

**■ 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

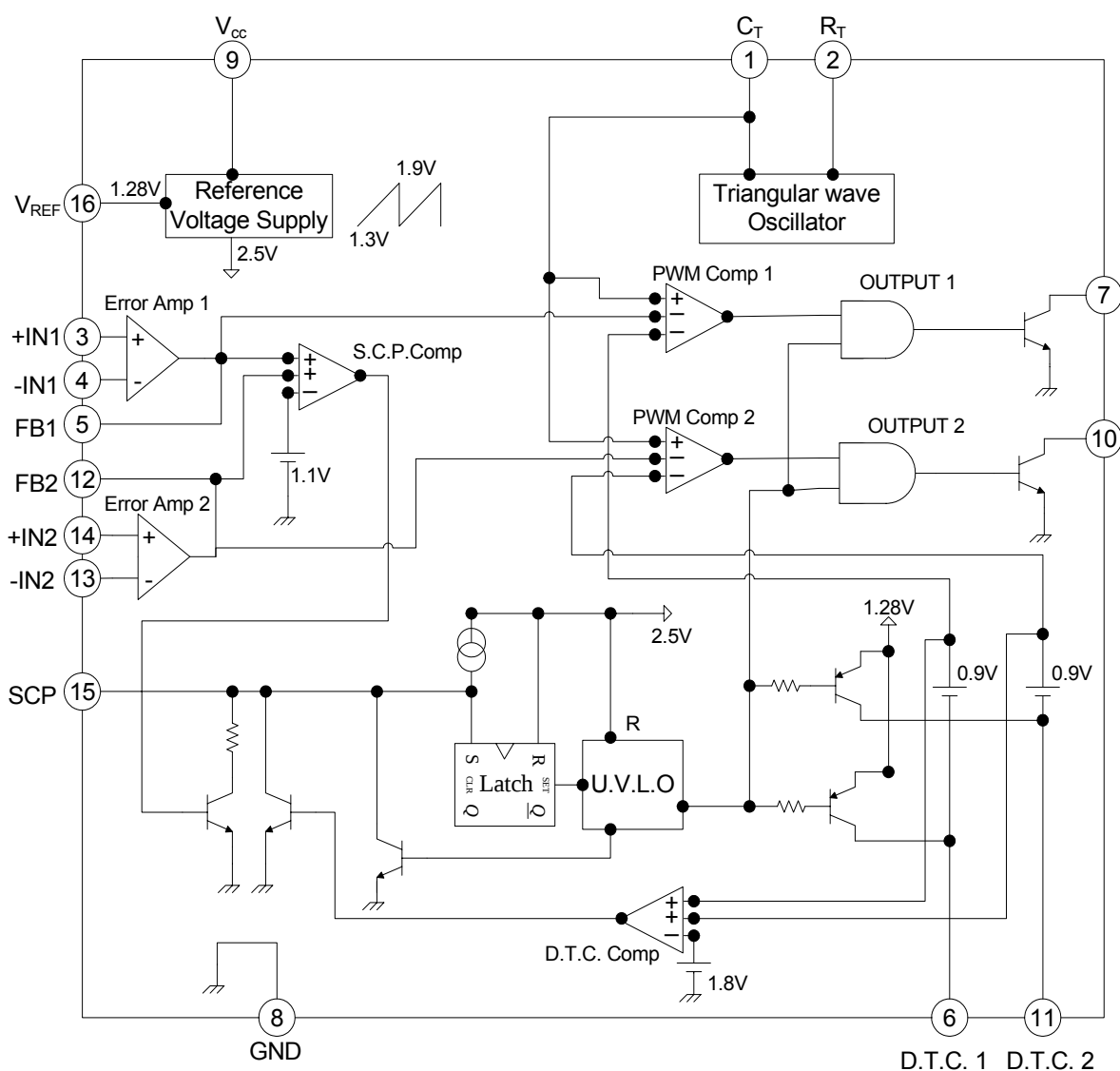
■ APPLICATIONS

- 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 _T	—	Pin for oscillation capacitor connection	9	V _{CC}	I	IC power supply pin
2	R _T	—	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 _{REF}	O	Reference voltage output pin

BLOCK DIAGRAM



■ ABSOLUTE MAXIMUM RATING

(Ta = +25 ° C)

Parameter	Symbol	Condition	Rating		Unit
			Min	Max	
Power Supply Voltage	V _{CC}	-	-	18	V
Error Amp. Input Voltage	V _I	-	-0.3	+10	V
Collector Output Voltage	V _O	-	-	18	V
Collector Output Current	I _O	-	-	75	mA
Power Dissipation	P _D	Ta ≤ +25°C	-	*430	mW
Operating Temperature	T _{OP}	-	-30	+85	°C
Storage temperature	T _{stg}	-	-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	V _{CC}	3.6	6.0	15	V
Error Amp. Input Voltage	V _I	-0.2	—	1.45	V
Collector Output Voltage	V _O	—	—	15	V
Collector Output Current	I _O	0.3	—	50	mA
Phase Compensation Capacitor	C _P	—	0.1	—	μ F
Timing Capacitor	C _T	150	—	15000	pF
Timing Resistor	R _T	5.1	—	100	kΩ
Oscillator Frequency	f _{OSC}	1	—	500	kHz
Reference Voltage Output Current	I _{REF}	-3	-1	—	mA
Operating Temperature	T _{OP}	-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.

