FAIRCHILD SEMICONDUCTOR®

April 2006

# FAN2011/FAN2012
# 1.5A Low Voltage Current Mode Synchronous PWM Buck Regulator

## Features

- 95% Efficiency, Synchronous Operation
- Adjustable Output Voltage from 0.8V to $V_{IN}$
- 4.5V to 5.5V Input Voltage Range
- Up to 1.5A Output Current
- Fixed Frequency 1.3 MHz PWM Operation
- 100% Duty Cycle Low Dropout Operation (LDO)
- Soft Start
- Excellent Load Transient Response
- 3x3mm 6-lead MLP Package

## Applications

- Hard Disk Drive
- Set Top Box
- Point of Load Power
- Notebook Computers
- Communications Equipment

## Description

The FAN2011/FAN2012 is a high-efficiency, low-noise synchronous Pulse Width Modulated (PWM) current mode DC-DC converter, designed for low voltage applications. It provides up to 1.5A continuous load current from the 4.5V to 5.5V input. The output voltage is adjustable over a wide range of 0.8V to $V_{IN}$ by means of an external voltage divider.

The FAN2011 is always on, while the FAN2012 has an "Enable Input," and the device can be put in the shutdown mode, in which the ground current falls below 1µA.

A current mode control loop with a fast transient response ensures excellent line and load regulation. The fixed 1.3MHz switching frequency enables the user to choose a small, inexpensive external inductor and capacitor. Filtering is also easily accomplished with very small components.

Protection features include input under-voltage lockout, short circuit protection and thermal shutdown. Soft-start limits in-rush current during start-up conditions.

The device is available in a 3x3mm 6-lead MLP package, making it possible to build a 1.5A complete DC-DC converter in a tiny space on the PCB.

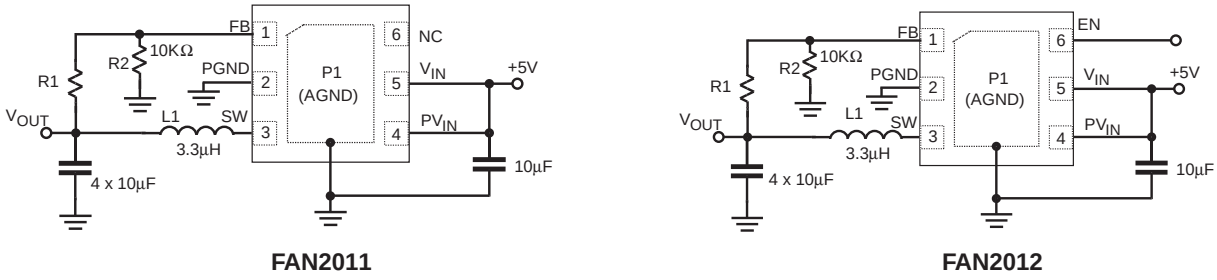
## Ordering Information

| Product Number | Output Voltage | Package Type | Ambient Operating Temperature | Order Code |
|---|---|---|---|---|
| FAN2011 | Adjustable | 3x3mm 6-Lead MLP | 0°C to 85°C | FAN2011MPX |
| FAN2012 | Adjustable | 3x3mm 6-Lead MLP | 0°C to 85°C | FAN2012MPX |
| FAN2011I | Adjustable | 3x3mm 6-Lead MLP | -40°C to 85°C | FAN2011EMPX |
| FAN2012I | Adjustable | 3x3mm 6-Lead MLP | -40°C to 85°C | FAN2012EMPX |



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## Typical Application

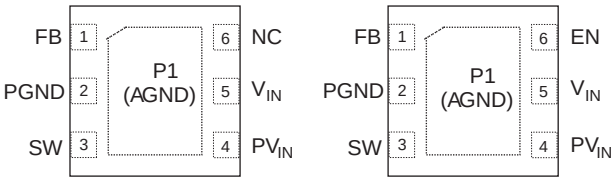



**FAN2011** **FAN2012**

**Figure 1. Typical Application**

## Pin Assignment

**Top View**




**FAN2011**
**3x3mm 6-Lead MLP**

**FAN2012**
**3x3mm 6-Lead MLP**

**Figure 2. Pin Assignment**

## Pin Description

### FAN2011 (3x3mm 6-Lead MLP)

| Pin No. | Pin Name | Pin Description |
|---|---|---|
| P1 | AGND | **Analog Ground.** P1 must be soldered to the PCB ground. |
| 1 | FB | **Feedback Input.** Adjustable voltage option; connect this pin to the resistor divider. |
| 2 | PGND | **Power Ground.** This pin is connected to the internal MOSFET switches. This pin must be externally connected to AGND. |
| 3 | SW | **Switching Node.** This pin is connected to the internal MOSFET switches. |
| 4 | $PV_{IN}$ | **Supply Voltage Input.** This pin is connected to the internal MOSFET switches. |
| 5 | $V_{IN}$ | **Supply Voltage Input.** |
| 6 | NC | **Not Connected.** This pin is not internally connected. |

