FUJITSU SEMICONDUCTOR
DATA SHEET

DS04-27706-2E

ASSP For Power Supply Applications (Secondary battery)

DC/DC Converter IC for Charging

MB3878

■ DESCRIPTION

The MB3878 is a DC/DC converter IC suitable for down-conversion, using pulse-width (PWM) charging and enabling output voltage to be set to any desired level from one cell to four cells.
These ICs can dynamically control the secondary battery's charge current by detecting a voltage drop in an AC adaptor in order to keep its power constant (dynamically-controlled charging).
The charging method enables quick charging, for example, with the AC adaptor during operation of a notebook PC
The MB3878 provides a broad power supply voltage range and low standby current as well as high efficiency, making it ideal for use as a built-in charging device in products such as notebook PC.
This product is covered by US Patent Number 6,147,477.

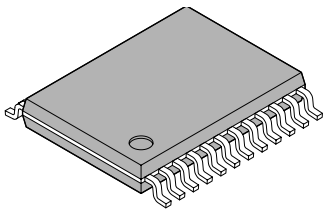
■ FEATURES

- Detecting a voltage drop in the AC adaptor and dynamically controlling the charge current (Dynamically-controlled charging)
- Output voltage setting using external resistor : 1 cell to 4 cells
- High efficiency : 94 %
- Wide range of operating supply voltages : 7 V to 25 V
- Output voltage setting accuracy : 4.2V ± 0.8% (per cell)
- Built-in frequency setting capacitor enables frequency setting using external resistor only
- Oscillator frequency range : 100kHz to 500kHz

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■ PACKAGE

24-pin plastic SSOP



(FPT-24P-M03)

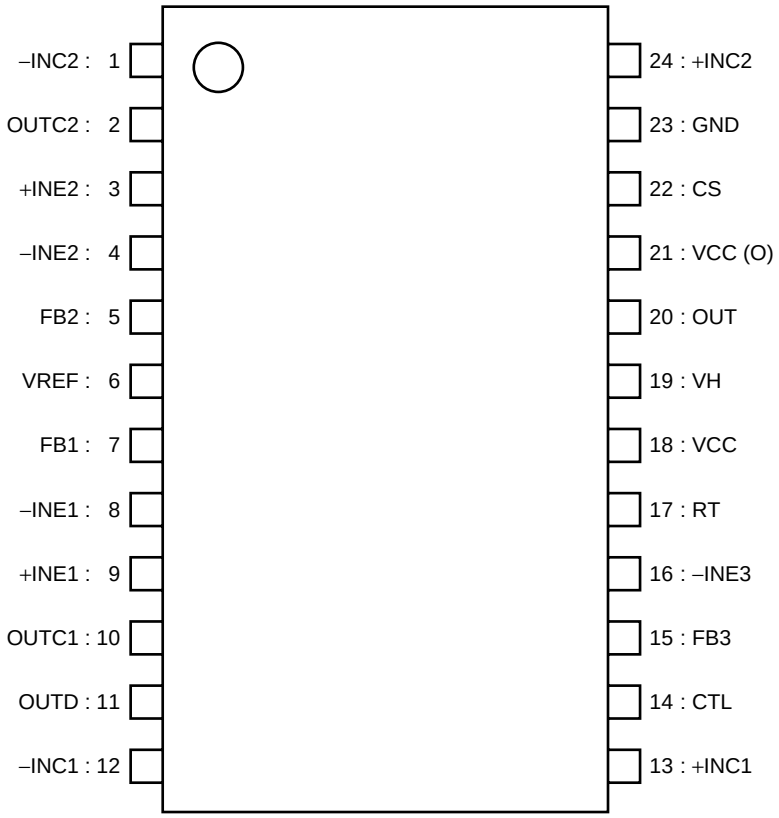
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- Built-in current detector amplifier with wide in-phase input voltage range : 0 V to Vcc
- In standby mode, leave output voltage setting resistor open to prevent inefficient current loss
- Built-in standby current function : 0 μA (standard)
- Built-in soft-start function
- Built-in totem-pole output stage supporting P-channel MOS FETs devices

■ PIN ASSIGNMENT

(TOP VIEW)

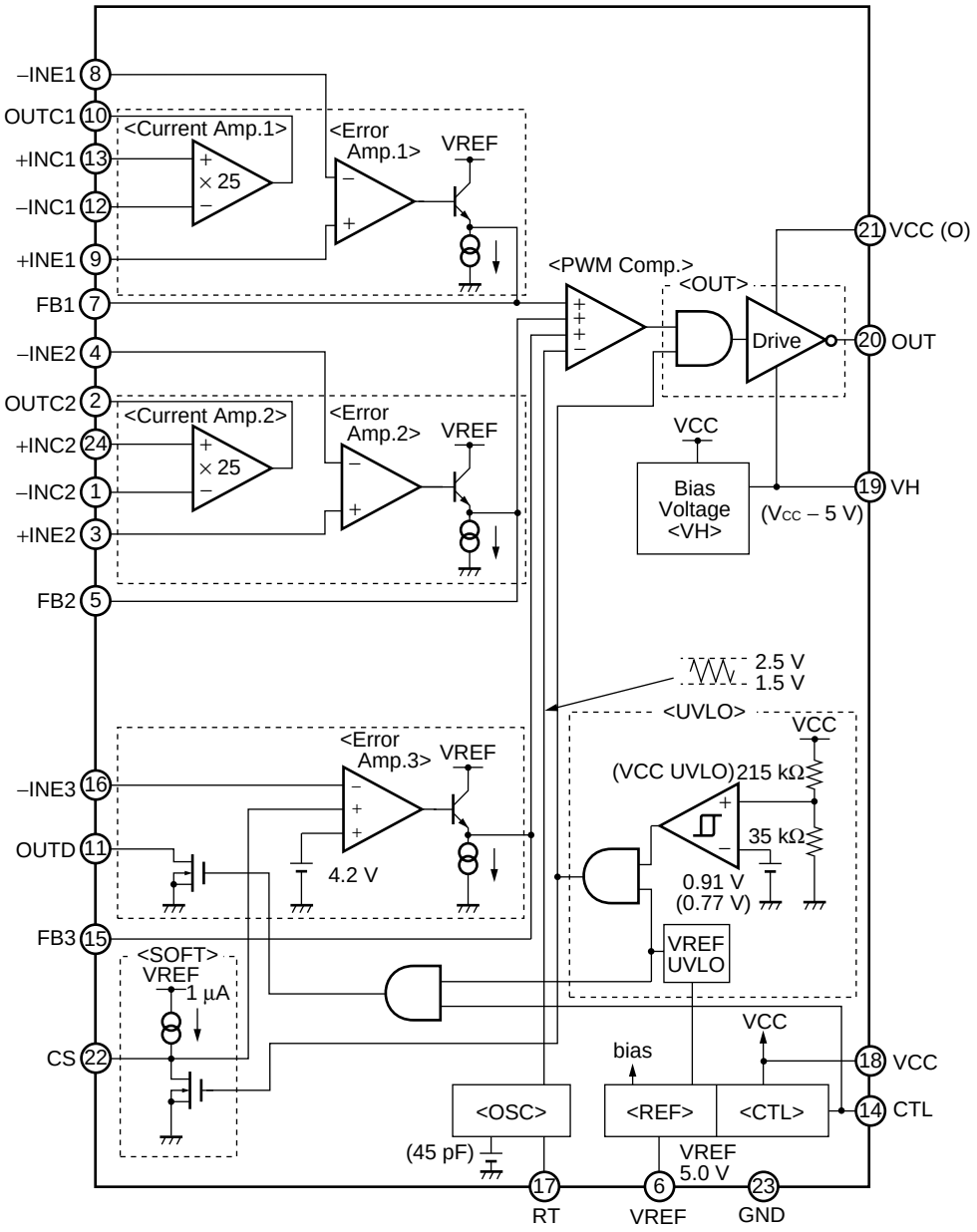


(FPT-24P-M03)

■ PIN DESCRIPTION

Pin No.	Symbol	I/O	Descriptions
1	–INC2	I	Current detection amplifier (Current Amp. 2) input pin.
2	OUTC2	O	Current detection amplifier (Current Amp. 2) output pin.
3	+INE2	I	Error amplifier (Error Amp. 2) non-inverted input pin.
4	–INE2	I	Error amplifier (Error Amp. 2) inverted input pin.
5	FB2	O	Error amplifier (Error Amp. 2) output pin.
6	VREF	O	Reference voltage output pin.
7	FB1	O	Error amplifier (Error Amp. 1) output pin.
8	–INE1	I	Error amplifier (Error Amp. 1) inverted input pin
9	+INE1	I	Error amplifier (Error Amp. 3) non-inverted input pin.
10	OUTC1	O	Current detection amplifier (Current Amp. 1) output pin.
11	OUTD	O	With IC in standby mode, this pin is left open to prevent loss of current through output voltage setting resistance. Set CTL pin to “H” level and OUTD pin to “L” level.
12	–INC1	I	Current detector amplifier (Current Amp. 1) input pin.
13	+INC1	I	Current detector amplifier (Current Amp. 1) input pin.
14	CTL	I	Power supply control pin. Setting the CTL pin low places the IC in the standby mode.
15	FB3	O	Error amplifier (Error Amp. 3) output pin.
16	–INE3	I	Error amplifier (Error Amp. 3) inverted input pin.
17	RT	—	Triangular-wave oscillation frequency setting resistor connection pin.
18	VCC	—	Power supply pin for reference power supply and control circuit.
19	VH	O	Power supply pin for FET drive circuit (VH = Vcc – 5 V).
20	OUT	O	High-side FET gate drive pin.
21	VCC (O)	—	Output circuit power supply pin.
22	CS	—	Soft-start capacitor connection pin.
23	GND	—	Ground pin.
24	+INC2	I	Current detection amplifier (Current Amp. 2) input pin.