■ ELECTRICAL CHARACTERISTICS

(Ta = +25 °C, Vcc = 6 V)

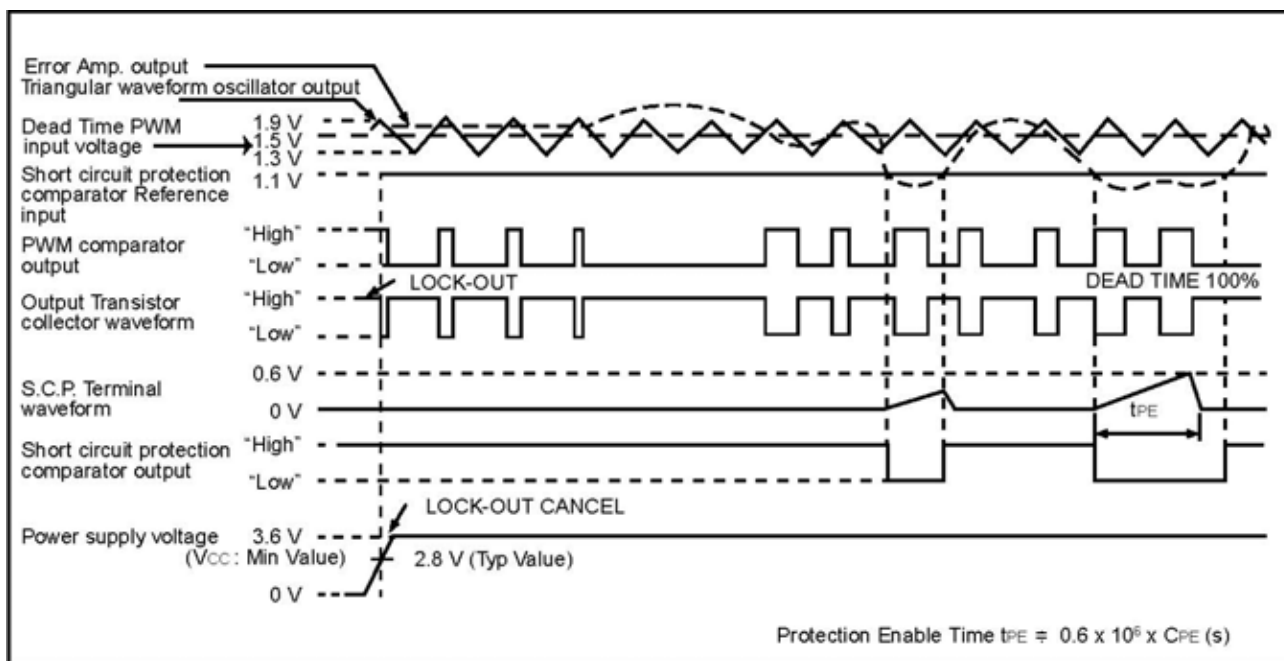
Parameter		condition	Symbol	Value			Unit
				Min	Typ	Max	
Reference Section	Output Voltage	I _{OR} = − 1 mA	V _{REF}	1.26	1.28	1.30	V
	Output Temp. Stability	T _a = − 30 ° C to +85 ° C	V _{RTC}	−2	±0.2	2	%
	Input Stability	V _{CC} = 3.6 V to 15 V	Line	−	2	10	mV
	Load Stability	I _{OR} = − 0.1 mA to − 1 mA	Load	−	1	7.5	mV
	Short Circuit Output Current	V _{REF} = 0 V	I _{OS}	−	−30	−10	mA
Under Voltage Lockout Protection Section	Threshold Voltage	I _{OR} = − 0.1 mA	V _{tH}	−	2.72	−	V
		I _{OR} = − 0.1 mA	V _{tL}	−	2.60	−	V
	Hysteresis Width	I _{OR} = − 0.1 mA	V _{HYS}	80	120	−	mV
	Reset Voltage (V _{cc})	−	V _R	1.5	1.9	−	V
Protection Circuit Section	Input Threshold Voltage	−	V _{tPC}	0.60	0.65	0.7	V
	Input Stand by Voltage	No pull up	V _{STB}	−	50	100	mV
	Input Latch Voltage	No pull up	V _I	−	50	100	mV
	Input Source Current	−	I _{bpc}	−1.4	−1.0	−0.6	μ A
	Comparator Threshold Voltage	Pin 5, Pin 12	V _{tC}	−	1.1	−	V
Triangular Waveform Oscillator Section	Oscillator Frequency	C _T = 330 pF, R _T = 15 kΩ	f _{osc}	−	200	−	kHz
	Frequency Deviation	C _T = 330 pF, R _T = 15 kΩ	f _{dev}	−	10	−	%
	Frequency Stability (V _{CC})	V _{CC} = 3.6 V to 15 V	f _{dV}	−	1	−	%
	Frequency Stability (T _a)	T _a = − 30 ° C to +85 ° C	f _{dT}	−4	−	4	%
Dead-Time Control Section	Input Threshold Voltage (f _{osc} = 10 kHz)	Duty Cycle = 0 %	V _{t0}	−	1.0	V _{REF} −0.15	V
		Duty Cycle = 100 %	V _{t100}	0.2	0.4	−	V
	Input Bias Current	−	I _{bdt}	−	−0.2	−1	μ A
	Latch Mode Source Current	V _{dt} = 0.7 V	I _{dt}	−	−150	−80	μ A
	Latch Input Voltage	I _{dt} = − 40 μ A	V _{dt}	V _{REF} −0.1	−	−	V
Error Amp. Section	Input Offset Voltage	V _O = 1.6 V	V _{IO}	−10	−	+10	mV
	Input Offset Current	V _O = 1.6 V	I _{IO}	−100	−	+100	nA
	Input Bias Current	V _O = 1.6 V	I _B	−500	−100	−	nA
	Common Mode Input Voltage Range	V _{CC} = 3.6 V to 15 V	V _{ICR}	−0.2	−	+1.45	V
	Voltage Gain		A _v	84	120	−	V/V
	Frequency Band Width	A _v = − 3 dB	BW	−	3	−	MHz

