Battery Powered, High Efficiency Synchronous DC/DC Boost Converter

General Description

EMH7601 designed with high efficiency step up DC/DC converter for portable devices applications. It features with extreme low 26μA quiescent current with no load which is the best fit for extending battery life during the standby mode.

The start-up voltage is 0.93V typically with operating voltage down to 0.7V. With Synchronous structure, it does not need any external Schottky diode. The peak current is limited to 1A for quick turn on.

This product can provide 500mA load current and still maintained at least 70% efficiency and above 90% efficiency when at 100mA load current.

The EMH7601 is available in SOT-23-5 & TDFN-6 package, With RoHS compliance.

Features

- Single or dual battery operation
- Achieve 93% efficiency
- Output Current up to 500mA
- Reference voltage 1.195V
- Typical Iq 26μA with no load
- No Schottky diode needed
- Shutdown current < 1μA
- Excellent Line and Load Transient Response

Applications

- Blue-Tooth devices
- Cellular and Smart Phones
- Personal multi-media Player (PMP)
- Wireless networking
- Hand-Held Devices with 1 to 3-Cell of NiMH/NiCd Batteries
- Digital Still Cameras
- Portable applications

Typical Application

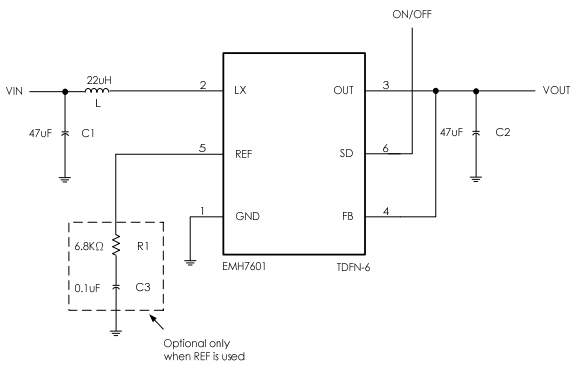


Fig. 1

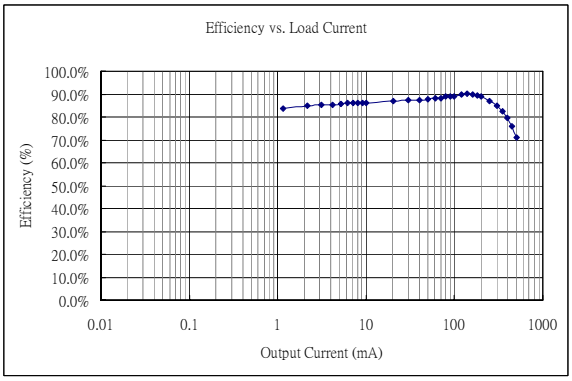
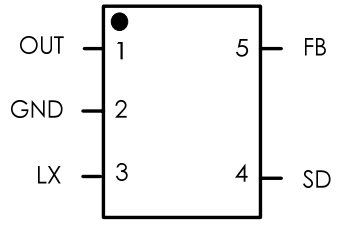


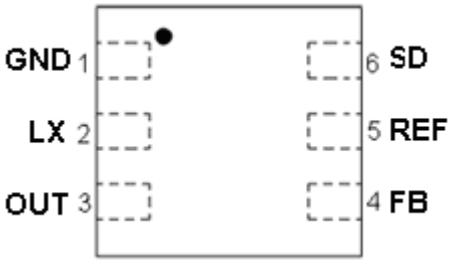
Fig. 2

Package configuration

SOT-23-5



TDFN-6



Order information

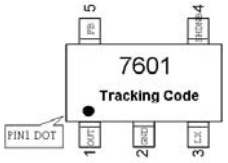
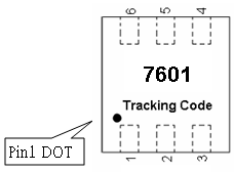
EMH7601-XXVF05GRR/NRR

XX Adjustable output voltage
VF05 SOT-23-5 Package
GRR RoHS (Pb Free)
Rating: -40 to 85°C
Package in Tape & Reel
NRR RoHS & Halogen free (By Request)
Rating: -40 to 85°C
Package in Tape & Reel

EMH7601-XXFE06NRR

XX Adjustable output voltage
FE06 TDFN-6 Package
NRR RoHS & Halogen free
Rating: -40 to 85°C
Package in Tape & Reel

Order, Mark & Packing Information

Package	Product ID	Vout	Marking	Packing
SOT-23-5	EMH7601-00VF05GRR	00 (adjustable)		3K units Tape & Reel
TDFN-6	EMH7601-00FE06NRR	00 (adjustable)		3K units Tape & Reel

Pin Functions

Pin Name	TDFN-6 Pin #	SOT-23-5 Pin #	Function
FB	**4**	**5**	Connecting to OUT to get +3.3V output, Connecting to GND to get +5.0V output, Using resistor network to set the output voltage from +1.8V to +5.5V.
SD	**6**	**4**	Shutdown input. "1" is enabled and "0"=shutdown
GND	**1**	**2**	Ground Pin.
LX	**2**	**3**	Switch Pin. Must be connected to Inductor.
OUT	**3**	**1**	Output Voltage Pin. This also provides bootstrap power to the IC.
REF	**5**		1.195V Output. In Case of driving load, Need R and C for stability

Absolute Maximum Ratings

Devices are subjected to failure if they stay above absolute maximum ratings.

