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# ASSP for Power Supply Applications

## Evaluation Board

# MB39A113

### DESCRIPTION

The MB39A113 evaluation board is a surface mount circuit board of down conversion circuit.

The MB39A113 evaluation board is a high-precision, high-efficiency battery charger capable of being set for 1 to 4 cells. It controls the charge voltage and charge current based on the power-supply voltage of, for example, an AC adapter to supply a current of up to 3 A.

This board can dynamically control of the secondary battery's charge current by detecting a voltage drop in an AC adapter to keep its power constant. (Dynamically-controlled charging.)

### EVALUATION BOARD SPECIFICATIONS

(Ta = + 25 °C)

Parameter		Value			Unit
		Min	Typ	Max	
Input voltage	12.6 V setting	13.2 <sup>*2</sup>	16	22	V
	16.8 V setting <sup>*1</sup>	17.4 <sup>*2</sup>	19	25	V
Output voltage	12.6 V setting	12.45	12.6	12.75	V
	16.8 V setting <sup>*1</sup>	16.59	16.8	17.01	V
Ripple voltage	12.6 V setting	—	126	252	mV
	16.8 V setting <sup>*1</sup>	—	168	336	mV
UVComp detection voltage (VCC = H→L)	12.6 V setting	12.6	12.8	13	V
	16.8 V setting <sup>*1</sup>	16.8	17	17.2	V
Output current	SW2 = ON	2.82	3.03	3.26	A
	SW2 = OFF	0.182	0.26	0.338	A
Dynamically-controlled charging detection voltage <sup>*2</sup>		17.6	18	18.4	V
Oscillation frequency		260	300	340	kHz
Soft-start time	Constant voltage mode	5.9	9.3	17	ms
	Constant current mode	2.8	4.4	8.2	ms

\*1 : 4 cells (16.8 V) charging is selected initially.

\*2 : The actual minimum value is the dynamically-controlled charging detection voltage.

## ■ TERMINAL DESCRIPTION

Symbol	Function
VAC	AC adapter input terminal
VIN	IC power supply terminal
V <sub>o</sub>	DC/DC converter output terminal VBATT = 16.8 V (Typ)
BATT	System output terminal
CTL	Power supply control terminal [at SW1 (switch1) = OFF] VCTL = 0 V to 0.8 V : Standby mode VCTL = 2.0 V to VIN : Operation mode
VREF	Reference voltage output terminal
MODE SW	Mode control terminal [at SW2 (switch2) = OFF] VMODE SW = 0 V to 1.0 V : Dead battery mode* <sup>1</sup> VMODE SW = High-Z ( or 2.5 V to VIN ) : DCC mode* <sup>2</sup>
CVM	Constant-voltage control state detection output terminal (open drain form) At constant-voltage control state : “L” level
OVP	DC/DC converter output overvoltage detection terminal (open drain form) At overvoltage : “H” level
GND	Battery charge system GND
SGND	IC control side GND

\*1 : This mode is used to check whether the battery is normal. The dead battery mode charge current value is set to about 260 mA (Typ) .

\*2 : Charging is performed in dynamically-controlled charging (DCC) mode. The DCC mode charge current value is set to 3 A (Typ) .

Note : The AC adapter detection voltage is set to 18.0 V to control a constant electric power. For normal operation, apply a voltage of at least 18.0 V to the VAC terminal.

## ■ SWITCH DESCRIPTION

SW	Name	Function	ON	OFF
1	CTL	Power supply control	Operation	Stand-by
2	Mode SW	Charge current mode control	DCC mode	Dead Battery mode

## ■ SETUP AND CHECKUP

### • Setup

- Connect power supply terminal side to VAC and GND. Connect the BATT terminal to required loading device or measuring instrument.
- Set SW to OFF.

### • Checkup

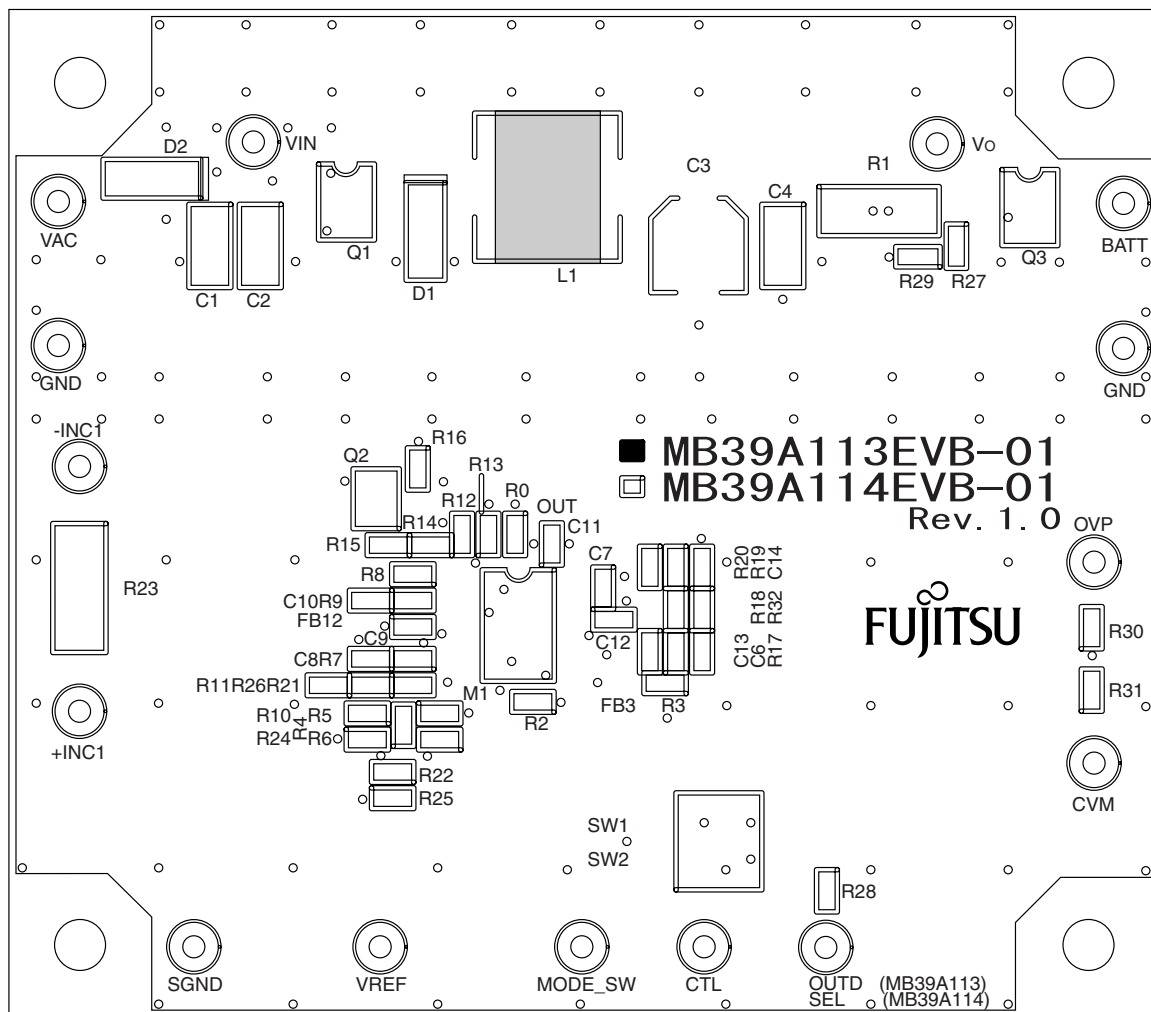
Turn on SW1 and turn on the power to the VAC (power supply) while turned on.

