ELM650DA CC/CV Mode 36V step down 2A DC/DC converter

■General description

ELM650DA is a step down switching regulator, which has a built-in 40V P-channel power MOSFET for delivering output current. ELM650A is designed to allow for operating a wide supply voltage range from 8V to 36V and capable of delivering 2A output current.

ELM650DA features programmable CV/CC mode control functions, the CV mode (Constant Voltage) function to provide a regulated voltage output and the CC mode (Constant Current) function provide a current limitation function, it is suitable for the DC/DC switching power applications when requested the current limitation function.

■Features

- CC/CV mode control
- Soft start function for start-up
- Output over-voltage protection
- Over temperature protection
- Fold back short-circuit protection
- High efficiency operation
- Input voltage range : 8V to 36V
- Input voltage surge : 40V
- Fixed operating frequency : 100kHz
- Voltage reference accuracy : ±1%
- Current limit accuracy : ±4%
- Package : SOP-8

■Application

- Car charger
- Portable charger applications
- DC/DC converters with current limited
- General purpose CV/CC power supply

■Maximum absolute ratings

Parameter	Symbol	Limit	Unit
VCC to GND	Vcc	-0.3 to +40.0	V
LX to VCC	LX	+0.3 to -40.0	V
VSEN to GND	Vsen	-0.3 to +7.0	V
ISEN+ to GND	ISEN+	-0.3 to +7.0	V
ISEN- to GND	ISEN-	-0.3 to +7.0	V
OVP to GND	OVP	-0.3 to +7.0	V
COMP to GND	COMP	-0.3 to +7.0	V
Output current	Icc	3	A
Power dissipation at Ta <60 °C	Pd	0.75	W
Operationg temperature	Top	-40 to +85	°C
Storage temperature range	Tstg	-60 to 150	°C

Caution:Permanent damage to the device may occur when ratings above maximum absolute ones are used.

■Selection guide

ELM650DA-N

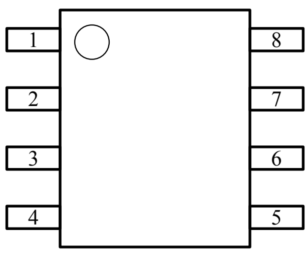
Symbol		
a	Package	D: SOP-8
b	Product version	A
c	Taping direction	N: Refer to PKG file

∗ Taping direction is one way.