PRELIMINARY

Switching Regulator Controller

	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

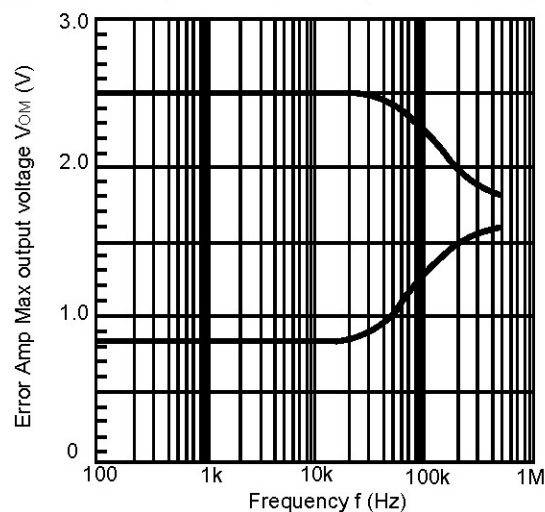
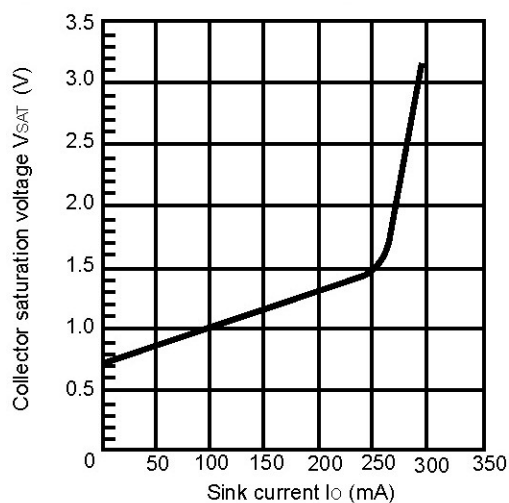
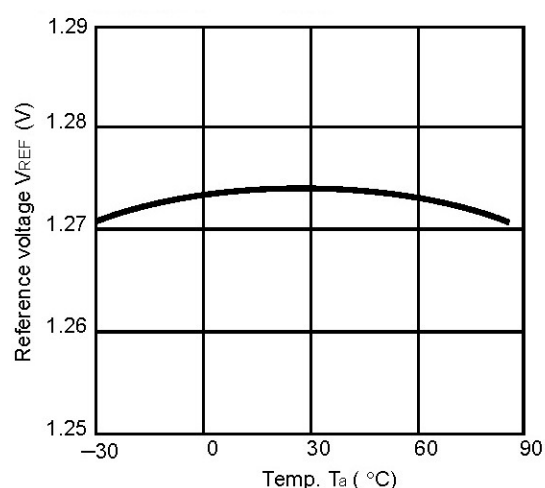
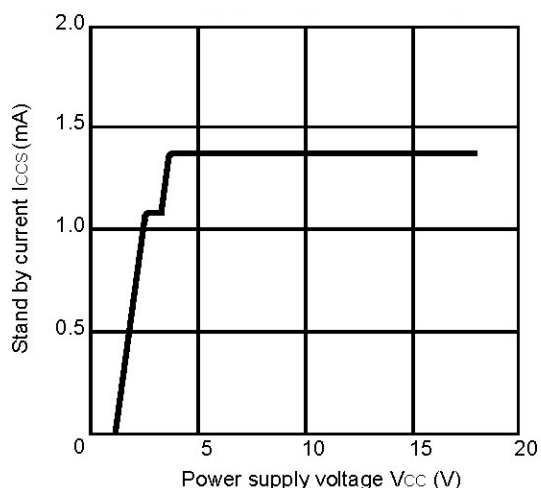
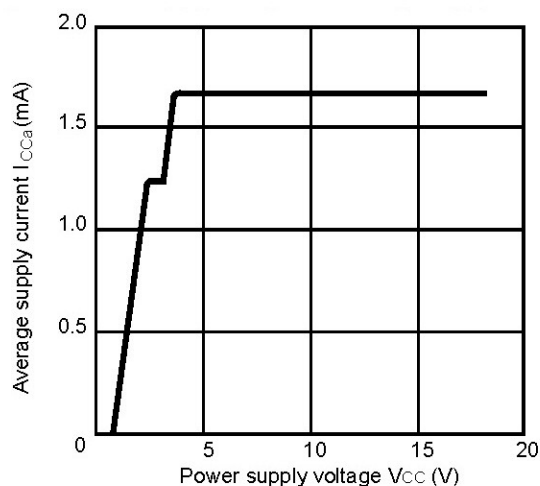
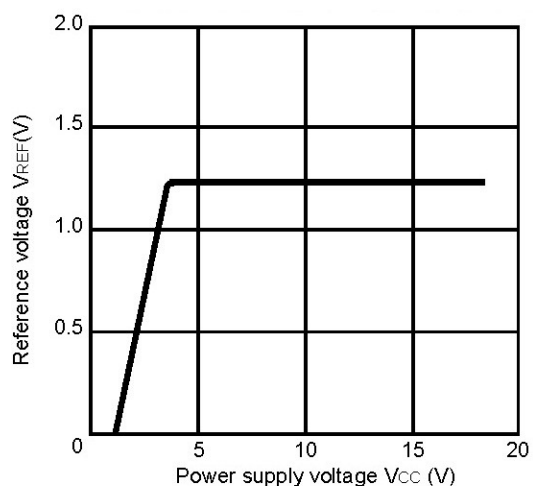
■ TIMING DIAGRAM