Input Voltage	– 0.3V to 6V
SD, V_{FB} Voltages	– 0.3V to V_{IN}
LX Voltage	– 0.3V to (V_{IN} + 0.3V)
PMOS Switch Source Current (DC)	0.5A
NMOS Switch Sink Current (DC)	0.5A

ESD Susceptibility

HBM	2kV
MM	200V

Peak Switch Sink and Source Current	1.5A
Operating Temperature Range	–40°C to 85°C
Junction Temperature (Notes 1, 3)	125°C
Storage Temperature Range	– 65°C to 150°C
Lead Temperature (Soldering, 10 sec)	260°C

Thermal Resistance

SOT-23-5 θ_{JA}	250°C/W

Electrical Characteristics

V_{IN}=2.0V, V_{OUT}=3.3V, FB=V_{OUT}, T_A=25℃, unless otherwise specified

PARAMETER	TEST CONDITION	MIN	TYP	MAX	UNIT
Minimum input voltage			0.7		V
Operating Voltage		1.1		5.5	V
Start-up Voltage	RL=3K		0.93	1.00	V
Start-up Voltage Tempco			-2		mV/◦C
Output Voltage Range	Vin<Vout	1.8		5.5	
Output Voltage	FB=Vout	3.17	3.3	3.43	V
Steady State Output Current	FB=Vout	200	245		mA
	FB=GND	120	190		mA
Reference Voltage		1.16	1.195	1.225	V
Reference Voltage Tempco	Temp=-40℃ to 85℃		0.015		mV/◦C
FB Input Threshold		1.16	1.195	1.225	V
Internal switch On-Resistance	ILX=100mA		0.4		ohm
LX switch Current Limit			1		A
LX Leakage Current	VLX=0V~4V;Vout=5.5V		0.05	1	μA
Operating Current into OUT	VFB=1.4V,Vout=3.3V		26	40	μA
Shutdown Current into OUT	SD=GND		0.1	1	μA
Efficiency	Vout=3.3V, Iload=200mA		90		%
	Vout=2V, Iload=1mA		85		
LX Switch On-Time	VFB=1V,Vout=3.3V	2	4	7	μS
LX Switch Off-Time	VFB=1V,Vout=3.3V	0.6	0.9	1.4	μS
FB Input Current	VFB=1.4V		0.03	50	nA
SD Input Current	VSD =0 or Vout		0.07	50	nA
SD Input Voltage **(*when SD="L" , Vout=Vin)**	VIL			0.2Vin	V
	VIH	0.8Vout			
	VIH, Vout=5V,Vin=3.3V	2.2			

Note 1: Specifications are tested at T_A=25°C. Specifications over temperature range are guarantee by design, characterization and correlation with Statistical Quality Controls (SQC).

Note 2: Start-up voltage operation is guaranteed without external Schottky diode

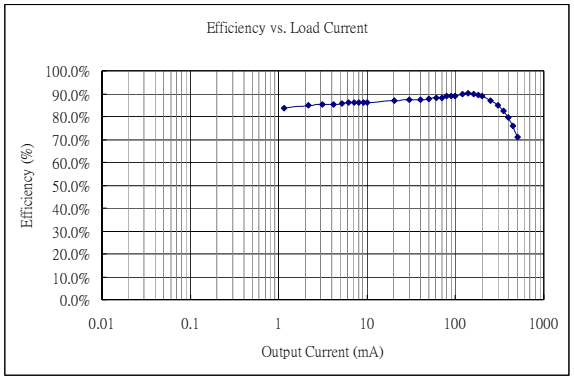
Note 3: Steady-state output current indicates that the device maintains regulation under load.

Note 4: Device is bootstrapped (power to the IC comes from OUT). This correlates directly with the actual battery supply.