ELM650DA - N
↑↑ ↑
a b c

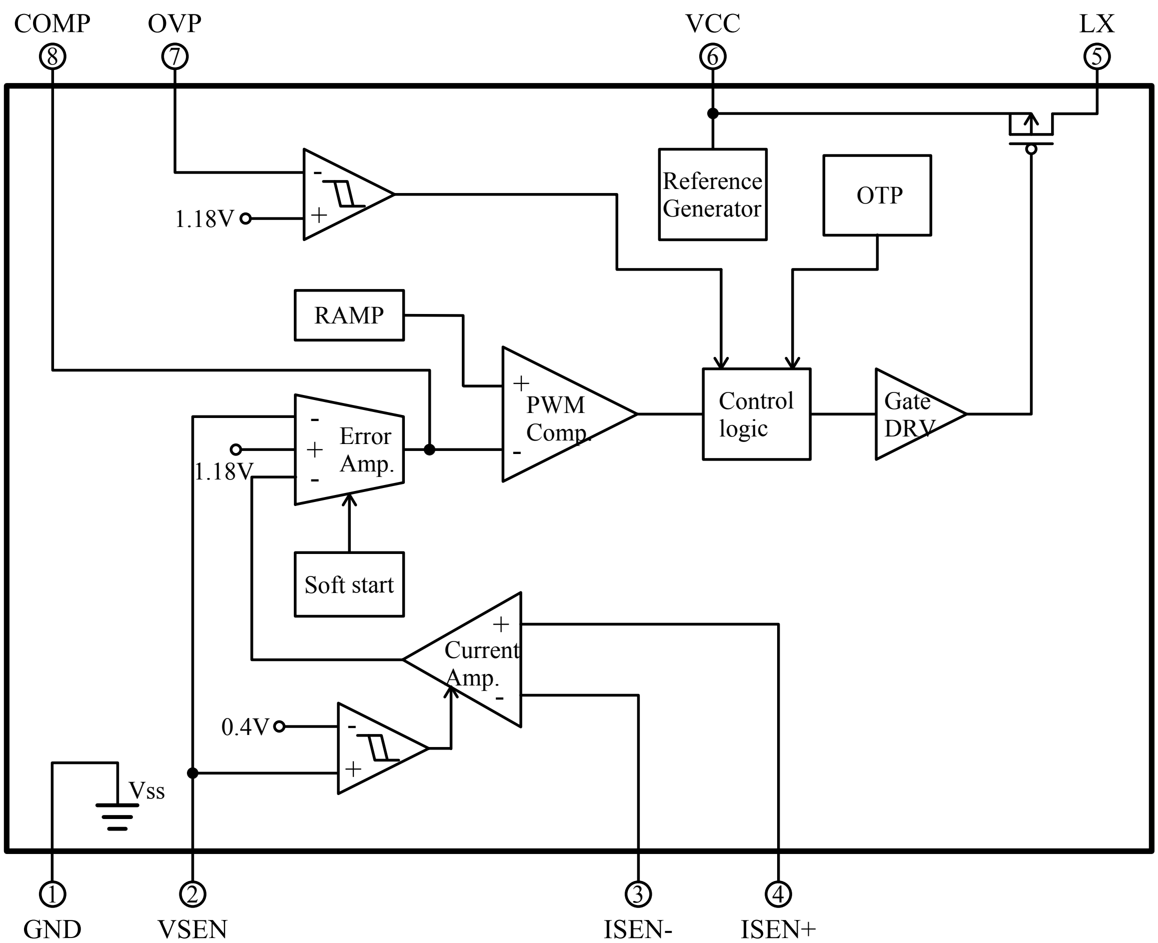
■Pin configuration

SOP-8(TOP VIEW)

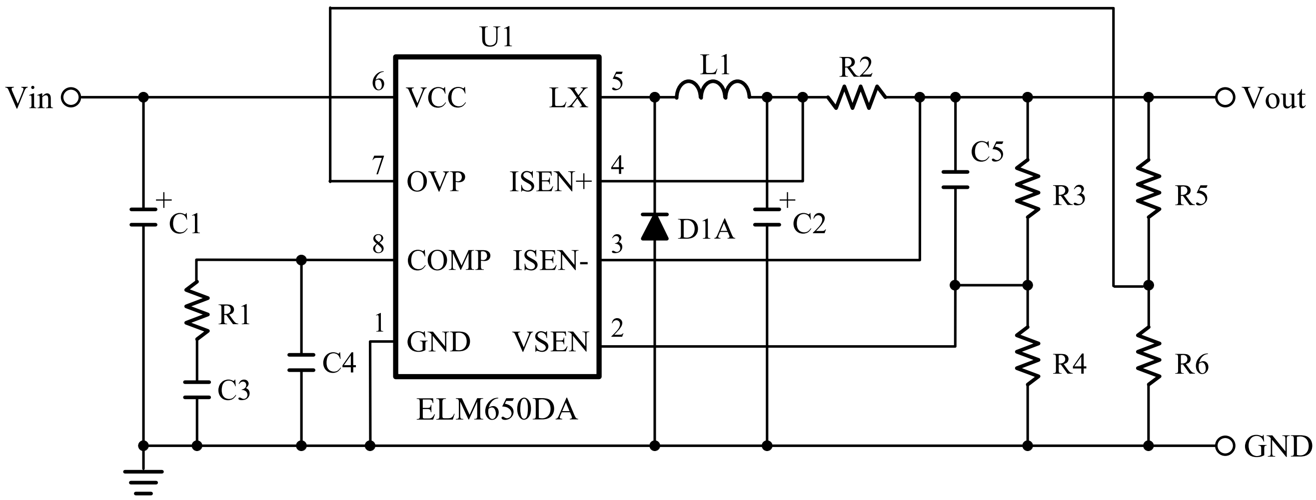


Pin No.	Pin name	Pin description
1	GND	GND
2	VSEN	The voltage sense input
3	ISEN-	The current sense negative input
4	ISEN+	The current sense positive input
5	LX	Regulator output
6	VCC	The input supply voltage
7	OVP	The over-voltage sense input
8	COMP	The E/A output pin for frequency compensation

■Block diagram



■Standard circuit



■Functional descriptions

1. CV/CC mode control

ELM650DA provides CV/CC function. The CV (constant voltage) function is implemented to deliver a regulated output voltage for the output terminal, and the CC (constant current) function is to limit output current to be a limited value to prevent the device damaged due to output short circuit or over current condition.

