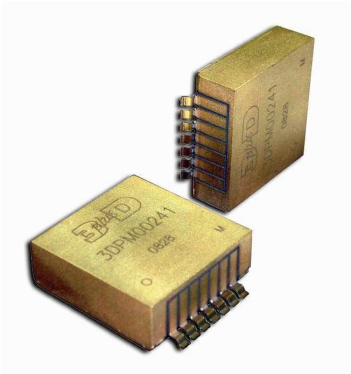
# Hi-Rel Point-Of-Load DC/DC Converter
## 5V Input, 1.5V to 4V Single Output
## Radiation Hardened Design

### Features

**3DPM0024-3-XX**

- Input Voltage: 5V ± 5%
- Output Voltage adjustable from 1.5V to 4V
- Output current up to 5A
- Efficiency: 88 % (3.3V/3A)
- Excellent Dynamic Performances
- Buck Converter Topology
- Fixed switching frequency (400kHz)
- Integrated EMC filter
- Input Under-voltage protection
- Thermal Shutdown and Current Limit Protection
- Power Good signal for Output voltage monitoring
- Soft Start, ON/OFF Command
- Space Qualified Technology
- Radiation Hardened design
- Junction Temperature Range -40°C / +125°C
- Compact Size and Low Weight
- 14-pin gull wing SMD
- ITAR Free Product



- Size: 26.5 x 25 x 10 mm
- Mass: 15 g

### Application

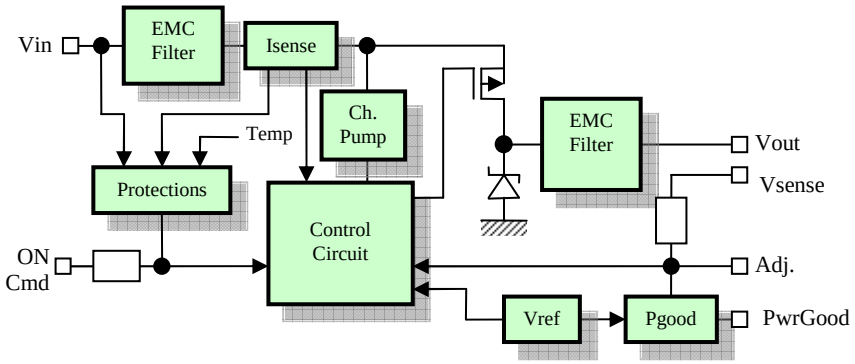
- Low voltage power distribution system for ASICs, FPGAs (ACTEL, XILINX,...) and Memory (SDRAM, DDR, DDR2,...)
- Point of Load Regulation / Distributed Power System for Space Applications

## General Description

The 3DPM0024-3 POL Converter provides high performances, high reliability, compact size and low weight for Space Applications.
Featuring specific radiation effect mitigation techniques and utilizing space design de-rating rules, the 3DPM0024-3 POL Converter is an ITAR Free product and features a SEL LETth of 80 Mev.cm2/mg and a TID of 50krad (Si).

Based on a Buck topology, the POL module uses a P channel Power MOSFET/Schottky Diode stage at 400 kHz switching frequency.
From a 5V now available on almost every digital system, the POL module provides low voltages power supplies for most of today's digital designs. Its Output voltage is adjusted from 1.5V to 4V by an external resistor. A very high speed control loop keeps the output voltage within regulation under the high transient load swings commonly found in high speed modern ASICs, FPGAs and Memory devices.
The POL Module is fully protected against output overload, input under-voltage and internal over heating. The external ON/OFF command and Soft Start function enable any power supply ON/OFF sequencing.
Power Good signal is available for module survey and may be used for Power on Reset.
Input and output EMC filters are integrated to simplify module implementation directly on the digital board with only one additional component (resistor for output voltage adjustment).