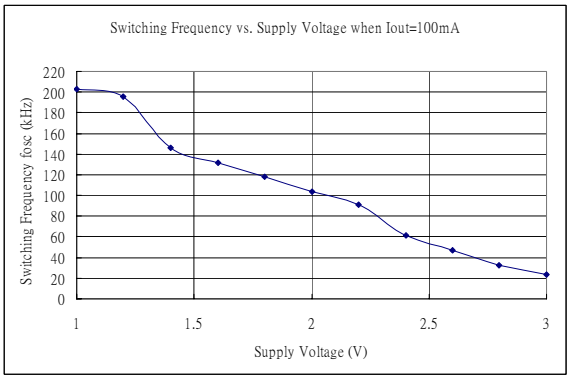
Typical Performance Characteristics

Vin=2.4V, Vout=3.3V unless otherwise specified

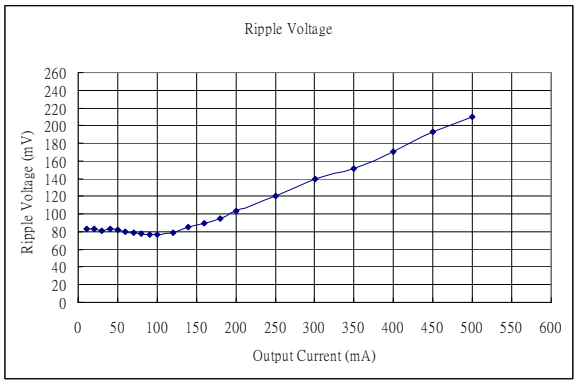
Efficiency vs Output Current



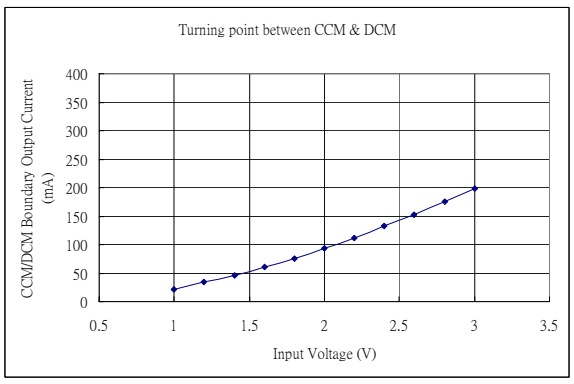
Switching Frequency vs input voltage



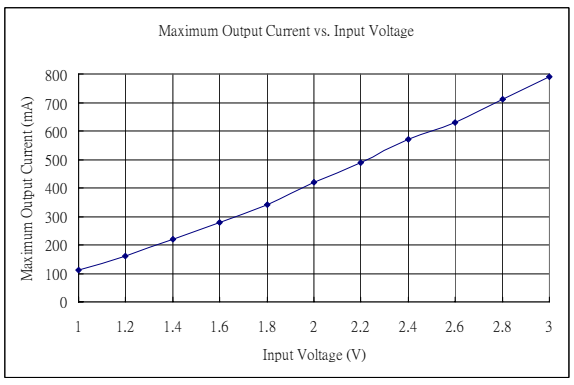
Ripple Voltage vs Output Current



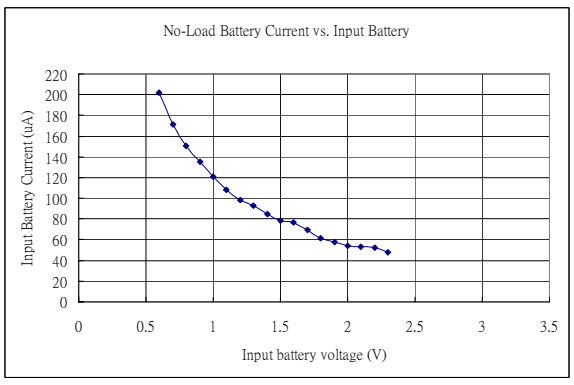
Turning point between CCM and DCM



Maximum output current vs input voltage



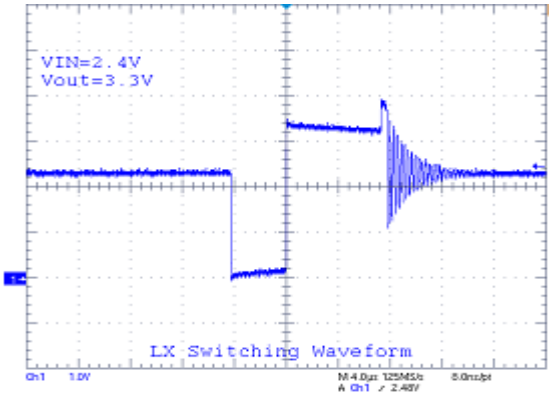
No Load battery current vs input voltage