2. Soft start function

ELM650DA is composed of built-in internal soft start function to prevent a large surge current happening when during start-up period due to the surge current charging output filter capacitors.

3. Output over-voltage protection

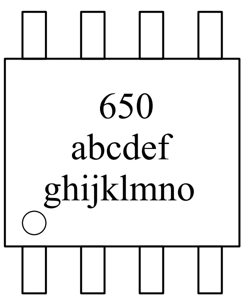
ELM650DA provides output over-voltage protection function. When output over-voltage happens, ELM650DA shuts down and recovers to normal state automatically if output over-voltage is released.

4. Output short-circuit protection

ELM650DA provides output short-circuit protection function. When output short-circuit happens, ELM650DA shuts down and recovers to normal state automatically if output short-circuit is released.

■Marking

SOP-8



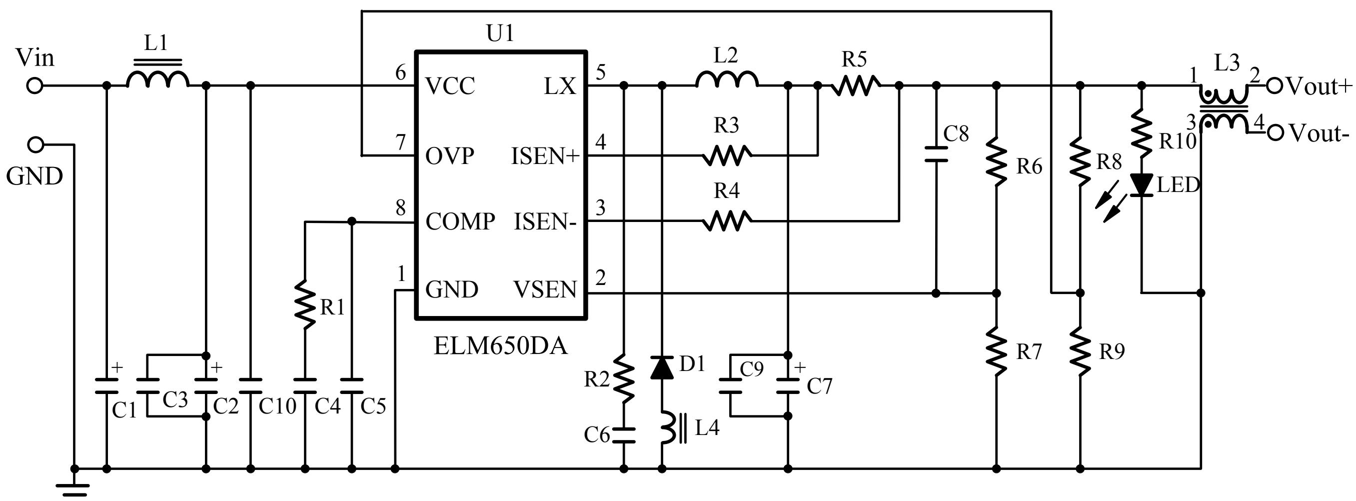
Mark	Content
650	Product No.code
a to o	Assembly lot No.

■Electrical characteristics

Vin=12V, Iout=1.0A, Top=25°C, unless otherwise specified

Parameter	Symbol	Condition	Min.	Typ.	Max.	Unit
Input voltage section						
Input voltage	Vin		8		36	V
Input no load current	Ino-load	Iout=0A			10	mA
Oscillator section						
Operating frequency	Fosc		90		110	kHz
Duty cycle range	Duty				95	%
Error amplifier section						
Reference voltage of the voltage error amplifier	Vvsen		1.168	1.180	1.192	V
Reference voltage of the current error amplifier	Visen		107.5	112.0	116.5	mV
Tran conductance of error amplifier	Gmerr			150		μA/V
Output over voltage protection section						
Reference voltage of the over voltage comparator	Vovp		1.145	1.180	1.215	V
Output short circuit protection section						
Reference voltage of the short circuit fold back comparator	Vscp			0.4		V
MOSFET section						
Drain-source breakdown voltage	V(br)dss	Vgs=0V, Iout=250μA	-40			V
Drain-source on-state resistance	Rds (on)	Vin=24V, Iout=1A			200	mΩ