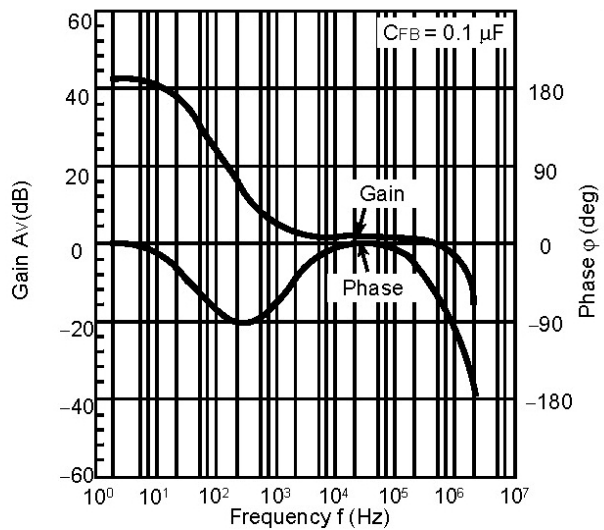
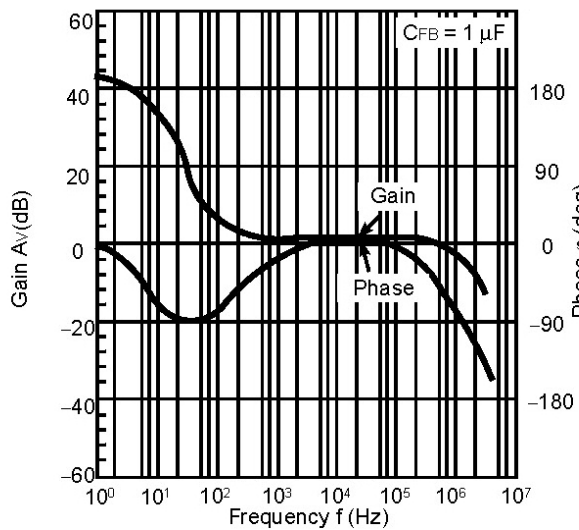
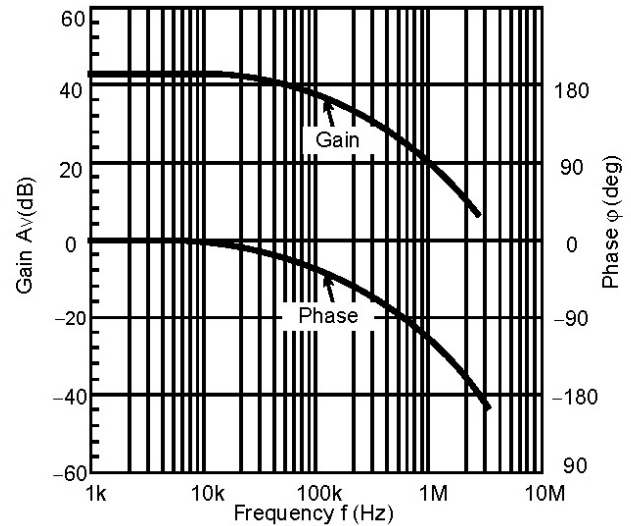
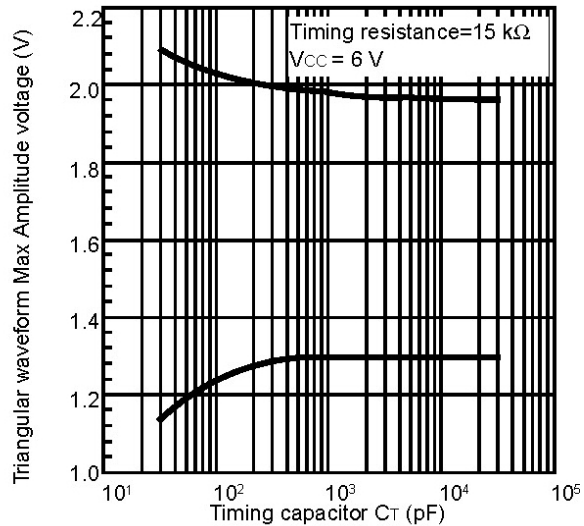
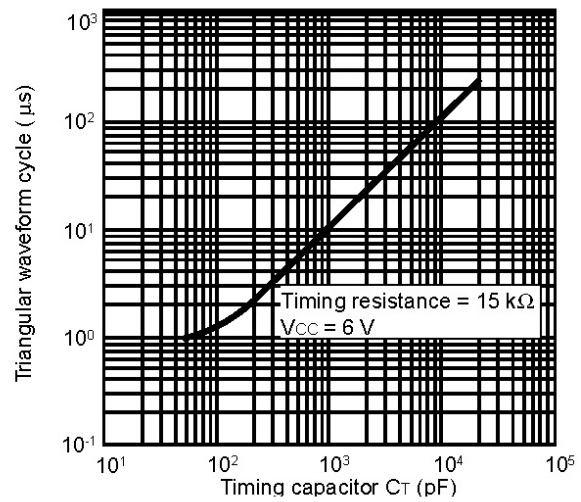
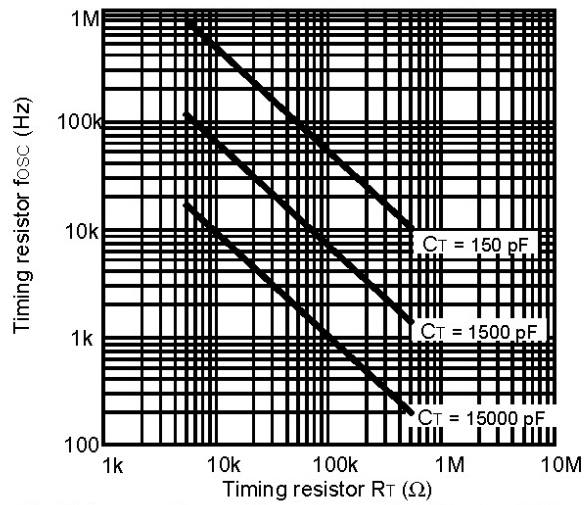