■ BLOCK DIAGRAM



■ ABSOLUTE MAXIMUM RAGINGS

Parameter	Symbol	Conditions	Rating		Unit
			Min	Max	
Power supply voltage	V_{CC}	VCC, VCC (O)	—	28	V
Output current	I_{OUT}	—	—	60	mA
Peak output current	I_{OUT}	Duty ≤ 5 % (t = 1 / f_{OSC} × Duty)	—	500	mA
Power dissipation	P_D	Ta ≤ +25 °C	—	740*	mW
Storage temperature	Tstg	—	–55	+125	°C

* : The package is mounted on the dual-sided epoxy board (10 cm × 10 cm).

WARNING: Semiconductor devices can be permanently damaged by application of stress (voltage, current, temperature, etc.) in excess of absolute maximum ratings. Do not exceed these ratings.

■ RECOMMENDED OPERATING CONDITIONS

Parameter	Symbol	Conditions	Value			Unit
			Min	Typ	Max	
Power supply voltage	V_{CC}	VCC, VCC (O)	7	—	25	V
Reference voltage output current	I_{REF}	—	–1	—	0	mA
VH pin output current	I_{VH}	—	0	—	30	mA
Input voltage	V_{INE}	–INE1 to –INE3, +INE1, +INE2	0	—	V_{CC} – 1.8	V
	V_{INC}	+INC1, +INC2, –INC1, –INC2	0	—	V_{CC}	V
OUTD pin output voltage	V_{OUTD}	—	0	—	17	V
OUTD pin output current	I_{OUTD}	—	0	—	2	mA
CTL pin input voltage	V_{CTL}	—	0	—	25	V
output current	I_{OUT}	—	–45	—	45	mA
Peak output current	I_{OUT}	Duty ≤ 5 % (t = 1 / fosc × Duty)	–450	—	450	mA
Oscillator frequency	f_{OSC}	—	100	290	500	kHz
Timing resistor	R_T	—	33	47	130	kΩ
Soft-start capacitor	C_S	—	—	2200	100000	pF
VH pin capacitor	C_{VH}	—	—	0.1	1.0	µF
Reference voltage output capacitor	C_{REF}	—	—	0.1	1.0	µF
Operating ambient temperature	Ta	—	–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.

Always use semiconductor devices within their recommended operating condition ranges. Operation outside these ranges may adversely affect reliability and could result in device failure.

No warranty is made with respect to uses, operating conditions, or combinations not represented on the data sheet. Users considering application outside the listed conditions are advised to contact their FUJITSU representatives beforehand.

■ ELECTRICAL CHARACTERISTICS

(Ta = +25 °C, VCC = 19 V, VCC (O) = 19 V, VREF = 0 mA)

Parameter		Symbol	Pin No.	Conditions	Value			Unit
					Min	Typ	Max	
Reference voltage block (Ref)	Output voltage	V_{REF}	6	Ta = +25 °C	4.995	5.000	5.045	V
				Ta = –30 °C to +85 °C	4.945	5.000	5.055	V
	Input stability	Line	6	VCC = 7 V to 25 V	—	3	10	mV
	Load stability	Load	6	VREF = 0 mA to –1 mA	—	1	10	mV
	Short-circuit output current	Ios	6	VREF = 1 V	–25	–15	–5	mA
Under voltage lockout protection circuit block (UVLO)	Threshold voltage	V_{TLH}	18	VCC = VCC (O) , VCC = ↗	6.1	6.4	6.7	V
		V_{THL}	18	VCC = VCC (O) , VCC = ↘	5.1	5.4	5.7	V
	Hysteresis width	V_H	18	VCC = VCC (O)	0.7	1.0	1.3	V
	Threshold voltage	V_{TLH}	6	VREF = ↗	2.6	2.8	3.0	V
		V_{THL}	6	VREF = ↘	2.4	2.6	2.8	V
	Hysteresis width	V_H	6	$V_H = V_{TLH} – V_{THL}$	0.05	0.20	0.35	V
Soft-start block (SOFT)	Charge current	I_{CS}	22	—	–1.3	–0.8	–0.5	µA
Triangular waveform oscillator circuit block (OSC)	Oscillation frequency	f_{OSC}	20	RT = 47 kΩ	260	290	320	kHz
	Frequency temperature stability	Δf/fdt	20	Ta = –30 °C to +85 °C	—	1*	—	%
Error amplifier block (Error Amp.1, Error Amp.2)	Input offset voltage	V_{IO}	3, 4, 8, 9	FB1 = FB2 = 2 V	—	1	5	mV
	Input bias current	I_B	3, 4, 8, 9	—	–100	–30	—	nA
	Common mode input voltage range	V_{CM}	3, 4, 8, 9	—	0	—	V_{CC} – 1.8	V
	Voltage gain	A_V	5, 7	DC	—	100*	—	dB
	Frequency bandwidth	B_W	5, 7	A_V = 0 dB	—	2.0*	—	MHz
	Output voltage	V_{FBH}	5, 7	—	4.7	4.9	—	V
		V_{FBL}	5, 7	—	—	20	200	mV
	Output source current	I_{SOURCE}	5, 7	FB1 = FB2 = 2 V	—	–2.0	–0.6	mA
	Output sink current	I_{SINK}	5, 7	FB1 = FB2 = 2 V	150	300	—	µA

* : Standard design value.

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(Ta = +25 °C, VCC = 19 V, VCC (O) = 19 V, VREF = 0 mA)

Parameter		Symbol	Pin No.	Conditions	Value			Unit
					Min	Typ	Max	
Error amplifier block (Error Amp.3)	Threshold voltage	V_{TH1}	16	FB3 = 2 V, Ta = +25 °C	4.167	4.200	4.233	V
		V_{TH2}	16	FB3 = 2 V, Ta = –30 °C to +85 °C	4.158	4.200	4.242	V
	Input current	I_{INE3}	16	–INE3 = 0 V	–100	–30	—	nA
	Voltage gain	A_V	15	DC	—	100*	—	dB
	Frequency bandwidth	B_W	15	A_V = 0 dB	—	2.0*	—	MHz
	Output voltage	V_{FBH}	15	—	4.7	4.9	—	V
		V_{FBL}	15	—	—	20	200	mV
	Output source current	I_{SOURCE}	15	FB3 = 2 V	—	–2.0	–0.6	mA
	Output sink current	I_{SINK}	15	FB3 = 2 V	150	300	—	µA
	OUTD pin output leak current	I_{LEAK}	11	OUTD = 16.8 V	—	0	1	µA
	OUTD pin output ON resistor	R_{ON}	11	OUTD = 1 mA	—	70	100	Ω
Current detection amplifier block (Current Amp.1, Current Amp.2)	Input current	I_{+INCH}	13, 24	+INC1 = +INC2 = 12.7 V, –INC1 = –INC2 = 12.6 V	—	10	20	µA
		$I_{–INCH}$	1, 12	+INC1 = +INC2 = 12.7 V, –INC1 = –INC2 = 12.6 V	—	0.1	0.2	µA
		I_{+INCL}	13, 24	+INC1 = +INC2 = 0.1 V, –INC1 = –INC2 = 0 V	–130	–65	—	µA
		$I_{–INCL}$	1, 12	+INC1 = +INC2 = 0.1 V, –INC1 = –INC2 = 0 V	–140	–70	—	µA
	Current detection voltage	V_{OUTC1}	2, 10	+INC1 = +INC2 = 12.7 V, –INC1 = –INC2 = 12.6 V	2.25	2.5	2.75	V
		V_{OUTC2}	2, 10	+INC1 = +INC2 = 12.63 V, –INC1 = –INC2 = 12.6 V	0.50	0.75	1.00	V
		V_{OUTC3}	2, 10	+INC1 = +INC2 = 0.1 V, –INC1 = –INC2 = 0 V	1.25	2.50	3.75	V
		V_{OUTC4}	2, 10	+INC1 = +INC2 = 0.03 V, –INC1 = –INC2 = 0 V	0.125	0.750	1.375	V
	Common mode input voltage range	V_{CM}	1, 12, 13, 24	—	0	—	Vcc	V
	Voltage gain	A_V	2, 10	+INC1 = +INC2 = 12.7 V, –INC1 = –INC2 = 12.6 V	22.5	25	27.5	V/V
	Frequency bandwidth	B_W	2, 10	A_V = 0 dB	—	2.0*	—	MHz

* : Standard design value.