## Bloc Diagram



## Absolute Maximum Ratings

*Operation beyond the following limits may cause module degradation, reliability reduction or permanent damage.*

| *Parameter* | *Conditions* | *Min* | *Typ* | *Max* | *Unit* |
|---|---|---|---|---|---|
| Input Voltage | Continuous | -0.3 | | 6 | V |
| ON Command | Continuous | -0.3 | | 6 | V |
| Output Current | - | Internally Limited | | | A |
| Storage Temperature | - | -55 | | +150 | °C |

## Recommended Operating Conditions

*For proper operation, the module should be used within the recommended operating conditions.*

| *Parameter* | *Conditions* | *Min* | *Typ* | *Max* | *Unit* |
|---|---|---|---|---|---|
| Input Voltage | Continuous | 4.75 | 5 | 5.25 | V |
| ON Command | Continuous | 0 | | 5.25 | V |
| Output Current | - | 0 | | 5 | A |
| Output Power | Continuous | | | 17 | W |
| Junction Temperature | - | -40 | | +125 | °C |
| Thermal Resistance ($\theta_{JC}$) | - | | | 15 | °C/W |

## Mechanical and Environmental Specification

| *Parameter* | *Conditions* | *Typ* | | | *Unit* |
|---|---|---|---|---|---|
| Weight | - | | 15 | | g |
| Dimensions | Overall (pin not included) | 26.5 (L) | 25 (W) | 10 (H) | mm |

| *Parameter* | *Conditions* | Min | Typ | Max | Unit |
|---|---|---|---|---|---|
| Total Irradiation Dose | - | 50 | | | Krad |
| Latch-up Immune LET Threshold | - | 80 | | | Mev.cm$^2$/mg |

| *Parameter* | *Conditions* | *Remarks* |
|---|---|---|
| Thermal Cycles | Mil-std-883 Method 1010 Condition B | 500 Cycles, -55°C/+125°C |
| High Temperature Storage | Mil-std-883 Method 1008<br>JESD22-A103-A | 2000hrs, 150°C |
| Shock | Mil-std-883 Method 2002 Condition B | Y1, 0.5 ms, 1500g |
| Sinusoidal Vibration | Mil-std-883 Method 2007 Condition A | 20Hz-2000Hz<br>peak acceleration 20g – 3 axes |
| Random Vibration | Mil-std-883 Method 2026 Condition I | Level H/J |
| HAST | JEDEC STD 22TMA110 | 264 hrs, +110°C |
| Outgazing | ESA-PSS-01-702 MA | TML&RML<1%, CVCM<0,1% |
| Lead Integrity | Mil-std-883 Method 2004 | |
| Solderability | Mil-std-883 Method 2003 | |
| Marking Permanency | Mil-std-883 Method 2015 | |

## Input Specifications

*Parameters are defined over the specified input voltage, output load and temperature range unless otherwise noted.*

| *Parameter* | *Conditions* | *Min* | *Typ* | *Max* | *Unit* |
|---|---|---|---|---|---|
| Input Characteristics | | | | | |
| Input Voltage Range | | 4.75 | | 5.25 | V |
| Input Current in OFF State | | | 16 | 20 | mA |
| Input Current in ON State | Vin = 5V, Vout = 3.3V, no load | | 30 | 40 | mA |
| ON Command Characteristics | | | | | |
| ON Voltage (Von) | | 2.4 | 3.3 | 3.9 | V |
| OFF Voltage (Voff) | | 1 | 2.2 | 2.8 | V |
| Hysteresis | | 0.5 | 1.1 | 1.8 | V |
| Input impedance | | 4.8 | 50 | | kΩ |

## Output Specifications

*Parameters are defined over the specified input voltage, output load and temperature range unless otherwise noted.*