PRELIMINARY

Switching Regulator Controller

■ TYPICAL CHARACTERISTICS







■ OPERATION DESCRIPTION

1. Reference voltage

This block is composed of the band gap circuit, and outputs the temperature compensated 2.5 V reference from Vcc (pin 9) for use by internal circuits. A reference voltage of temperature compensated 1/2 Vref can be obtained to external circuit by Vref 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_T (pin 1) and resistor R_T (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".

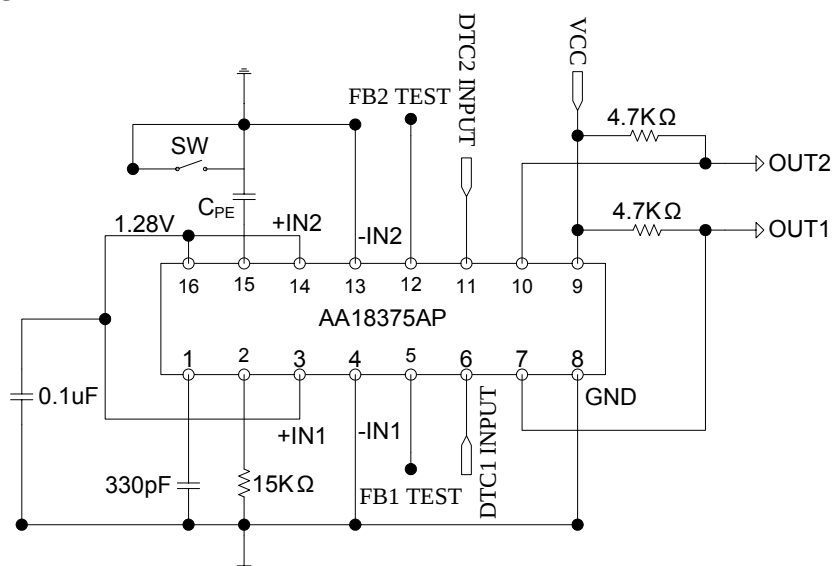
6. PWM comparator

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

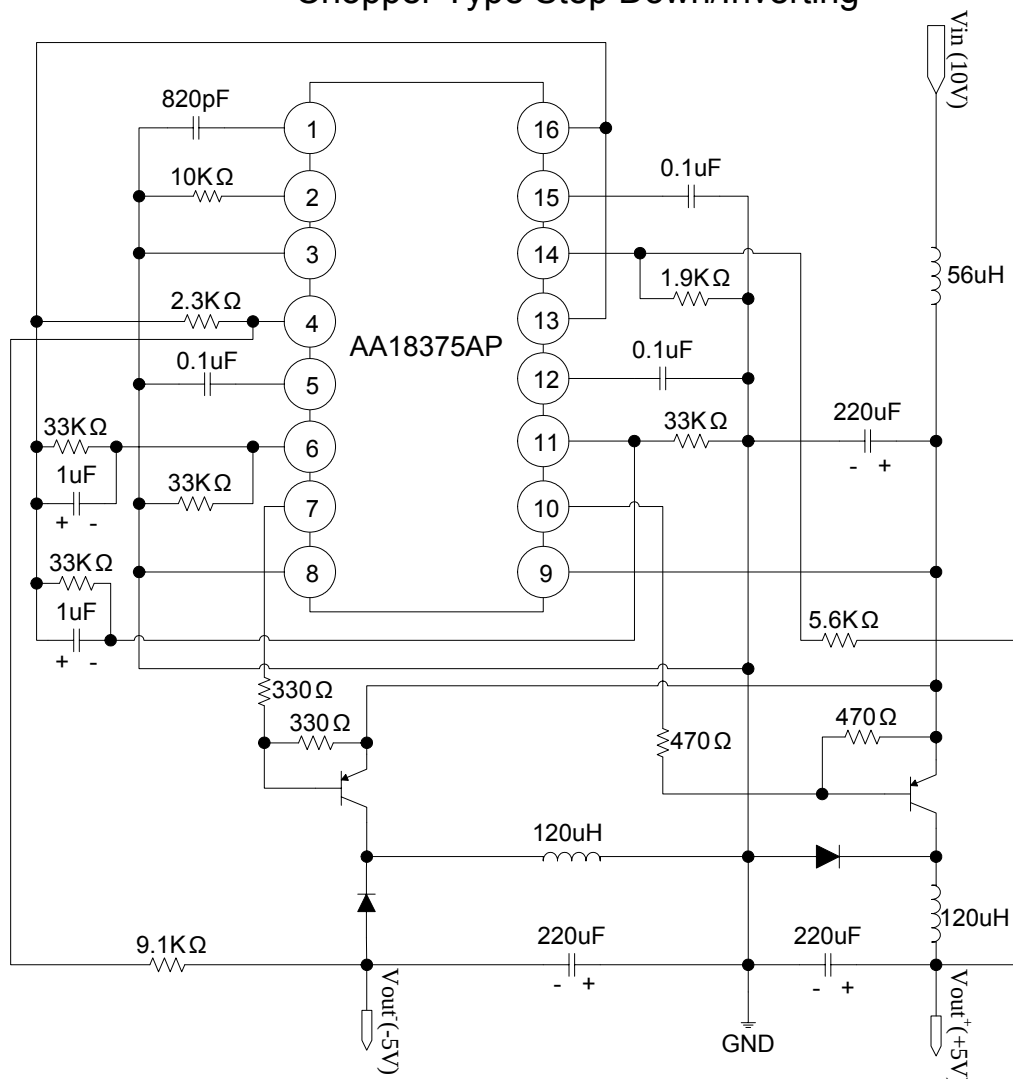
This output circuit is open-collector type. The available output current is up to 50 mA. The breakdown voltage of output terminal is 15V.

■ TEST CIRCUIT



■ TYPICAL APPLICATION EXAMPLE

Chopper Type Step Down/Inverting





PRELIMINARY

Switching Regulator Controller

The diagram illustrates a Chopper Type Step up/Inverting circuit for high-speed applications, centered around the AA18375AP operational amplifier. The circuit is powered by a $V_{in} (+5V)$ supply and a $V_{out} (+12V)$ supply, with a common ground (GND).

Op-Amp Configuration: The AA18375AP is configured with pins 1, 2, 3, 4, 5, 6, 7, and 8 connected to the $V_{in} (+5V)$ supply. Pins 9, 10, 11, 12, 13, 14, 15, and 16 are connected to the $V_{out} (+12V)$ supply. The op-amp is used in a step-up/inverting configuration.

Input Stage: The input signal is coupled through a $33K\Omega$ resistor and a $1\mu F$ capacitor to the non-inverting input (pin 6). The inverting input (pin 7) is biased through a $33K\Omega$ resistor and a $1\mu F$ capacitor to the $V_{in} (+5V)$ supply. The input signal is also coupled through a $33K\Omega$ resistor and a $1\mu F$ capacitor to the inverting input (pin 7).

Feedback and Output Stage: The feedback path consists of a $33K\Omega$ resistor and a $1\mu F$ capacitor connected between the output (pin 16) and the inverting input (pin 7). The output (pin 16) is coupled through a $33K\Omega$ resistor and a $1\mu F$ capacitor to the $V_{out} (+12V)$ supply. The output is also coupled through a $33K\Omega$ resistor and a $1\mu F$ capacitor to the inverting input (pin 7).