The IC works normally with the following outputs : BATT = 16.8 V (Typ)

SW2 = ON : DCC mode

SW2 = OFF : Dead battery mode

## ■ COMPONENT LAYOUT

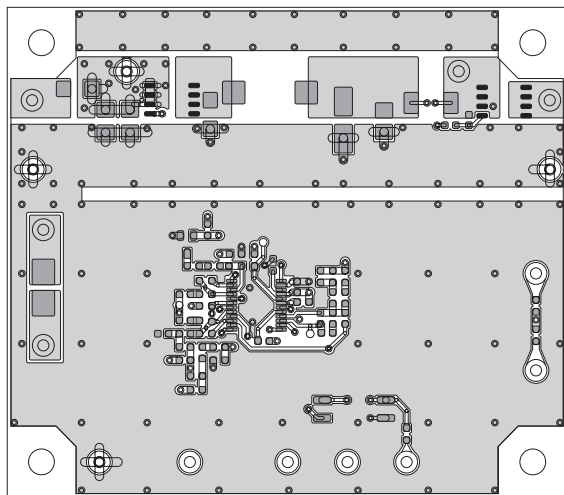


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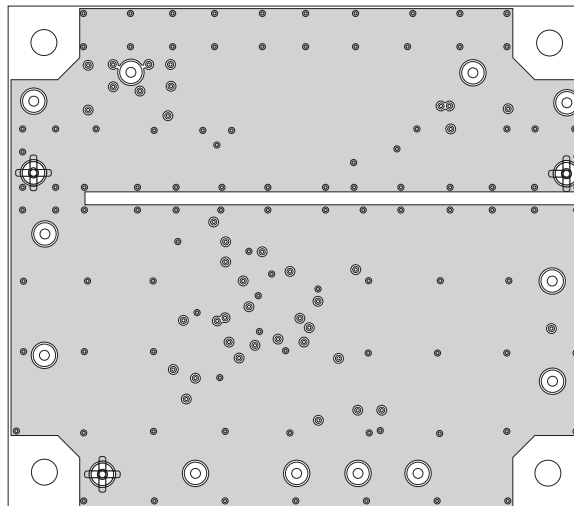
# MB39A113

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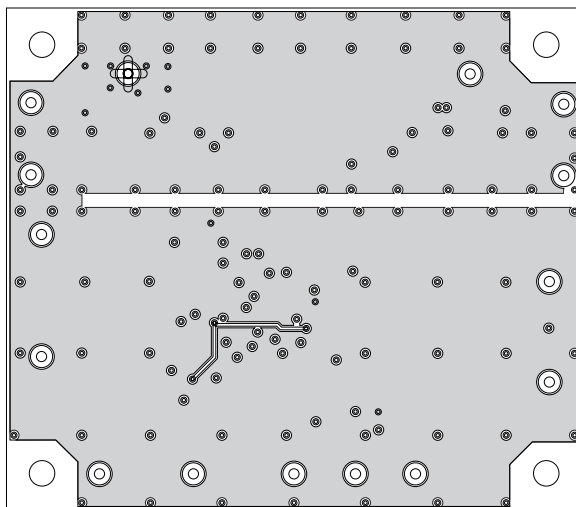
- Board layout



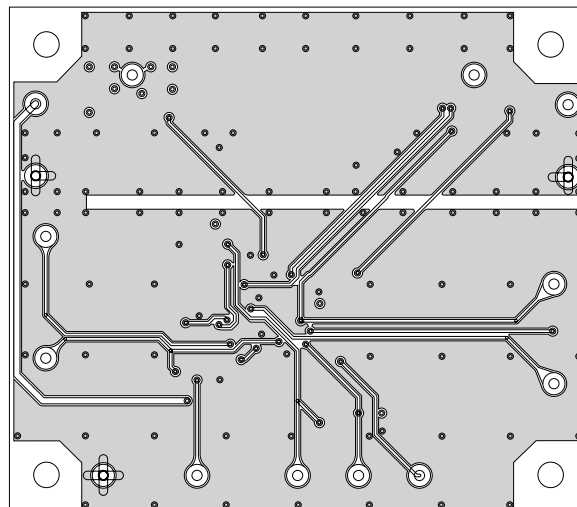
Top Side



Inside GND (Layer2)