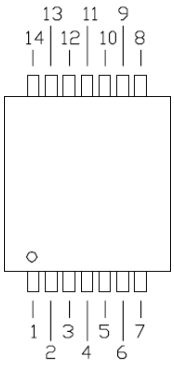
| *Parameter* | *Conditions* | *Min* | *Typ* | *Max* | *Unit* |
|---|---|---|---|---|---|
| Output Characteristics | | | | | |
| Output Voltage range | | 1.5 | | 4 | V |
| Set-point Accuracy | -40°C to 100°C | -1.1 | | 1.4 | % |
| Load Regulation | min to max load | | | 0.4 | % |
| Ageing drift | 10 years @ 50 krad | -0.25 | | 0.25 | % |
| Start-up time | ON cmd -> PGood ON | 2 | 3 | 4 | ms |
| Load Transient | Iout = +/- 3A, di/dt = 10A/µs (min DC load = 750mA) | | 65 | 80 | mV |
| Load Capacitance | | | | 650 | µF |
| Output Ripple | Measurement BW limited to 20MHz | | 35 | 60 | mVpp |
| | | | 5 | 10 | mVrms |
| Switching Frequency | | 370 | 400 | 430 | kHz |
| Efficiency | Vin = 5V, Vout = 3.3V / Iout = 3A | 86.5 | 88.2 | | % |
| | Vin = 5V, Vout = 3.3V / Iout = 5A | 85 | 86.8 | | % |
| PGOOD (Power Good) signal | | | | | |
| Output Voltage Threshold | Falling threshold (Vout ok) | 92 | 95.6 | 97 | % |
| | Rising threshold (Vout ko) | 92.5 | 93 | 93.5 | % |
| Active Voltage Level | Sink current = 1mA | | | 1.1 | V |

## Protections

*Parameters are defined over the specified input voltage, output load and temperature range unless otherwise noted.*

| *Parameter* | *Conditions* | *Min* | *Typ* | *Max* | *Unit* |
|---|---|---|---|---|---|
| Overload Protection | | | | | |
| Maximum output Current | Before POL switch OFF | 5 | 6 | 7.4 | A |
| Under-voltage Protection | | | | | |
| Input UVD | | 4.35 | 4.45 | 4.60 | V |
| UVD hysteresis | | 180 | 200 | 205 | mV |
| Under-voltage Protection | | | | | |
| Internal thermal shutdown temperature | | 115 | 125 | 135 | °C |

## Pin definition & assignments




Pin 1, 2, 10 & 11: GND
Reference grounds for the POL module.
Have to be connected on large PCB ground plane for optimal heat dissipation.

Pin 3, 4 & 5: Vin
Input voltage pins. DC supply for the POL Module. These are input pins.

Pin 6: PGOOD
Power Good Open collector signal. Signal used to survey POL correct operation. Pulled to ground when the POL module is running correctly. In open state when the output voltage is not within ±5% of regulation point. This is an output pin.