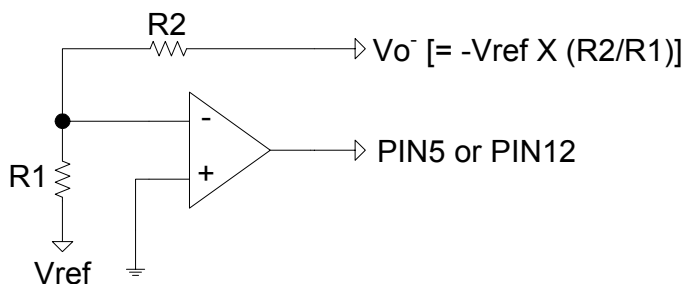
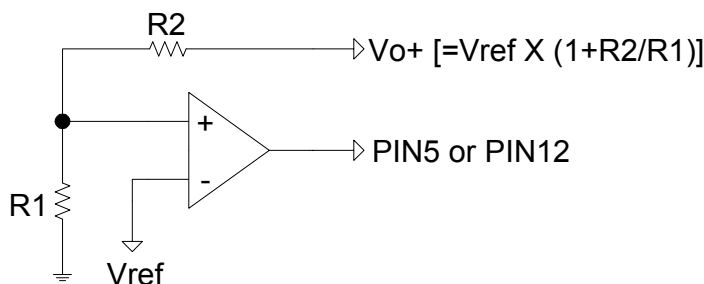
Power Supply Regulation: The $V_{in} (+5V)$ supply is regulated by a $56\mu H$ inductor and a $220\mu F$ capacitor. The $V_{out} (+12V)$ supply is regulated by a $120\mu H$ inductor and a $220\mu F$ capacitor. The $V_{out} (-5V)$ supply is regulated by a $120\mu H$ inductor and a $220\mu F$ capacitor.

Component Values:

- Resistors: $33K\Omega$, $10K\Omega$, $2.3K\Omega$, $0.1\mu F$, $33K\Omega$, 470Ω , 220Ω , 470Ω , $33K\Omega$, $330pF$, $33K\Omega$, $9.1K\Omega$, $16K\Omega$, 150Ω .
- Capacitors: $820pF$, $0.1\mu F$, $1\mu F$, $220\mu F$, $120\mu H$.
- Inductors: $56\mu H$, $120\mu H$.

■ 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 V to $+1.45\text{ V}$. When the amplifiers are operated non-inverting, tie the inverting terminal to V_{REF} (1.28 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 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:

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

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

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

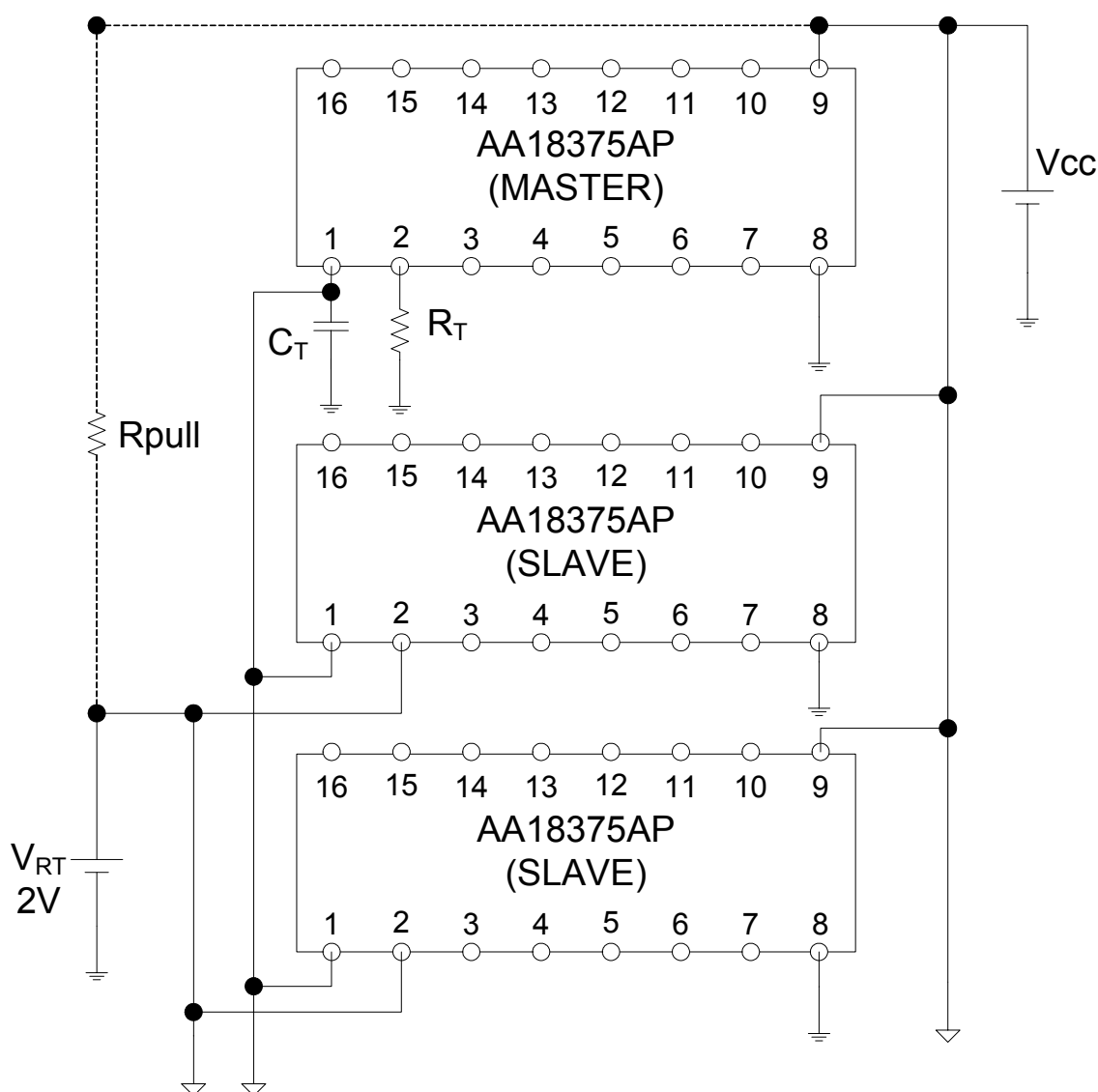
When the power supply is turned on, the output is considered to be short-circuited state so that the S.C.P. terminal voltage starts charging. It is necessary to set the external capacitor so as to start up the DC-DC converter output voltage before setting the latch circuit in the later stage. Especially,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

