LM5072 12Vout 25W PoE PD Power Eval-Board for IP Camera

National Semiconductor
LM5072
Honsun Tan
February 2008

1.0 Design Specifications

Inputs	Output #1
VinMin=38V	Vout1=12V
VinMax=60V	Iout1=2.1A

2.0 Design Description

This LM5072 25W PoE PD Power Eval-board is specially designed for IP Net Cameras powered by PoE. As the PD side's power converter of a PoE system, this Eval-board converts 48Vdc to 12Vdc to directly power the motor driver for the IP Net Camera's body rotation and zoom lens. Other regulators such as LM26400 from National Semiconductor can be used to convert the 12Vdc to 3.3Vdc, 2.5Vdc, 1.8Vdc and 1.2Vdc to power the processor of an IP Net Camera as shown in figure 11. This board can provide total power up to 25W as specified by the PoE Plus IEEE802.3at standard. In addition, this Eval-board can be interfaced to any PSE that follows detection and classification procedures defined by the IEEE802.3af standard. In summary, this Eval-board is the ideal solution for a Pre-PoE Plus IP Net Camera application.

This design has 2 auxilliary inputs to allow use of inexpensive 12Vdc and 24Vac regulated adapters to take advantage of the LM5072's versatile auxiliary power options. 12Vdc power can by provided to the load, bypassing the LM5072, by connecting a 12Vdc regulated adapter to the 12V AUX Input Port.

When regulated 12Vdc is available, it can be delivered directly to the load, bypassing the LM5072, by connecting to the 12V AUX Input Port. When the regulated 12Vdc is present at the 12V AUX input port before 48V PoE voltage is present, the PoE startup signature detection resistance of the PD is significantly reduced. This signals the PSE to not deliver power to the PD. If 12Vdc is added after 48V PoE voltage is present, the PD signature resistance changes and will signal the PSE to stop providing power to the PD. In either case the regulated 12Vdc will turn off the LM5072 and can reduce power losses from the converter and the PoE line.

The LM5072's RAUX configuration is utilized for the 24V AUX input port to bypass the internal hot swap MOSFET allowing the 800mA current limit of the LM5072 to be ignored. This allows the input voltage for the 24V AUX input port to go down to 16Vdc and up to 60Vdc. A key function for automatic selection of supply Dominance Option is implemented for the 24V AUX input port. By connecting pin 1 and pin 2 by a jumper, as shown in figure 4, the 24V AUX is made to be the dominant input voltage, even if 48V PoE input voltage is present. Alternatively, if pin 2 and pin 3 are jumpered, as shown in figure 4, the LM5072 will be placed in non-dominance mode.

The theory and general application of PoE is beyond the scope of this document. For detailed PoE information, please see the LM5072 datasheet.

This document includes a schematic, BOM, layout and detailed test results.

3.0 Features

Energy Efficient Eval-Board

DC/DC converter efficiency of 89% at PoE 48Vin with 25W Load.
Overall efficiency of 85.5% at PoE 48Vin with 25W load.
DC/DC converter efficiency of 90% at 24Vin with 25W load.
Overall efficiency of 89% at 24Vin with 25W load.

Versatile Input Power Options

PoE input Port: 38Vdc-60Vdc range with PoE interface.
24V AUX input Port: 24Vac from inexpensive 24Vac adapter or 16Vdc-60Vdc range
12V AUX input Port: Regulated 12Vdc from inexpensive 12Vdc adapter.

Full Protection for PoE

Compliant 802.3af PD interface
Inrush current limit.
Accurate 800mA over current protection.
Short-circuit protection, hiccup mode.
Input UVLP with 7V hysteresis, 37V on and 30V shutdown
LED indicates power from PoE

Uses Standard Transformer FA2900 from Coilcraft

This Eval-board is easily modified to 3.3Vdc, 5Vdc, 9Vdc and 15Vdc output with standard Coilcraft transformers FA2677, FA2898, FA2899 and FA2901 respectively.