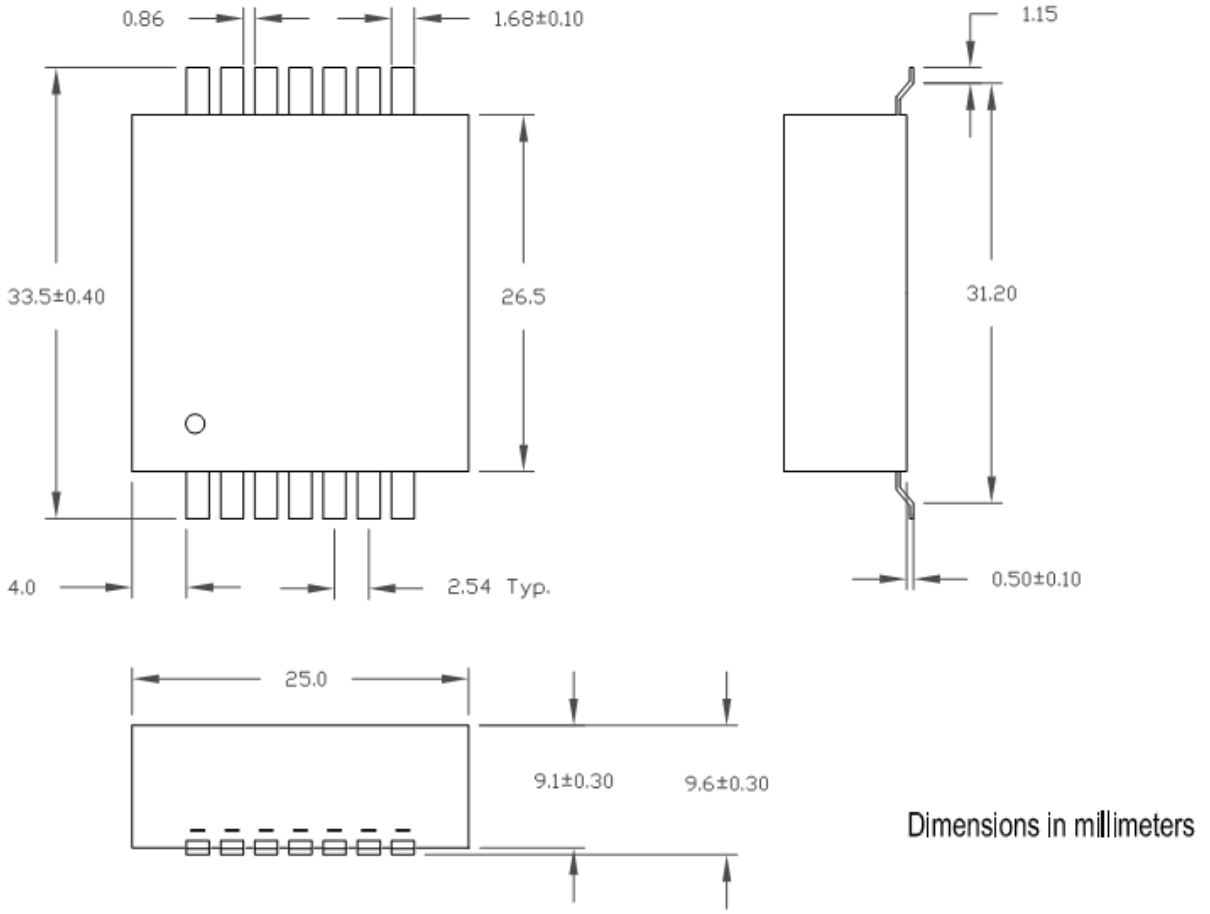
Pin 7: ON
ON command pin. When left unconnected or when applied voltage is low, the POL converter is in OFF state. To start the POL, a high level voltage has to be applied on this pin.
When POL is OFF, voltage to apply on the ON command pin to start the POL must be greater than 3.3V typical.
When POL is ON, voltage to apply on the ON command pin to stop the POL must be lower than 2.2V typical.
This is an input pin.

Pin 8: Vadj.
Adjustment pin used to set output voltage regulation point. A resistor connected to ground is used for voltage adjustment. This resistor has to be located close to the POL module with short PCB tracks to minimise risk of noise coupling. This is an output pin.

Pin 9: Vsense
Sense pin. Used to sense the output voltage for improved accuracy. Can be connected to Vout pin for local sensing or connected to Vout at load location for remote sensing. This is an input pin.

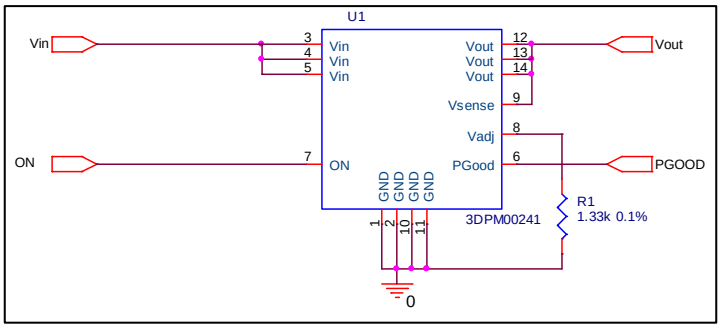
Pin 12, 13 & 14: Vout
Output voltage pins. This is the output supply provided by the POL module to power the load. These are output pins.