### FAN2012 (3x3mm 6-Lead MLP)

| Pin No. | Pin Name | Pin Description |
|---|---|---|
| P1 | AGND | **Analog Ground.** P1 must be soldered to the PCB ground. |
| 1 | FB | **Feedback Input.** Adjustable voltage option; connect this pin to the resistor divider. |
| 2 | PGND | **Power Ground.** This pin is connected to the internal MOSFET switches. This pin must be externally connected to AGND. |
| 3 | SW | **Switching Node.** This pin is connected to the internal MOSFET switches. |
| 4 | $PV_{IN}$ | **Supply Voltage Input.** This pin is connected to the internal MOSFET switches. |
| 5 | $V_{IN}$ | **Supply Voltage Input.** |
| 6 | EN | **Enable Input.** Logic high enables the chip and logic low disables the chip, reducing the supply current to less than 1µA. Do not float this pin. |

## Absolute Maximum Ratings

Stresses above those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. This is a stress rating only and functional operation of the device at these or any other conditions above those indicated in the operational section of this specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability. Absolute maximum ratings apply individually only, not in combination. Unless otherwise specified, all other voltages are referenced to AGND.

| Parameter | | Min. | Max. | Unit |
|---|---|---|---|---|
| $V_{IN}$ | | -0.3 | 7 | V |
| $PV_{IN}$ and any other pin | | -0.3 | $V_{IN}$ | V |
| Thermal Resistance-Junction to Tab ($\theta_{JC}$), 3mm x 3mm 6-lead MLP(1) | | – | 8 | °C/W |
| Lead Soldering Temperature (10 seconds) | | – | 260 | °C |
| Storage Temperature | | -65 | 150 | °C |
| Junction Temperature | | -40 | 150 | °C |
| Electrostatic Discharge (ESD) Protection Level(2) | HBM | 4 | – | kV |
| | CDM | 2 | – | |

## Recommended Operating Conditions

| Parameter | | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|
| Supply Voltage Range | | 4.5 | – | 5.5 | V |
| Output Voltage Range, Adjustable Version | | 0.8 | – | $V_{IN}$ | V |
| Output Current | | – | – | 1500 | mA |
| Inductor(3) | | – | 3.3 | – | µH |
| Input Capacitor(3) | | – | 10 | – | µF |
| Output Capacitor(3) | | – | 4 x 10 | – | µF |
| Operating Ambient Temperature Range | FAN2011 and FAN2012 | 0 | – | +85 | °C |
| | FAN2011I and FAN2012I | -40 | – | +85 | |

**Notes:**

1. Junction to ambient thermal resistance, $\theta_{JA}$, is a strong function of PCB material, board thickness, thickness and number of copper planes, number of via used, diameter of via used, available copper surface, and attached heat sink characteristics.
2. Using Mil Std. 883E, method 3015.7(Human Body Model) and EIA/JESD22C101-A (Charge Device Model).
3. Refer to the applications section for further details.

## Electrical Characteristics

$V_{IN}$ = 4.5V to 5.5V, $V_{OUT}$ = 1.2V, $I_{OUT}$ = 200mA, $C_{IN}$ = 10µF, $C_{OUT}$ = 4 x 10µF, L = 3.3µH, $T_A$ = 0°C to +85°C, unless otherwise noted. Typical values are at $T_A$ = 25°C.