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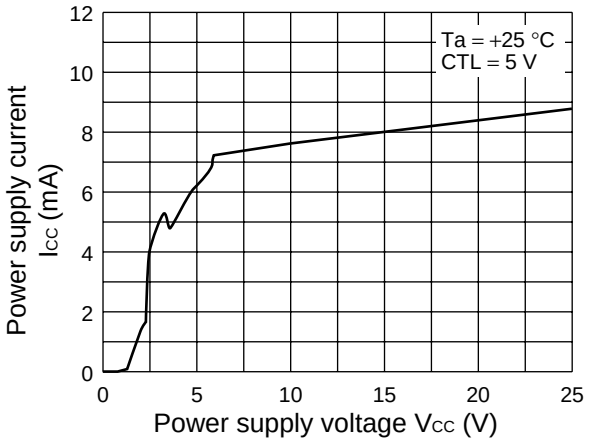
(Ta = +25 °C, VCC = 19 V, VCC (O) = 19 V, VREF = 0 mA)

Parameter		Symbol	Pin No.	Conditions	Value			Unit
					Min	Typ	Max	
Current detection amplifier block (Current Amp.1, Current Amp.2)	Output voltage	V_{OUTCH}	2, 10	—	4.7	4.9	—	V
		V_{OUTCL}	2, 10	—	—	20	200	mV
	Output source current	I_{SOURCE}	2, 10	OUTC1 = OUTC2 = 2 V	—	–2.0	–0.6	mA
	Output sink current	I_{SINK}	2, 10	OUTC1 = OUTC2 = 2 V	150	300	—	µA
PWM comparator block (PWM Comp.)	Threshold voltage	V_{TL}	5, 7, 15	Duty cycle = 0 %	1.4	1.5	—	V
		V_{TH}	5, 7, 15	Duty cycle = 100 %	—	2.5	2.6	V
Output block (OUT)	Output source current	I_{SOURCE}	20	OUT = 11 V, Duty ≤ 5 % (t = 1 / fosc × Duty)	—	–200*	—	mA
	Output sink current	I_{SINK}	20	OUT = 16 V, Duty ≤ 5 % (t = 1 / fosc × Duty)	—	200*	—	mA
	Output ON resistor	R_{OH}	20	OUT = –45 mA	—	8.0	12.0	Ω
		R_{OL}	20	OUT = 45 mA	—	6.5	9.7	Ω
	Rise time	tr1	20	OUT = 3300 pF (equivalent to Si4435 × 1)	—	70*	—	ns
	Fall time	tf1	20	OUT = 3300 pF (equivalent to Si4435 × 1)	—	60*	—	ns
Control block (CTL)	CTL input voltage	V_{ON}	14	Active mode	2	—	25	V
		V_{OFF}	14	Standby mode	0	—	0.8	V
	Input current	I_{CTLH}	14	CTL = 5 V	—	100	200	µA
		I_{CTLL}	14	CTL = 0 V	—	0	1	µA
Bias voltage block (VH)	Output voltage	VH	19	VCC = VCC (O) = 7 V to 25 V, VH = 0 to 30 mA	V_{CC} – 5.5	V_{CC} – 5.0	V_{CC} – 4.5	V
General	Standby current	I_{CCS}	18, 19	VCC = VCC (O) , CTL = 0 V	—	0	10	µA
	Power supply current	I_{CC}	18, 19	VCC = VCC (O) , CTL = 5 V	—	8.0	12.0	mA

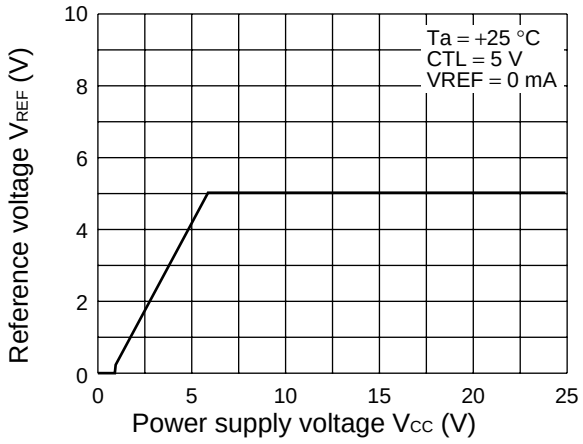
* : Standard design value

■ TYPICAL CHARACTERISTICS

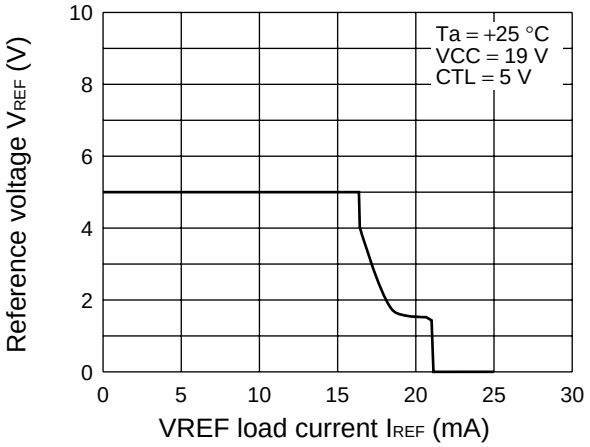
Power supply current vs. power supply voltage



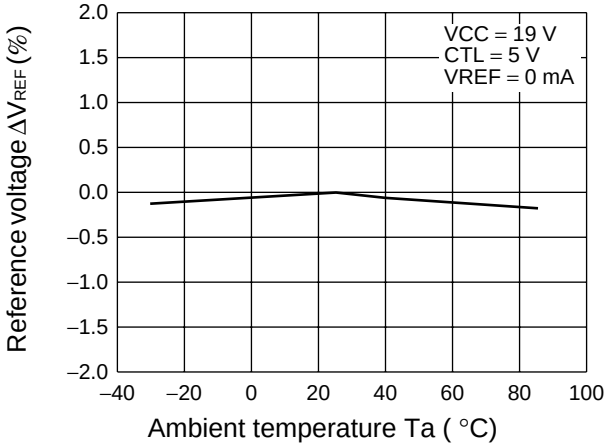
Reference voltage vs. power supply voltage



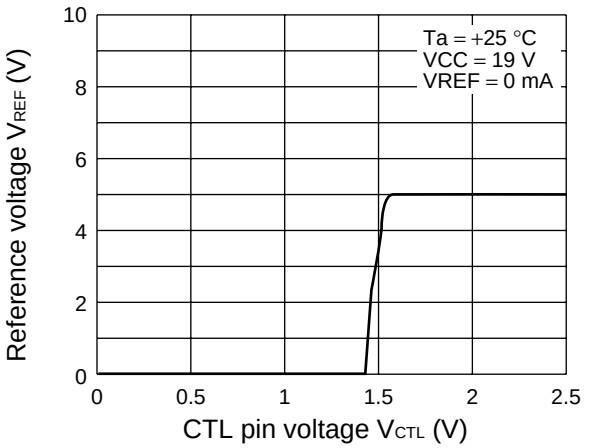
Reference voltage vs. VREF load current



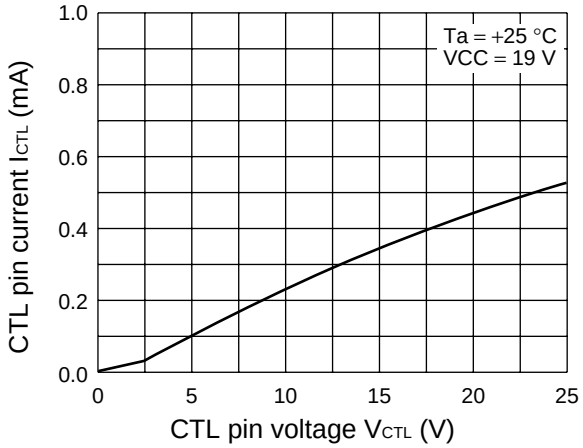
Reference voltage vs. ambient temperature



Reference voltage vs. CTL pin voltage

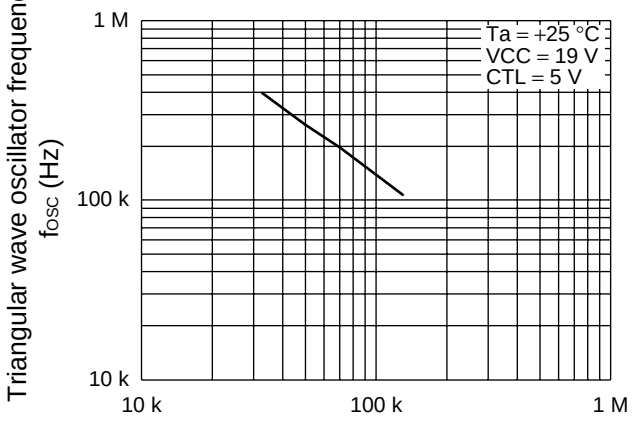


CTL pin current vs. CTL pin voltage

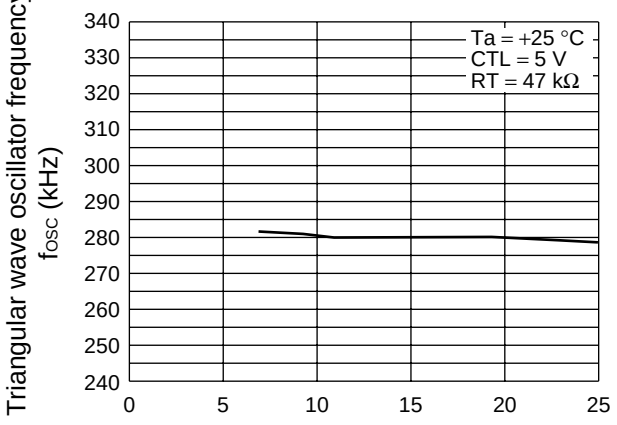


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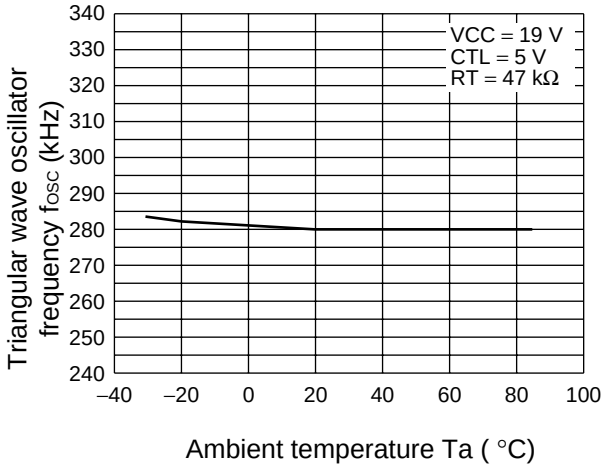
Triangular wave oscillator frequency vs. timing resistor