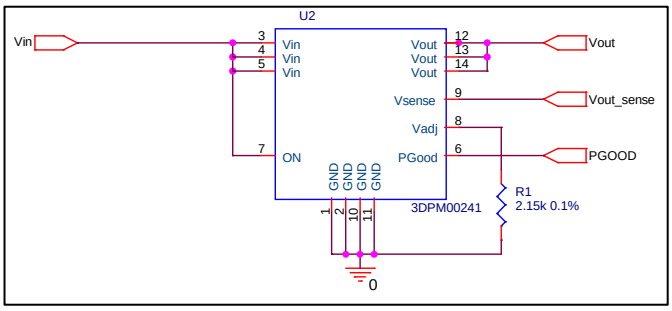
## Module Mechanical Drawing



## Typical application schematic

Case 1:
Typical application schematic.
POL can be commanded ON by application of a voltage greater than 3.3V on the ON pin.
Output voltage is locally sensed by Vsense.
Vout is set to 3.3V by selecting R1 = 1.33kΩ.




Case 2:
POL is always ON (ON pin to Vin).
Voltage is regulated at load level through the Vout_sense pin which is connected to Vout at load location. This improves load regulation by removing influence of track path resistance between the POL and the load (for high current applications).
Vout is set to 2.5V by selecting R1 = 2.15kΩ.

## Output Voltage Setting

Output voltage is adjusted by setting a resistor value between Vadj and ground. A 0.1% (25 ppm) resistor is recommended to meet output voltage accuracy performances.

Resistor value is selected according to the following table:

| Vout | Radj (kOhm) | Vout | Radj (kOhm) | Vout | Radj (kOhm) |
|---|---|---|---|---|---|
| 1,5 | 10,00 | 2,6 | 2,01 | 3,7 | 1,12 |
| 1,6 | 7,38 | 2,7 | 1,88 | 3,8 | 1,08 |
| 1,7 | 5,83 | 2,8 | 1,76 | 3,9 | 1,03 |
| 1,8 | 4,81 | 2,9 | 1,65 | 4 | 1,00 |
| 1,9 | 4,10 | 3 | 1,56 | | |
| 2 | 3,57 | 3,1 | 1,48 | | |
| 2,1 | 3,16 | 3,2 | 1,40 | | |
| 2,2 | 2,84 | 3,3 | 1,33 | | |
| 2,3 | 2,58 | 3,4 | 1,27 | | |
| 2,4 | 2,36 | 3,5 | 1,22 | | |
| 2,5 | 2,15 | 3,6 | 1,17 | | |

Example:

- for Vout = 1.5V, uses Radj = 10kΩ
- for Vout = 1.8V, uses Radj = 4.81kΩ
- for Vout = 2.5V, uses Radj = 2.15kΩ
- for Vout = 3.3V, uses Radj = 1.33kΩ

## Features description

Selected topology for the POL module is a Buck regulator. It uses a P channel MOSFET for the high side switch and a schottky diode to improve the efficiency.

The buck regulator works at a fixed switching frequency of 400kHz to minimize module dimensions.
This rather high switching frequency allows maximizing voltage regulation bandwidth to offer very good dynamic performances in case of output current transients. This is very important when the POL module is used to power last generation of digital loads which change their power demand very rapidly.

EMC filters at converter input and output are integrated into the module to avoid the use of external filters which take PCB area and make converter design and integration much more difficult.

Output voltage can be adjusted to the user needs by adding a simple resistor between the Vadjust pin and ground (see table provided before).

POL module is fully protected against output overload.
Internal input under-voltage detection and internal over temperature protection are also integrated to offer robust power supply solution (see next section for more details).

ON signal is available for POL ON/OFF command. This external command can also be used to control voltage sequencing in multiple power supplies application (to avoid risk of load latch up).

Output voltage profile during start-up is controlled by the internal soft start function. Voltage profile is the same whatever is the output load. This allows having a close control of the time delay between ON command and final output voltage value.