4.0 Schematic

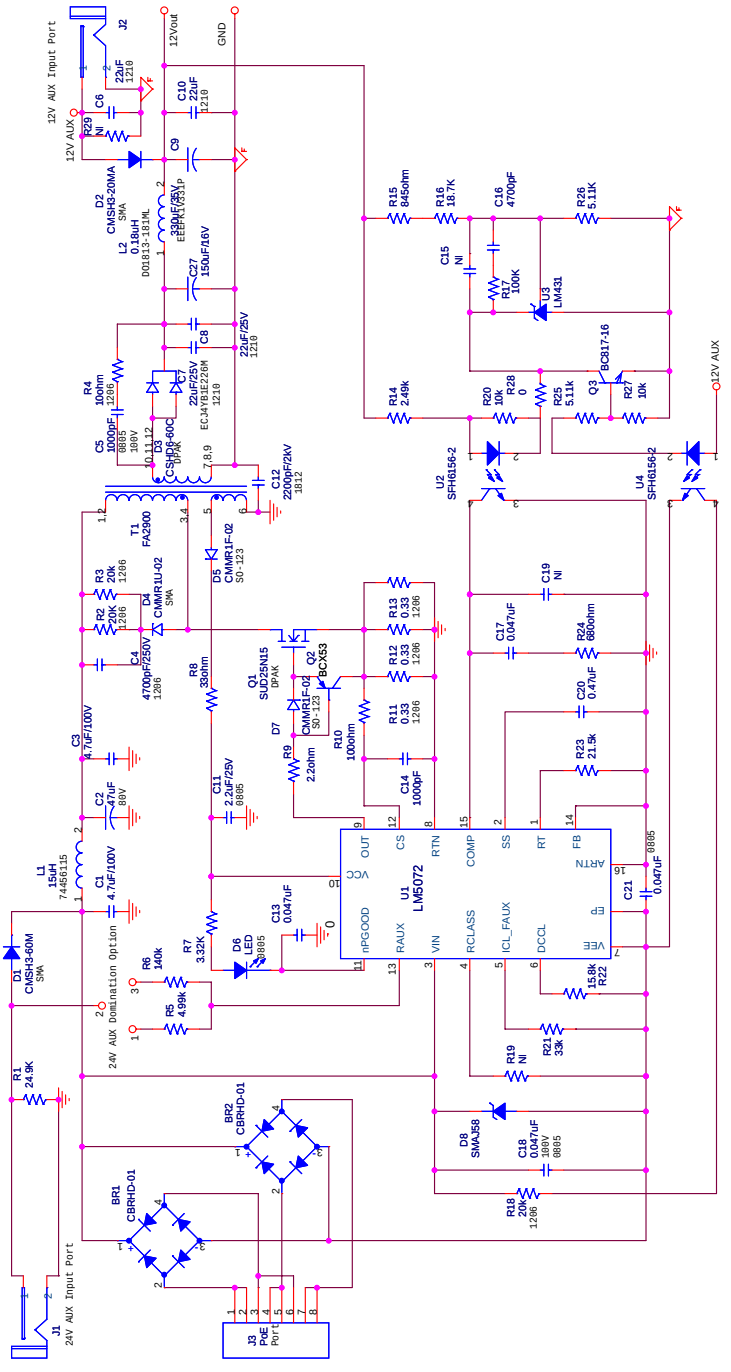


FIGURE 1. Schematic

5.0 Bill of Materials

Designtor	Part Type	Footprint	Description	Manufacture
BR1, BR2	CBRHD-01,0.8A/100V	SMD-HD	Bridge diode	Central Semiconductor
C1	4.7uF/100V Cap	SMD 2220	Ceramic X7R C5750X7R2A475K	TDK
C2	47uF/80V Cap	SMD	Aluminum Eletrolytic Capacitor EEETG1K470UP	Panasonic
C3	4.7uF/100V Cap	SMD 2220	Ceramic X7R C5750X7R2A475K	TDK
C4	4700pF/250V Cap	SMD 1206	Ceramic X7R C3216X7R2E472K	TDK
C5	1000pF/100V Cap	SMD 0805	Ceramic X7R C2012X7R2A103K	TDK
C6,C7,C8,C10	22uF/25V Cap	SMD 1210	Ceramic X7R ECJ4YB1E226M	Panasonic
C9	330uF/35V Cap	SMD	Aluminum Eletrolytic Capacitor EEEFK1V331P	Panasonic
C11	2.2uF/25V Cap	SMD 0805	Ceramic X7R	Murata
C12	2200pF/2KV Cap	SMD 1812	Ceramic X7R C4532X7R3D222K	TDK
C13	0.047uF/50V Cap	SMD 0603	Ceramic X7R	Murata
C14	1000pF/50V Cap	SMD 0603	Ceramic X7R	Murata
C15	NI	SMD 0603	Ceramic X7R	Murata
C16	4700pF/50V Cap	SMD 0603	Ceramic X7R	Murata
C17	0.047uF/50V Cap	SMD 0603	Ceramic X7R	Murata
C18	0.047uF/100V Cap	SMD 0805	Ceramic X7R	Murata
C19	NI	SMD 0603	Ceramic X7R	Murata
C20	0.47uF/50V Cap	SMD 0603	Ceramic X7R	Murata
C21	0.047uF/100V	SMD 0805	Ceramic X7R	Murata
C27	150uF/16V Cap	SMD	150uF/16V ; 293D157_016E2_E3	Vishay
D1	3A/60V Diode	SMA	Schottky Diode CMSH3-60M	Central Semiconductor
D2	3A/20V Diode	SMA	Schottky Diode CMSH3-20MA	Central Semiconductor
D3	6A/60V Diode	DPAK	Schottky Diode CSHD6-60C	Central Semiconductor
D4	1A/200V Diode	SMA	Ultra-fast Diode CMMR1U-02	Central Semiconductor