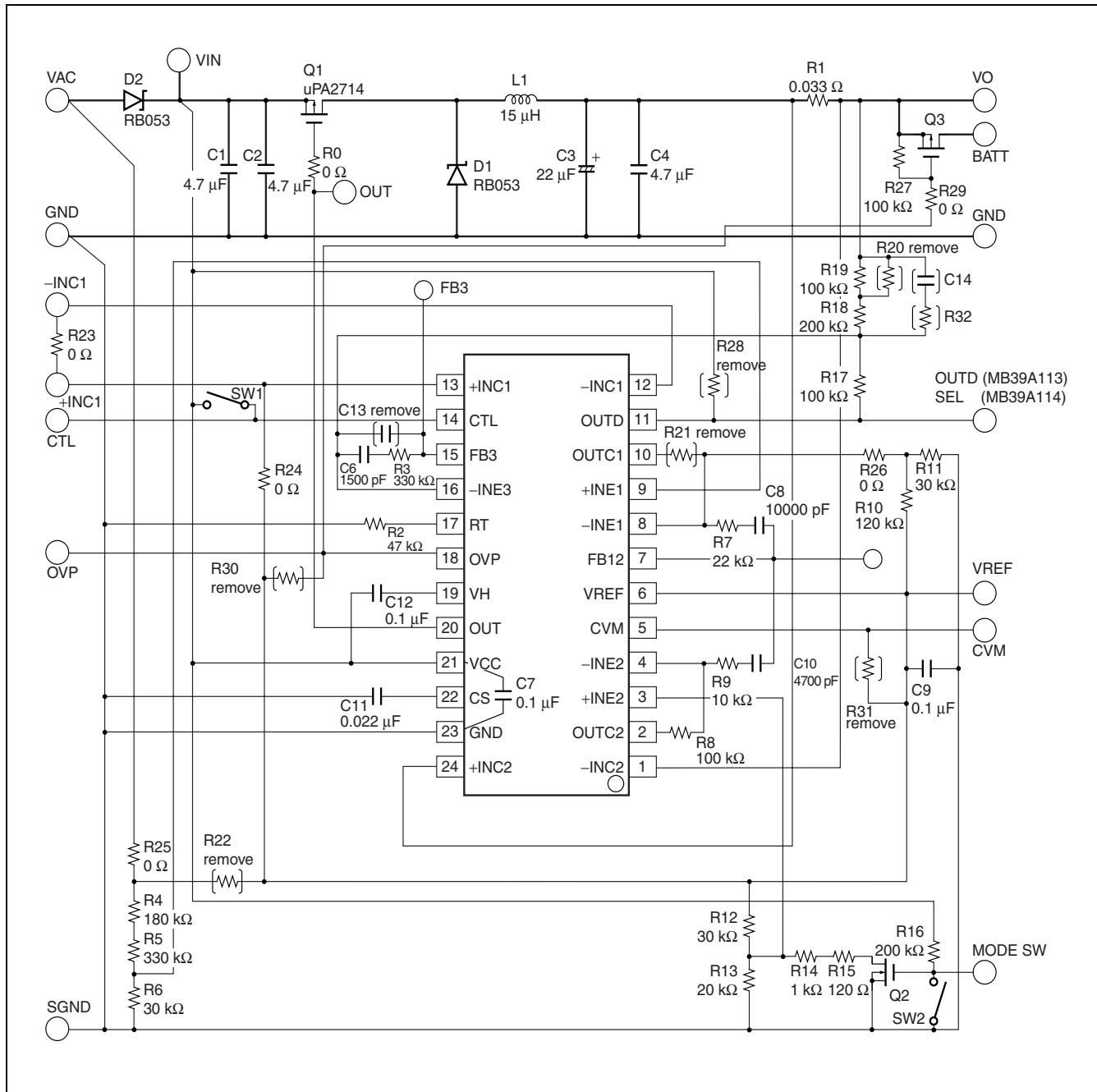


Inside VIN (Layer3)



Bottom Side

## CONNECTION DIAGRAM



# MB39A113

## ■ PARTS LIST

Symbol	Part name	Model name	Specification						Package	Manufacturer	Note
			Rating 1	Rating 2	Rating 3	Value	Deviation	Features			
M1	IC	MB39A113 PFT	—	—	—	—	—	—	FPT-24P-M03	FUJITSU MICROELECTRONICS	
Q1	Pch FET	μPA2714GR	PD = 2 W	VGSS = - 30 V	ID = 7 A	—	—	—	SO-8	NEC	
Q2	Nch FET	MCH3405	PD = 0.8 W	VGSS = 20 V	ID = 1.8 A	—	—	—	MCPH3	SANYO	
Q3	Pch FET	μPA2714GR	PD = 2 W	VGSS = - 30 V	ID = 7 A	—	—	—	SO-8	NEC	
D1	SBD	RB053L-30	VF = 0.42 V at 3 A	VRRM = 30 V	—	—	—	—	PMDS	ROHM	
D2	SBD	RB053L-30	VF = 0.42 V at 3 A	VRRM = 30 V	—	—	—	—	PMDS	ROHM	
L1	Coil	CDRH104R150	RDC = 3.6 A	—	—	15 μH	± 30%	DCR = 50 mΩ	SMD	SUMIDA	
C1	Ceramic condenser	C3225JB1E475K	25 V	—	—	4.7 μF	± 10%	Temperature characteristics B	3225	TDK	
C2	Ceramic condenser	C3225JB1E475K	25 V	—	—	4.7 μF	± 10%	Temperature characteristics B	3225	TDK	
C3	OS-CON™	20SVP22M	20 V	1450 mArms	—	22 μF	—	ESR = 60 mΩ	SMD	SANYO	
C4	Ceramic condenser	C3225JB1E475K	25 V	—	—	4.7 μF	± 10%	Temperature characteristics B	3225	TDK	
C6	Ceramic condenser	C1608JB1H152K	50 V	—	—	1500 pF	± 10%	Temperature characteristics B	1608	TDK	
C7	Ceramic condenser	C1608JB1H104K	50 V	—	—	0.1 μF	± 10%	Temperature characteristics B	1608	TDK	
C8	Ceramic condenser	C1608JB1H103K	50 V	—	—	0.01 μF	± 10%	Temperature characteristics B	1608	TDK	
C9	Ceramic condenser	C1608JB1H104K	50 V	—	—	0.1 μF	± 10%	Temperature characteristics B	1608	TDK	
C10	Ceramic condenser	C1608JB1H472K	50 V	—	—	4700 pF	± 10%	Temperature characteristics B	1608	TDK	
C11	Ceramic condenser	C1608JB1H223K	50 V	—	—	0.022 μF	± 10%	Temperature characteristics B	1608	TDK	
C12	Ceramic condenser	C1608JB1H104K	50 V	—	—	0.1 μF	± 10%	Temperature characteristics B	1608	TDK	

Note : OS - CON™ is a trademark of SANYO Electric Co., Ltd.

(Continued)

Symbol	Part name	Model name	Specification						Package	Manu- facturer	Note
Circuit diagram mark			Rating 1	Rating 2	Rating 3	Value	Deviation	Features			
C13	Ceramic condenser	C1608JB1 H104K	50 V	—	—	0.1 μF	± 10%	Temperature characteristics B	1608	TDK	Not mounted
C14	Ceramic condenser	C1608JB1 H104K	50 V	—	—	0.1 μF	± 10%	Temperature characteristics B	1608	TDK	Not mounted
R0	Jumper	RK73Z1J	1 A	—	—	0 Ω	Max 50 mΩ	—	1608	KOA	
R1	Resistor	SL1TTE33 LOF	1 W	—	—	33 mΩ	± 1%	—	6.2x4.5mm	KOA	
R2	Resistor	PR0816P- 473-D	1/16 W	—	—	47 kΩ	± 0.5%	± 25 ppm/ °C	1608	ssm	
R3	Resistor	PR0816P- 334-D	1/16 W	—	—	330 kΩ	± 0.5%	± 25 ppm/ °C	1608	ssm	
R4	Resistor	PR0816P- 184-D	1/16 W	—	—	180 kΩ	± 0.5%	± 25 ppm/ °C	1608	ssm	
R5	Resistor	PR0816P- 334-D	1/16 W	—	—	330 kΩ	± 0.5%	± 25 ppm/ °C	1608	ssm	
R6	Resistor	PR0816P- 303-D	1/16 W	—	—	30 kΩ	± 0.5%	± 25 ppm/ °C	1608	ssm	
R7	Resistor	PR0816P- 223-D	1/16 W	—	—	22 kΩ	± 0.5%	± 25 ppm/ °C	1608	ssm	
R8	Resistor	PR0816P- 104-D	1/16 W	—	—	100 kΩ	± 0.5%	± 25 ppm/ °C	1608	ssm	
R9	Resistor	PR0816P- 103-D	1/16 W	—	—	10 kΩ	± 0.5%	± 25 ppm/ °C	1608	ssm	
R10	Resistor	PR0816P- 124-D	1/16 W	—	—	120 kΩ	± 0.5%	± 25 ppm/ °C	1608	ssm	
R11	Resistor	PR0816P- 303-D	1/16 W	—	—	30 kΩ	± 0.5%	± 25 ppm/ °C	1608	ssm	
R12	Resistor	PR0816P- 303-D	1/16 W	—	—	30 kΩ	± 0.5%	± 25 ppm/ °C	1608	ssm	
R13	Resistor	PR0816P- 203-D	1/16 W	—	—	20 kΩ	± 0.5%	± 25 ppm/ °C	1608	ssm	
R14	Resistor	PR0816P- 102-D	1/16 W	—	—	1 kΩ	± 0.5%	± 25 ppm/ °C	1608	ssm	
R15	Resistor	PR0816P- 121-D	1/16 W	—	—	120 Ω	± 0.5%	± 25 ppm/ °C	1608	ssm	
R16	Resistor	PR0816P- 204-D	1/16 W	—	—	200 kΩ	± 0.5%	± 25 ppm/ °C	1608	ssm	
R17	Resistor	PR0816P- 104-D	1/16 W	—	—	100 kΩ	± 0.5%	± 25 ppm/ °C	1608	ssm	
R18	Resistor	PR0816P- 204-D	1/16 W	—	—	200 kΩ	± 0.5%	± 25 ppm/ °C	1608	ssm	
R19	Resistor	PR0816P- 104-D	1/16 W	—	—	100 kΩ	± 0.5%	± 25 ppm/ °C	1608	ssm	
R20	Jumper	RK73Z1J	1 A	—	—	0 Ω	Max 50 mΩ	—	1608	KOA	Not mounted

