

**PRELIMINARY****Switching Regulator Controller****OVERVIEW**

The AA18375AP is a two-channel PWM DC-DC converter control IC that features low-voltage operation. This IC can obtain the step-up, step-down and inverting voltages with a small number of external components. Because the IC is compactly packaged, it is best suited for use as a power supply in portable equipment.

**FEATURES**

- Wide supply voltage range: 3.6 V to 15 V
- Low current consumption: 1.3 mA typical
- Control in a wide output frequency range is possible (1 kHz to 500 kHz).
- Timer latch, short-circuit protection circuit is built in.
- Circuit to prevent malfunction during low input voltage is built in.
- Built-in reference voltage (1.28V) output pin.
- Dead time period is adjustable over the whole range of duty ratio.
- Synchronization operation is possible.

**PIN Configuration**

(TOP VIEW)

$C_T$	1	16	$V_{REF}$
$R_T$	2	15	SCP
+IN1	3	14	+IN2
-IN1	4	13	-IN2
FB1	5	12	FB2
D.T.C.1	6	11	D.T.C.2
OUT1	7	10	OUT2
GND	8	9	VCC

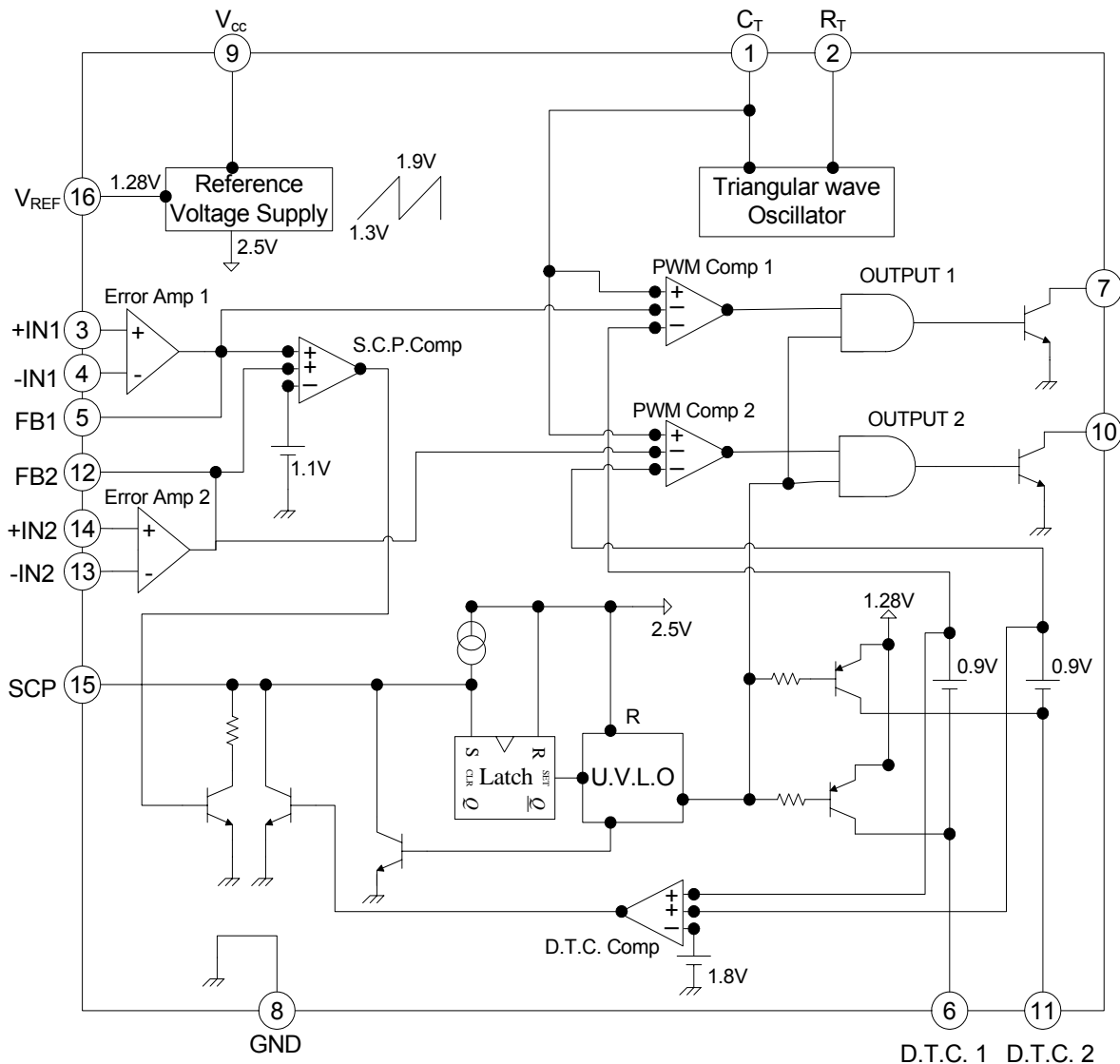
**APPLICATIONS**

- LCD Displays
- PDAs
- Digital Still Cameras
- Hand-held and portable instruments

## PIN DESCRIPTIONS

Pin No.	Symbol	I/O	Description	Pin No.	Symbol	I/O	Description
1	C <sub>T</sub>	—	Pin for oscillation capacitor connection	9	V <sub>CC</sub>	I	IC power supply pin
2	R <sub>T</sub>	—	Pin for oscillation timing resistor connection	10	OUT2	O	Output2 block push-pull type output pin
3	+IN1	I	Error amplifier 1 block non-inverting input pin	11	D.T.C.2	I	PWM2 block dead-time setting pin
4	-IN1	I	Error amplifier 1 block inverting input pin	12	FB2	O	Output pin of error amplifier 2 block
5	FB1	O	Output pin of error amplifier 1 block	13	-IN2	I	Error amplifier 2 block inverting input pin
6	D.T.C.1	I	PWM1 block dead-time setting pin	14	+IN2	I	Error amplifier 2 block non-inverting input pin
7	OUT1	O	Output1 block push-pull type output pin	15	SCP	—	Soft start and short circuit protection setting capacitor connection pin
8	GND	—	Ground pin	16	V <sub>REF</sub>	O	Reference voltage output pin

## BLOCK DIAGRAM





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**ABSOLUTE MAXIMUM RATING**

(Ta = +25 ° C)

Parameter	Symbol	Condition	Rating		Unit
			Min	Max	
Power Supply Voltage	Vcc	-	-	18	V
Error Amp. Input Voltage	Vi	-	-0.3	+10	V
Collector Output Voltage	Vo	-	-	18	V
Collector Output Current	Io	-	-	75	mA
Power Dissipation	Pd	Ta ≤ +25°C	-	*430	mW
Operating Temperature	TOP	-	-30	+85	°C
Storage temperature	Tstg	-	-55	+125	°C

\*: The packages are mounted on the epoxy board (4 cm x 4 cm x 1.5 mm).