| Parameter | Conditions | | Min. | Typ. | Max. | Units |
|---|---|---|---|---|---|---|
| Input Voltage | | | 4.5 | – | 5.5 | V |
| Quiescent Current | $I_{OUT}$ = 0mA | | – | 7 | 10 | mA |
| UVLO Threshold | $V_{IN}$ Rising | | 3.4 | 3.7 | 4 | V |
| | Hysteresis | | – | 150 | – | mV |
| PMOS On Resistance | $V_{IN} = V_{GS}$ = 5V | | – | 150 | 290 | mΩ |
| NMOS On Resistance | $V_{IN} = V_{GS}$ = 5V | | – | 150 | 290 | mΩ |
| P-channel Current Limit | 4.5V < $V_{IN}$ < 5.5V | | 2200 | 2600 | 3500 | mA |
| Over-Temperature Protection | Rising Temperature | | – | 150 | – | °C |
| | Hysteresis | | – | 20 | – | °C |
| Switching Frequency | | | 1000 | 1300 | 1600 | kHz |
| Line Regulation | $V_{IN}$ = 4.5 to 5.5V, $I_{OUT}$ = 100mA | | – | 0.16 | – | % / V |
| Load Regulation | 0mA ≤ $I_{OUT}$ ≤ 1500mA | | – | 0.2 | 0.5 | % |
| Output Voltage During Load Transition[4] | $I_{OUT}$ from 700mA to 100mA | | – | – | 5 | % |
| Output Voltage During Load Transition[4] | $I_{OUT}$ from 100mA to 700mA | | -5 | – | – | % |
| Reverse Leakage Current Into Pin SW | $V_{IN}$ = Open, EN = GND, $V_{sw}$ = 5.5V | | – | 0.1 | 1 | µA |
| Reference Voltage, $V_{REF}$ | | | – | 0.8 | | V |
| Output Voltage Accuracy | $V_{IN}$ = 4.5 to 5.5V<br>0mA ≤ $I_{OUT}$ ≤ 1500mA | FAN2011<br>FAN2012 | -2 | – | 2 | % |
| | | FAN2011I<br>FAN2012I<br>-40°C to +85°C | -3 | – | 3 | % |

**Notes:**

4. Load transient response test waveform.

### Additional Electrical Characteristics for FAN2012

$T_A$ = 0°C to +85°C, $V_{IN}$ = 4.5 to 5.5V. Typical values are at $T_A$ = 25°C.

| Parameter | Conditions | Min. | Typ. | Max. | Units |
|---|---|---|---|---|---|
| Shutdown Mode Supply Current | $V_{EN}$ = 0V | – | 0.1 | 1 | µA |
| EN Bias Current | | – | – | 0.1 | µA |
| EN High Voltage | | 1.3 | – | – | V |
| EN Low Voltage | | – | – | 0.4 | V |

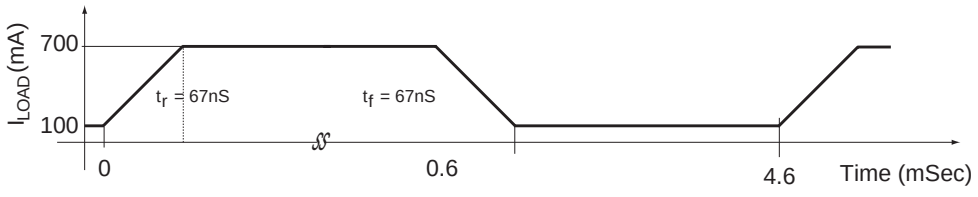
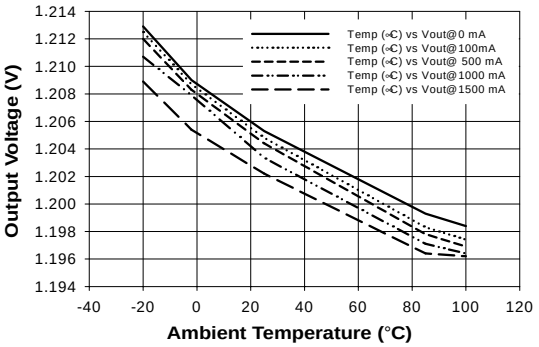



**Figure 3. Load Transient Response Test Waveform**

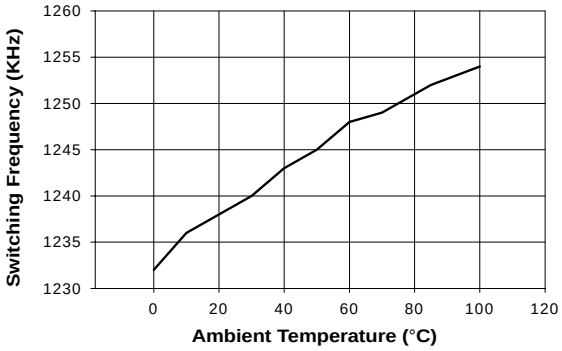
## Typical Performance Characteristics

$T_A$ = 25°C, $C_{IN}$ = 10µF, $C_{OUT}$ = 40µF, L = 3.3µH, $V_{IN}$ = 5V, unless otherwise noted.