(Continued)



# MB39A113

(Continued)

Symbol Circuit diagram mark	Part name	Model name	Specification						Package	Manufacturer	Note
			Rating 1	Rating 2	Rating 3	Value	Deviation	Features			
R21	Resistor	PR0816P-104-D	1/16 W	—	—	100 kΩ	± 0.5%	± 25 ppm/ °C	1608	ssm	Not mounted
R22	Jumper	RK73Z1J	1 A	—	—	0 Ω	Max 50 mΩ	—	1608	KOA	Not mounted
R23	Jumper	RK73Z1J	1 A	—	—	0 Ω	Max 50 mΩ	—	1608	KOA	
R24	Jumper	RK73Z1J	1 A	—	—	0 Ω	Max 50 mΩ	—	1608	KOA	
R25	Jumper	RK73Z1J	1 A	—	—	0 Ω	Max 50 mΩ	—	1608	KOA	
R26	Jumper	RK73Z1J	1 A	—	—	0 Ω	Max 50 mΩ	—	1608	KOA	
R27	Resistor	PR0816P-104-D	1/16 W	—	—	100 kΩ	± 0.5%	± 25 ppm/ °C	1608	ssm	
R28	Resistor	PR0816P-104-D	1/16 W	—	—	100 kΩ	± 0.5%	± 25 ppm/ °C	1608	ssm	Not mounted
R29	Jumper	RK73Z1J	1 A	—	—	0 Ω	Max 50 mΩ	—	1608	KOA	
R30	Resistor	PR0816P-104-D	1/16 W	—	—	100 kΩ	± 0.5%	± 25 ppm/ °C	1608	ssm	Not mounted
R31	Resistor	PR0816P-104-D	1/16 W	—	—	100 kΩ	± 0.5%	± 25 ppm/ °C	1608	ssm	Not mounted
R32	Resistor	PR0816P-103-D	1/16 W	—	—	10 kΩ	± 0.5%	± 25 ppm/ °C	1608	ssm	Not mounted
SW1, SW2	Switch	DMS-2H	—	—	—	2 poles	—	—	—	MATSUKYU	
—	Terminal pins	WT-2-1	—	—	—	—	—	—	—	MacEight	

NEC NEC corporation  
 ROHM ROHM CO., LTD.  
 SUMIDA Sumida Corporation  
 SANYO SANYO Electric Co., Ltd  
 TDK TDK Corporation  
 KOA KOA Corporation  
 ssm SUSUMU CO., LTD.  
 MATSUKYU Matsukyu Co., Ltd.  
 MacEight MacEight Co., Ltd

Resistor value at 3-cell or 4-cell

Battery	3-cell	4-cell
R20 [Ω]	0	Remove
V <sub>o</sub> [V]	12.6	16.8

## ■ INITIAL SETTINGS

### (1) Output voltage

$$V_O (V) = \frac{(R19 + R18 + R17)}{R17} \times 4.2 = 16.8 (V)$$

Notes : • For resistors R17, R18 and R19, use a resistor value at which the ON resistance (35 Ω, 1 mA) of the internal FET connected to the OUTD terminal (pin 17) can be ignored.  
• For 3-cell charge, place a jumper at R20.

### (2) Dynamically-controlled charging detection voltage (DCC mode)

$$V_{th} = \frac{R11}{R10 + R11} \times V_{REF} \times \frac{R4 + R5 + R6}{R6} = 18.0 (V)$$

Note : Change the setting when the product is used with a 16 V AC adapter.

### (3) Maximum charge current (CC mode)

$$I_{O (Max)} (A) = \frac{V_{REF} \times R13}{(R12 + R13) \times 20 \times R1} = 3.03 (A)$$

### (4) Dead battery mode charge current

$$I_{D EAD} (A) = \frac{V_{REF} \times R13 \times (R14 + R15)}{(R12 \times R13 + (R12 + R13) \times (R14 + R15)) \times 20 \times R1} = 0.25 (A)$$

### (5) Soft-start time

Constant-voltage mode soft-start time  
 $t_s (ms) = 0.42 \times C11 (\mu F) = 9.2 (ms)$

Constant-current mode soft-start time  
 $t_s (ms) = \frac{R13}{(R12 + R13)} \times \frac{V_{REF}}{10 (\mu A)} \times C11 (\mu F) = 4.4 (ms)$

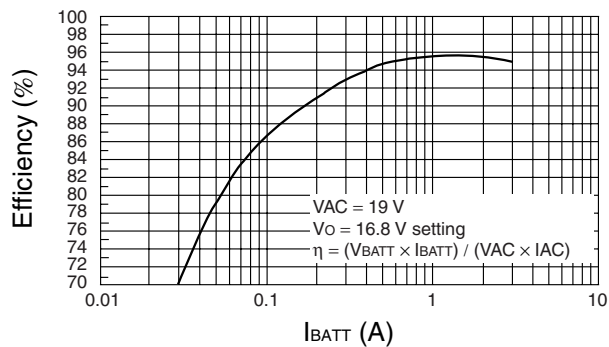
### (6) Oscillation frequency

$$f_{osc} (kHz) = \frac{14100}{R2 (k\Omega)} = 300 (kHz)$$

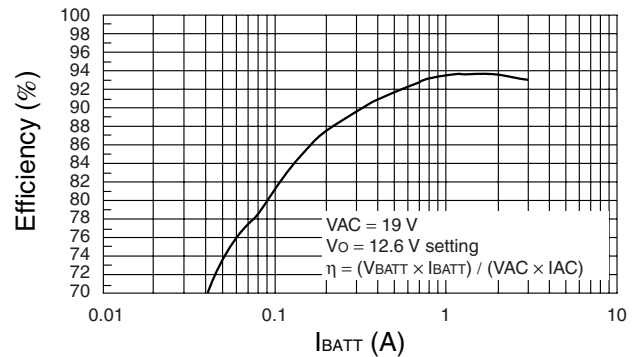
## ■ REFERENCE DATA

### 1. Conversion efficiency

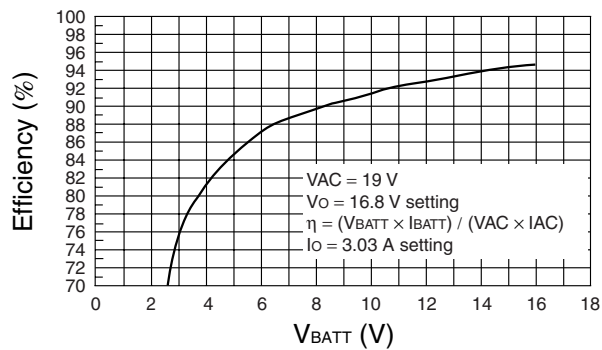
$V_O = 16.8\text{ V}$  setting constant-voltage control  
 $I_{BATT}$  vs. Efficiency (Constant Voltage mode)