■Application circuits



BOM list for application circuits

Device	Description	Value	Q'ty
C1	Input ECAP, 47μF/35V, 6.3*7mm	47μF/35V	1
C2	Input ECAP, 100μF/35V, 6.3*7mm	100μF/35V	1
C3	MLCC, 0603, X7R	104	1
C4	MLCC, 0603, X7R	473	1
C5	MLCC, 0603, NPO	47pF	1
C6	MLCC, 0805, X7R	102	1
C7	Output ECAP, 220μF/6.3V, 6.3φ*7mm	220μF/6.3V	1
C8	MLCC, 0603, X7R	NA	0
C9	MLCC, 0603, X7R	104	1
C10	MLCC, 0603, X7R	104	1
D1	Schottky diode, SMB, 40V/5A	SB54	1
L1	DR Choke, 4φ*6mm	15μH	1
L2	Power inductor, T- 5052B, L= 100μH wire=0.65	100μH	1
L3	T Core, 6*3*3, 0.5φ*2C*3Ts	22μH	1
L4	SMD bead core , 0805, 220Ω 3000mA	BEAD	1
LED	LED, GREEN	LED	1
R1	Chip R , 0603 , 5%	100K	1
R2	Chip R , 0805 , 5%	10R	1
R3	Chip R , 0603 , 5%	51R	1
R4	Chip R , 0603 , 5%	51R	1
R5	Chip R , 1206 , 1%	0.045R	1
R6	Chip R , 0603 , 1%	390K	1
R7	Chip R , 0603 , 1%	118K	1
R8	Chip R , 0603 , 5%	470R	1
R9	Chip R , 0603 , 5%	120R	1
R10	Chip R , 0603 , 5%	1K	1
U1	Buck controller, CC/CV function, Vin 8~36V, SOP-8	ELM650DA	1

■Application notes

1. Output voltage setting

Figure 1 shows the connections for setting the output voltage value. Typically, selecting the proper ratio of the two feedback resistors Rvsen1 and Rvsen2 by using Rvsen2 ≈ 118kΩ and determining Vsen from the following equation: Rvsen1 = Rvsen2 (Vout / 1.18V - 1)

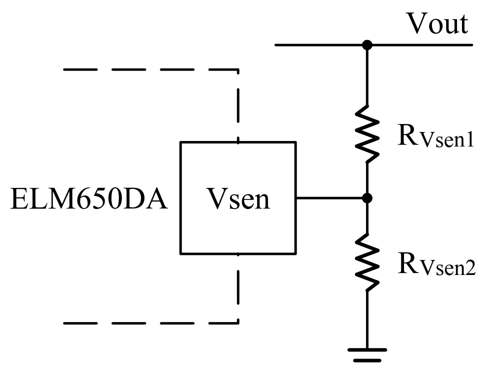


Fig-1: Output voltage setting

2. CC current setting

The constant current value of ELM650DA is set by a Rs resistor which is connected between Isen+ and Isen- pin. The output current of CC mode and Rs resistor are set by the following equation: Rs = 0.112 / ICC

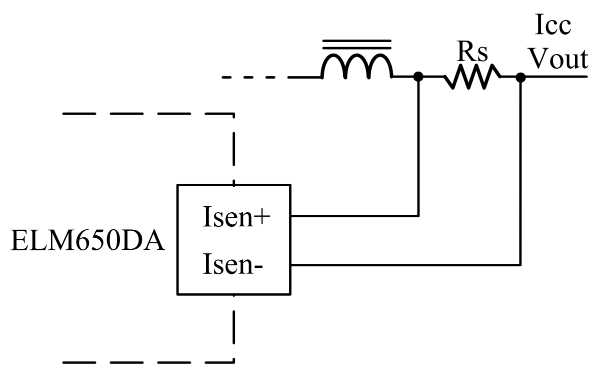


Fig-2 : Constant current mode setting

When output voltage is set over 6V, the voltage of the V(Isen+), V(Isen-) should be set under 6V by the following equation: $Visen\pm = (1/ks)\ Vout \leq 6V$, $ks = (Rs_1 + Rs_2) / Rs_2 = (Rs_3 + Rs_4) / Rs_4$

Also $ks = (Rs_1 + Rs_2) / Rs_2$, and $Rs = ks \times 0.112/Icc$ at this time.