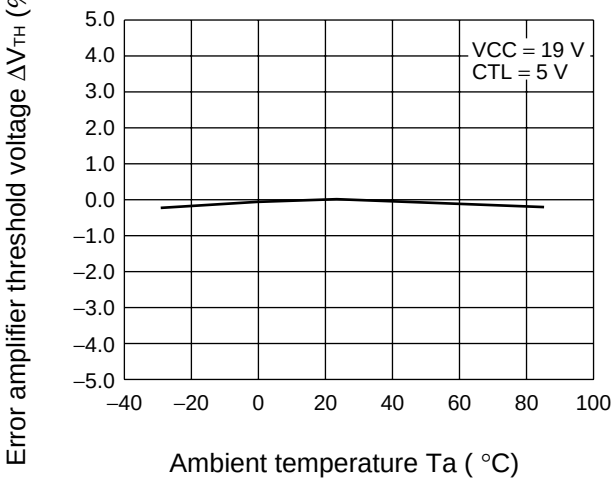
Triangular wave oscillator frequency vs. power supply voltage



Triangular wave oscillator frequency



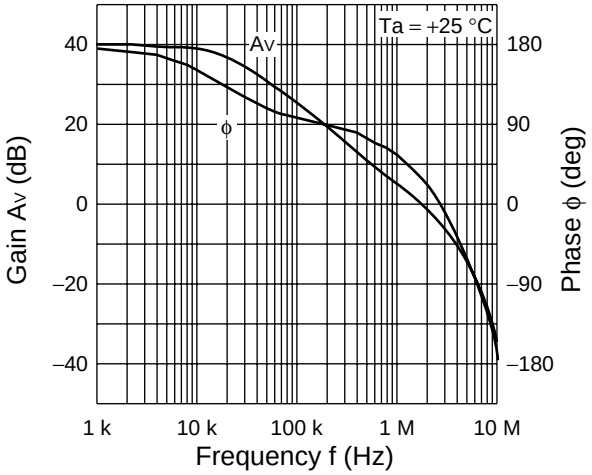
Error amplifier threshold voltage vs. ambient temperature (Error Amp.3)

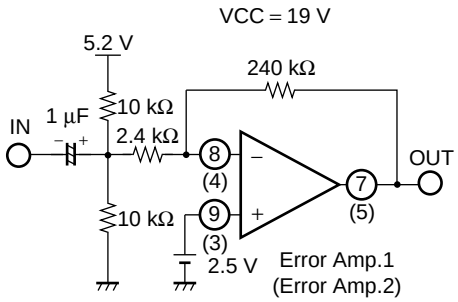


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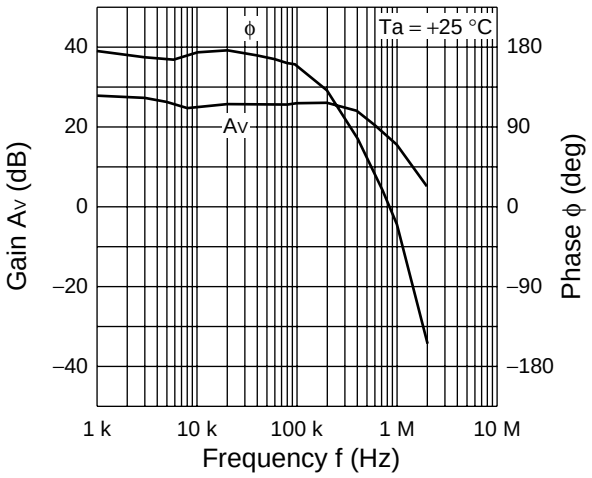
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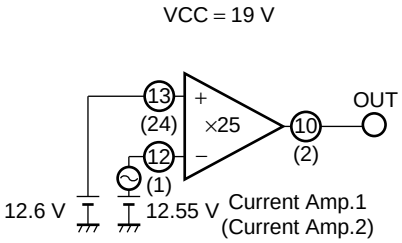
Error amplifier gain and phase vs. frequency



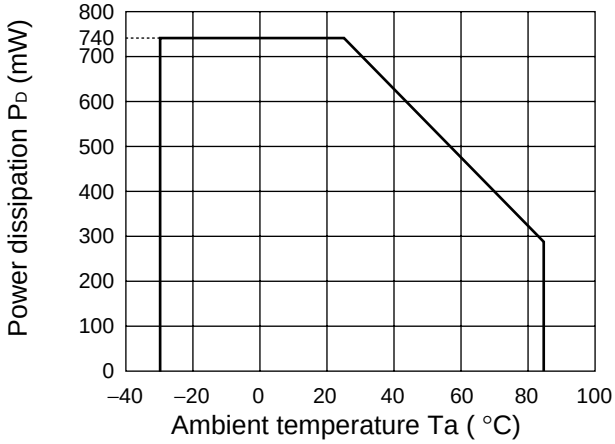


Current detection amplifier gain and phase vs. frequency





Power dissipation vs. ambient temperature



■ FUNCTIONAL DESCRIPTION

1. DC/DC Converter Unit

(1) Reference voltage block (Ref)

The reference voltage generator uses the voltage supplied from the VCC terminal (pin 18) to generate a temperature-compensated, stable voltage (5.0V Typ) used as the reference supply voltage for the IC's internal circuitry.

This pin can also be used to obtain a load current to a maximum of 1mA from the reference voltage VREF terminal (pin 6).

(2) Triangular wave oscillator block (OSC)

The triangular wave oscillator builds the capacitor for frequency setting into, and generates the triangular wave oscillator waveform by connecting the frequency setting resistor with the RT terminal (pin 17).

The triangular wave is input to the PWM comparator on the IC.

(3) Error amplifier block (Error Amp.1)

This amplifier detects the output signal from the current detector ampifier (Current amp .1), compares this to the +INE1 terminal (pin 9), and outputs a PWM control signal to be used in controlling the charging current.

In addition, an arbitrary loop gain can be set up by connecting a feedback resistor and capacitor between the FB1 terminal (pin 7) and -INE terminal (pin 8), providing stable phase compensation to the system.

(4) Error amplifier block (Error Amp.2)

This amplifier (Error Amp.2) detects voltage pendency of the AC adaptor and outputs a PWM control signal.

In addition, an arbitrary loop gain can be set by connecting a feedback resistor and capacitor from the FB2 terminal (pin 5) to the -INE2 terminal (pin 4) of the error amplifier, enabling stable phase compensation to the system.

(5) Error amplifier block (Error Amp.3)

This error amplifier (Error Amp. 3) detects the output voltage from the DC/DC converter and outputs the PWM control signal. External output voltage setting resistors can be connected to the error amplifier inverse input pin to set the desired level of output voltage from 1 cell to 4 cells.

In addition, an arbitrary loop gain can be set by connecting a feedback resistor and capacitor from the FB3 terminal (pin 15) to the –INE3 terminal (pin 16) of the error amplifier, enabling stable phase compensation to the system.

Connecting a soft-start capacitor to the CS terminal (pin 22) prevents surge currents when the IC is turned on. Using an error amplifier for soft-start detection makes the soft-start time constant, independent of the output load.

(6) Current detector amplifier block (Current Amp.1)

The current detection amplifier (Current Amp.1) detects a voltage drop which occurs between both ends of the output sense resistor (R_S) due to the flow of the charge current, using the +INC1 terminal (pin 13) and –INC1 terminal (pin 12). Then it outputs the signal amplified by 25 times to the error amplifier (Error Amp.1) at the next stage.

(7) PWM comparator block (PWM Comp.)

The PWM comparator circuit is a voltage-pulse width converter for controlling the output duty of the error amplifiers (Error Amp. 1 to Error Amp. 3) depending on their output voltage.

The PWM comparator circuit compares the triangular wave generated by the triangular wave oscillator to the error amplifier output voltage and turns on the external output transistor during the interval in which the triangular wave voltage is lower than the error amplifier output voltage.

(8) Output block (OUT)

The output circuit uses a totem-pole configuration capable of driving an external P-channel MOS FET.

The output “L” level sets the output amplitude to 5 V (Typ) using the voltage generated by the bias voltage block (VH).

This results in increasing conversion efficiency and suppressing the withstand voltage of the connected external transistor in a wide range of input voltages.

(9) Control block (CTL)

Setting the CTL terminal (pin 14) low places the IC in the standby mode. (The supply current is 10 μA at maximum in the standby mode.)

(10) Bias voltage block (VH)

The bias voltage circuit outputs Vcc – 5 V (Typ) as the minimum potential of the output circuit. In the standby mode, this circuit outputs the potential equal to Vcc.