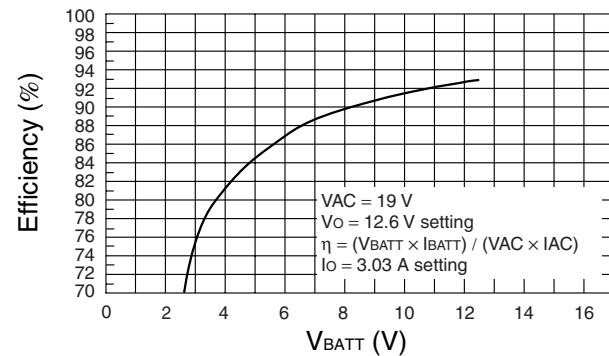
$V_O = 12.6\text{ V}$  setting constant-voltage control  
 $I_{BATT}$  vs. Efficiency (Constant Voltage mode)



$V_O = 16.8\text{ V}$  setting constant-current control  
 $V_{BATT}$  vs. Efficiency (Constant Current mode)

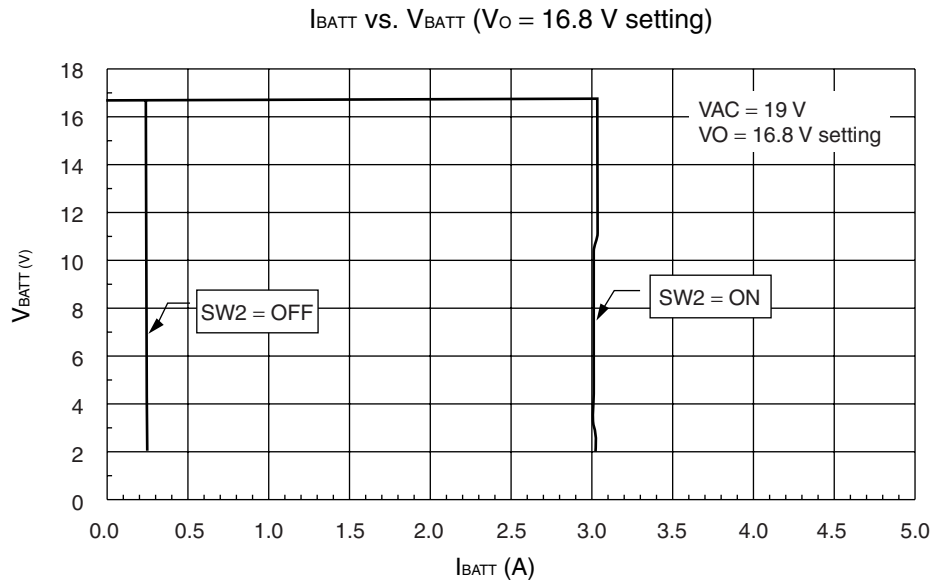


$V_O = 12.6\text{ V}$  setting constant-current control  
 $V_{BATT}$  vs. Efficiency (Constant Current mode)

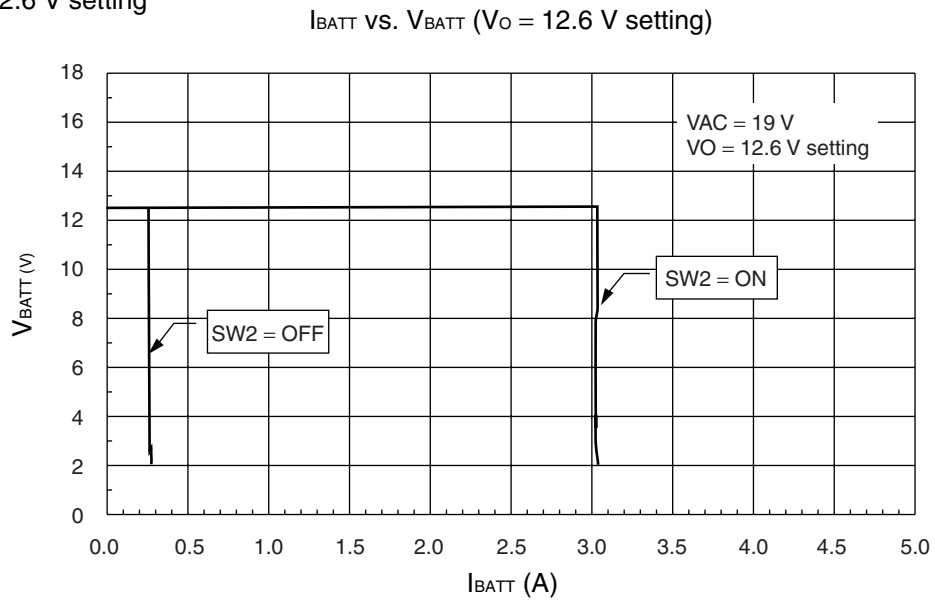


## 2. Dropping characteristic

$V_O = 16.8 \text{ V}$  setting

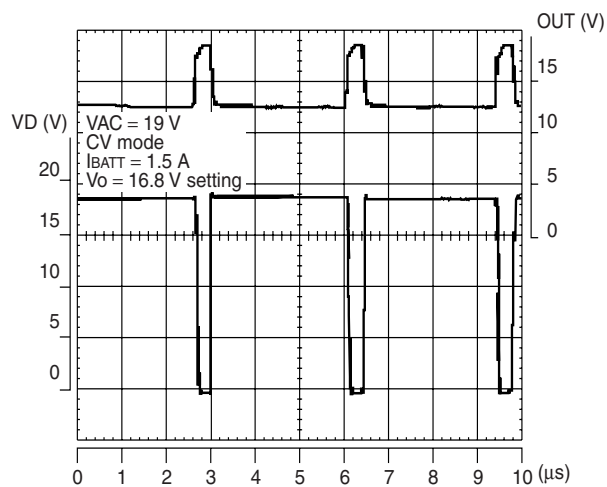


$V_O = 12.6 \text{ V}$  setting

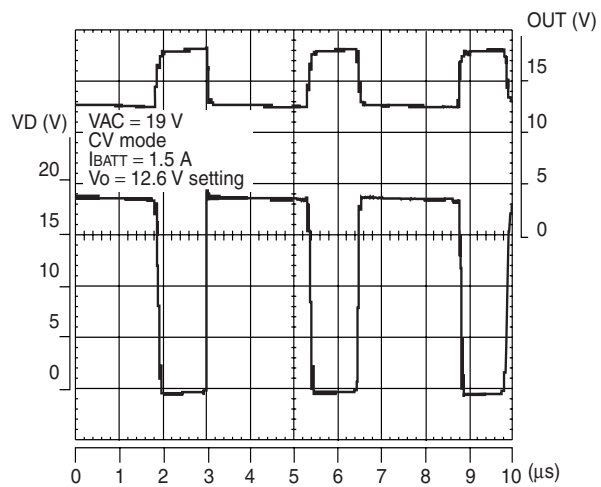


## 3. Switching waveform

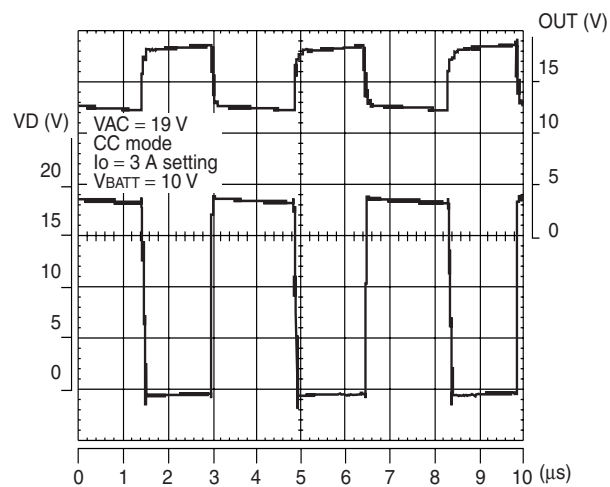
$V_o = 16.8\text{ V}$  setting constant-voltage control