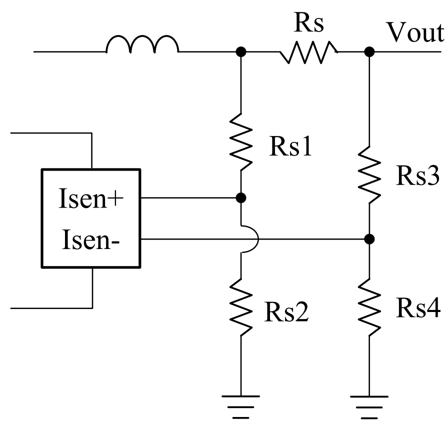


Fig-3 : Constant current mode setting (At Vout ≥ 6V)

3. Input capacitor selection

The bulk input capacitor selection is based on the voltage rating, the RMS current carrying capability, and the required input voltage ripple.

The capacitor voltage rating is recommended with 1.5 times for the maximum input voltage as conservative guideline, depending on the application condition.

The capacitor RMS current rating is considered for stress condition, and the trapezoid current waveform as the simplified formula is described:

$$Irms = Iout(max) * \sqrt{(Vout / Vin)}$$

Vin = input voltage ; Vout = output voltage ; Iout(max) = maximum output current.

The capacitor values with respect to the required input voltage ripple if neglect ESR is described:

$$C = Iout(max) * \Delta T / \Delta V$$

ΔT = capacitor supplied charging time ; ΔV = allowable input voltage ripple.

4. Output rectifier selection

The output rectifier is selected by the consideration of the reverse voltage rating, the current rating' and the reverse recovery time and forward voltage drop for the power loss.

The reverse voltage rating should be at least 1.25 times the maximum input voltage for the consideration of voltage arc.

The current rating should be larger than the maximum inductor current.

The diode conduction loss is due to the forward conduction and is described:

$$Pcond = Iout(max) * Vf * (1 - Vout / Vin)$$

Vin = input voltage ; Vout = output voltage ; Iout(max) = maximum output current ;
Vf = diode forward voltage.

The diode reverse recovery loss is due to the reverse recovery from the forward conduction to the reverse blocking state, and is described:

$$Prr = Qrr * Vin / Tsw$$

Vin = input voltage ; Qrr = diode reverse recovery charge ; Tsw = switching period.

5. Output inductor selection

The output inductor is selected for the trade-offs between the output inductor current ripple, dc resistance for power loss, load transient response time, and the physical size.

The output inductor current ripple determines the output voltage ripple requirement, and the inductor's dc resistance concerns the power loss. The larger the inductor value, the smaller the inductor ripple current, but the slower the transient response time, the larger the inductor dc resistance, and hence the larger the power loss.

The inductance value is described:

$$L = Vout * (1 - Vout / Vin) * Tsw / \Delta Ll$$

Vin = input voltage ; Vout = output voltage ;
Tsw = switching period ; ΔLl = inductor ripple current.

6. Output capacitor selection

The output capacitor is selected for the trade-offs between output ripple voltage requirement, the output voltage rating, the RMS current rating, the ESR and ESL for the load transient, and the physical size.

The capacitor voltage rating is recommended with 1.5 times for the maximum output voltage as conservative guideline.

The capacitor RMS current rating is considered for stress condition' and the trapezoid current waveform as the simplified formula is described:

$$Irms = \Delta IL / 2\sqrt{3}$$; ΔIL = inductor ripple current.

The output ripple voltage with respect to the capacitor ESR is described:

$$\Delta V = \Delta I * (ESR + Tsw / (8 * C))$$

ΔI = capacitor ripple current' which is equivalent to the inductor ripple current ;
ESR = capacitor equivalent series resistance ; Tsw = switching period.

7. PC board layout consideration

Good PC Board layout is very important in switching converter design. If designed improperly, the PC Board could radiate excessive noise and contribute to the converter instability.

Follows below PC board layout guidelines could get better performance:

1) Path A :

The Vout- is returned to input bulk capacitor C2, by passing through output capacitor C7.

2) Path B :

The output rectifier D1, together with Snubber R2 and C2, are shunt to common ground and returned to input bulk capacitor C2.

3) Path C and D :

The decoupling capacitor C11, the compensation network R1, C4, C5, the voltage feedback network R6, R7, C8, and the overvoltage sensing network R8, R9, are connected to IC ground, and returned to input bulk capacitor C2 and output capacitor C7.