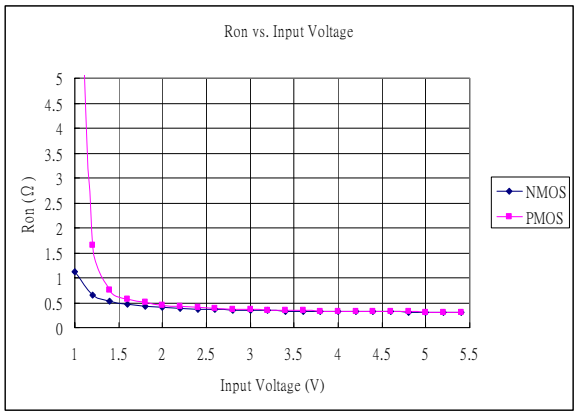
Typical Performance Characteristics

Vin=2.4V, Vout=3.3V unless otherwise specified

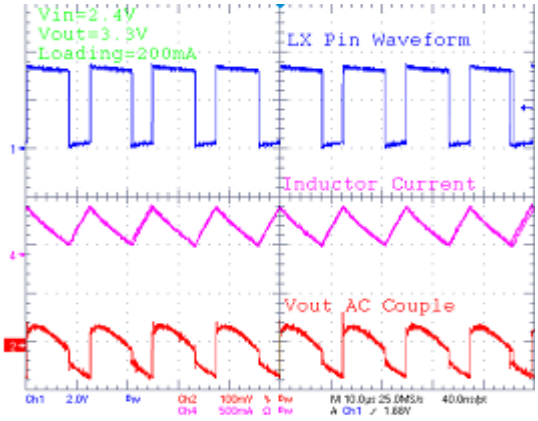
LX Switching waveform at no load



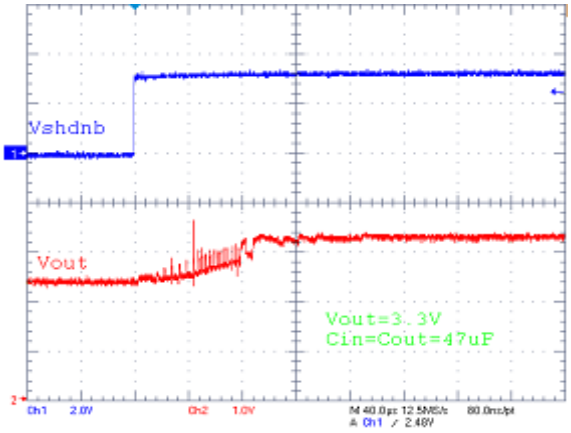
$R_{DS(ON)}$ vs Input Voltage



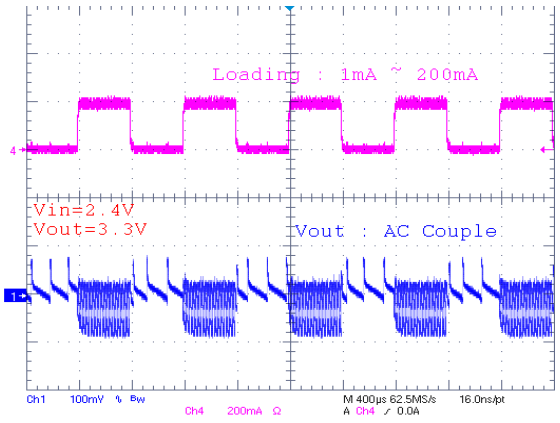
LX Switching waveform at heavy load



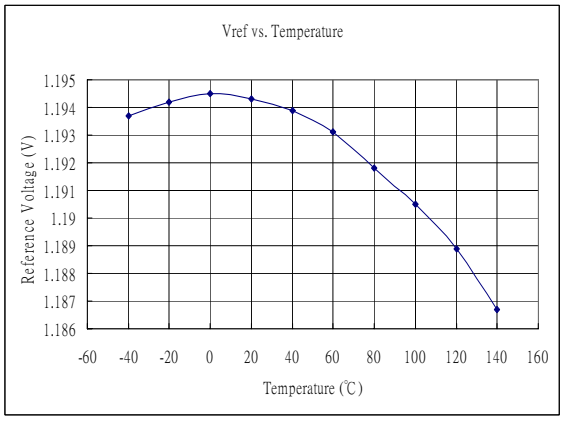
Exiting Shutdown



Load Transient response



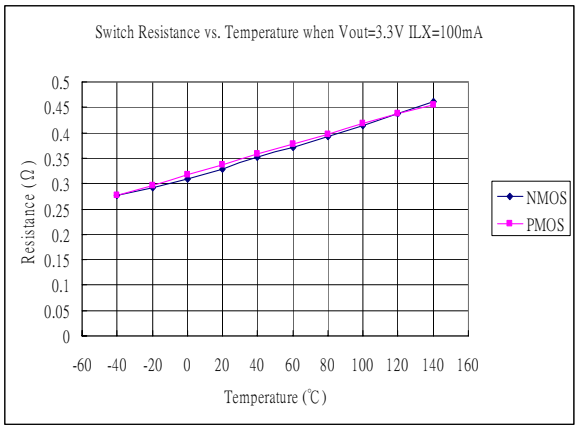
Vref voltage vs temperature



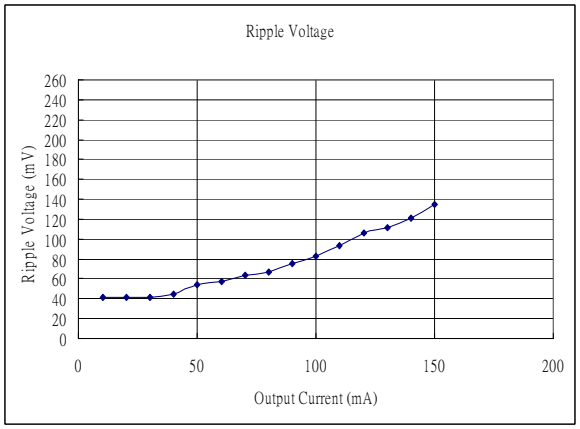
Typical Performance Characteristics

Vin=2.4V, Vout=3.3V unless otherwise specified

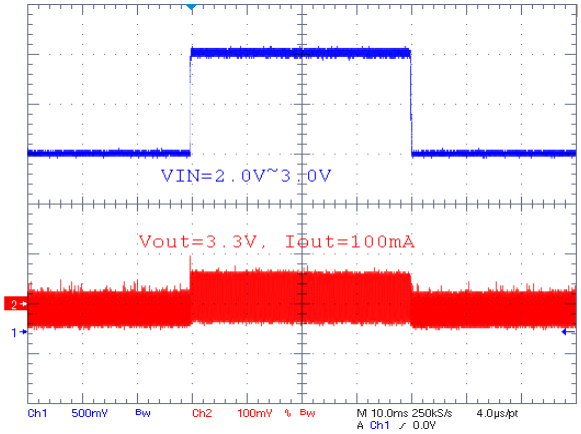
Switch Ron vs Temperature



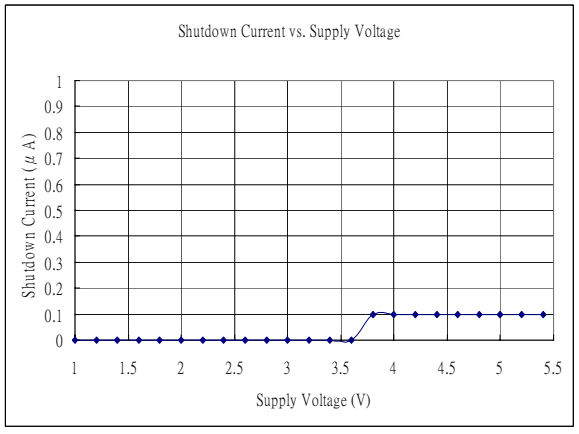
Ripple Voltage vs Output Current when Vin=1.2V