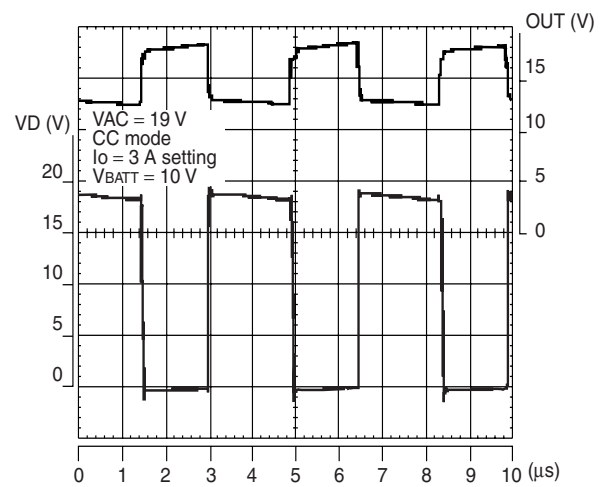
$V_o = 12.6\text{ V}$  setting constant-voltage control



$V_o = 16.8\text{ V}$  setting constant-current control



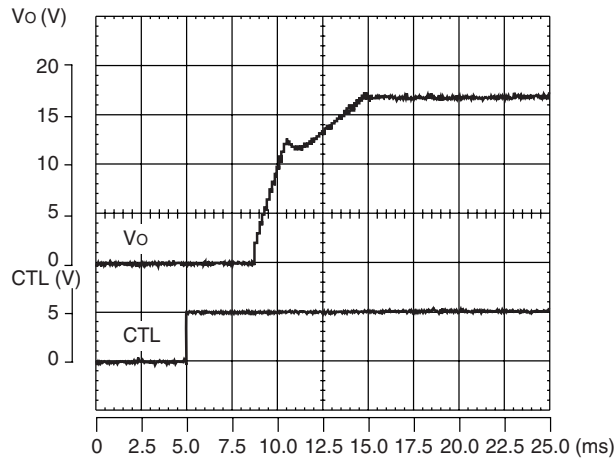
$V_o = 12.6\text{ V}$  setting constant-current control



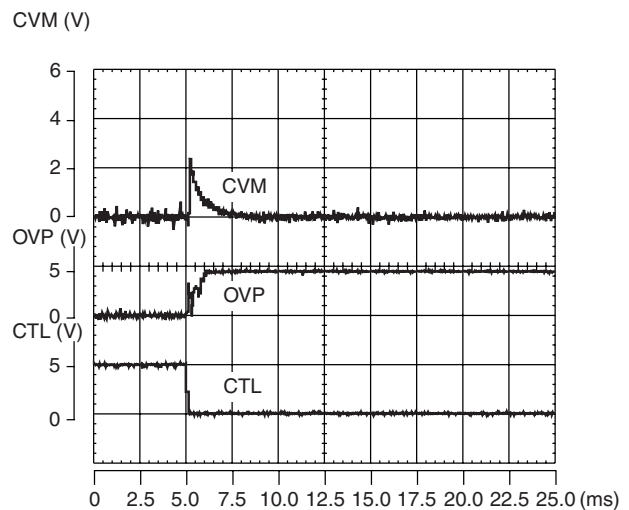
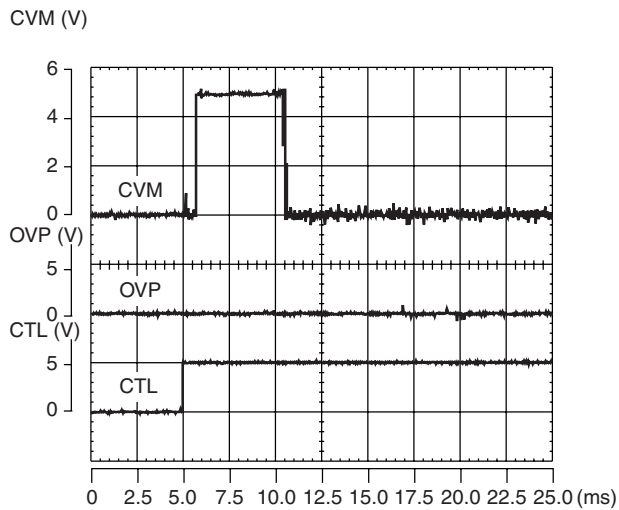
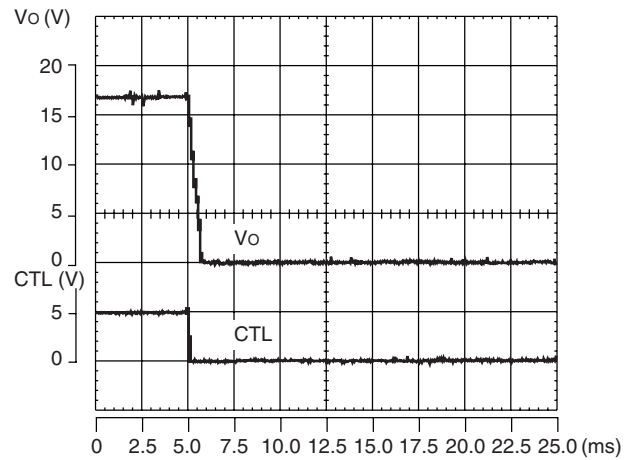
## 4. Soft-start/discharge operation waveform