4) Path E :

Input capacitor C2 is returned to input ground, after all ground networks are following the above paths designed.

Fig-4 : PC board layout guidelines

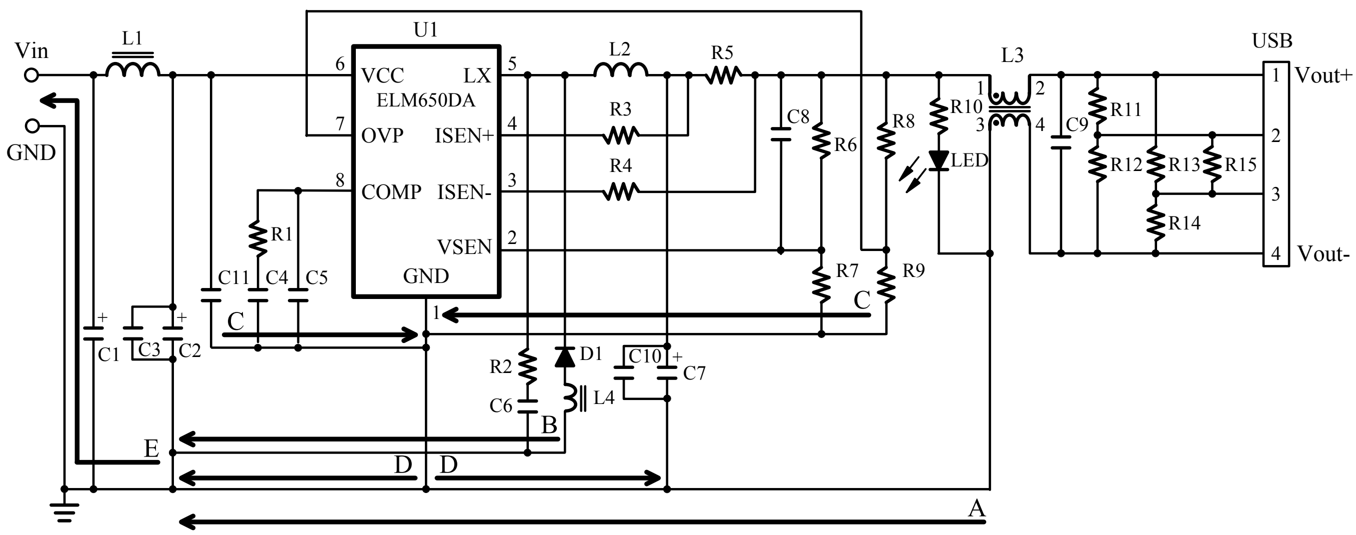
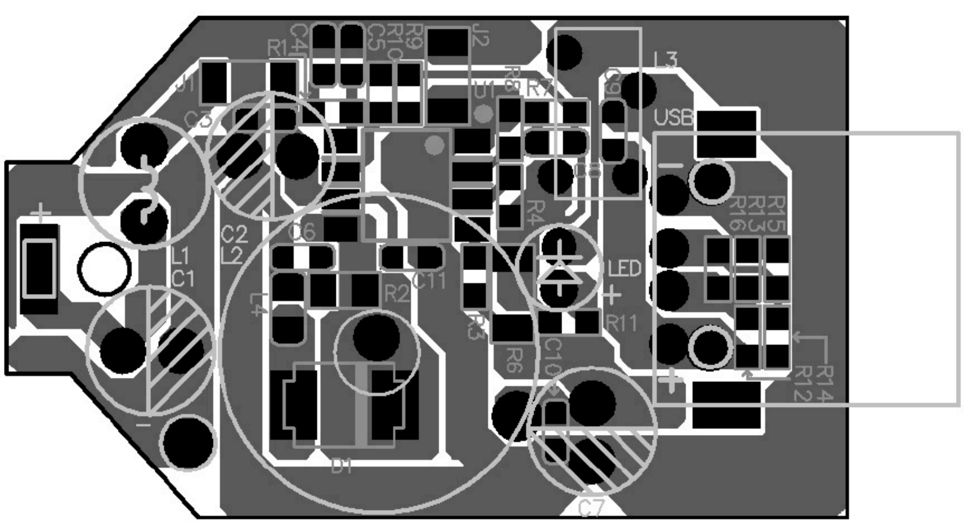
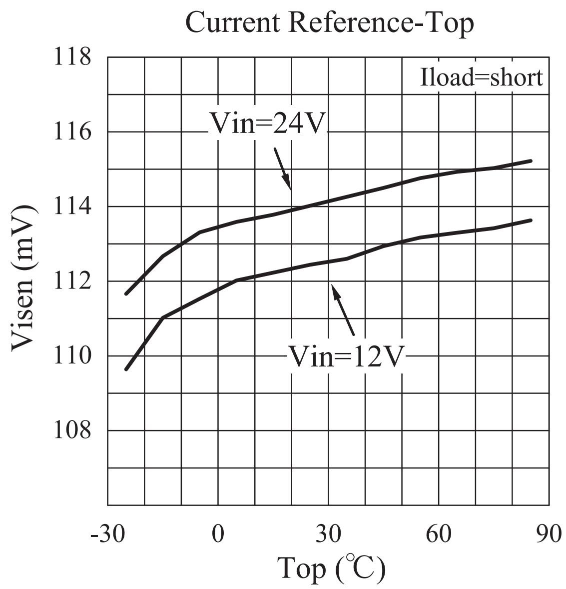