D5,D7	1A/200V Diode	SMA	Ultra-fast Diode CMMR1U-02	Central Semiconductor
D6	LED	SMD 1206	20mA LED	
D8	ZVS	SMA	SMAJ58	Diodes
J1, J2	Jacket		DC Power Jacket	
J3	PCRJ458-2		RJ45 Jacket,	Coilcraft
L1	15uH Inductor	SMD	74456115	Wurth
L2	Inductor, 0.18uH,	SMD	DO1813H-181ML	Coilcraft
Q1	25A/150V MOSFET	D-pak	N-Type MOSFET SUD25N15	Vishay
Q2	BCX53	SMD	PNP Transistor,	Philips
Q3	BC817	SOT23	NPN Transistor	Vishay
R1	24.9K	SMD 0805	Resistor	Vishay
R2,R3	20K	SMD 1206	Resistor	Vishay
R4	10ohm	SMD 1206	Resistor	Vishay
R5	4.99K	SMD 0805	Resistor	Vishay
R6	140K	SMD 0805	Resistor	Vishay
R7	3.32k	SMD 0805	Resistor	Vishay
R8	33ohm	SMD 0805	Resistor	Vishay
R9	2.2ohm	SMD 0603	Resistor	Vishay
R10	100ohm	SMD 0603	Resistor	Vishay
R11,R12,R13	0.33ohm	SMD 1206	Resistor	Vishay
R14	2.49k	SMD 0603	Resistor	Vishay
R15	845ohm	SMD 0603	Resistor	Vishay
R16	18.7K	SMD 0603	Resistor	Vishay
R17	100K	SMD 0603	Resistor	Vishay
R18	20K	SMD 1206	Resistor	Vishay
R19	NI	SMD 0603	Resistor	Vishay
R20	10K	SMD 0603	Resistor	Vishay
R21	33K	SMD 0603	Resistor	Vishay
R22	15.8K	SMD 0603	Resistor	Vishay
R23	21.5K	SMD 0603	Resistor	Vishay
R24	680ohm	SMD 0603	Resistor	Vishay
R27	1K	SMD 0603	Resistor	Vishay
R25, R26	5.11K	SMD 0603	Resistor	Vishay
R28	0ohm	SMD 0603	Resistor	Vishay
R29	NI			
T1	EFD20	SMD	Main transformer FA2900	Coilcraft
U1	LM5072MH-80	SMD TSSOP	Integrated PoE Chip:	National Semiconductor
U2,U4	SFH6156-2	SMD	Optocoupler,	NEC
U3	LM431AIM3	SMD SOT23	2.5V Shunt Voltage Reference	National Semiconductor
Spare PCB				