$V_o = 16.8 \text{ V}$  setting  $BATT = 10 \Omega$

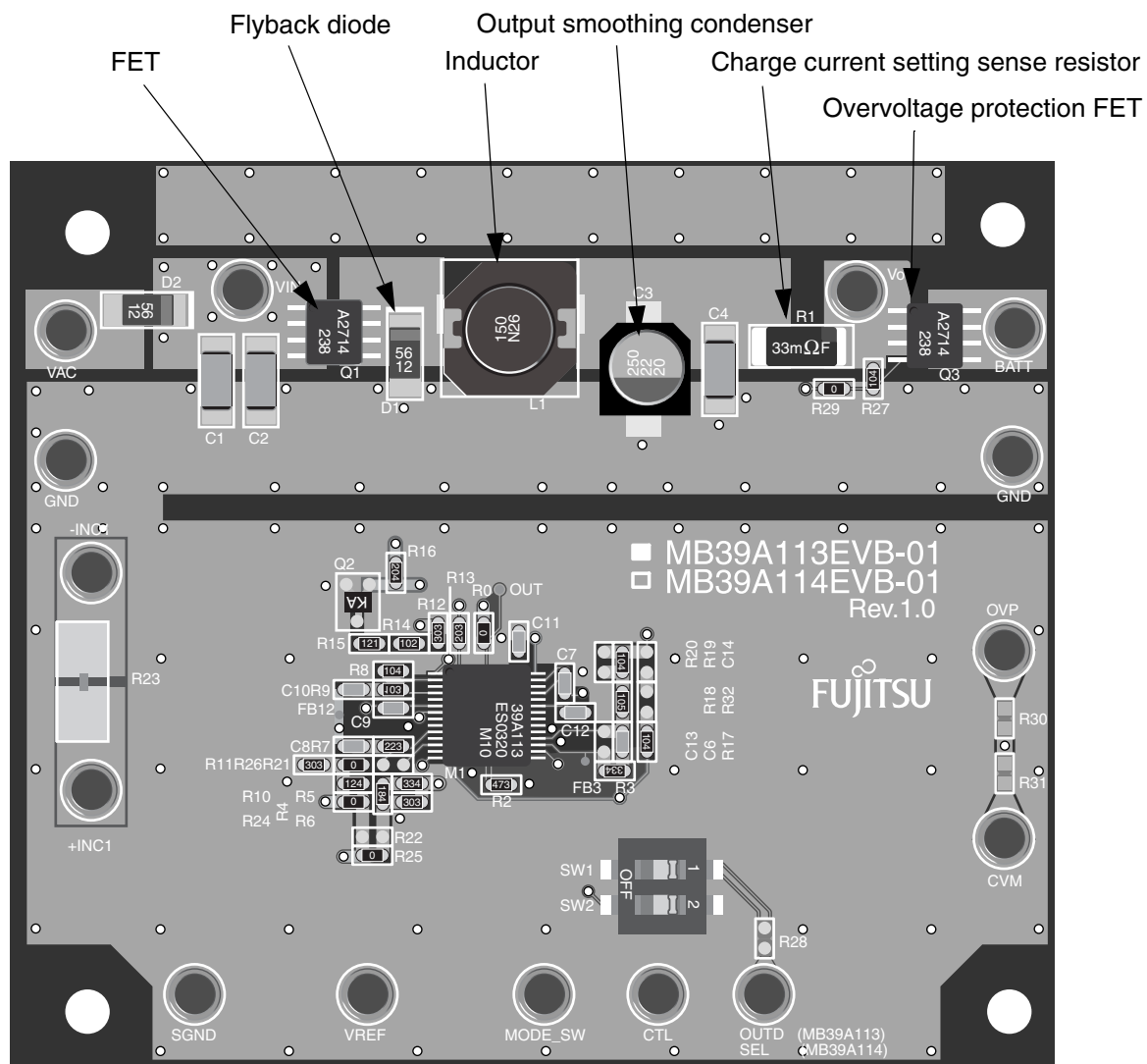
Soft-start operation waveform



Discharge operation waveform



## ■ COMPONENT SELECTION METHODS



- 16.8 V output

$$V_{IN} = 25 \text{ V (Max)} , V_O = 16.8 \text{ V}, I_O = 3 \text{ A}, f_{OSC} = 300 \text{ kHz}$$

## 1. P-ch MOS FET (μPA2714 (NEC product) )

$$V_{DS} = -30 \text{ V}, V_{GS} = \pm 20 \text{ V}, I_D = 7 \text{ A}, R_{DS(ON)} = 16 \text{ m}\Omega \text{ (Typ)} , Q_g = 31 \text{ nC (Typ)}$$

### Drain current : peak value

The peak drain current of this FET must be within its rated current.

If the FET's peak drain current is  $I_D$ , it is obtained by the following formula.

Main

$$\begin{aligned} I_D &\geq I_O + \frac{V_{IN} - V_O}{2L} t_{ON} \\ &\geq 3 + \frac{25 - 16.8}{2 \times 15 \times 10^{-6}} \times \frac{1}{300 \times 10^3} \times 0.672 \\ &\geq \underline{3.6 \text{ A}} \end{aligned}$$

## 2. Inductor (CDRH104R-150 : SUMIDA product)

15 μH (tolerance ± 30%) , rated current = 3.6 A

### L value at full load current condition:

Peak-to-peak value of ripple current should be set under half load current.

$$\begin{aligned} L &\geq \frac{2(V_{IN} - V_O)}{I_O} t_{ON} \\ &\geq \frac{2 \times (25 - 16.8)}{3} \times \frac{1}{300 \times 10^3} \times 0.672 \\ &\geq \underline{12.2 \mu\text{H}} \end{aligned}$$

### The load current satisfying the continuous current condition

$$\begin{aligned} I_O &\geq \frac{V_O}{2L} t_{OFF} \\ &\geq \frac{16.8}{2 \times 15 \times 10^{-6}} \times \frac{1}{300 \times 10^3} \times (1 - 0.672) \\ &\geq \underline{0.61 \text{ A}} \end{aligned}$$

### Ripple current : peak value

The peak ripple current must be within the rated current of the inductor.

If the peak ripple current is  $I_L$ , it is obtained by the following formula.

$$\begin{aligned} I_L &\geq I_O + \frac{V_{IN} - V_O}{2L} t_{ON} \\ &\geq 3 + \frac{25 - 16.8}{2 \times 15 \times 10^{-6}} \times \frac{1}{300 \times 10^3} \times 0.672 \\ &\geq \underline{3.6 \text{ A}} \end{aligned}$$

### Ripple current : peak-to-peak value

If the peak-to-peak ripple current is  $\Delta I_L$ , it is obtained by the following formula.

$$\begin{aligned} \Delta I_L &= \frac{V_{IN} - V_O}{L} t_{ON} \\ &= \frac{25 - 16.8}{15 \times 10^{-6}} \times \frac{1}{300 \times 10^3} \times 0.672 \\ &\div \underline{1.22 \text{ A}} \end{aligned}$$



### 3. Output smoothing condenser(20SVP22M : SANYO product)

22  $\mu$ F, rated voltage = 20 V, ESR = 60 m $\Omega$ , maximum allowable ripple current = 1450 mArms

Assume the output ripple voltage as  $\Delta V_o$  (1% of output voltage) , output smoothing condenser as  $C_L$ , ripple current as  $I_{CLrms}$ , series resistance as ESR.

Series resistance

$$\begin{aligned} ESR &\leq \frac{\Delta V_o}{\Delta I_L} - \frac{1}{2 \pi f C_L} \\ &\leq \frac{0.168}{1.22} - \frac{1}{2 \pi \times 300 \times 10^3 \times 22 \times 10^{-6}} \\ &\leq \underline{114 \text{ m}\Omega} \end{aligned}$$

Condenser

$$\begin{aligned} C_L &\geq \frac{\Delta I_L}{2 \pi f (\Delta V_o - \Delta I_L \times ESR)} \\ &\geq \frac{1.22}{2 \pi \times 300 \times 10^3 \times (0.168 - 1.22 \times 0.06)} \\ &\geq \underline{6.8 \mu F} \end{aligned}$$

Ripple current

$$\begin{aligned} I_{CLrms} &\geq \frac{(V_{IN} - V_o) t_{ON}}{2 \sqrt{3} L} \\ &\geq \frac{(25 - 16.8) \times 0.672}{2 \sqrt{3} \times 15 \times 10^{-6} \times 300 \times 10^3} \\ &\geq \underline{707 \text{ mArms}} \end{aligned}$$