**RECOMMENDED OPERATING CONDITIONS**

Parameter	Symbol	Value			Unit
		Min	Typ	Max	
Power Supply Voltage	VCC	3.6	6.0	15	V
Error Amp. Input Voltage	Vi	-0.2	-	1.45	V
Collector Output Voltage	Vo	-	-	15	V
Collector Output Current	Io	0.3	-	50	mA
Phase Compensation Capacitor	CP	-	0.1	-	μ F
Timing Capacitor	CT	150	-	15000	pF
Timing Resistor	RT	5.1	-	100	kΩ
Oscillator Frequency	fOSC	1	-	500	kHz
Reference Voltage Output Current	IREF	-3	-1	-	mA
Operating Temperature	TOP	-30	25	85	°C

**WARNING:** The recommended operating conditions are required in order to ensure the normal operation of the semiconductor device. All of the device's electrical characteristics are warranted when the device is operated within these ranges.

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**ELECTRICAL CHARACTERISTICS**

(Ta = +25 °C, Vcc = 6 V)

Parameter	condition	Symbol	Value			Unit	
			Min	Typ	Max		
Reference Section	Output Voltage	IOR = - 1 mA	VREF	1.26	1.28	1.30	V
	Output Temp. Stability	Ta = - 30 ° C to +85 ° C	VRTC	-2	±0.2	2	%
	Input Stability	VCC = 3.6 V to 15 V	Line	-	2	10	mV
	Load Stability	IOR = - 0.1 mA to - 1 mA	Load	-	1	7.5	mV
	Short Circuit Output Current	VREF = 0 V	IOS	-	-30	-10	mA
Under Voltage Lockout Protection Section	Threshold Voltage	IOR = - 0.1 mA	VtH	-	2.72	-	V
		IOR = - 0.1 mA	VtL	-	2.60	-	V
	Hysteresis Width	IOR = - 0.1 mA	VHYS	80	120	-	mV
	Reset Voltage (Vcc)	-	VR	1.5	1.9	-	V
Protection Circuit Section	Input Threshold Voltage	-	VtPC	0.60	0.65	0.7	V
	Input Stand by Voltage	No pull up	VSTB	-	50	100	mV
	Input Latch Voltage	No pull up	VI	-	50	100	mV
	Input Source Current	-	Ibpc	-1.4	-1.0	-0.6	μ A
	Comparator Threshold Voltage	Pin 5, Pin 12	VtC	-	1.1	-	V
Triangular Waveform Oscillator Section	Oscillator Frequency	CT = 330 pF, RT = 15 kΩ	fosc	-	200	-	kHz
	Frequency Deviation	CT = 330 pF, RT = 15 kΩ	fdev	-	10	-	%
	Frequency Stability (Vcc)	VCC = 3.6 V to 15 V	fdV	-	1	-	%
	Frequency Stability (Ta)	Ta = - 30 ° C to +85 ° C	fdT	-4	-	4	%
Dead-Time Control Section	Input Threshold Voltage (fosc = 10 kHz)	Duty Cycle = 0 %	Vt0	-	1.0	VREF-0.15	V
		Duty Cycle = 100 %	Vt100	0.2	0.4	-	V
	Input Bias Current	-	Ibdt	-	-0.2	-1	μ A
	Latch Mode Source Current	Vdt = 0.7 V	I dt	-	-150	-80	μ A
	Latch Input Voltage	I dt = - 40 μ A	Vdt	VREF-0.1	-	-	V
Error Amp. Section	Input Offset Voltage	Vo = 1.6 V	VIO	-10	-	+10	mV
	Input Offset Current	Vo = 1.6 V	IIO	-100	-	+100	nA
	Input Bias Current	Vo = 1.6 V	IB	-500	-100	-	nA
	Common Mode Input Voltage Range	VCC = 3.6 V to 15 V	VICR	-0.2	-	+1.45	V
	Voltage Gain		Av	84	120	-	V/V
	Frequency Band Width	Av = - 3 dB	BW	-	3	-	MHz

