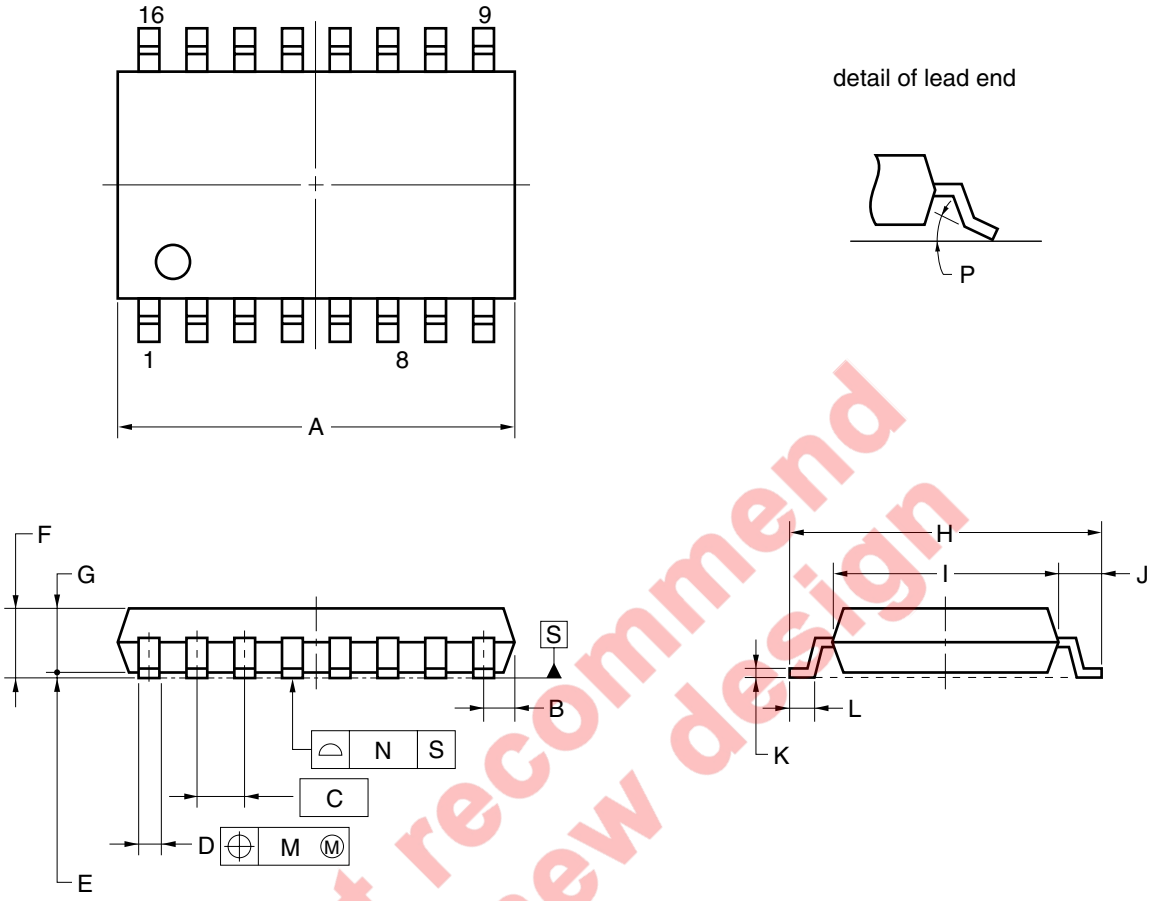
Each lead centerline is located within 0.12 mm of its true position (T.P.) at maximum material condition.

ITEM	MILLIMETERS
A	10.2±0.26
B	0.805 MAX.
C	1.27 (T.P.)
D	$0.42^{+0.08}_{-0.07}$
E	0.125±0.075
F	2.9 MAX.
G	2.50±0.2
H	10.3±0.3
I	7.2±0.2
J	1.6±0.2
K	$0.17^{+0.08}_{-0.07}$
L	0.8±0.2
M	0.12
N	0.10
P	$3^{\circ}{}^{+7^{\circ}}_{-3^{\circ}}$

P16GT-50-375B-2

μPC494GS, 494GS-A

16-PIN PLASTIC SOP (7.62 mm (300))



NOTE

Each lead centerline is located within 0.12 mm of its true position (T.P.) at maximum material condition.

ITEM	MILLIMETERS
A	10.2±0.2
B	0.78 MAX.
C	1.27 (T.P.)
D	$0.42^{+0.08}_{-0.07}$
E	0.1±0.1
F	1.65±0.15
G	1.55
H	7.7±0.3
I	5.6±0.2
J	1.1±0.2
K	$0.22^{+0.08}_{-0.07}$
L	0.6±0.2
M	0.12
N	0.10
P	$3^{\circ}{}^{+7^{\circ}}_{-3^{\circ}}$

P16GM-50-300B-6

<R> RECOMMENDED SOLDERING CONDITIONS

The μPC494 should be soldered and mounted under the following recommended conditions.