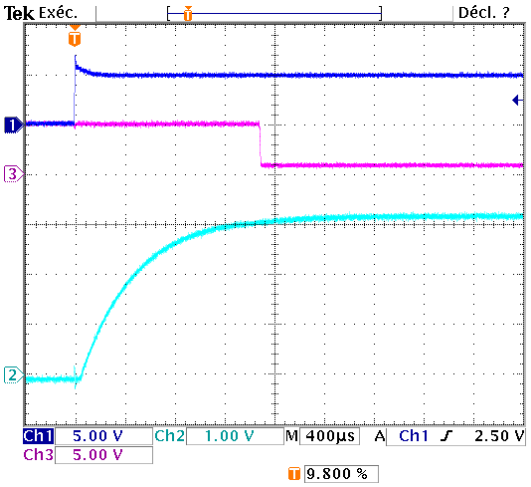



**Figure 1: POL Start-up by TC ON**

**CH1 = ON, CH2 = Vout, CH3 = PGood**

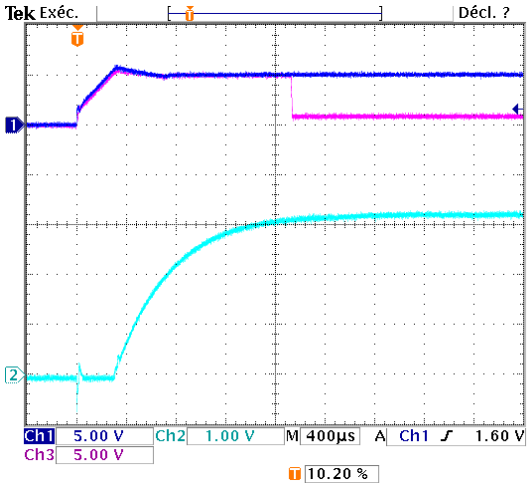



**Figure 2: POL Start-up at power up**

**CH1 = Vin, CH2 = Vout, CH3 = PGood**

If ON command is connected to Vin, POL module starts automatically at Vin application. Start-up time is a bit longer (additional delay before output voltage starts due to internal function initialisation).

Power Good status is provided for fine converter monitoring. This signal can also be used to reset digital loads.

## Protections

Overload protection:

POL monitors its output current and trigs the overload protection if output current threshold is exceeded. Typical current threshold is 6A.

When in overload conditions, POL is switched OFF after about 200µs. It automatically restarts under the control of the soft-start function every about 3ms to check if the abnormal condition is still present.

This low operating duty cycle in overload condition allows controlling POL internal temperature and applied thermal cycles to the power parts. Thanks to this low duty cycle operation, the POL can run in overload condition without reliability reduction.