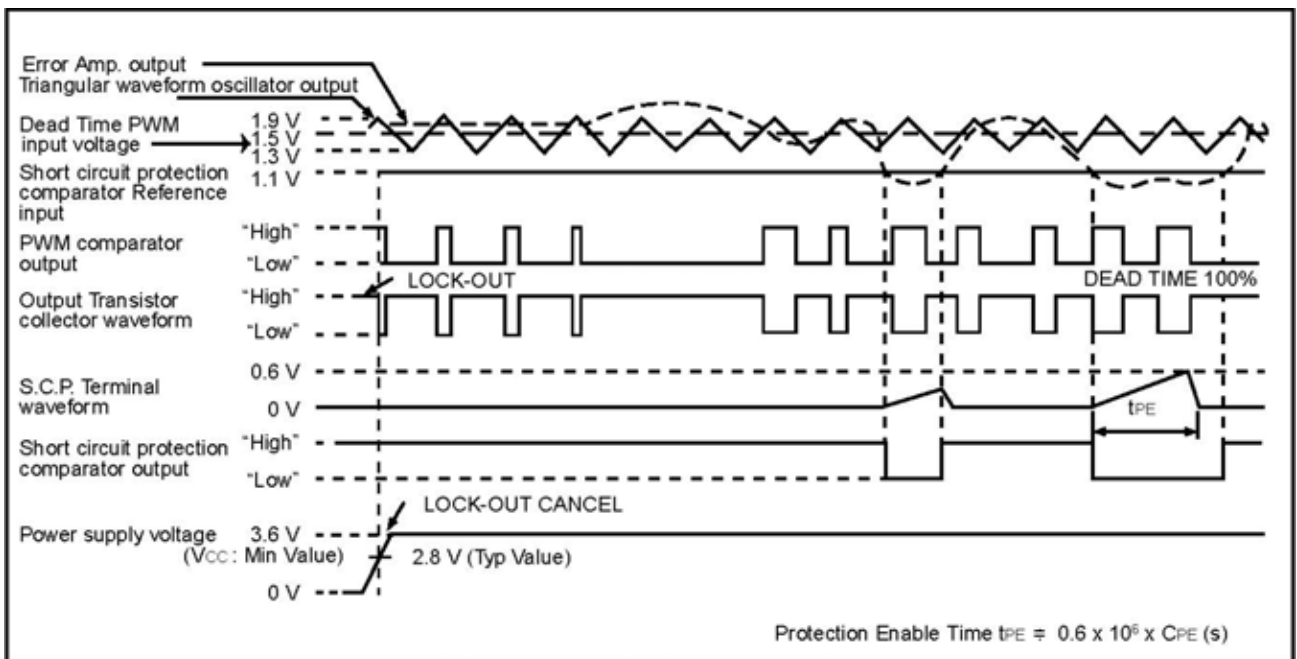


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	Common Mode Rejection Ratio		CMRR	60	80	-	dB
	Max Output Voltage Width		VOM+	2.2	2.4	-	V
			VOM	-	0.7	0.9	V
	Output Sink Current	Vo = 1.6 V	IOM+	24	50	-	μ A
Output Source Current	Vo = 1.6 V	IOM	-	-1.2	-0.7	mA	
PWM Comparator Section	Input Threshold Voltage (fosc=10 kHz)	Duty Cycle = 0 %	Vt0	-	1.9	2.1	V
		Duty Cycle = 100 %	Vt100	1.05	1.3	-	V
	Input Sink Current	Pin 5, Pin 12 = 1.6 V	IIN+	24	50	-	μ A
	Input Source Current	Pin 5, Pin 12 = 1.6 V	IIN	-	-1.2	-0.7	mA
Output Section	Output Leak Current	Vo = 15 V	Leak	-	-	10	μA
	Output Saturation Voltage	Io = 50 mA	VSAT	-	1.1	1.4	V
Stand by Current		Output "OFF"	ICCS	-	1.3	1.8	mA
Average Supply Current		RT = 15 kΩ	ICCa	-	1.7	2.4	mA

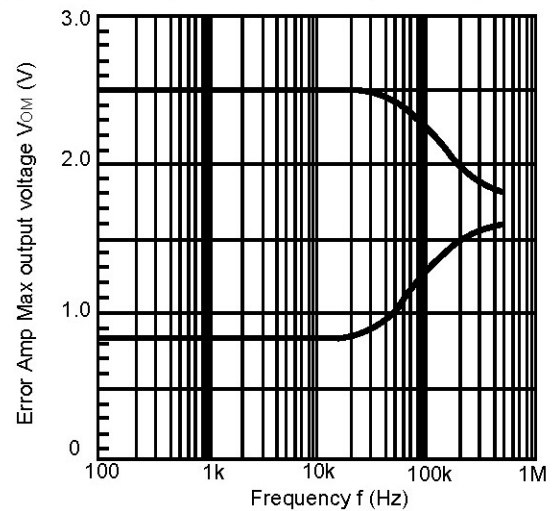
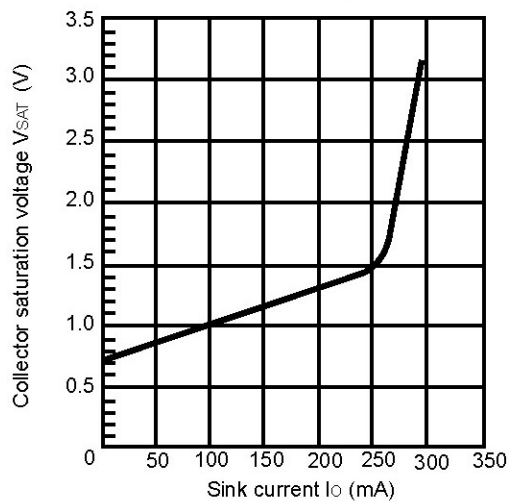
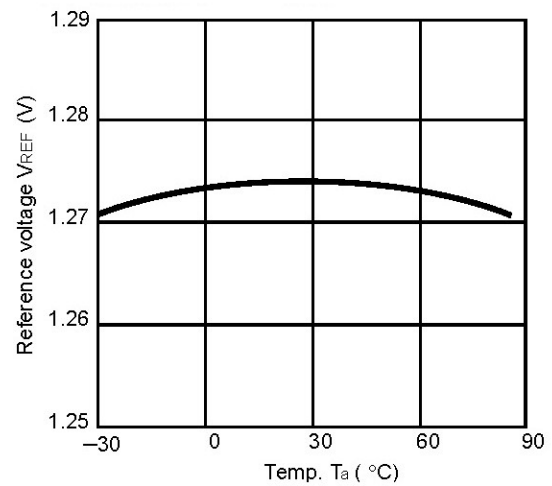
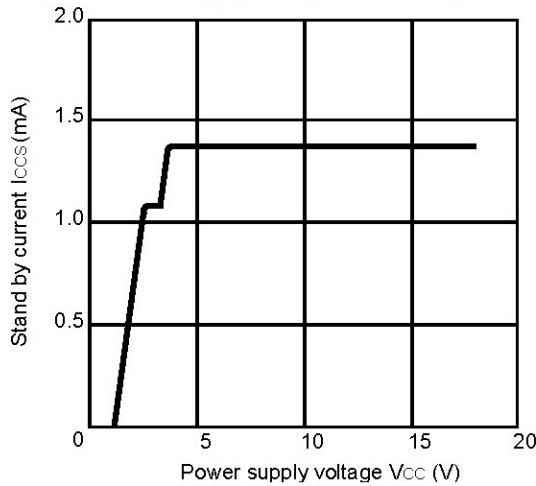
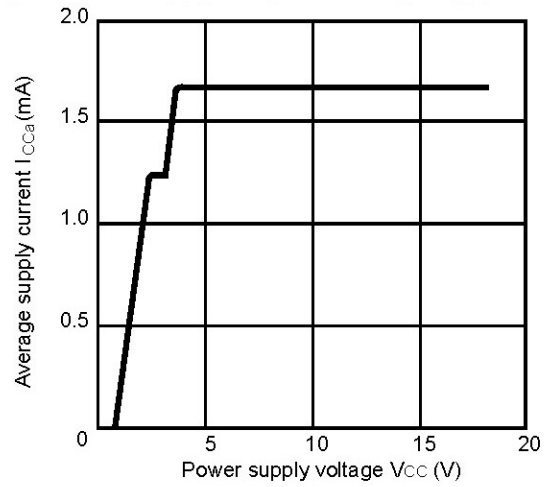
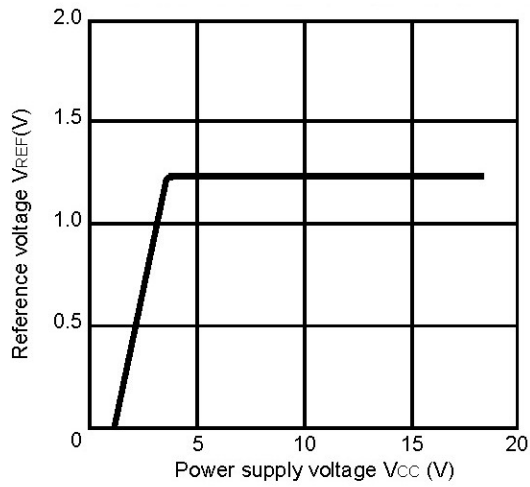
**TIMING DIAGRAM**