bom

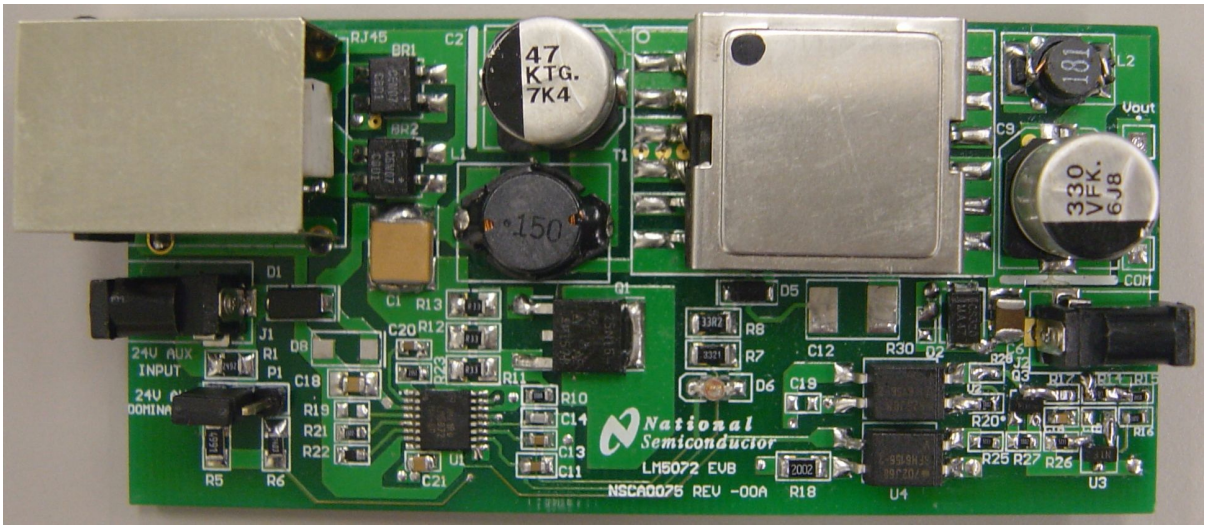
FIGURE 2. BOM

6.0 Other Operating Values

Operating Values

Description	Parameter	Value	Unit
Modulation Frequency	Frequency	250	KHz
Total output power	Pout	25	W
Steady State Efficiency	Efficiency	85	%
Control scheme	Control scheme	current Mode	
Peak-to-peak ripple voltage	Vout p-p	50	mV
Static load regulation	Static load	100	mV
Dynamic load regulation	Dynamic load	250	mV