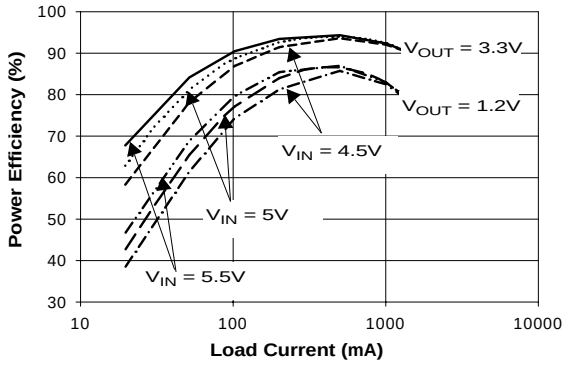
**Output Voltage vs. Ambient Temperature**




**Switching Frequency vs. Ambient Temperature**



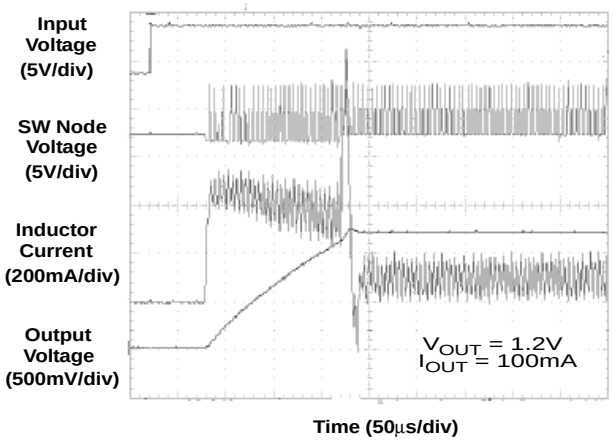

**Efficiency vs. Load Current**



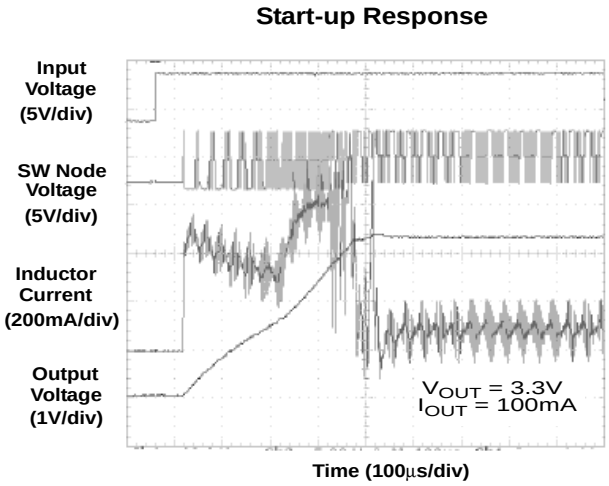
## Typical Performance Characteristics (Continued)

$T_A$ = 25°C, $C_{IN}$ = 10µF, $C_{OUT}$ = 40µF, L = 3.3µH, $V_{IN}$ = 5V, unless otherwise noted.