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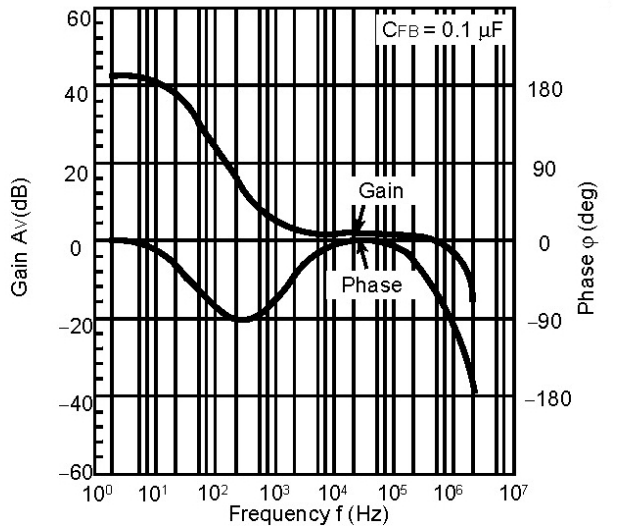
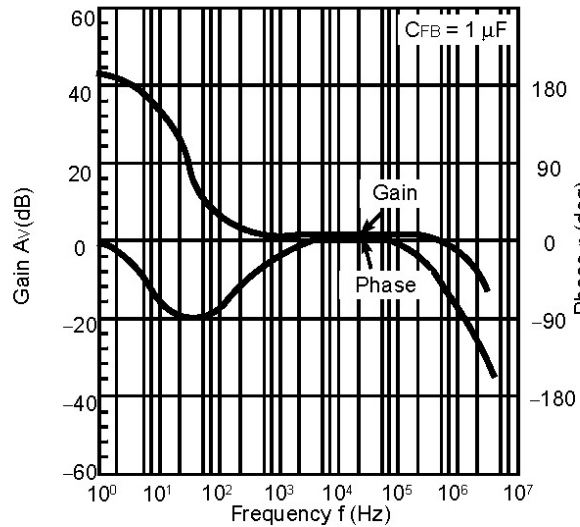
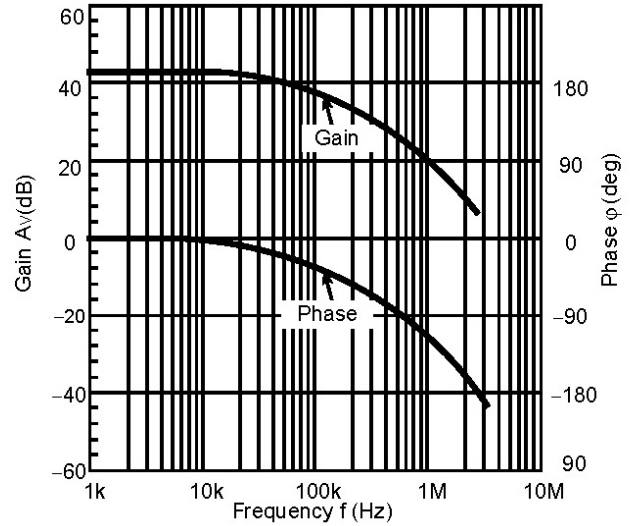
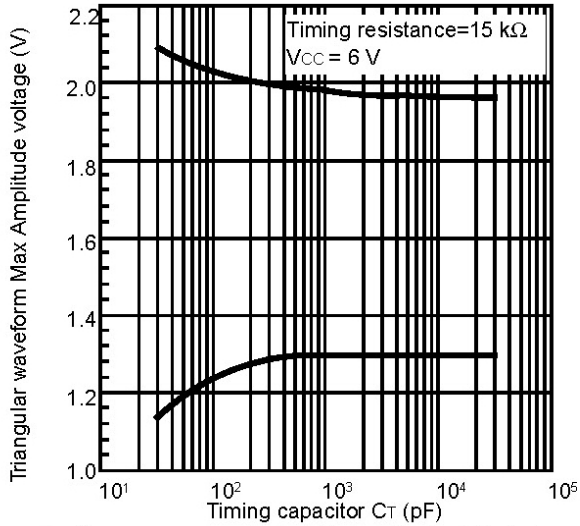
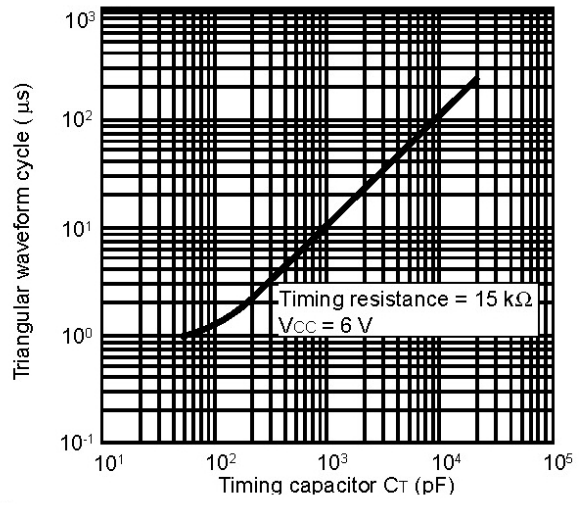
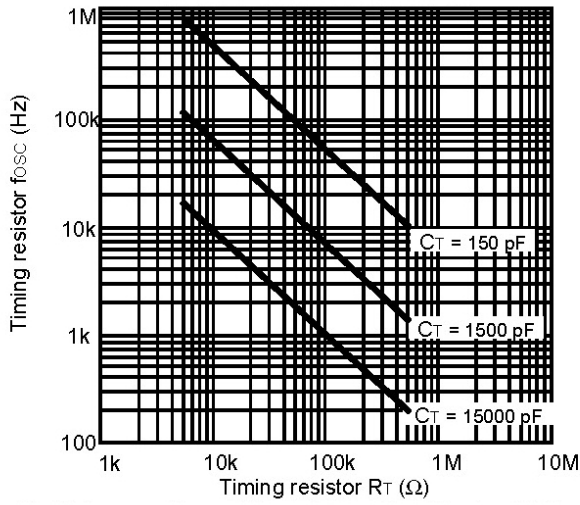
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TYPICAL CHARACTERISTICS



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## OPERATION DESCRIPTION

### 1. Reference voltage

This block is composed of the band gap circuit, and outputs the temperature compensated 2.5 V reference from V<sub>CC</sub> (pin 9) for use by internal circuits. A reference voltage of temperature compensated 1/2 V<sub>ref</sub> can be obtained to external circuit by V<sub>ref</sub> terminal (pin 16).