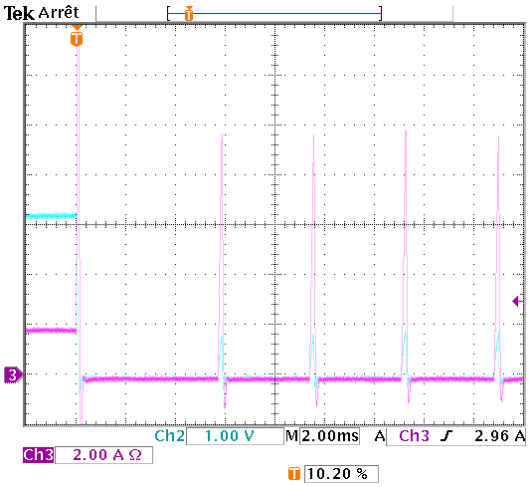



**Figure 3: Short circuit application**

**CH2 = Vout, CH3 = Iout**

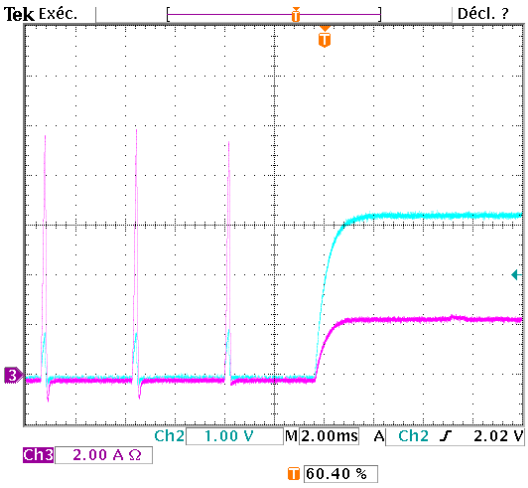



**Figure 4: Short circuit is removed**

**CH2 = Vout, CH3 = Iout**

As soon as overload condition is removed, the POL recovers normal condition.

Again, voltage profile is controlled by the soft-start function as in case of normal operation.

Input under-voltage protection:

POL input voltage is monitored by the under-voltage protection.
POL is commanded OFF if input voltage is lower than 4.45V typical. When in OFF state, a minimum voltage of 4.65V is needed for the POL to restart. This voltage difference (called hysteresis) avoids oscillation between ON and OFF states at low input voltage.

Internal over-temperature protection:

Internal POL temperature is monitored by the over-temperature protection. Thermal sensor is located close to the most dissipative parts (Power MOSFET and Schottky diode).
If internal temperature at sensor point is greater than 125°C, POL is commanded OFF. It restarts automatically as soon as temperature decreases by at least 5°C.

## EMC

POL implements internally input and output filters for easier compliance to EMC requirements. No external filters are required to operate the POL module.

Output filter:

Output filter is designed to almost cancel all output noise.

Observed typical noise when POL is heavily loaded is lower than 40mVpp and less than 5mV rms.

Main noise is at POL switching frequency that is 400kHz.

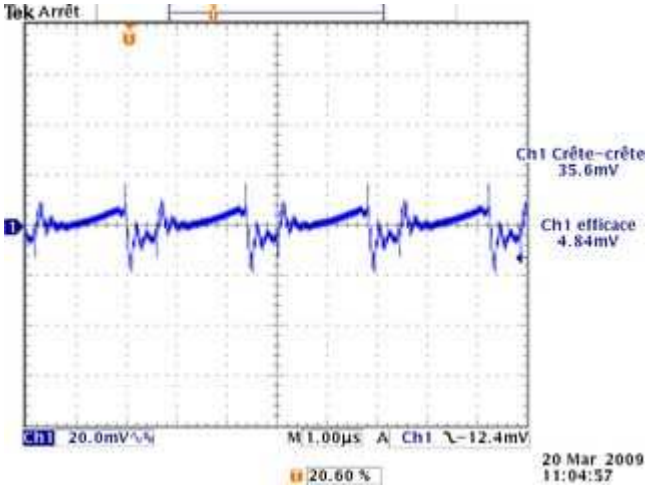



**Figure 5: Output noise Vout = 3.3V – 3A load**

Input Filter:

Input filter is implemented to limit input ripple current draw from the 5V DC supply.

Ripple current reduction is function of the input parasitic inductance presented by the PCB tracks that carries the 5V supply from the source to the POL module.

In most practical situation, the parasitic inductance is high enough to make input current DC.

In worst case situation, min parasitic inductance is estimated to 20nH (1cm PCB track for go and return). In this very worst case condition, ripple current at switching frequency is limited to 350mA rms for a POL module fully loaded.

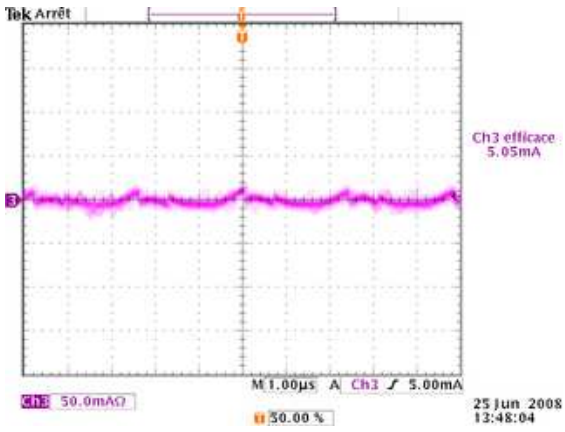



**Figure 6: Practical reflected input current**

## Layout Recommendations

POL module shall be mounted over a large ground plane to minimize thermal resistance (gap filler under to module recommended).