For soldering methods and conditions other than those recommended below, contact an NEC Electronics sales representative.

For technical information, see the following website.

Semiconductor Device Mount Manual (http://www.necel.com/pkg/en/mount/index.html)

Type of Through-hole Device

μPC494C: 16-pin plastic DIP (7.62 mm (300))

Process	Conditions	Symbol
Wave Soldering (only to leads)	Solder temperature: 260°C or below, Flow time: 10 seconds or less	WS60-00
Partial Heating Method	Pin temperature: 300°C or below, Heat time: 3 seconds or less (Per each side of the device)	P300

Caution For through-hole device, the wave soldering process must be applied only to leads, and make sure that the package body does not get jet soldered.

Type of Surface Mount Device

μPC494GS: 16-pin plastic SOP (7.62 mm (300))

Process	Conditions	Symbol
Infrared Ray Reflow	Maximum temperature (package's surface temperature): 235°C or below, Time at maximum temperature: 10 seconds or less, Time at temperature higher than 210°C: 30 seconds or less, Preheating time at 100 to 160°C: 30 to 60 seconds, Times: 3 times, Flux: Rosin flux with low chlorine (0.2 Wt% or below) recommended.	IR35-00-3
Vapor Phase Soldering	Maximum temperature (package's surface temperature): 215°C or below, Reflow time: 25 to 40 seconds or less (at 200°C or higher), Preheating time at 120 to 150°C: 30 to 60 seconds, Times: 3 times, Flux: Rosin flux with low chlorine (0.2 Wt% or below) recommended.	VP15-00-3
Wave Soldering	Solder temperature: 260°C or below, Flow time: 10 seconds or less, Maximum number of flow processes: 1 time, Preheating temperature: 120°C MAX. (Package surface temperature).	WS60-00-1
Partial Heating Method	Pin temperature: 350°C or below, Heat time: 3 seconds or less (Per each side of the device), Flux: Rosin flux with low chlorine (0.2 Wt% or below) recommended.	P350

Caution Apply only one kind of soldering condition to a device, except for "partial heating method", or the device will be damaged by heat stress.

μPC494GT-A [Note1]: 16-pin plastic SOP (9.53 mm (375))

Process	Conditions	Symbol
Infrared Ray Reflow	Maximum temperature (package's surface temperature): 260°C or below, Time at maximum temperature: 10 seconds or less, Time at temperature higher than 220°C: 60 seconds or less, Preheating time at 160 to 180°C: 60 to 120 seconds, Times: 3 times, Exposure limit: 7 days [Note2] (after that, prebake at 125°C for 20 hours), Flux: Rosin flux with low chlorine (0.2 Wt% or below) recommended.	IR60-207-3
Wave Soldering	Solder temperature: 260°C or below, Flow time: 10 seconds or less, Maximum number of flow processes: 1 time, Preheating temperature: 120°C MAX. (Package surface temperature), Exposure limit: 7 days [Note2] (after that, prebake at 125°C for 20 hours).	WS60-207-1
Partial Heating Method	Pin temperature: 350°C or below, Heat time: 3 seconds or less (Per each side of the device), Flux: Rosin flux with low chlorine (0.2 Wt% or below) recommended.	P350

Notes 1. Pb-free (This product does not contain Pb in the external electrode and other parts.)

2. After opening the dry pack, store it a 25°C or less and 65% RH or less for the allowable storage period.

μPC494GS-A [Note]: 16-pin plastic SOP (7.62 mm (300))

Process	Conditions	Symbol
Infrared Ray Reflow	Maximum temperature (package's surface temperature): 260°C or below, Time at maximum temperature: 10 seconds or less, Time at temperature higher than 220°C: 60 seconds or less, Preheating time at 160 to 180°C: 60 to 120 seconds, Times: 3 times, Flux: Rosin flux with low chlorine (0.2 Wt% or below) recommended.	IR60-00-3
Wave Soldering	Solder temperature: 260°C or below, Flow time: 10 seconds or less, Maximum number of flow processes: 1 time, Preheating temperature: 120°C MAX. (Package surface temperature).	WS60-00-1
Partial Heating Method	Pin temperature: 350°C or below, Heat time: 3 seconds or less (Per each side of the device), Flux: Rosin flux with low chlorine (0.2 Wt% or below) recommended.	P350

Note Pb-free (This product does not contain Pb in the external electrode and other parts.)

Caution Apply only one kind of soldering condition to a device, except for "partial heating method", or the device will be damaged by heat stress.

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