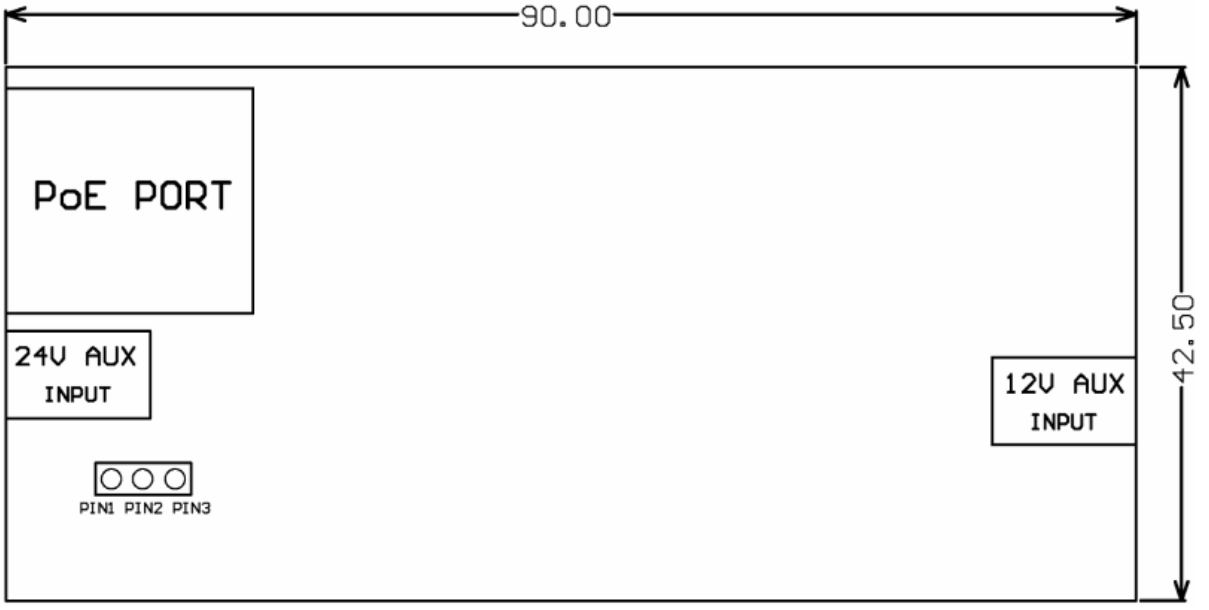
7.0 Board Photos



boardphoto1

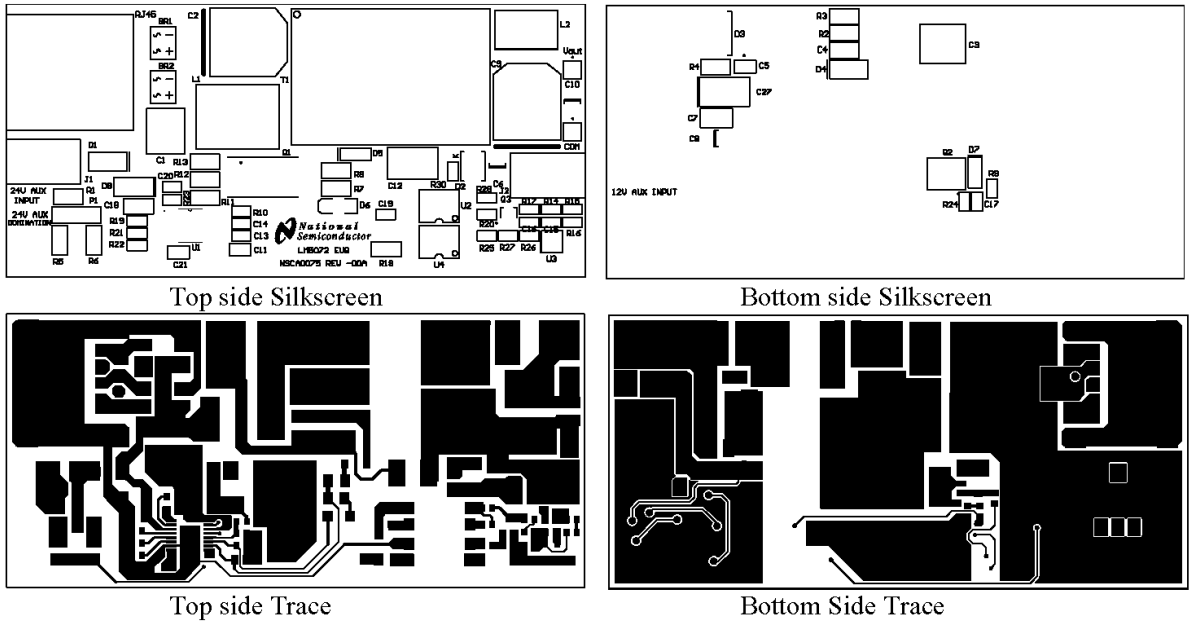
FIGURE 3. Eval-board Photo

8.0 Layouts



layout

FIGURE 4. PCB Board Outline



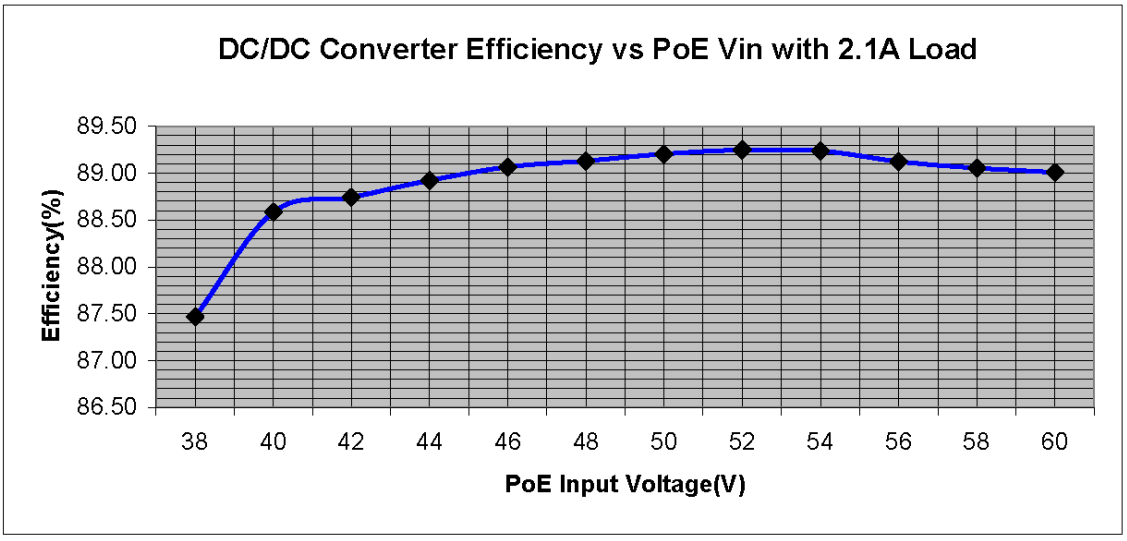
layout1

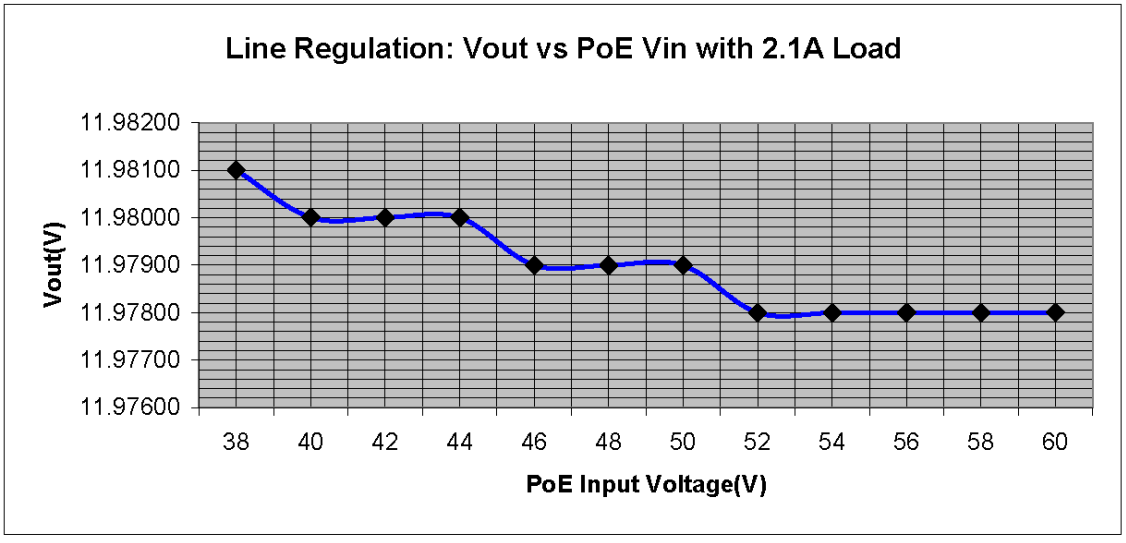
FIGURE 5. Layout Drawing

9.0 Waveforms

DC/DC Converter Efficiency vs PoE Vin with 2.1A Load(Not including the diode Bridges)

Vin (V)	Iin (A)	Pin (W)	Vout (V)	Iout (A)	Pout (W)	Ploss (W)	Efficiency (%)	Remark
38	0.757	28.766	11.981	2.1	25.1601	3.6059	87.46	
40	0.710	28.400	11.98	2.1	25.1580	3.2420	88.58	
42	0.675	28.350	11.98	2.1	25.1580	3.1920	88.74	
44	0.643	28.292	11.98	2.1	25.1580	3.1340	88.92	
46	0.614	28.244	11.979	2.1	25.1559	3.0881	89.07	
48	0.588	28.224	11.979	2.1	25.1559	3.0681	89.13	
50	0.564	28.200	11.979	2.1	25.1559	3.0441	89.21	
52	0.542	28.184	11.978	2.1	25.1538	3.0302	89.25	
54	0.522	28.188	11.978	2.1	25.1538	3.0342	89.24	
56	0.504	28.224	11.978	2.1	25.1538	3.0702	89.12	
58	0.487	28.246	11.978	2.1	25.1538	3.0922	89.05	
60	0.471	28.260	11.978	2.1	25.1538	3.1062	89.01	