### 2. Oscillator

The sawtooth-waveform-like triangular wave having a peak of approximately 1.9 V and a trough of approximately 1.3 V can be generated by connecting the timing capacitor C<sub>T</sub> (pin 1) and resistor R<sub>T</sub> (pin 2). The usable oscillation frequency is from 1 kHz to the maximum 500 KHz. The triangular wave is connected with the non-inverting input of PWM comparator for channel 1 side and channel 2 side within the IC inside.

### 3. Error amplifiers

The output voltage of DC-DC converter is detected by the error-amplifier and the amplified signal is input to the PWM comparator. Also, it is possible to perform the gain setting and the phase compensation arbitrarily by connecting a resistor and a capacitor from the FB terminals (pins 5 and 12) to GND. The error amplifier output is internally connected to the inverting inputs of the PWM comparators and also to the short protection circuit.

### 4. Timer latch short protection circuit

This circuit protects the external main switching devices, flywheel diodes, and choke coils, etc. from destruction or deterioration if overload or short-circuit condition of power supply output lasts for a certain time. The timer latch short-circuit protection circuit detects the output level of the error amplifier. If one or both error amplifier outputs are 1.1 V or lower, the low-level output is given and the timer circuit is actuated to start the charge of the external protection-enable capacitor. If the output level of the error amplifier does not drop below the normal voltage range before the capacitor voltage reaches the 1.19 V, it sets the latch circuit, and cuts off the output drive transistor, and sets the dead-time to 100%.

### 5. Under voltage lockout protection circuit

This circuit protects the system from destruction or deterioration due to control malfunction when the supply voltage is low in the transient state of power on/off. The under voltage lockout protection circuit compares the internal reference voltage level with the supply voltage level. If the supply voltage level falls below the reference level it cuts off the output drive transistor, and sets the dead time to 100%. The protection enable terminal (pin 15) is pulled "Low".

### 6. PWM comparator

Each PWM comparator has two inverting inputs and one non-inverting input. This voltage-to-pulse-width converter controls the output pulse width according to the input voltage. The PWM comparator turns the output drive transistor on when the oscillator triangular waveform is higher than the error amplifier output and the dead time control terminal voltage.

### 7. Output drive transistor

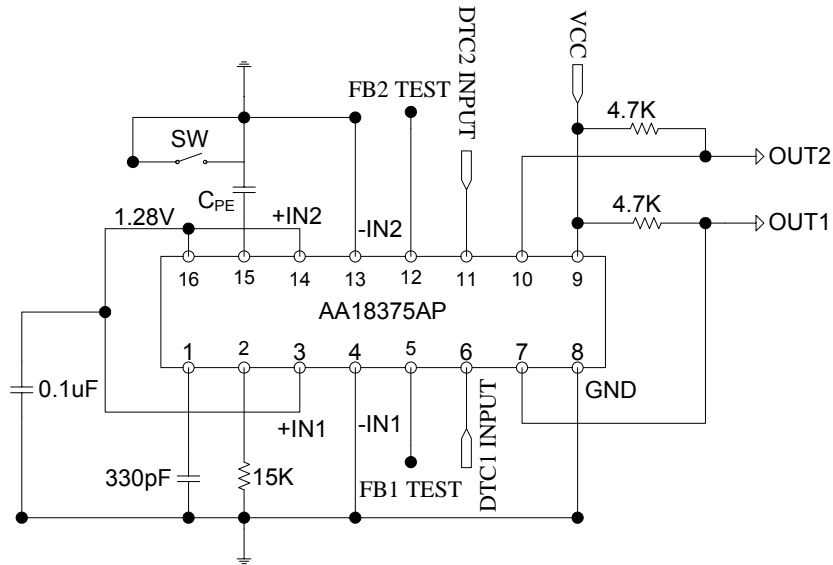
This output circuit is open-collector type. The available output current is up to 50 mA. The breakdown voltage of output terminal is 15V.