2. Protection Functions

Under voltage lockout protection circuit (UVLO)

The transient state or a momentary decrease in supply voltage or internal reference voltage (VREF), which occurs when the power supply is turned on, may cause malfunctions in the control IC, resulting in breakdown or degradation of the system. To prevent such malfunction, the under voltage lockout protection circuit detects a supply voltage or internal reference voltage drop and fixes the OUT terminal (pin 20) to the “H” level. The system restores voltage supply when the supply voltage or internal reference voltage reaches the threshold voltage of the under voltage lockout protection circuit.

3. Soft-start Function

Soft-start block (SOFT)

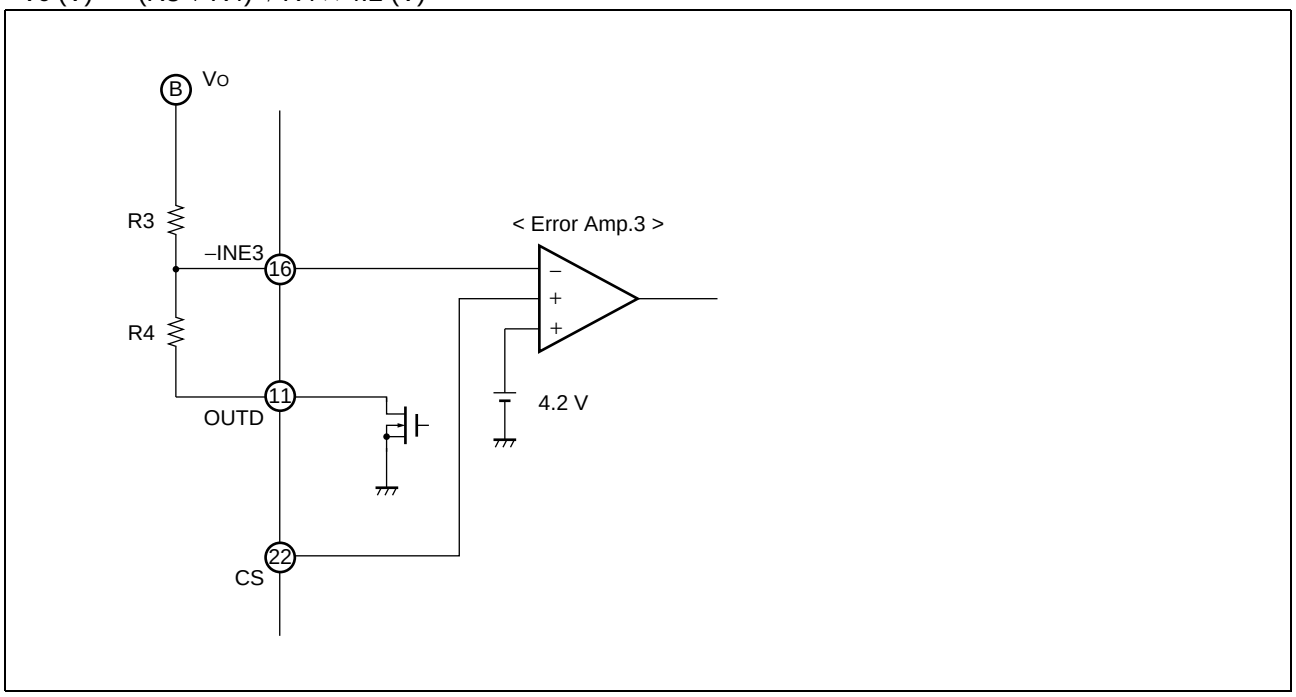
Connecting a capacitor to the CS terminal (pin 22) prevents surge currents when the IC is turned on. Using an error amplifier for soft-start detection makes the soft-start time constant, independent of the output load of the DC/DC converter.

■ SETTING THE CHARGING VOLTAGE

The charging voltage (DC/DC output voltage) can be set by connecting external voltage setting resistors (R3, R4) to the -INE3 terminal. Be sure to select a resistor value that allows you to ignore the on resistor (70 Ω, 1mA) of the internal FET connected to the OUTD terminal (pin 11).

Battery charging voltage: V_O

V_O (V) = (R3 + R4) / R4 × 4.2 (V)



■ METHOD OF SETTING THE CHARGING CURRENT

The charge current (output control current) value can be set with the voltage at the +INE1 terminal (pin 9).

If a current exceeding the set value attempts to flow, the charge voltage drops according to the set current value.

Battery charge current setting voltage : +INE1

+INE1 (V) = 25 × I1 (A) × R_S (Ω)

■ METHOD OF SETTING THE SOFT-START TIME

Upon activation, the IC starts charging the capacitor (Cs) connected to the CS terminal (pin 22).

The error amplifier causes soft-start operation to be performed with the output voltage in proportion to the CS terminal voltage regardless of the load current of the DC/DC converter.

Soft-start time: ts (Time taken for the output voltage to reach 100 %)

ts (s) ≒ 4.2 × C_S (μF)

■ METHOD OF SETTING THE TRIANGULAR WAVE OSCILLATOR FREQUENCY

The trianguar wave oscillator frequency can be set by the timing resistor (R_T) connected the RT terminal (pin 17).

Triangular wave oscillator frequency: f_{OSC}

f_{OSC} (kHz) ≒ 13630 / R_T (kΩ)

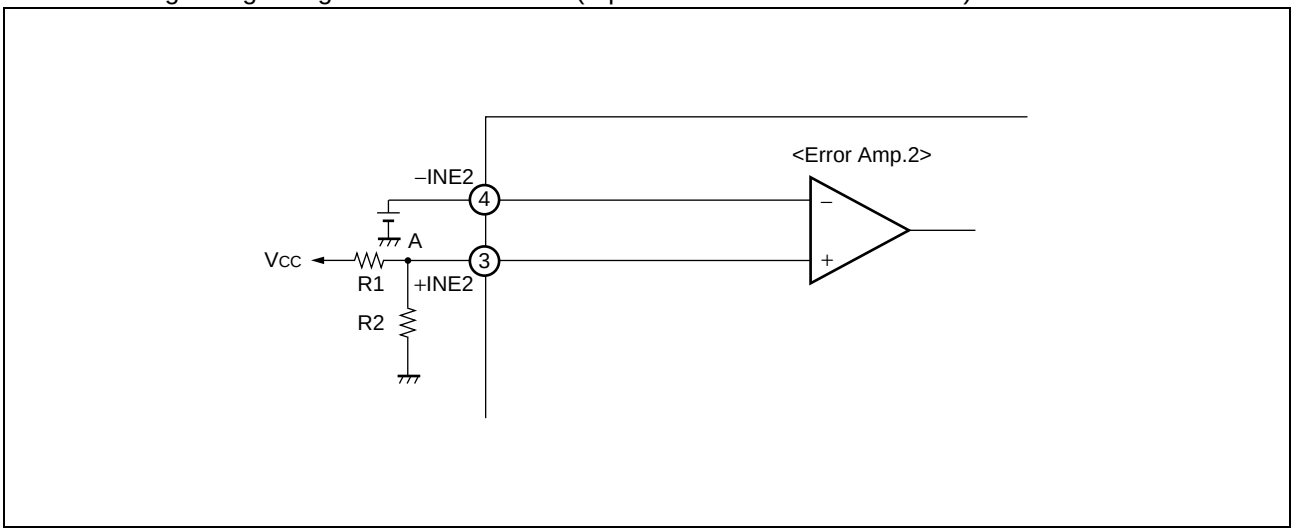
■ AC ADAPTOR VOLTAGE DETECTION

With an external resistor connected to the +INE2 terminal(pin 3), the IC enters the dynamically-controlled charging mode to reduce the charge current to keep AC adaptor power constant when the partial potential point A of the AC adaptor voltage (Vcc) becomes lower than the voltage at the -INE2 terminal.

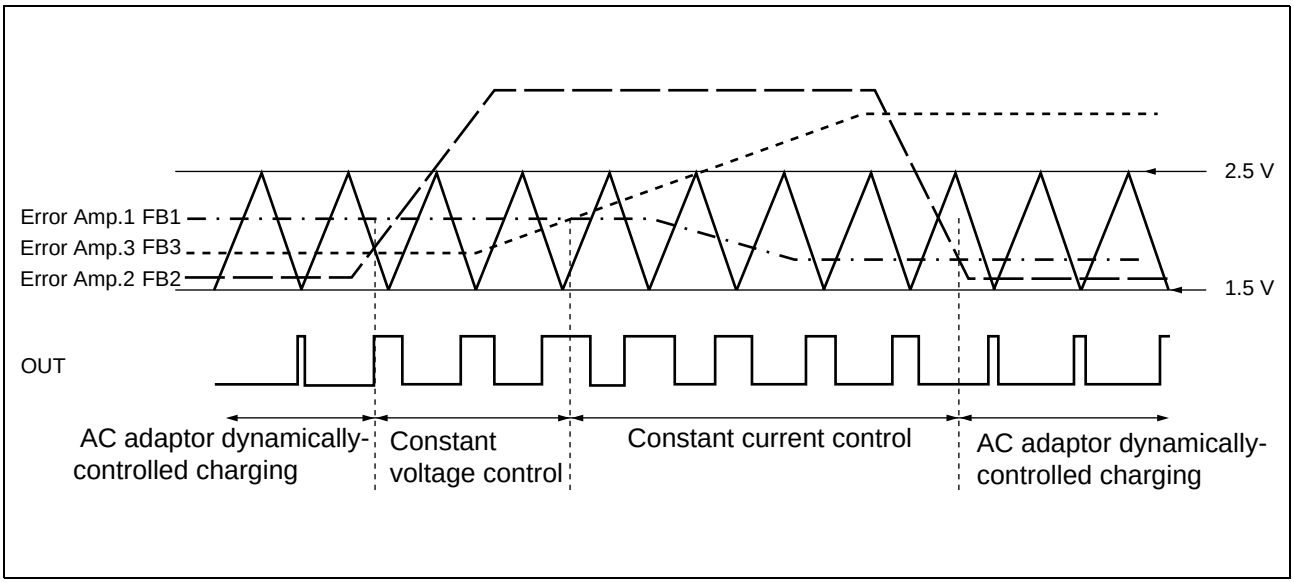
AC adaptor detected voltage setting: Vth