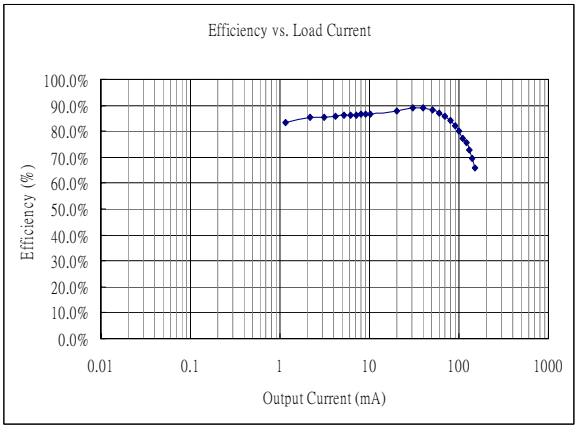
Line Transient Response



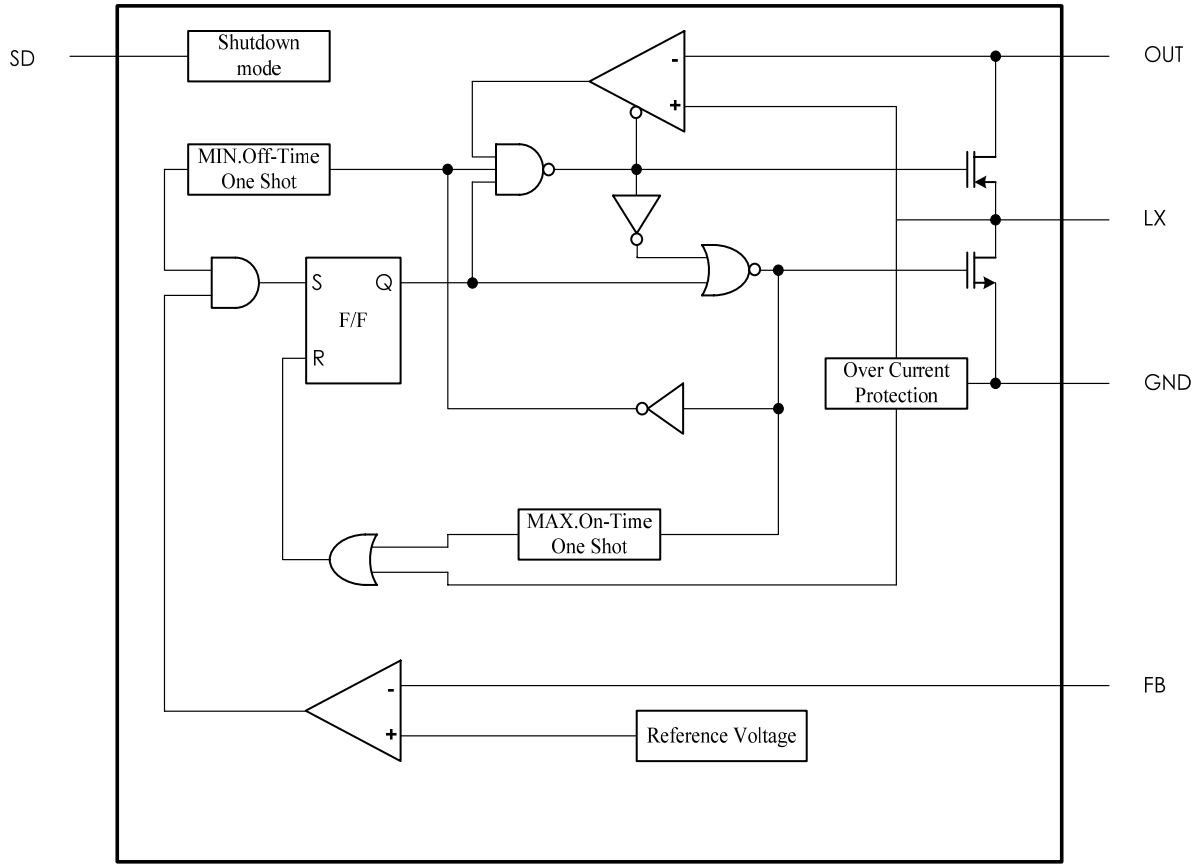
Shutdown current vs input voltage



Efficiency vs Load current at Vin=1.2V



Functional Block Diagram



EMH7601 Block diagram

Applications

Overview

EMP7601 is high efficiency, step-up DC-DC converters, designed to feature a built-in synchronous rectifier, which reduces size and cost by eliminating the need for an external Schottky diode. The start-up voltage is as low as 0.93V and it operates with an input voltage down to 0.7V. Quiescent supply current is only 26μA.The internal P-MOSFET on resistance is typically 0.4Ω to improve overall efficiency by minimizing AC losses. The output voltage can be easily set by two external resistors from 1.8V to 5.5V, connecting FB to OUT to get 3.3V, or connecting to GND to get 5.0V.

The current limit is 1A still it can reliably provide up to 500mA load current and still maintained a decent efficiency.

PFM Control Scheme

The key feature of the design is to apply a unique minimum off-time, constant on-time and current-limited Pulse Frequency Modulation (PFM) control scheme (see BLOCK DIAGRAM) with the ultra-low quiescent current. The peak current of the internal N MOSFET power switch can be fixed at 1.0A. The switching frequency can be up to 200KHz depending on the loading current. The minimum off-time is 1μS and the maximum on-time is 4μS.

Synchronous Rectification

With the internal synchronous rectifier, it eliminates the need for an external Schottky diode. This saves the cost and board space. During the cycle of off-time, P-MOSFET turns on and shunts N- MOSFET. Due to the low turn-on resistance of MOSFET, synchronous rectifier significantly improves efficiency without an additional external Schottky diode. Thus, the conversion efficiency can be as high as 93%.

Reference Voltage

The reference voltage (REF) is nominally 1.195V with excellent temperature performance. In addition, REF pin can source up to 10μA to external circuit with good load regulation (<10mV). A bypass capacitor of 0.1μF in series with 6.8kΩ resistor is required for proper operation and good stability. If no loading requirement, this R and C are not required at all.

Shutdown

The device is in shutdown mode when V_{SD} is low. At shutdown mode, the current can flow from battery to output due to body diode of the P-MOSFET. V_{OUT} falls to approximately Vin-0.6V and LX remains in high impedance. The Cload and load current at OUT determine the rate of how V_{OUT} decays. Shutdown can be pulled as high as 6V regardless of the voltage at OUT.

Applications (continued)

Selecting the Output Voltage

V_{OUT} can be simply set to 3.3V/5.0V by connecting FB pin to OUT/GND due to the use of internal resistor divider in the IC. In order to adjust output voltage, a resistor divider is connected to V_{OUT}, FB, GND. The Vout can be calculated by the following equation:

$R5=R6\ [(V_{OUT} / V_{REF})-1]$ .....(1)

Where V_{REF} =1.195V and V_{OUT} is ranging from 1.8V to 5.5V. The recommended R6 is 240KΩ.

Component Selection

1. Inductor Selection

An inductor value of 22µH performs well in most applications. The device also works with inductors in the 10µH to 47µH range. An inductor with higher peak inductor current tends a higher output voltage ripple (I_{PEAK}×output filter capacitor ESR). The inductor's DC resistance significantly affects efficiency. We can calculate the maximum output current as follows:

$$I_{OUT}(MAX) = \frac{V_{IN}}{V_{OUT}}\left[I_{LIM} - t_{OFF}\left(\frac{V_{OUT} - V_{IN}}{\mathbf{2} \times L}\right)\right]\eta \quad \text{.....(2)}$$

where I_{OUT} (MAX)=max. output current in amps

V_{IN}=input voltage

L = inductor value in µH

η = efficiency (typically 0.9)

t_{OFF} = LX switch' off-time in µS

I_{LIM} =1.0A

2. Capacitor Selection

The output ripple voltage relates with the peak inductor current and the output capacitor's ESR. Besides output ripple voltage, the output ripple current also needs to be concerned. A filter capacitor with low ESR is helpful to the efficiency and steady state output current. A smaller capacitor (down to 47µF with higher ESR) is acceptable for light loads or in applications of which can tolerate higher output ripple.