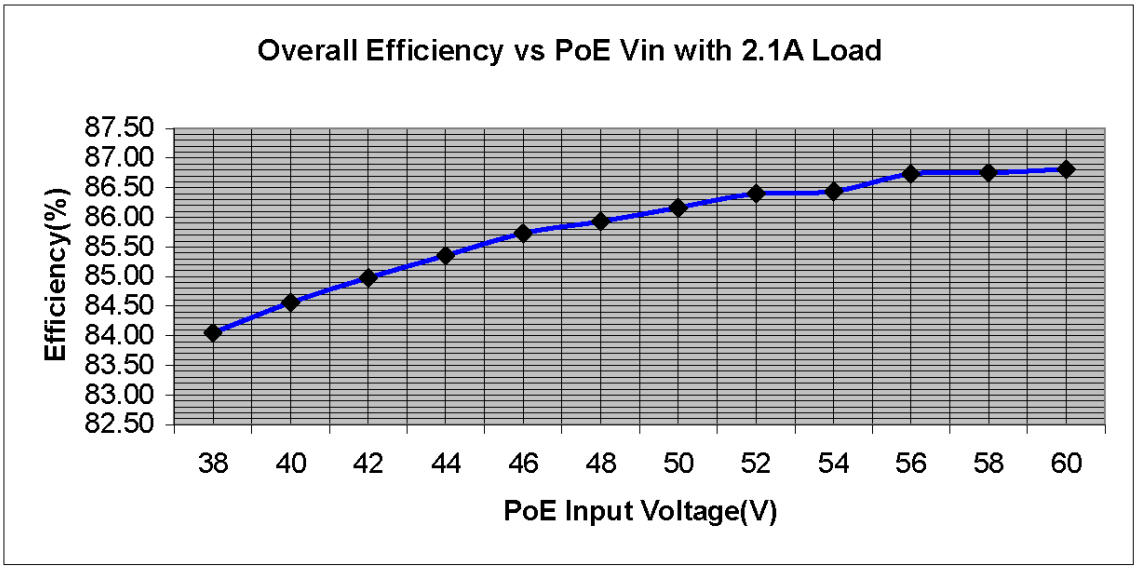


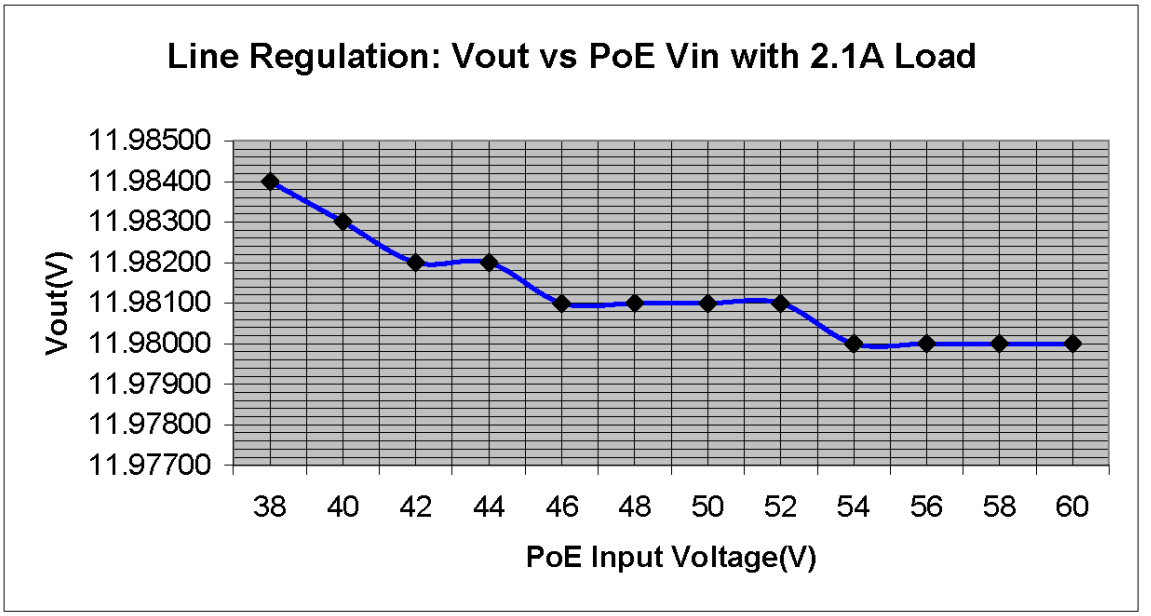
waveform

FIGURE 6. DC to DC Converter Efficiency at PoE Input

Overall Efficiency vs PoE Vin with 2.1A Load(Including the diode Bridges)

Vin (V)	Iin (A)	Pin (W)	Vout (V)	Iout (A)	Pout (W)	Ploss (W)	Efficiency (%)	Remark
38	0.788	29.944	11.984	2.1	25.1664	4.7776	84.04	
40	0.744	29.760	11.983	2.1	25.1643	4.5957	84.56	
42	0.705	29.610	11.982	2.1	25.1622	4.4478	84.98	
44	0.670	29.480	11.982	2.1	25.1622	4.3178	85.35	
46	0.638	29.348	11.981	2.1	25.1601	4.1879	85.73	
48	0.610	29.280	11.981	2.1	25.1601	4.1199	85.93	
50	0.584	29.200	11.981	2.1	25.1601	4.0399	86.16	
52	0.560	29.120	11.981	2.1	25.1601	3.9599	86.40	
54	0.539	29.106	11.98	2.1	25.1580	3.9480	86.44	
56	0.518	29.008	11.98	2.1	25.1580	3.8500	86.73	
58	0.500	29.000	11.98	2.1	25.1580	3.8420	86.75	
60	0.483	28.980	11.9800	2.1	25.1580	3.8220	86.81	