Vth (V) = (R1 + R2) / R2 × –INE2

–INE2 setting voltage range : 1.176 V to 4.2 V (equivalent to 7 V to 25 V for Vcc)

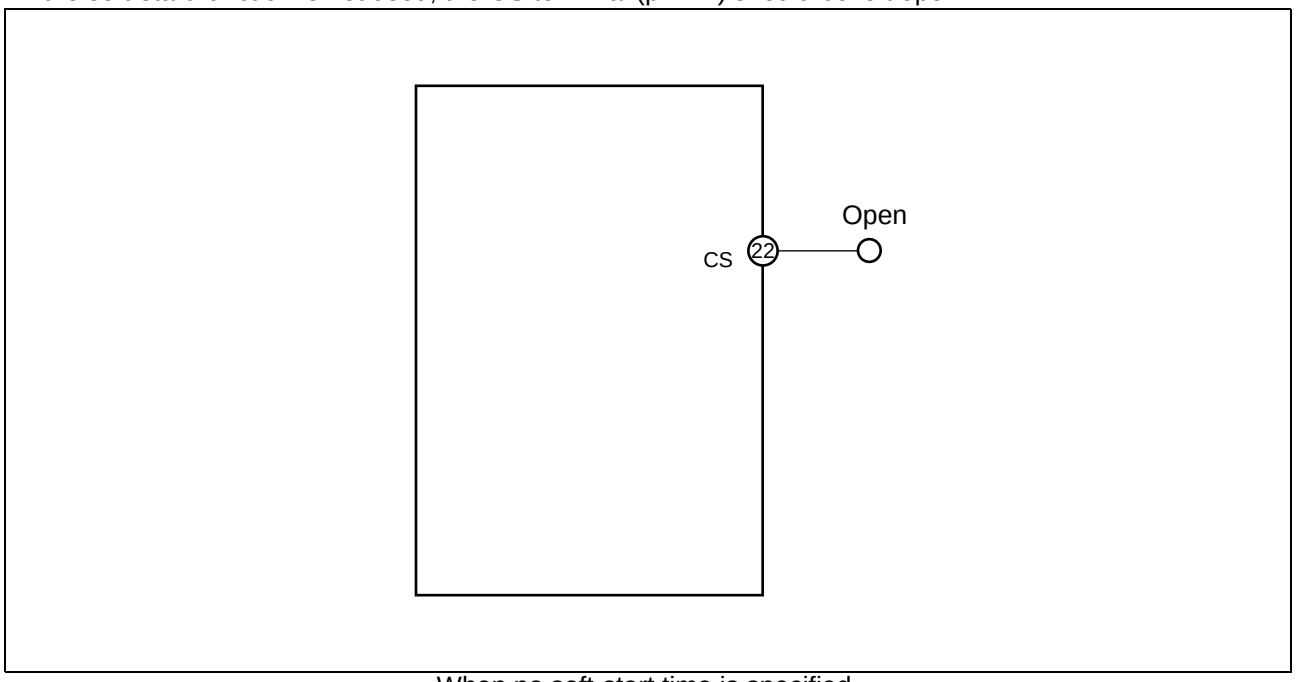


■ OPERATION TIMING DIAGRAM



■ PROCESSING WITHOUT USE OF THE CS PIN

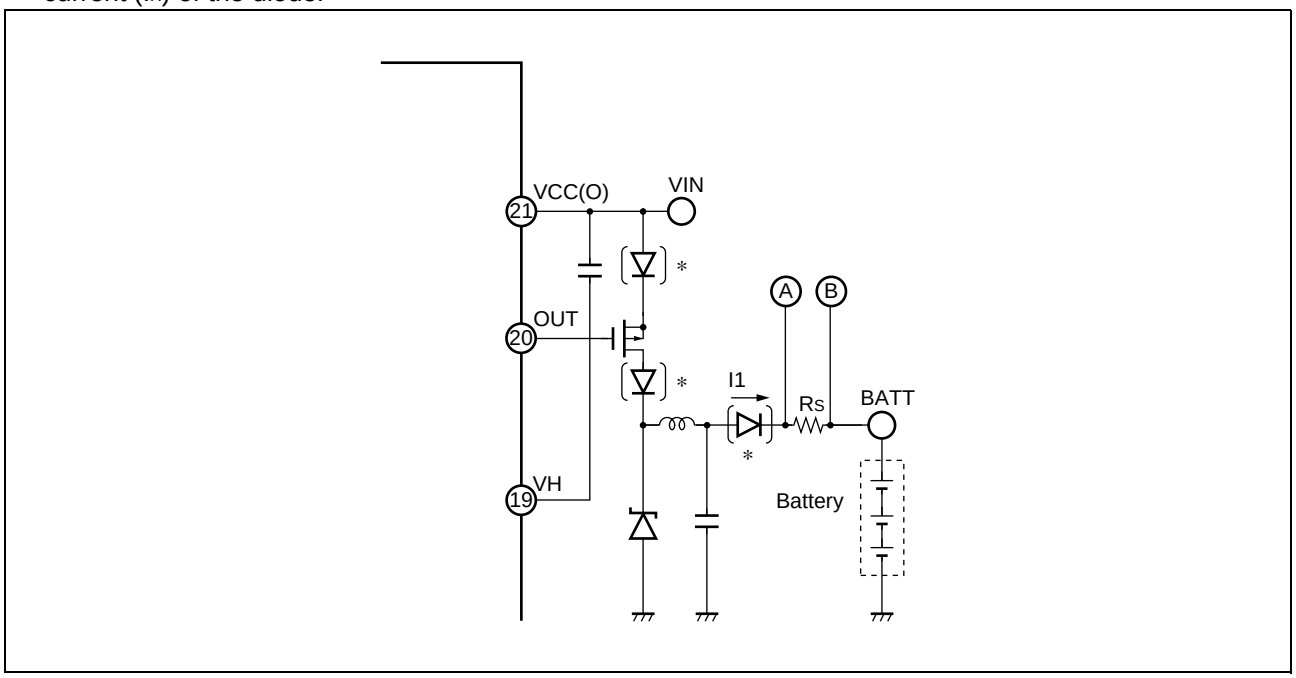
If the soft-start function is not used, the CS terminal (pin 22) should be left open.



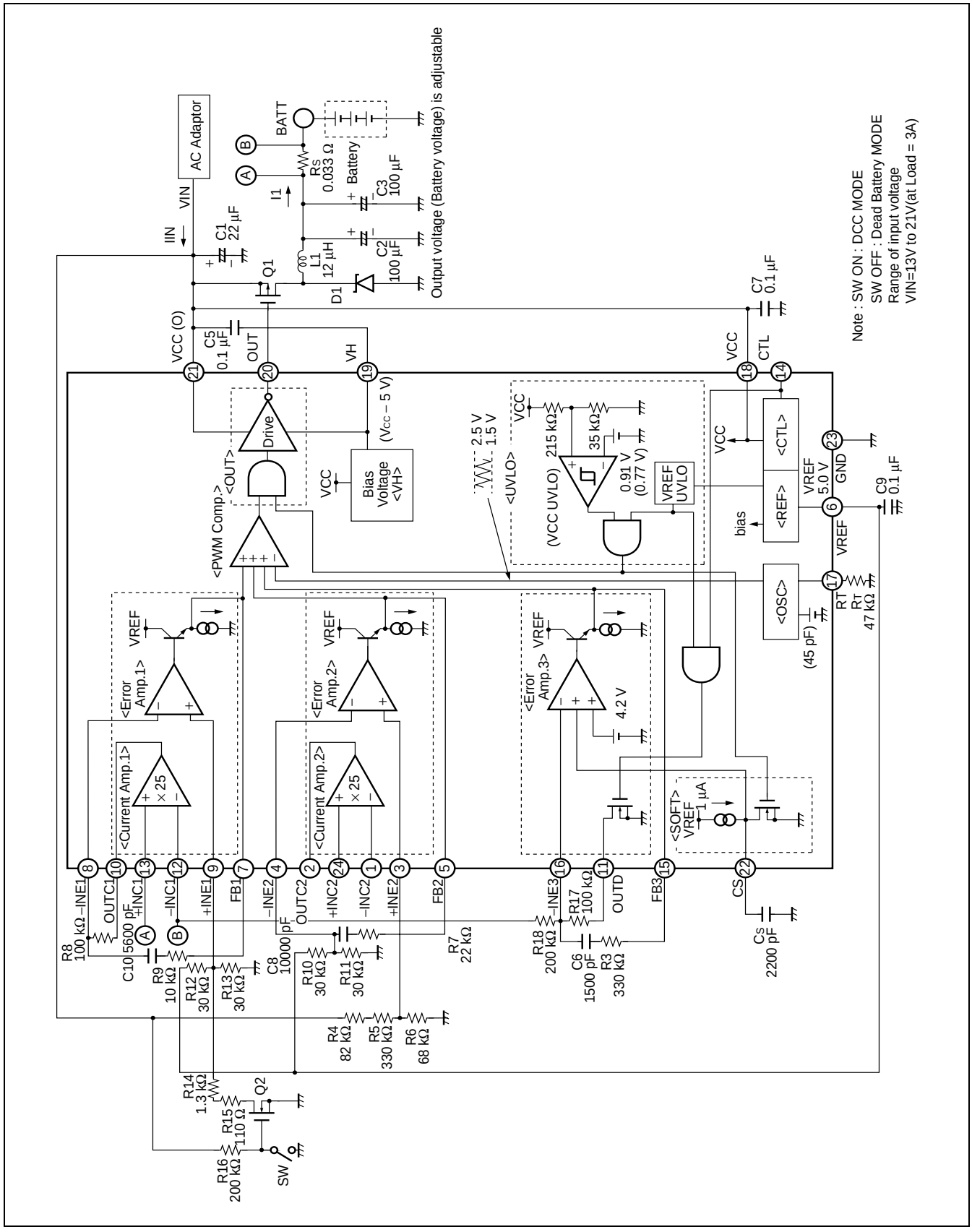
When no soft-start time is specified.