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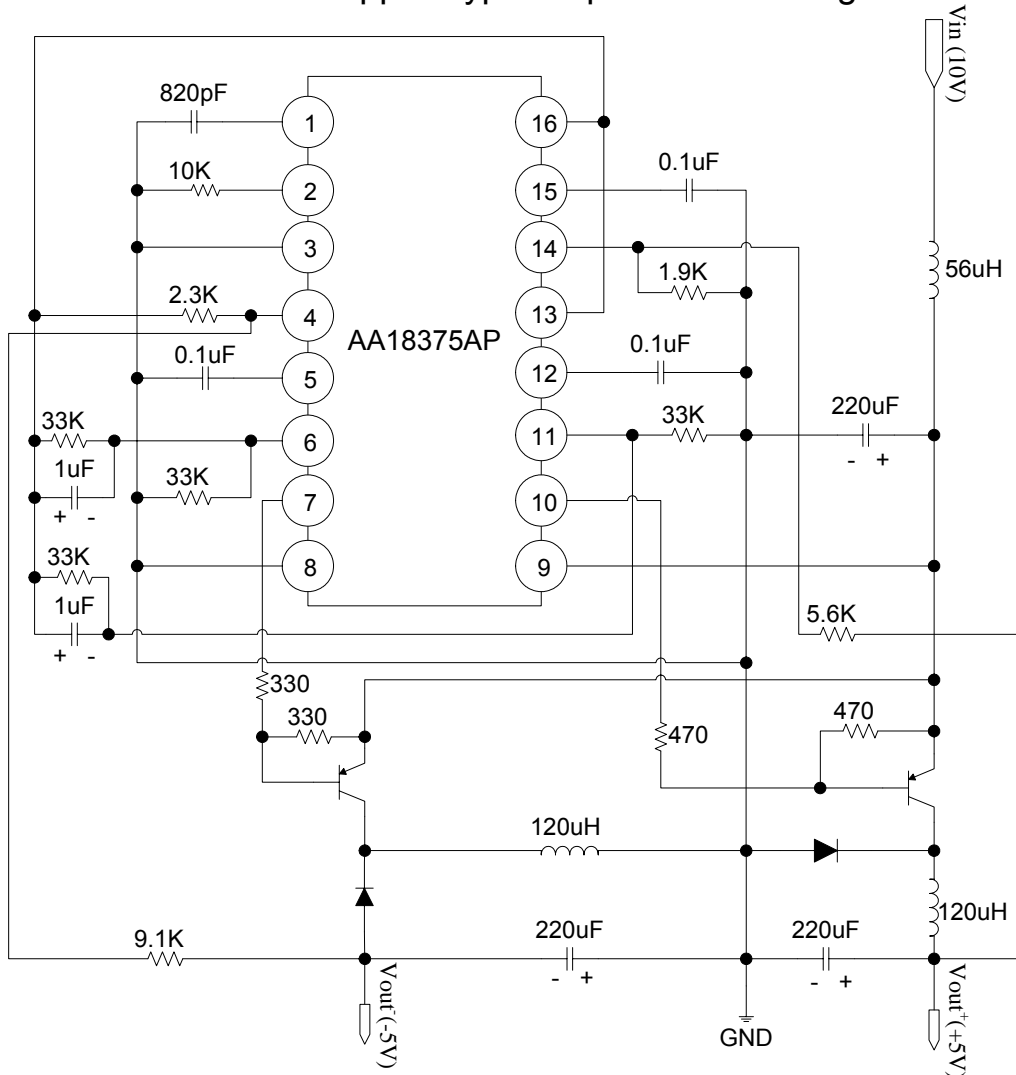
**Switching Regulator Controller**