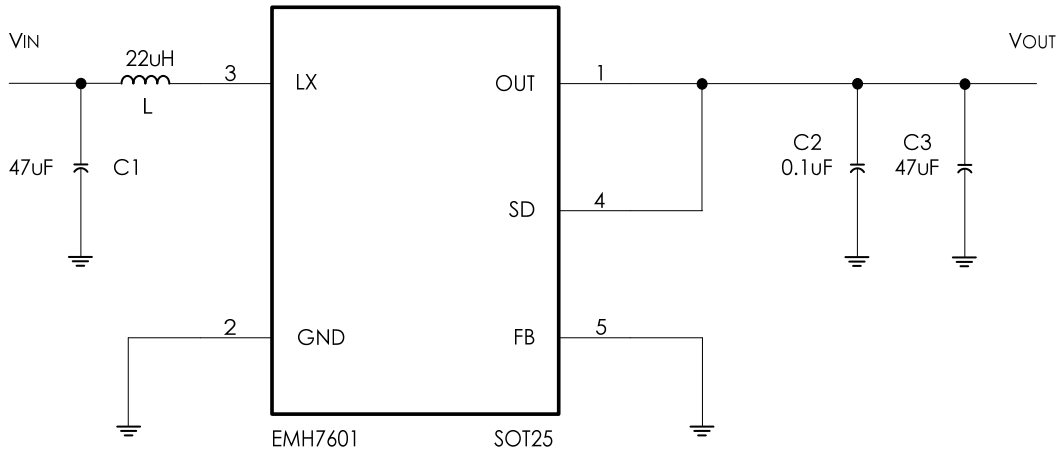
3. PCB Layout and Grounding

Since EMH7601's switching frequency can range up to 200kHz, it is sensitive to how PCB is layout. PCB layout is important for minimizing ground bounce and noise. The GND pin should be placed close to the ground plane. Keep the IC's GND pin and the ground leads of the input and output filter capacitors as short as possible. In addition, keep all connections to the FB and LX pins as short as possible. In particular, in case of using external feedback resistors, locate them as close to the FB as possible. To maximize output power and efficiency and minimize output ripple voltage, use a ground plane right under the soldered IC.

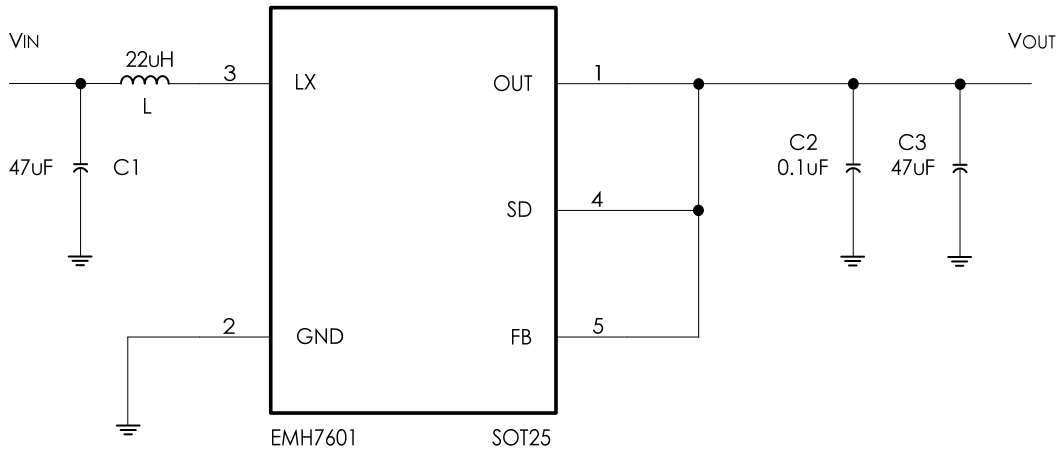
Ripple Voltage Reduction

The output ripple voltage can be significant improved by using two or three parallel output capacitors. The addition of an extra input capacitor also results in a stable output voltage.

Application (Continued)