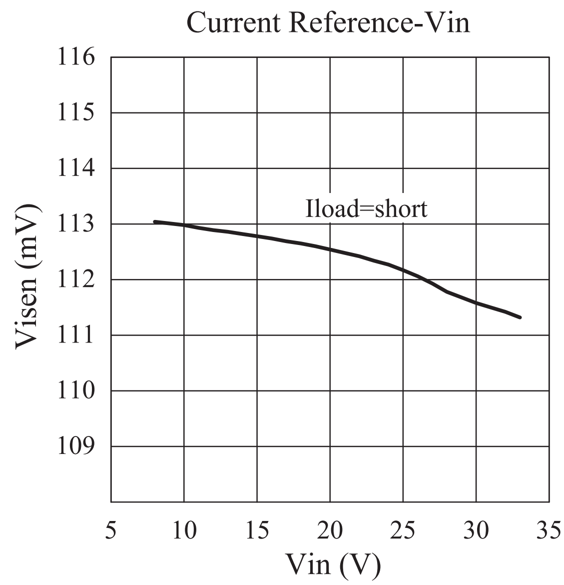
Fig-5 : The PCB layout of car charger with ELM650DA controller

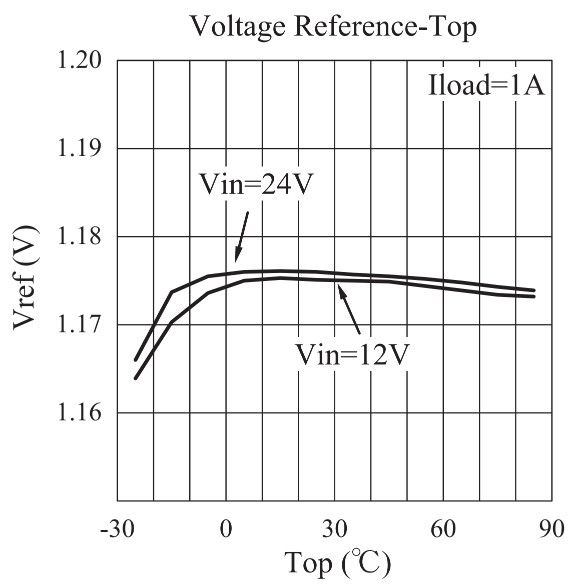


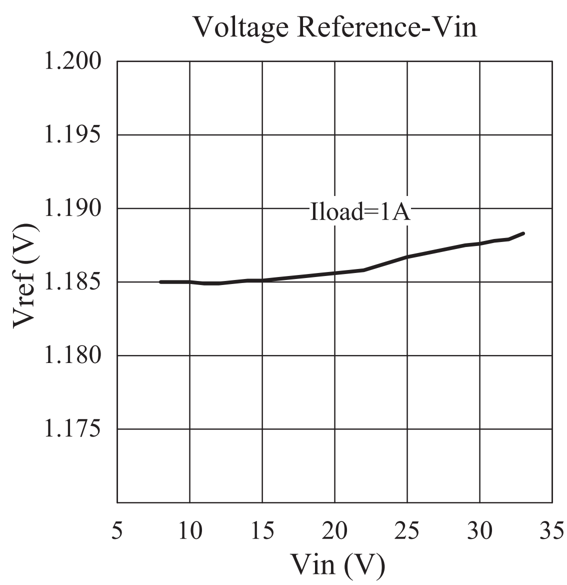
■Typical characteristics

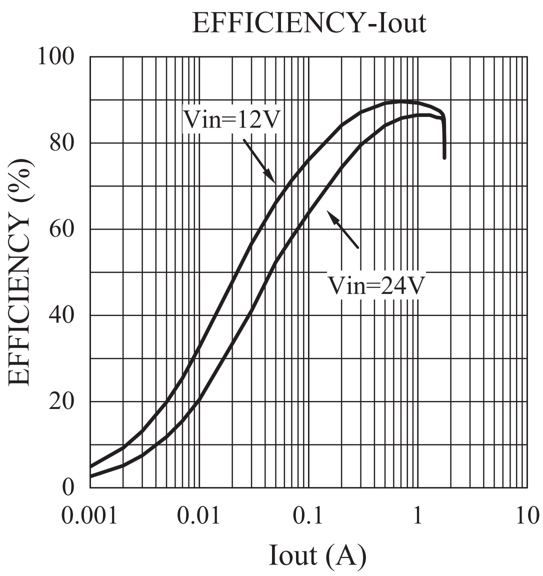
- Vout=5V : Cin=47μF, Cout=220μF, L=100μH, R1=100kΩ, R2=0.0625Ω, R3=390kΩ
  R4=118kΩ, R5=470Ω, R6=120Ω, C3=0.047μF, C4=47pF, Top=25°C