■ NOTE ON AN EXTERNAL REVERSE-CURRENT PREVENTIVE DIODE

- Insert a reverse-current preventive diode at one of the three locations marked * to prevent reverse current from the battery.
- When selecting the reverse current prevention diode, be sure to consider the reverse voltage (V_R) and reverse current (I_R) of the diode.



■ APPLICATION EXAMPLE 1



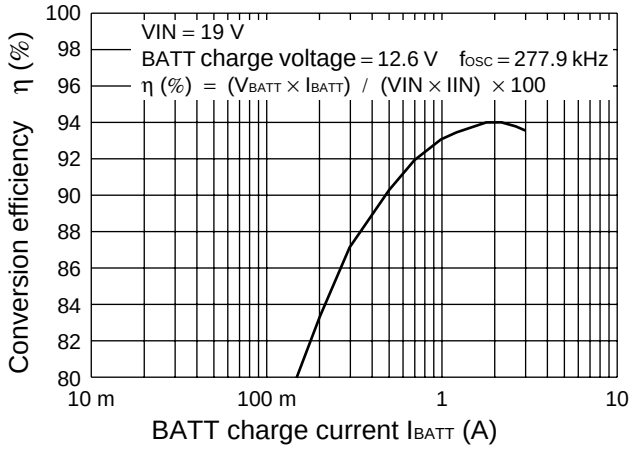
■ PARTS LIST (for APPLICATION EXAMPLE 1)

COMPONENT	ITEM	SPECIFICATION		VENDOR	PARTS No.
Q1 Q2	FET FET	Si4435DY 2N7002		VISHAY SILICONIX VISHAY SILICONIX	Si4435DY 2N7002
D1	Diode	MBRS130LT3		MOTOROLA	MBRS130LT3
L1	Coil	12 µH	4.0 A, 38 mΩ	SUMIDA	CDRH124-12 µH
C1	OS Condenser	22 µF	25 V (10 %)	—	—
C2, C3	OS Condenser	100 µF	25 V (10 %)		
C_S	Ceramics Condenser	2200 pF	10 %		
C5	Ceramics Condenser	0.1 µF	16 V		
C6	Ceramics Condenser	1500 pF	10 %		
C7	Ceramics Condenser	0.1 µF	25 V		
C8	Ceramics Condenser	10000 pF	10 %		
C9	Ceramics Condenser	0.1 µF	16 V		
C10	Ceramics Condenser	5600 pF	10 %		
R_S	Resistor	0.033 Ω	1.0 %	—	—
R_T	Resistor	47 kΩ	1.0 %		
R3	Resistor	330 kΩ	1.0 %		
R4	Resistor	82 kΩ	0.5 %		
R5	Resistor	330 kΩ	0.5 %		
R6	Resistor	68 kΩ	0.5 %		
R7	Resistor	22 kΩ	1.0 %		
R8	Resistor	100 kΩ	1.0 %		
R9	Resistor	10 kΩ	1.0 %		
R10 to R13	Resistor	30 kΩ	0.5 %		
R14	Resistor	1.3 kΩ	0.5 %		
R15	Resistor	110 Ω	0.5 %		
R16	Resistor	200 kΩ	5 %		
R17	Resistor	100 kΩ	0.5 %		
R18	Resistor	200 kΩ	0.5 %		

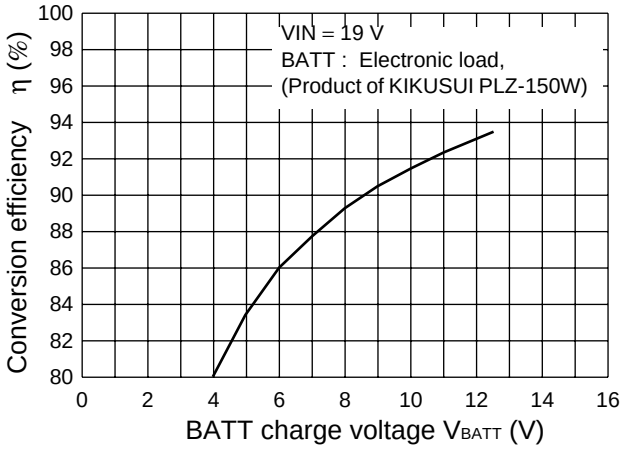
Note VISHAY SILICONIX : VISHAY Intertechnology, Inc.
MOTOROLA : Motorola Japan Ltd.
SUMIDA : SUMIDA ELECTRIC CO., Ltd.

■ REFERENCE DATA

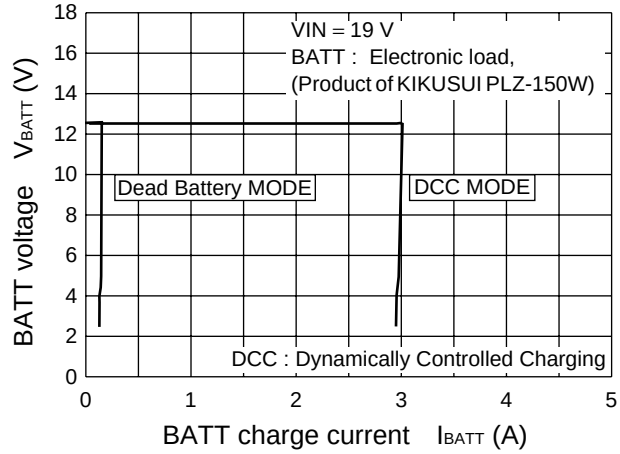
Conversion efficiency vs. charge current
(Fixed voltage mode)



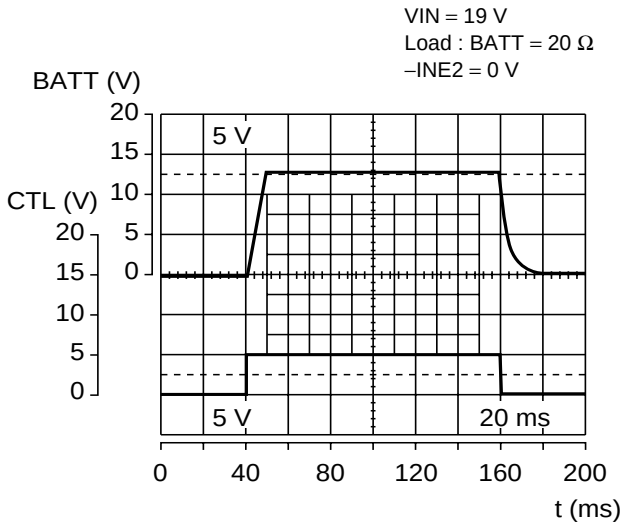
Conversion efficiency vs. charge voltage
(Fixed current mode)