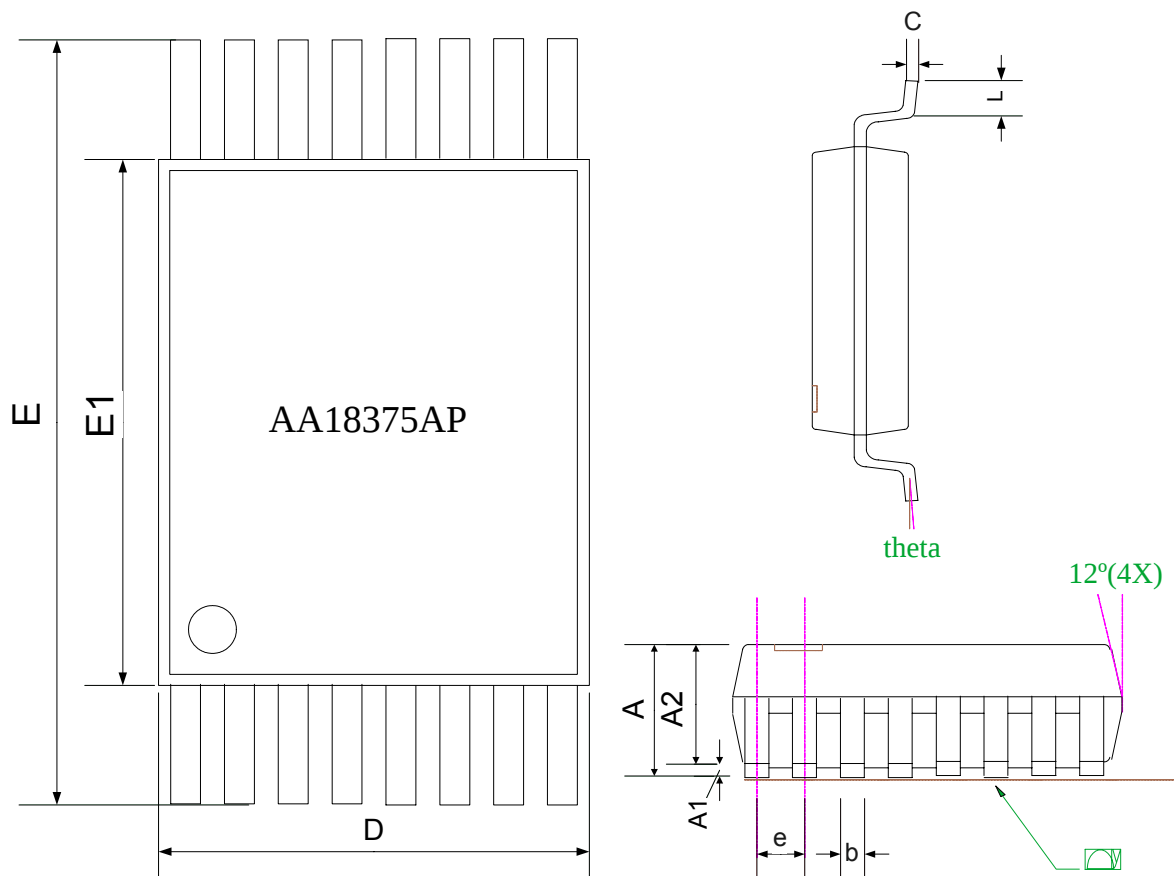
$$\frac{V_{CC}}{0.5 \times N} \leq R_{pull}$$

R_{pull} : Pull up Resistor (k Ω)
 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 ± 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.