**TEST CIRCUIT**

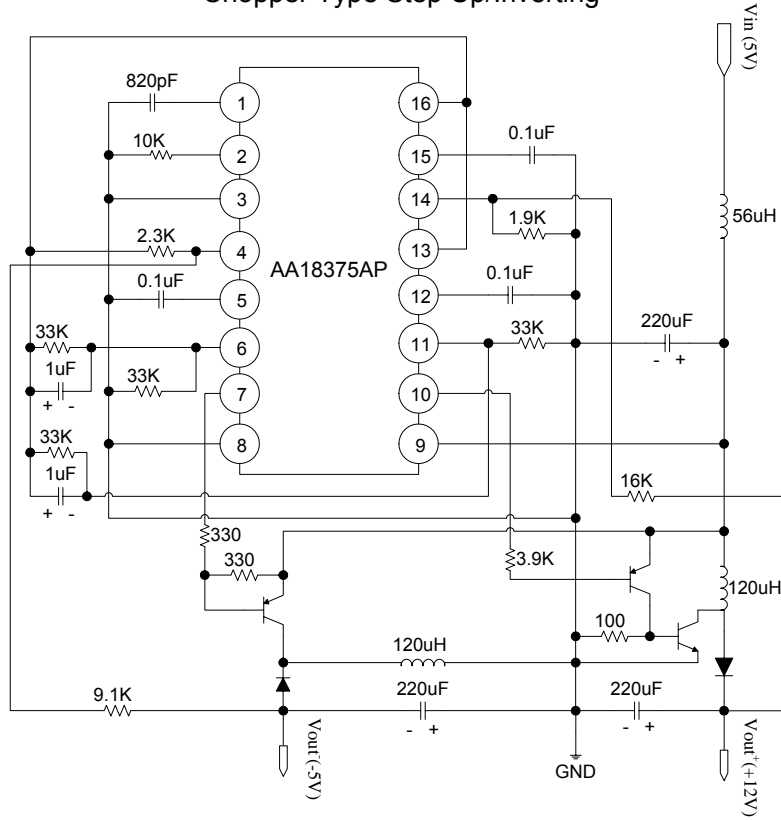


**TYPICAL APPLICATION EXAMPLE**

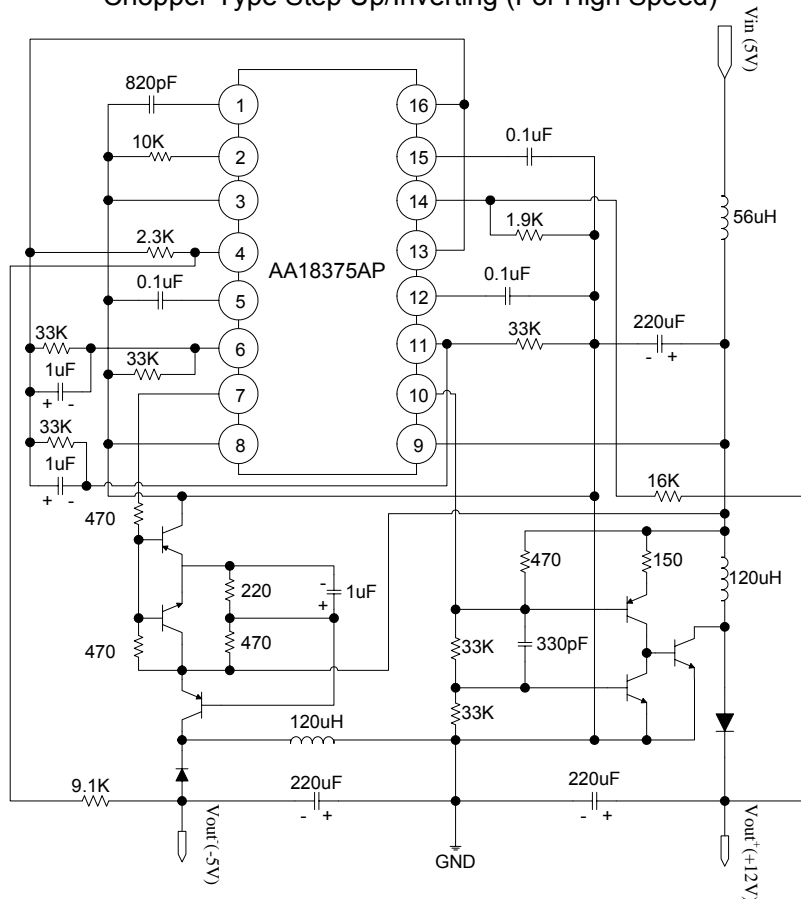
**Chopper Type Step Down/Inverting**



Chopper Type Step Up/Inverting

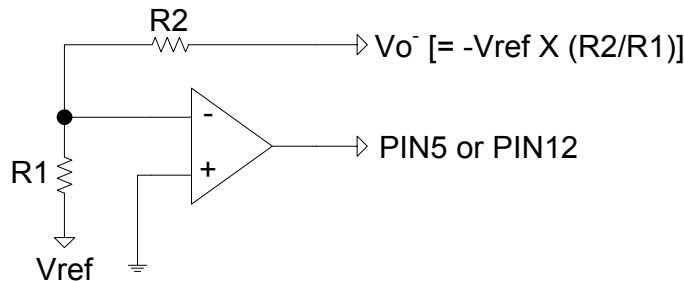
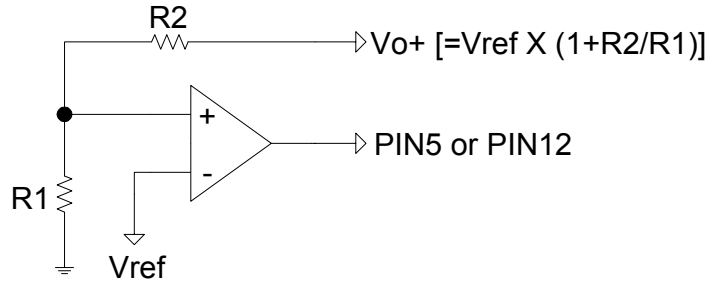


Chopper Type Step Up/Inverting (For High Speed)



### HOW TO SET OUTPUT VOLTAGE

The output voltage is set using the connection shown below. The error amplifiers are supplied to the internal reference voltage circuit as are the other internal circuits. The common-mode input voltage range is from  $-0.2\text{ V}$  to  $+1.45\text{ V}$ . When the amplifiers are operated non-inverting, tie the inverting terminal to  $V_{REF}$  ( $1.28\text{ V}$ ). When the amplifiers are operated inverting, tie the non-inverting terminal to ground.



### HOW TO SET TIME CONSTANT FOR TIMER LATCH SHORT PROTECTION CIRCUIT

If the load condition drastically changes due to a load short-circuit and if low-level signals ( $1.1\text{ V}$  or lower) are input to the non-inverting inputs of the short-circuit protection comparator from the error amplifiers, the short circuit protection comparator outputs a "Low" level. The protection enable terminal voltage is discharged, and then the short-circuit protection comparator charges the externally connected protection enable capacitor  $C_{PE}$  according to the following formula:

$$V_{PE} = 50\text{ mV} + t_{PE} \times 10^{-6} / C_{PE}$$

$$0.65 = 50\text{ mV} + t_{PE} \times 10^{-6} / C_{PE}$$

$$C_{PE} = t_{PE} / 0.6 (\mu\text{F})$$

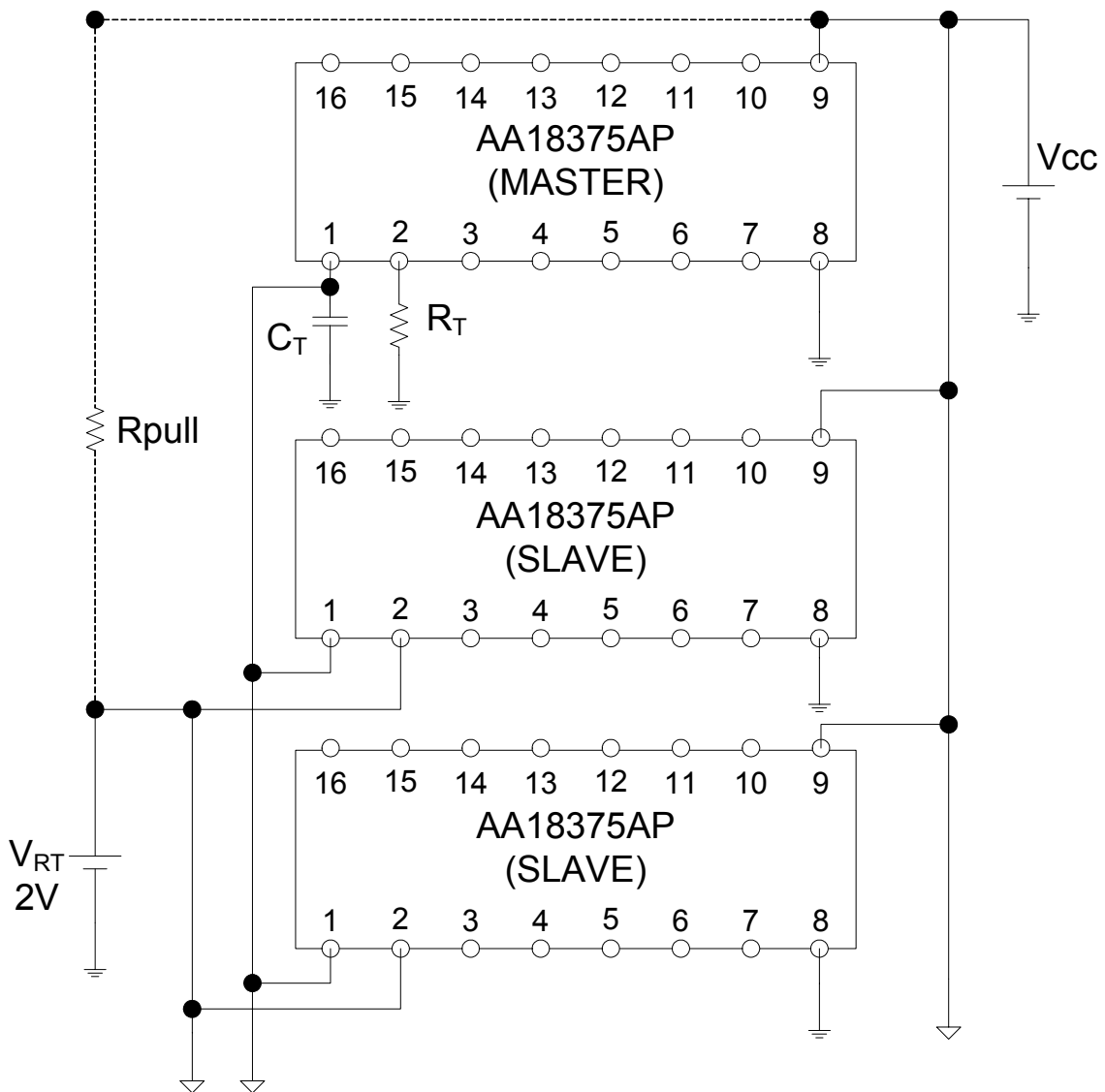
When the power supply is turned on, the output is considered to be short-circuited state so that the S.C.P. terminal voltage starts charging. It is necessary to set the external capacitor so as to start up the DC-DC converter output voltage before setting the latch circuit in the later stage. Especially, pay attention to the delay of the start-up time when applying the soft-start function.