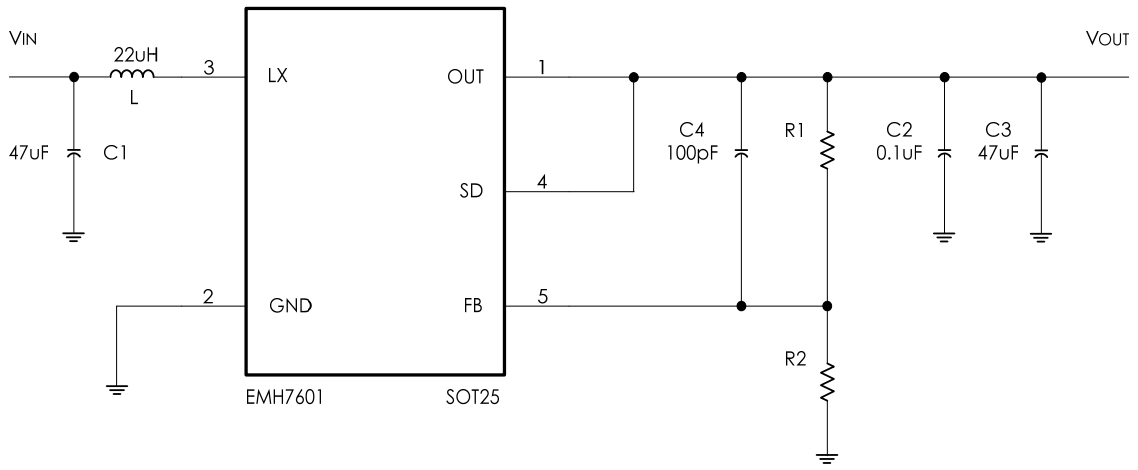


Application circuit for V_{OUT}=5V

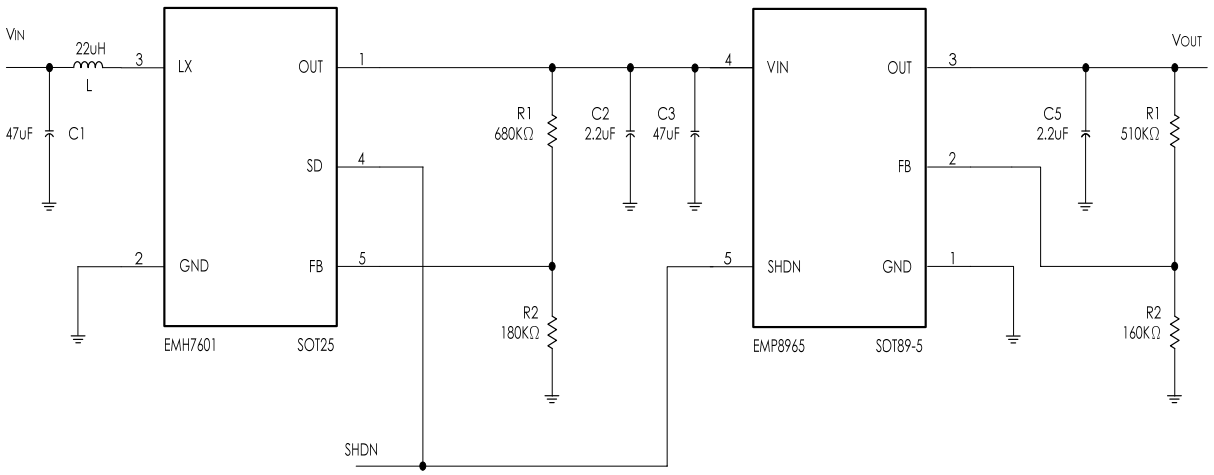


Application circuit for V_{OUT}=3.3V

Application (Continued)



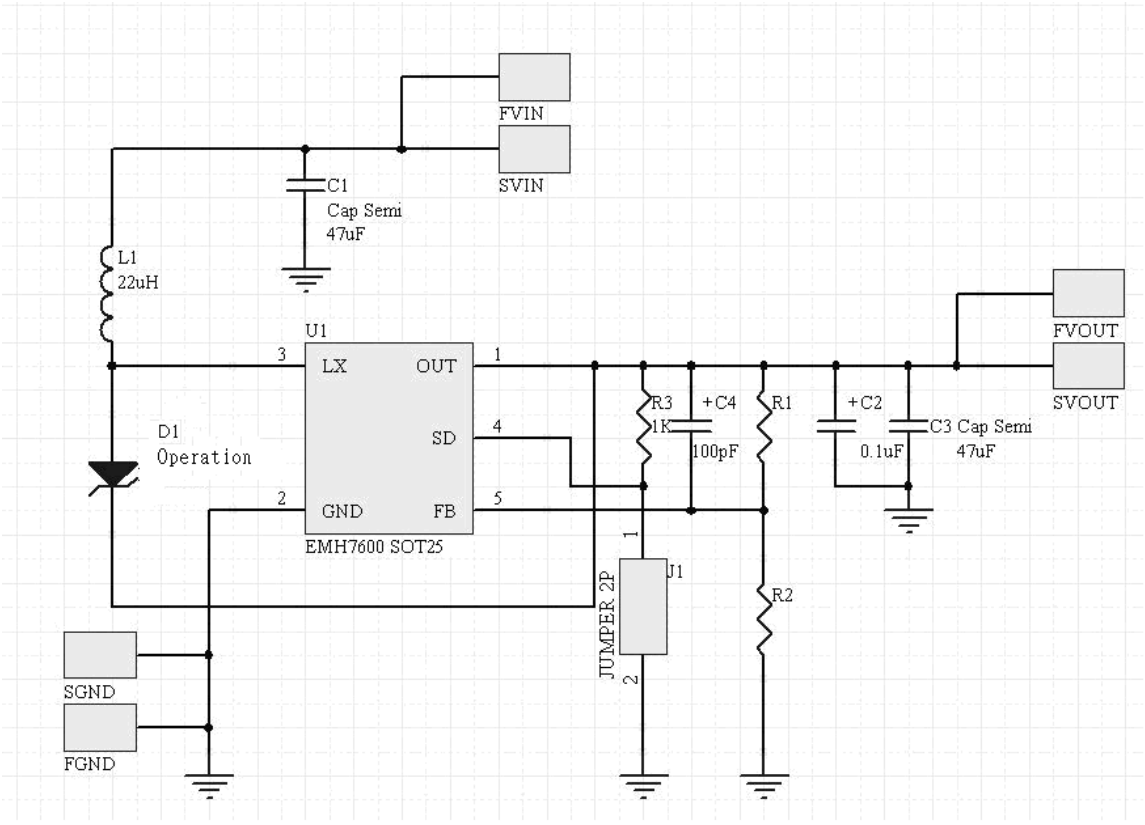
Application circuit for adjustable V_{OUT} using formula (R1+R2)/R2*1.195

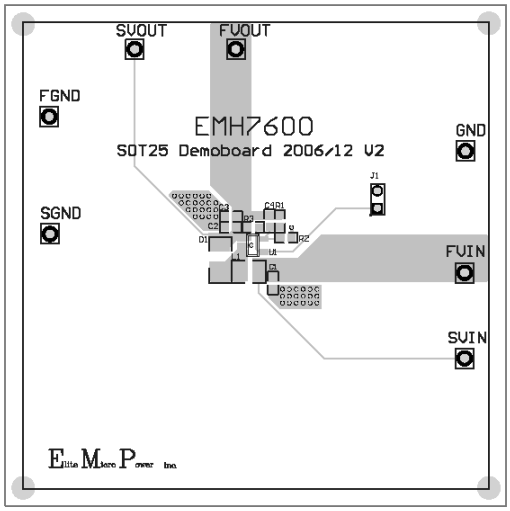


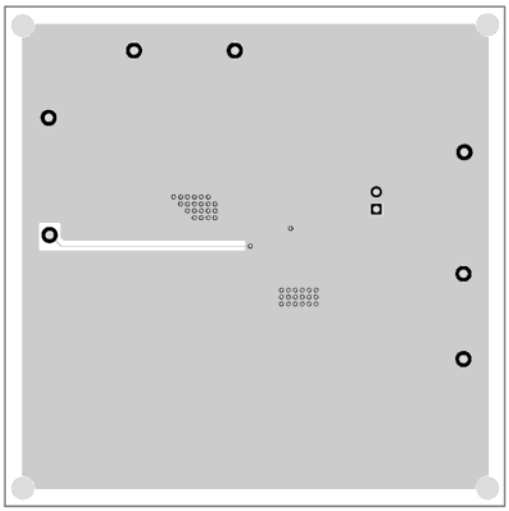
*This application circuit improve the output ripple voltage with 1mV (max) up to 500mA loading.