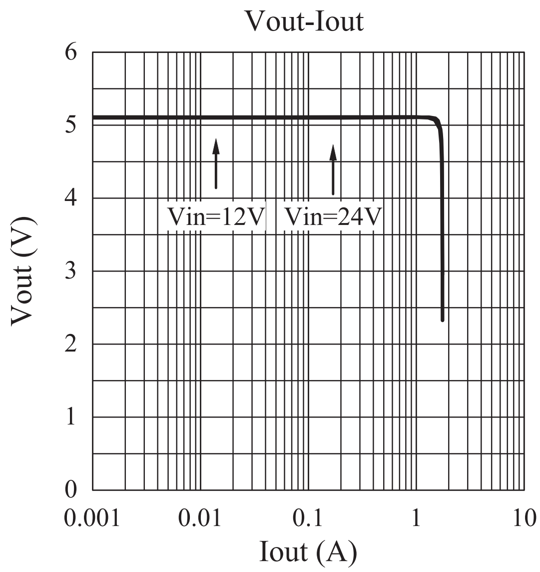


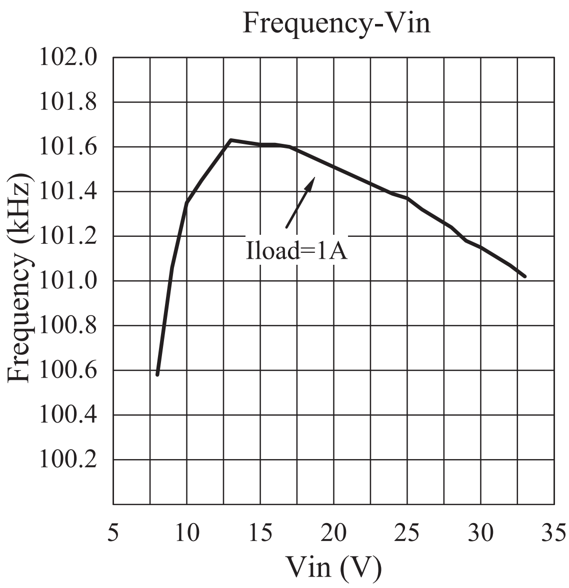







EFFICIENCY-Iout
100
80
60
40
20
0
EFFICIENCY (%)
Vin=12V
Vin=24V
0.001
0.01
0.1
1
10
Iout (A)


Vout-Iout
6
5
4
3
2
1
0
Vout (V)
Vin=12V
Vin=24V
0.001
0.01
0.1
1
10
Iout (A)


Frequency-Vin
102.0
101.8
101.6
101.4
101.2
101.0
100.8
100.6
100.4
100.2
Frequency (kHz)
Iload=1A
5
10
15
20
25
30
35
Vin (V)