## SYNCHRONIZATION OF ICs

Multiple instances of this IC can be operated in parallel. If the  $C_T$  and  $R_T$  terminals are connected to each other as shown below, the ICs will operate at the same frequency. Instead of applying  $V_{RT}$  to the  $R_T$  terminals, these terminals can be pulled up by a resistor (see resistance indicated by the dashed line in). Select the pull-up resistance  $R_{pull}$  from the formula given below.

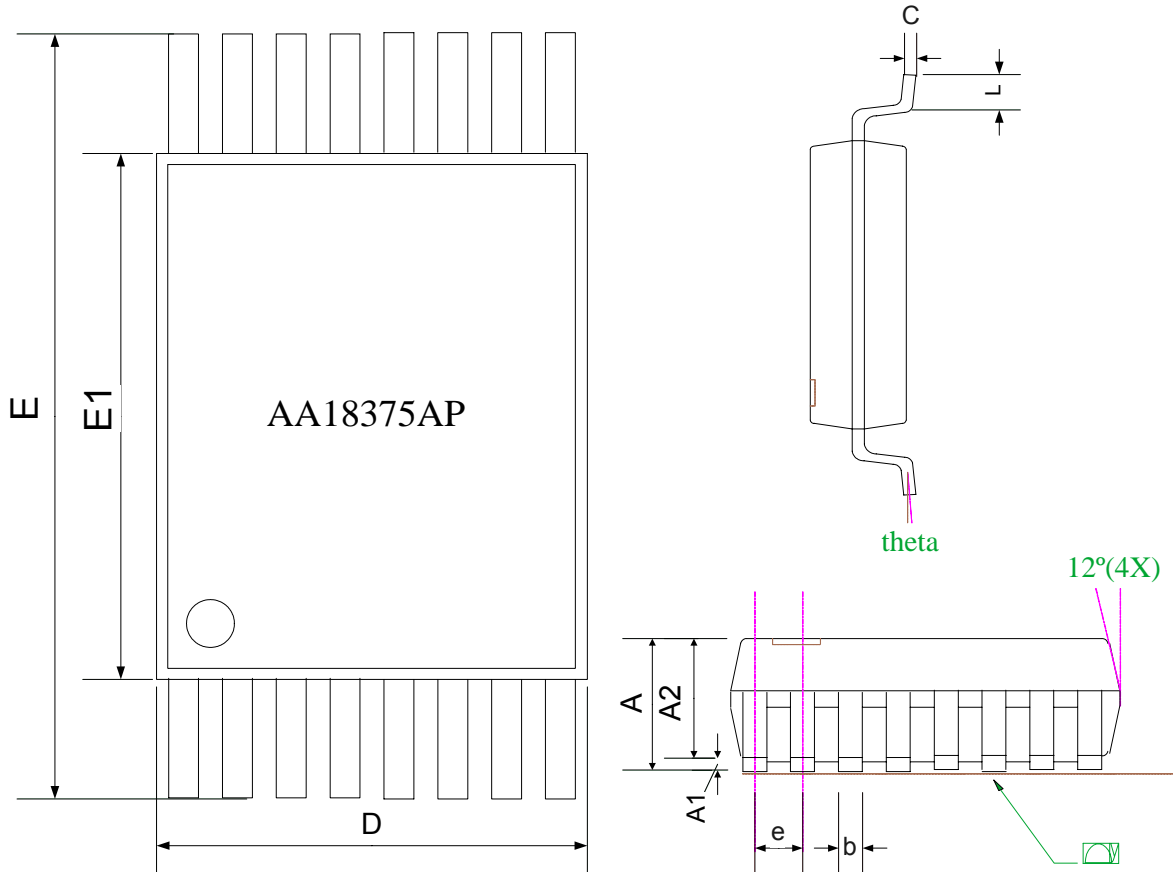
$$\frac{V_{CC}}{0.5 \times N} \leq R_{pull}$$

$R_{pull}$ : Pull up Resistor (k $\Omega$ )  
 $V_{CC}$ : Power Supply Voltage (V)  
 $N$ : Number of Slave ICs



PACKAGE

## AA18375AP - 16-pin Plastic TSSOP



SYMBOLS	DIMENSIONS IN MILLIMETERS			DIMENSIONS IN INCHES		
	MIN	NOM	MAX	MIN	NOM	MAX
A	---	---	1.20	---	---	0.048
A1	0.05	---	0.15	0.002	---	0.006
A2	0.80	1.00	1.05	0.031	0.039	0.041
b	0.19	---	0.30	0.007	---	0.012
C	0.09	---	0.20	0.004	---	0.008
D	4.90	5.00	5.10	0.193	0.197	0.201
E	6.20	6.40	6.60	0.244	0.252	0.260
E1	4.30	4.40	4.50	0.169	0.173	0.177
e	---	0.65	---	---	0.026	---
L	0.45	0.60	0.75	0.018	0.024	0.030
y	---	---	0.10	---	---	0.004
theta	0°	---	8°	0°	---	8°

NOTE

1. PACKAGE BODY SIZES EXCLUDE MOLD FLASH PROTRUSIONS OR GATE BURRS
2. TOLERANCE  $\pm 0.1$  mm UNLESS OTHERWISE SPECIFIED
3. COPLANARITY : 0.1 mm
4. CONTROLLING DIMENSION IS MILLIMETER. CONVERTED INCH DIMENSIONS ARE NOT NECESSARILY EXACT.
5. FOLLOWED FROM JEDEC MO-153



## NOTES ON USE

- **The information described herein is subject to change without notice.**
- The specifications for the product described in this document are for reference only. Upon actual use, therefore, please request that specifications to be separately delivered.
- The application circuit examples explain typical applications of the products, and do not guarantee the success of any specific mass-production design.
- Application circuit diagrams and circuit constants contained herein are shown as examples of standard use and operation. Please pay careful attention to the peripheral conditions when designing circuits and deciding upon circuit constants in the set.
- Take account of common impedance when designing the earth line on a printed wiring board.