Application circuit for V_{OUT}=0V in shutdown mode

Typical schematic for PCB layout

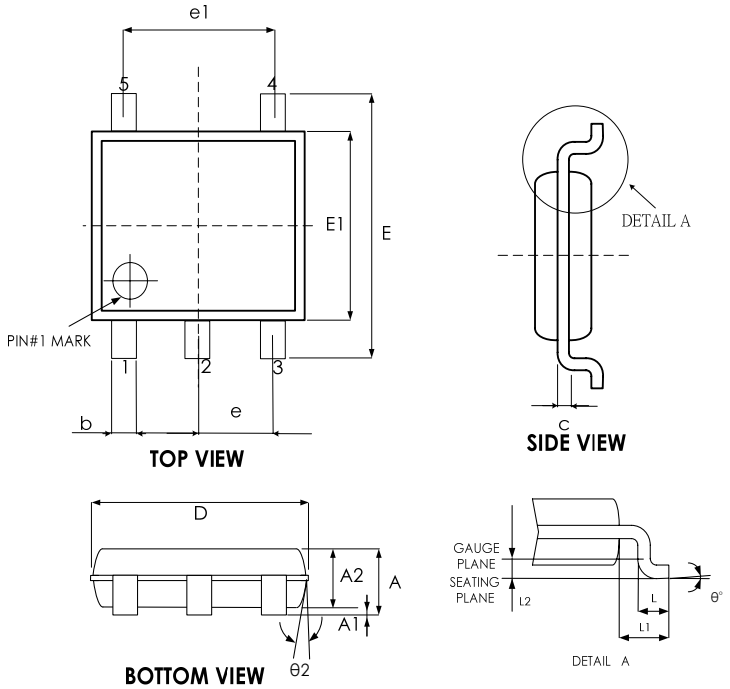






Package Information

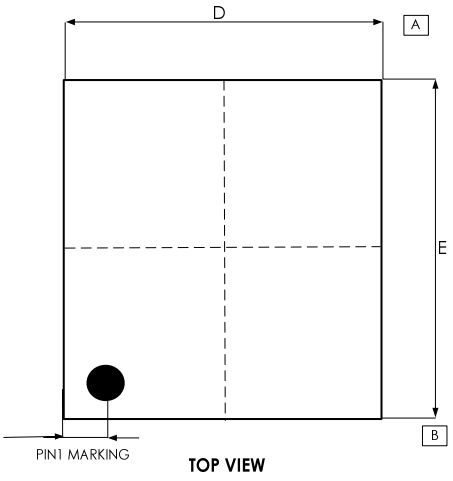
SOT-23-5



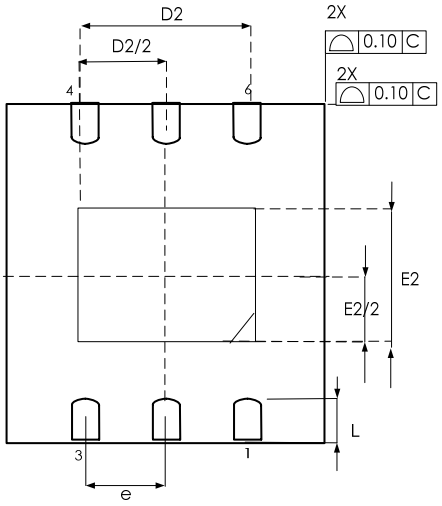
SYMBPLS	MIN.	NOM.	MAX.
A	1.05	1.2	1.35
A1	0.05	0.1	0.15
A2	1	1.1	1.2
b	0.3	—	0.5
c	0.08	—	0.2
D	2.8	2.9	3
E	2.6	2.8	3
E1	1.5	1.6	1.7
e	0.95 BSC		
e1	1.90 BSC		
L	0.3	0.45	0.55
L1	0.60 REF		
θ°	0	5	10
θ2°	6	8	10

UNIT: MM

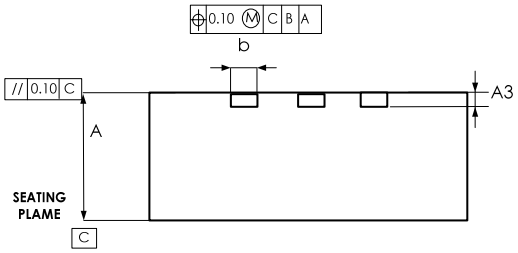
TDFN-6



TOP VIEW



BOTTOM VIEW



SILD VIEW

SYMBOL	COMMON					
	DIMENSIONS MILLIMETER			DIMENSIONS INCH		
	MIN.	NOM.	MAX.	MIN.	NOM.	MAX.
A	0.70	0.75	0.80	0.027	0.029	0.031
A3	0.200 REF			0.008 REF		
b	0.25	0.30	0.35	0.010	0.012	0.014
D	2.00 BSC			0.079 BSC		
D2	1.20	1.30	1.40	0.046	0.050	0.054
E	2.00 BSC			0.079 BSC		
E2	0.50	0.60	0.70	0.022	0.024	0.026
e	0.650 BSC			0.026 BSC		
L	0.25	0.30	0.35	0.009	0.011	0.013

Notice

Old Order, Mark & Packing Information

Package	Product ID	Vout	Marking	Packing
SOT-23-5	EMH7601-00VF05GRR	00 (adjustable)	H100 Date Code	3K units Tape & Reel
SOT-23-5	EMH7601-00VF05GRR	00 (adjustable)	H7601 Date Code	3K units Tape & Reel

Revision History

Revision	Date	Description
2.0	2009.06.08	EMP transferred from version 1.3

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