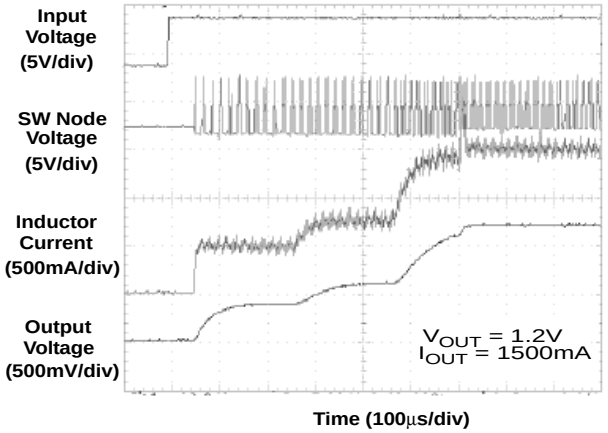
**Start-up Response**



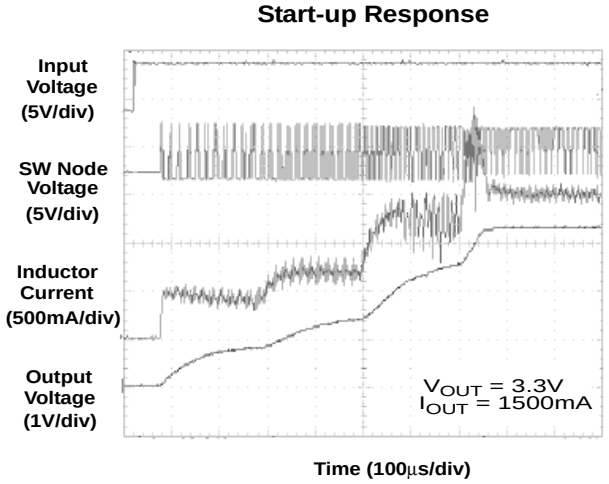

**Start-up Response**



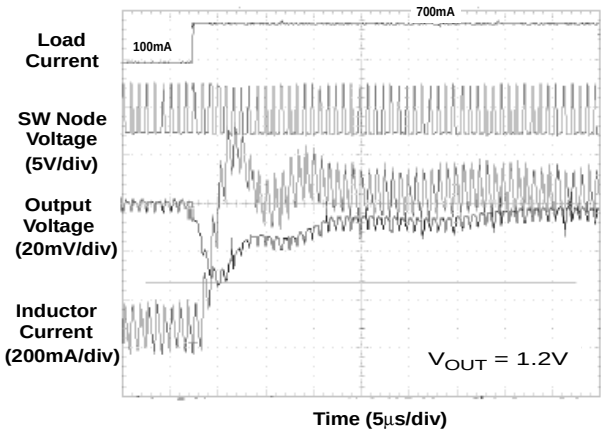

**Start-up Response**



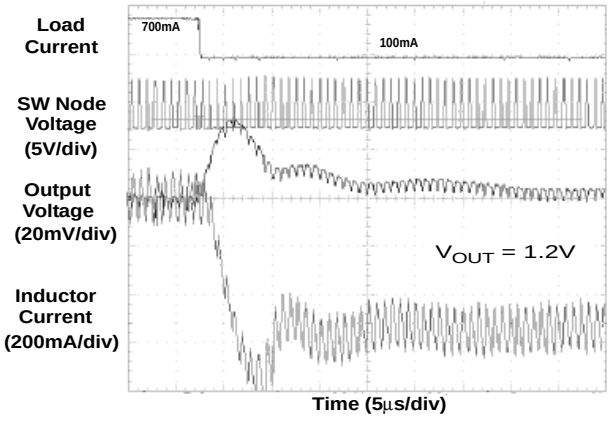

**Start-up Response**




**Transient Response**




**Transient Response**



## Block Diagram

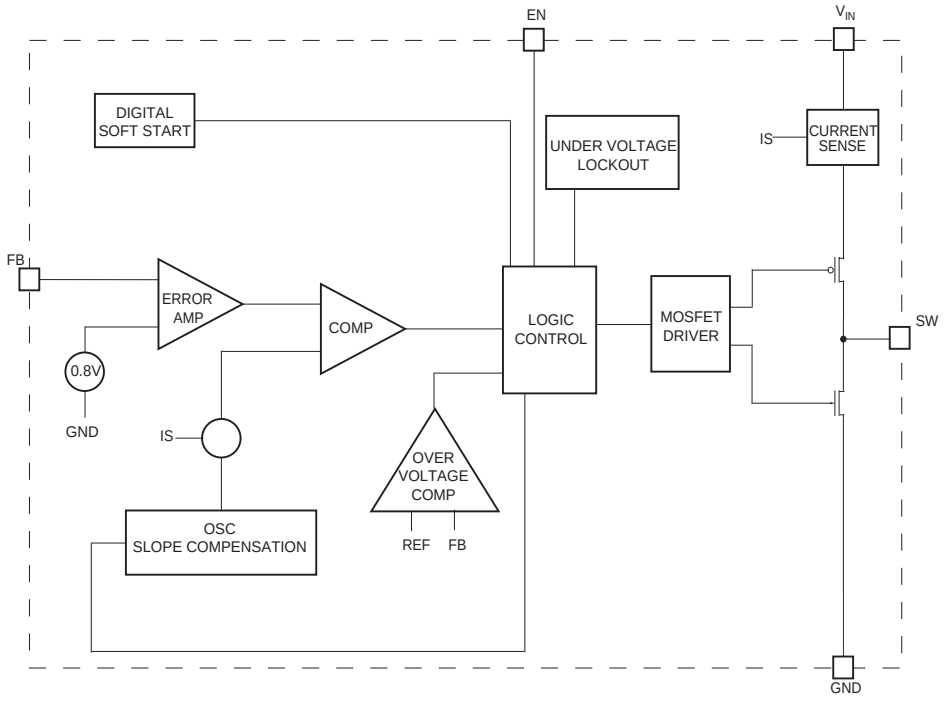



**Figure 4. Block Diagram**

## Detailed Operation Description

The FAN2011 is a step-down pulse width modulated (PWM) current mode converter with a typical switching frequency of 1.3MHz. At the beginning of each clock cycle, the P-channel transistor is turned on. The inductor current ramps up and is monitored via an internal circuit. The P-channel switch is turned off when the sensed current causes the PWM comparator to trip when the output voltage is in regulation or when the inductor current reaches the current limit (set internally, typically 2600mA). After a minimum dead time, the N-channel transistor is turned on and the inductor current ramps down. As the clock cycle is completed, the N-channel switch is turned off and the next clock cycle starts. The duty cycle is solely given by the ratio of output voltage and input voltage. Therefore, the converter runs with a minimum duty cycle when output voltage is at minimum and input voltage is at maximum.

### 100% Duty Cycle Operation

As the input voltage approaches the output voltage and the duty cycle exceeds the typical 95%, the converter turns the P-channel transistor continuously on. In this mode, the output voltage is equal to the input voltage minus the voltage drop across the P-channel transistor:

$V_{OUT} = V_{IN} – I_{LOAD} \times (R_{DS_ON} + R_L)$, where

$R_{DS_ON}$ = P-channel switch ON resistance
$I_{LOAD}$ = Output current
$R_L$ = Inductor DC resistance

### UVLO and Soft Start

The reference and the circuit remain reset until the $V_{IN}$ crosses its UVLO threshold.

The FAN2011 has an internal soft-start circuit that limits the in-rush current during start-up. This prevents possible voltage drops of the input voltage and eliminates the output voltage overshoot. The soft-start is implemented as a digital circuit, increasing the switch current in four steps to the P-channel current limit (2600mA). Typical start-up time for a 40µF output capacitor and a load current of 1500mA is 800µs.