### 4. Flyback diode (RB053L-30 : ROHM product)

$V_R$  (DC reverse voltage) = 30 V, mean output current = 3.0 A, peak surge current = 70 A

$V_R$  = value enough to satisfy the input voltage  $\rightarrow$  30 V

With the diode conduction time assumed as  $t_D$  (Max) , the diode mean current  $I_{Di}$  is obtained by the following formula.

$$I_{Di} \geq I_o \times \left(1 - \frac{V_o}{V_{IN}}\right) = 3 \times (1 - 0.672) \div \underline{984 \text{ mA}}$$

With the diode conduction time assumed as  $t_D$  (Max) , the diode peak surge current  $I_{Dip}$  is obtained by the following formula.

$$I_{Dip} \geq \left(I_o + \frac{V_o}{2L} t_{OFF}\right) \div \underline{3.6 \text{ A}}$$

### 5. Charge current setting sense resistor (SL1TTE33LOF : KOA product) 33 m $\Omega$

Where the +INE2 terminal voltage is 2 V and the charge current is 3 A,  $R_1$  is obtained by the following formula.

$$\begin{aligned} R_1 &= \frac{+INE2}{20 \times I_1} \\ &= \frac{2}{20 \times 3} \\ &\div \underline{33 \text{ m}\Omega} \end{aligned}$$

- 12.6 V output

$$V_{IN} = 22 \text{ V (Max)} , V_o = 12.6 \text{ V}, I_o = 3 \text{ A}, f_{OSC} = 300 \text{ kHz}$$

## 1. P-ch MOS FET ( $\mu$ PA2714 (NEC product) )

$$V_{DS} = -30 \text{ V}, V_{GS} = \pm 20 \text{ V}, I_D = 7 \text{ A}, R_{DS(on)} = 16 \text{ m}\Omega \text{ (Typ)} , Q_g = 31 \text{ nC (Typ)}$$

### Drain current : peak value

The peak drain current of this FET must be within its rated current.

If the FET's peak drain current is  $I_D$ , it is obtained by the following formula.

Main

$$\begin{aligned} I_D &\geq I_o + \frac{V_{IN} - V_o}{2L} t_{ON} \\ &\geq 3 + \frac{25 - 12.6}{2 \times 15 \times 10^{-6}} \times \frac{1}{300 \times 10^3} \times 0.572 \\ &\geq \underline{3.6 \text{ A}} \end{aligned}$$

## 2. Inductor (CDRH104R-150 : SUMIDA product)

15  $\mu$ H (tolerance  $\pm 30\%$ ) , rated current = 3.6 A

### L value at full load current condition :

Peak-to-peak value of ripple current should be set under half load current.

$$\begin{aligned} L &\geq \frac{2(V_{IN} - V_o)}{I_o} t_{ON} \\ &\geq \frac{2 \times (22 - 12.6)}{3} \times \frac{1}{300 \times 10^3} \times 0.572 \\ &\geq \underline{12.0 \mu\text{H}} \end{aligned}$$

### The load current satisfying the continuous current condition

$$\begin{aligned} I_o &\geq \frac{V_o}{2L} t_{OFF} \\ &\geq \frac{12.6}{2 \times 15 \times 10^{-6}} \times \frac{1}{300 \times 10^3} \times (1 - 0.572) \\ &\geq \underline{0.60 \text{ A}} \end{aligned}$$

### Ripple current : peak value

The peak ripple current must be within the rated current of the inductor.

If the peak ripple current is  $I_L$ , it is obtained by the following formula.

$$\begin{aligned} I_L &\geq I_o + \frac{V_{IN} - V_o}{2L} t_{ON} \\ &\geq 3 + \frac{22 - 12.6}{2 \times 15 \times 10^{-6}} \times \frac{1}{300 \times 10^3} \times 0.572 \\ &\geq \underline{3.6 \text{ A}} \end{aligned}$$

### Ripple current : peak-to-peak value

If the peak-to-peak ripple current is  $\Delta I_L$ , it is obtained by the following formula.

$$\begin{aligned} \Delta I_L &= \frac{V_{IN} - V_o}{L} t_{ON} \\ &= \frac{22 - 12.6}{15 \times 10^{-6}} \times \frac{1}{300 \times 10^3} \times 0.572 \\ &\div \underline{1.2 \text{ A}} \end{aligned}$$

### 3. Output smoothing condenser (20SVP22M : SANYO product)

22  $\mu$ F, rated voltage = 20 V, ESR = 60 m $\Omega$ , maximum allowable ripple current = 1450 mArms

Assume the output ripple voltage as  $\Delta V_o$  (1% of output voltage) , output smoothing condenser as  $C_L$ , ripple current as  $I_{CLrms}$ , series resistance as ESR.

Series resistance

$$\begin{aligned} ESR &\leq \frac{\Delta V_o}{\Delta I_L} - \frac{1}{2 \pi f C_L} \\ &\leq \frac{0.126}{1.2} - \frac{1}{2 \pi \times 300 \times 10^3 \times 22 \times 10^{-6}} \\ &\leq \underline{80 \text{ m}\Omega} \end{aligned}$$

Condenser

$$\begin{aligned} C_L &\geq \frac{\Delta I_L}{2 \pi f (\Delta V_o - \Delta I_L \times ESR)} \\ &\geq \frac{1.2}{2 \pi \times 300 \times 10^3 \times (0.126 - 1.2 \times 0.06)} \\ &\geq \underline{11.8 \mu F} \end{aligned}$$

Ripple current

$$\begin{aligned} I_{CLrms} &\geq \frac{(V_{IN} - V_o) t_{ON}}{2 \sqrt{3} L} \\ &\geq \frac{(22 - 12.6) \times 0.572}{2 \sqrt{3} \times 15 \times 10^{-6} \times 300 \times 10^3} \\ &\geq \underline{690 \text{ mArms}} \end{aligned}$$

### 4. Flyback diode (RB053L-30 : ROHM product)

$V_R$  (DC reverse voltage) = 30 V, mean output current = 3.0 A, peak surge current = 70 A

$V_R$  : value enough to satisfy the input voltage  $\rightarrow$  30 V

With the diode conduction time assumed as  $t_D$  (Max) , the diode mean current  $I_{Di}$  is obtained by the following formula.

$$I_{Di} \geq I_o \times \left(1 - \frac{V_o}{V_{IN}}\right) = 3 \times (1 - 0.572) \div \underline{1284 \text{ mA}}$$

With the diode conduction time assumed as  $t_D$  (Max) , the diode peak surge current  $I_{Dip}$  is obtained by the following formula.

$$I_{Dip} \geq \left(I_o + \frac{V_o}{2L} t_{OFF}\right) \div \underline{3.6 \text{ A}}$$

### 5. Charge current setting sense resistor (SL1TTE33LOF : KOA product) 33 m $\Omega$

Where the +INE2 terminal voltage is 2 V and the charge current is 3 A,  $R_1$  is obtained by the following formula.

$$\begin{aligned} R_1 &= \frac{+INE2}{20 \times I_1} \\ &= \frac{2}{20 \times 3} \\ &\div \underline{33 \text{ m}\Omega} \end{aligned}$$

## ■ ORDERING INFORMATION

EV board part No.	EVboard version No.	Remarks
MB39A113EVB-01	MB39A113EVB-01 Rev 1.0	

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