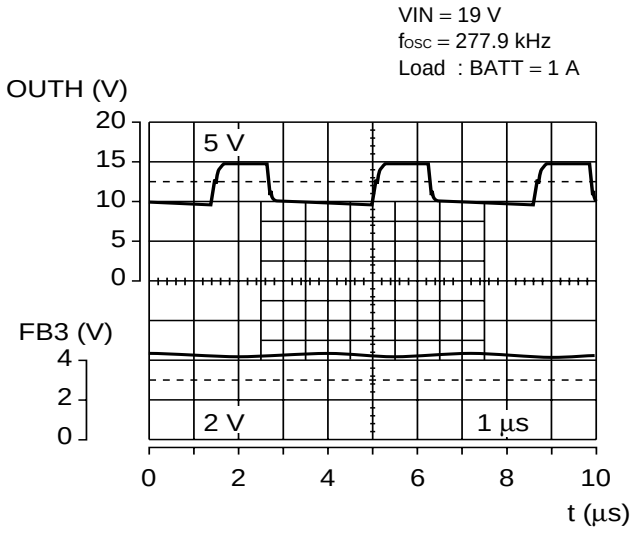
BATT voltage vs. BATT charge current



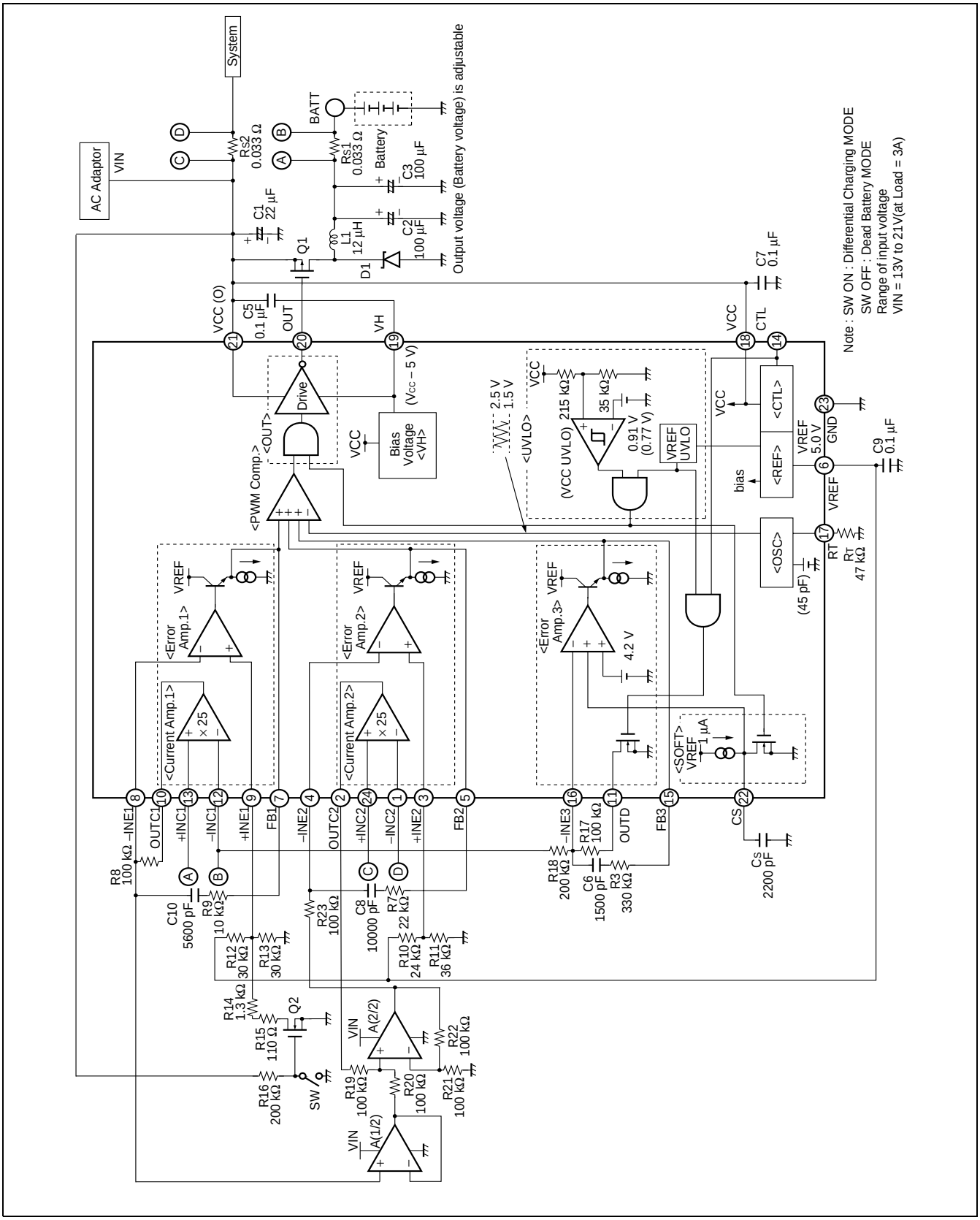
Soft-start operating waveforms



DC/DC converter switching waveforms



■ APPLICATION EXAMPLE 2



■ PARTS LIST (for APPLICATION EXAMPLE 2)

COMPONENT	ITEM	SPECIFICATION		VENDOR	PARTS No.
Q1 Q2	FET FET	Si4435DY 2N7002		VISHAY SILICONIX VISHAY SILICONIX	Si4435DY 2N7002
D1	Diode	MBRS130LT3		MOTOROLA	MBRS130LT3
A	Dual Op-amp	MB47358		Our Company	MB47358
L1	Coil	12 µH	4.0 A, 38 mΩ	SUMIDA	CDRH124-12 µH
C1	OS Condenser	22 µF	25 V (10 %)	—	—
C2, C3	OS Condenser	100 µF	25 V (10 %)		
C_S	Ceramics Condenser	2200 pF	10 %		
C5	Ceramics Condenser	0.1 µF	16 V		
C6	Ceramics Condenser	1500 pF	10 %		
C7	Ceramics Condenser	0.1 µF	25 V		
C8	Ceramics Condenser	10000 pF	10 %		
C9	Ceramics Condenser	0.1 µF	16 V		
C10	Ceramics Condenser	5600 pF	10 %		
R_{S1}, R_{S2}	Resistor	0.033 Ω	1.0 %	—	—
R_T	Resistor	47 kΩ	1.0 %		
R3	Resistor	330 kΩ	1.0 %		
R7	Resistor	22 kΩ	1.0 %		
R8	Resistor	100 kΩ	1.0 %		
R9	Resistor	10 kΩ	1.0 %		
R10	Resistor	36 kΩ	0.5 %		
R11	Resistor	27 kΩ	0.5 %		
R12, R13	Resistor	30 kΩ	0.5 %		
R14	Resistor	1.3 kΩ	0.5 %		
R15	Resistor	110 Ω	0.5 %		
R16	Resistor	200 kΩ	5 %		
R17	Resistor	100 kΩ	1.0 %		
R18	Resistor	200 kΩ	0.5 %		
R19, R20	Resistor	100 kΩ	1.0 %		
R21, R22	Resistor	100 kΩ	0.5 %		
R23	Resistor	100 kΩ	1.0 %		

Note VISHAY SILICONIX : VISHAY Intertechnology, Inc.
MOTOROLA : Motorola Japan Ltd.
SUMIDA : SUMIDA ELECTRIC CO., Ltd.

■ USAGE PRECAUTIONS

• Printed circuit board ground lines should be set up with consideration for common impedance.

• Take appropriate static electricity measures.

- Containers for semiconductor materials should have anti-static protection or be made of conductive material.
- After mounting, printed circuit boards should be stored and shipped in conductive bags or containers.
- Work platforms, tools, and instruments should be properly grounded.
- Working personnel should be grounded with resistance of 250 kΩ to 1 MΩ between body and ground.

• Do not apply negative voltages.

The use of negative voltages below –0.3 V may create parasitic transistors on LSI lines, which can cause abnormal operation

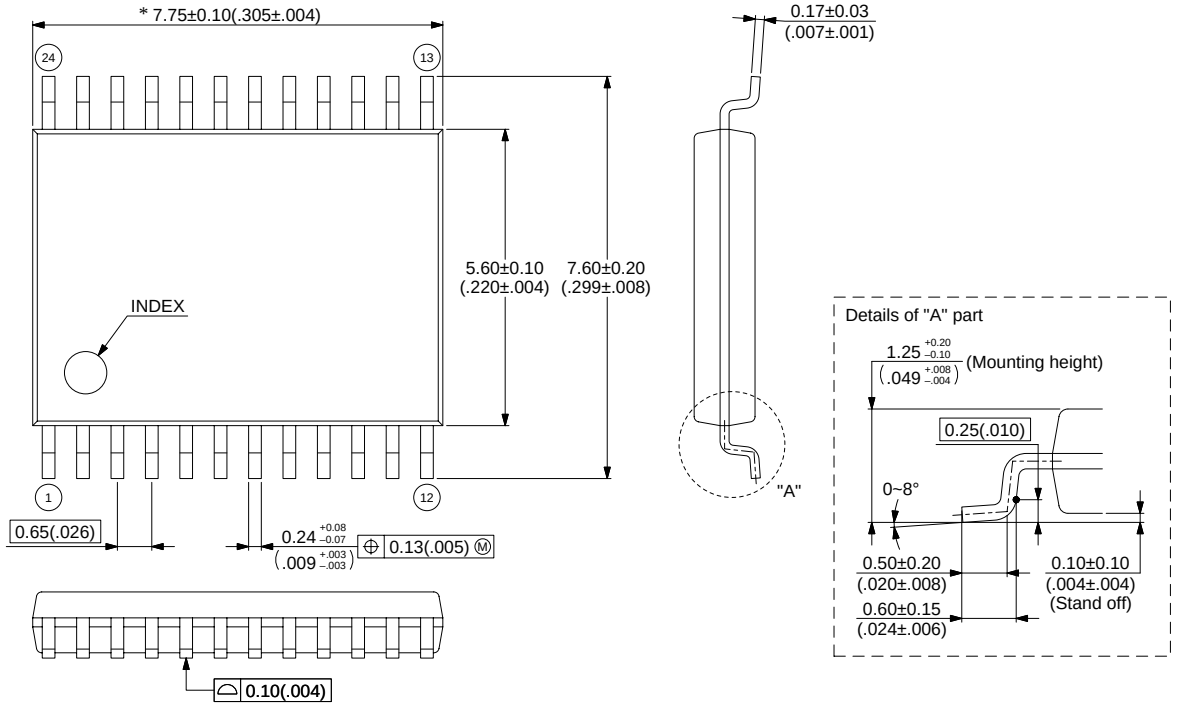
■ ORDERING INFORMATION

Part number	Package	Remarks
MB3878PFV	24-pin plastic SSOP (FPT-24P-M03)	

■ PACKAGE DIMENSION

24-pin plastic SSOP
(FPT-24P-M03)

Note1: Pins width and pins thickness include plating thickness.
Note2: * This dimension does not include resin protrusion.



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Dimensions in mm (inches)

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