### Short Circuit Protection

The switch peak current is limited cycle by cycle to a typical value of 2600mA. In the event of an output voltage short circuit, the device operates with a frequency of 400kHz and minimum-duty cycle, therefore the average input current is typically 350mA.

### Thermal Shutdown

When the die temperature exceeds 150°C, a reset occurs and remains in effect until the die cools to 130°C, at which point, the circuit restarts.

## Applications Information

### Setting the Output Voltage

The internal reference is 0.8V. The output is divided down by a voltage divider, R1 and R2 to the FB pin. The output voltage is:

$$V_{OUT} = V_{REF}\left(1 + \frac{R_1}{R_2}\right)$$

According to this equation, and assuming desired output voltage of 1.5096V, and given R2 = 10KΩ, the calculated value of R1 is 8.87KΩ.

### Inductor Selection

The inductor parameters directly related to device performances are saturation current and DC resistance. The FAN2011/FAN2012 operates with a typical inductor value of 3.3µH. The lower the dc resistance, the higher the efficiency. For saturation current, the inductor should be rated higher than the maximum load current, plus half of the inductor ripple current calculated as follows:

$$\Delta I_L = V_{OUT} \times \frac{1 - (V_{OUT}/V_{IN})}{L \times f}$$

where:
$\Delta I_L$ = Inductor Ripple Current
f = Switching Frequency
L = Inductor Value

Some recommended inductors are suggested in the table below:

**Table 1. Recommended Inductors**

| Inductor Value | Vendor | Part Number |
|---|---|---|
| 3.3µH | Panasonic | ELL6PM3R3N |
| 3.3µH | Murata | LQS66C3R3M04 |
| 3.3µH | Coiltronics | SD-3R3-R |

### Capacitors Selection

For best performances, a low ESR input capacitor is required. A ceramic capacitor of at least 10µF, placed as close to the $V_{IN}$ and AGND pins of the device is recommended. The output capacitor determines the output ripple and the transient response.