Large tracks shall be used for Vin and Vout connections.

Because of high speed regulation loop, Radj shall be located close to the module with short PCB tracks to avoid noise coupling on this line.

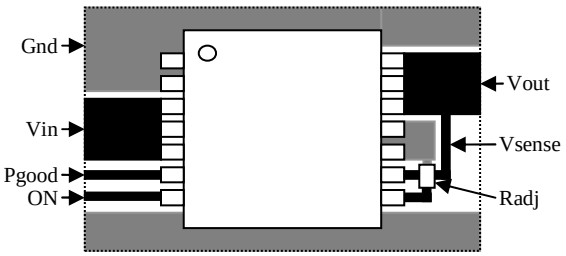



**Figure 7: Suggested Module Layout and tracking**

## Efficiency and Input Current

Efficiency:

Figure 8 gives the typical measured POL module efficiency for the most common output voltages that is 3.3V, 2.5V and 1.5V.
Efficiency is given for output current ranging from 0.5A to 5A.

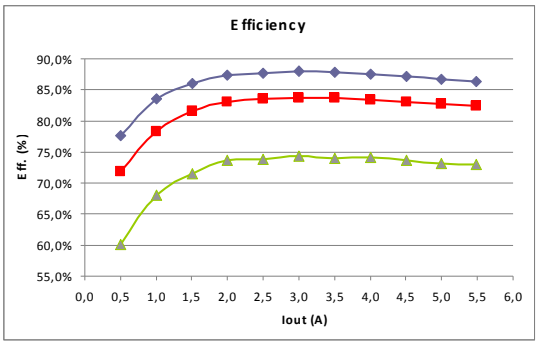



**Figure 8: Efficiency vs output load (Vin = 5V)**

**Vout = 3.3V (Blue) / 2.5V (Red) / 1.5V (green)**

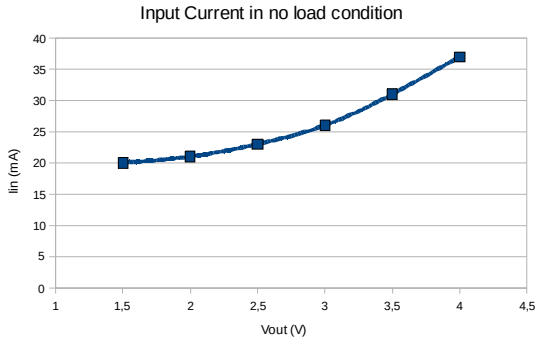



**Figure 9: Input current - No load**

Input current:

Input current when POL is ON but not loaded varies with the selected output voltage.
Typical measured input current is given in Figure 9.

## Part Number / Ordering Information

3DPM0024-3-XX

Temperature Range
- C : 0°C /+70°C
- I : -40°C / + 85°C
- S : -40°C / +95°C

Quality Grade (Screening Level)
- N : Commercial
- B : Industrial
- S : Space

## Main Sales Office

| | | | | | |
|---|---|---|---|---|---|
| **FRANCE** | 3D PLUS<br>641, rue Hélène Boucher ZI.<br>78532 BUC Cedex | Tel : 33 (0)1 30 83 26 50 | Fax : 33 (0)1 39 56 25 89 | Web : www.3d-plus.com<br>e-mail : sales@3d-plus.com | |
| **USA** | 3D PLUS U.S.A, Inc<br>2570 Eldorado Parcway<br>Suite 150<br>Mckinney, TX 75070 | Tel : (214) 733-8505 | Fax : (214) 733-8506 | e-mail : jquinn@3d-plususa.com | |