**Table 2. Recommended Capacitors**

| Capacitor Value | Vendor | Part Number |
|---|---|---|
| 10µF | Taiyo Yuden | JMK212BJ106MG |
| | | JMK316BJ106KL |
| | TDK | C2012X5ROJ106K |
| | | C3216X5ROJ106M |
| | Murata | GRM32ER61C106K |

## PCB Layout Recommendations

The inherently high peak currents and switching frequency of power supplies require a careful PCB layout design. Therefore, use wide traces for high-current paths and place the input capacitor, the inductor, and the output capacitor as close as possible to the integrated circuit terminals. To minimize voltage stress to the device resulting from ever-present switching spikes, use an input bypass capacitor with low ESR. Use of an external Schottky diode, with its anode connected to SW node and cathode connected to $PV_{IN}$, further reduces switching spikes. Note that the peak amplitude of the switching spikes depends upon the load current; the higher the load current, the higher the switching spikes.

The resistor divider that sets the output voltage should be routed away from the inductor to avoid RF coupling. The ground plane at the bottom side of the PCB acts as an electromagnetic shield to reduce EMI. The recommended PCB layout is shown below in Figure 5.

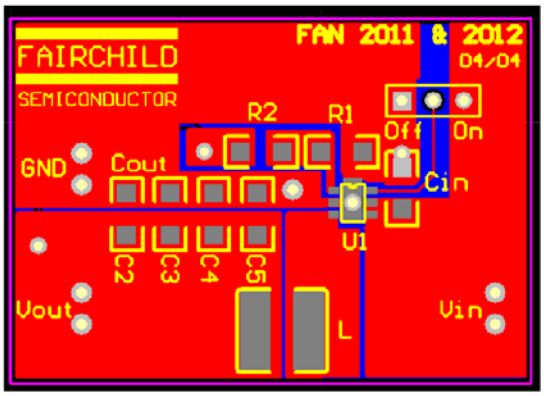
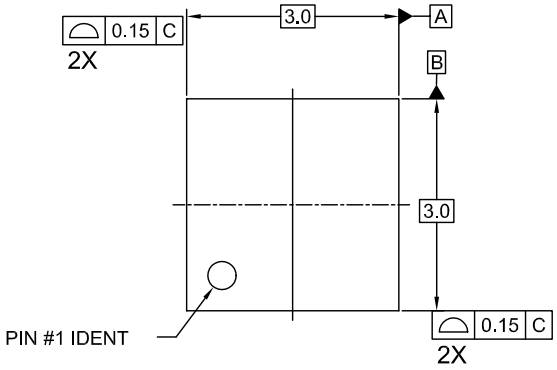


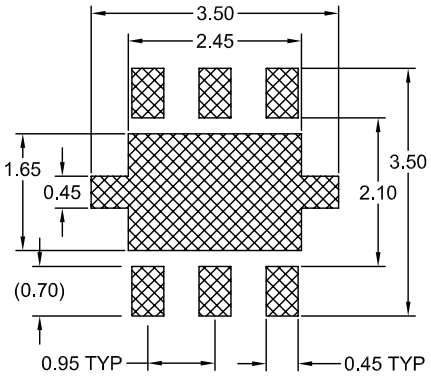

**Figure 5. Recommended PCB Layout**

## Mechanical Dimensions

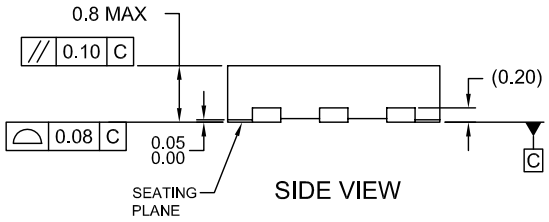
### 3x3mm 6-Lead MLP



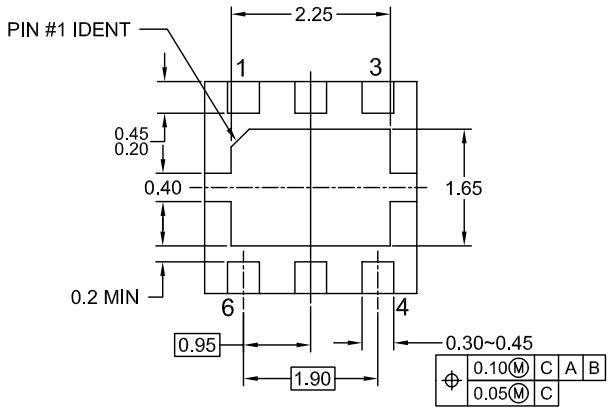

TOP VIEW




RECOMMENDED LAND PATTERN




SIDE VIEW




BOTTOM VIEW

NOTES:

A. CONFORMS TO JEDEC REGISTRATION MO-229, VARIATION WEEA, DATED 11/2001 EXCEPT FOR DAP EXTENSION TABS

B. DIMENSIONS ARE IN MILLIMETERS.

C. DIMENSIONS AND TOLERANCES PER ASME Y14.5M, 1994

MLP06FrevA

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| Bottomless™ | FPS™ | MICROCOUPLER™ | QFET® | SyncFET™ |
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| *CROSSVOLT*™ | GTO™ | MICROWIRE™ | Quiet Series™ | TINYOPTO™ |
| DOME™ | HiSeC™ | MSX™ | RapidConfigure™ | TruTranslation™ |
| EcoSPARK™ | I²C™ | MSXPro™ | RapidConnect™ | UHC™ |
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| EnSigna™ | ImpliedDisconnect™ | OCXPro™ | ScalarPump™ | UniFET™ |
| FACT™ | IntelliMAX™ | OPTOLOGIC® | SILENT SWITCHER® | VCX™ |
| FACT Quiet Series™ | | OPTOPLANAR™ | SMART START™ | Wire™ |
| Across the board. Around the world.™ | | PACMAN™ | SPM™ | |
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| Programmable Active Droop™ | | Power247™ | SuperFET™ | |
| | | PowerEdge™ | SuperSOT™-3 | |

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2. A critical component is any component of a life support device or system whose failure to perform can be reasonably expected to cause the failure of the life support device or system, or to affect its safety or effectiveness.

### PRODUCT STATUS DEFINITIONS

**Definition of Terms**

| Datasheet Identification | Product Status | Definition |
|---|---|---|
| Advance Information | Formative or In Design | This datasheet contains the design specifications for product development. Specifications may change in any manner without notice. |
| Preliminary | First Production | This datasheet contains preliminary data, and supplementary data will be published at a later date. Fairchild Semiconductor reserves the right to make changes at any time without notice in order to improve design. |
| No Identification Needed | Full Production | This datasheet contains final specifications. Fairchild Semiconductor reserves the right to make changes at any time without notice in order to improve design. |
| Obsolete | Not In Production | This datasheet contains specifications on a product that has been discontinued by Fairchild semiconductor. The datasheet is printed for reference information only. |

Rev. I18

# OCEAN CHIPS
## Океан Электроники
## Поставка электронных компонентов

Компания «Океан Электроники» предлагает заключение долгосрочных отношений при поставках импортных электронных компонентов на взаимовыгодных условиях!

Наши преимущества:

- Поставка оригинальных импортных электронных компонентов напрямую с производств Америки, Европы и Азии, а так же с крупнейших складов мира;
- Широкая линейка поставок активных и пассивных импортных электронных компонентов (более 30 млн. наименований);
- Поставка сложных, дефицитных, либо снятых с производства позиций;
- Оперативные сроки поставки под заказ (от 5 рабочих дней);
- Экспресс доставка в любую точку России;
- Помощь Конструкторского Отдела и консультации квалифицированных инженеров;
- Техническая поддержка проекта, помощь в подборе аналогов, поставка прототипов;
- Поставка электронных компонентов под контролем ВП;
- Система менеджмента качества сертифицирована по Международному стандарту ISO 9001;
- При необходимости вся продукция военного и аэрокосмического назначения проходит испытания и сертификацию в лаборатории (по согласованию с заказчиком);
- Поставка специализированных компонентов военного и аэрокосмического уровня качества (Xilinx, Altera, Analog Devices, Intersil, Interpoint, Microsemi, Actel, Aeroflex, Peregrine, VPT, Syfer, Eurofarad, Texas Instruments, MS Kennedy, Miteq, Cobham, E2V, MA-COM, Hittite, Mini-Circuits, General Dynamics и др.);

Компания «Океан Электроники» является официальным дистрибьютором и эксклюзивным представителем в России одного из крупнейших производителей разъемов военного и аэрокосмического назначения «**JONHON**», а так же официальным дистрибьютором и эксклюзивным представителем в России производителя высокотехнологичных и надежных решений для передачи СВЧ сигналов «**FORSTAR**».

AVIC JONHON

**«JONHON»** (основан в 1970 г.)

Разъемы специального, военного и аэрокосмического назначения:

(Применяются в военной, авиационной, аэрокосмической, морской, железнодорожной, горно- и нефтедобывающей отраслях промышленности)

**«FORSTAR»** (основан в 1998 г.)

ВЧ соединители, коаксиальные кабели, кабельные сборки и микроволновые компоненты:

(Применяются в телекоммуникациях гражданского и специального назначения, в средствах связи, РЛС, а так же военной, авиационной и аэрокосмической отраслях промышленности).

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