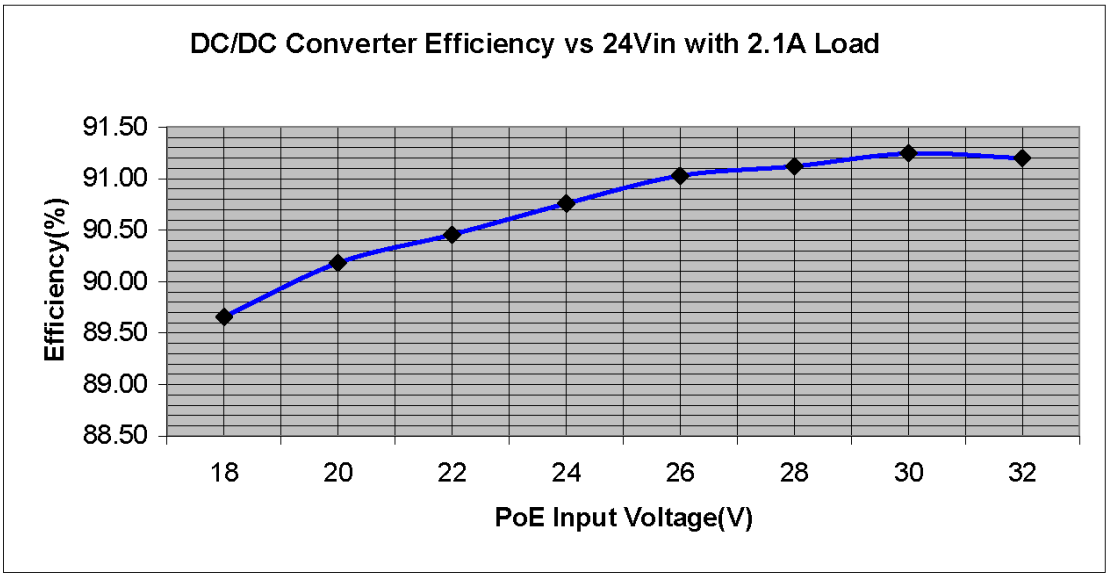


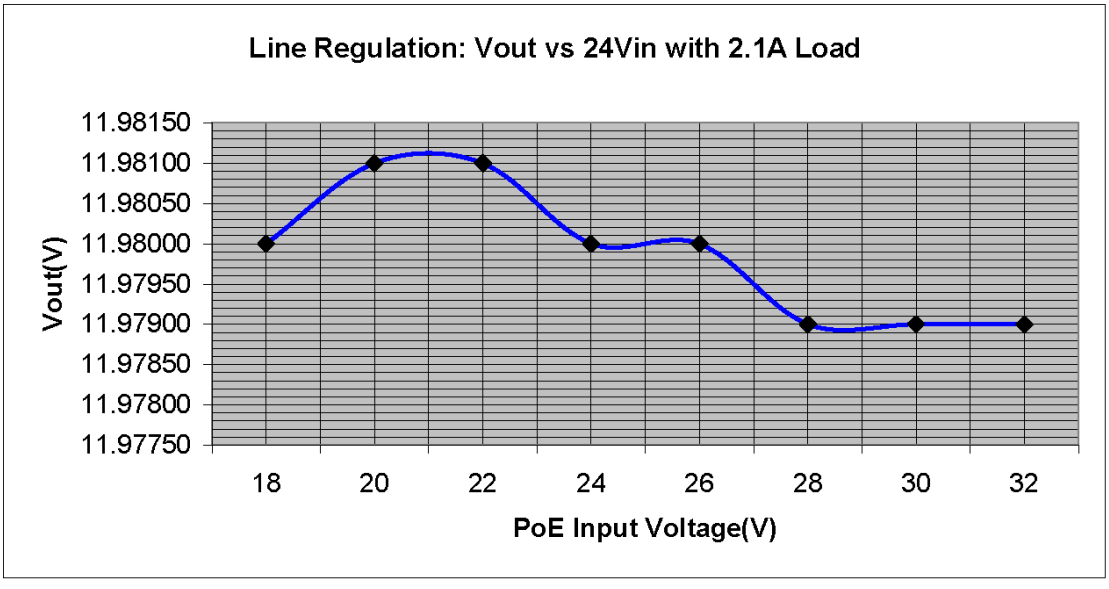


waveform1

DC/DC Converter Efficiency vs 24Vin with 2.1A Load(Not including the Oring diode)

Vin (V)	Iin (A)	Pin (W)	Vout (V)	Iout (A)	Pout (W)	Ploss (W)	Efficiency (%)	Remark
18	1.558	28.044	11.973	2.1	25.1433	2.9007	89.66	
20	1.395	27.900	11.981	2.1	25.1601	2.7399	90.18	
22	1.264	27.815	11.981	2.1	25.1601	2.6545	90.46	
24	1.155	27.720	11.98	2.1	25.1580	2.5620	90.76	
26	1.063	27.638	11.98	2.1	25.1580	2.4800	91.03	
28	0.986	27.608	11.979	2.1	25.1559	2.4521	91.12	
30	0.919	27.570	11.979	2.1	25.1559	2.4141	91.24	
32	0.862	27.584	11.979	2.1	25.1559	2.4281	91.20	



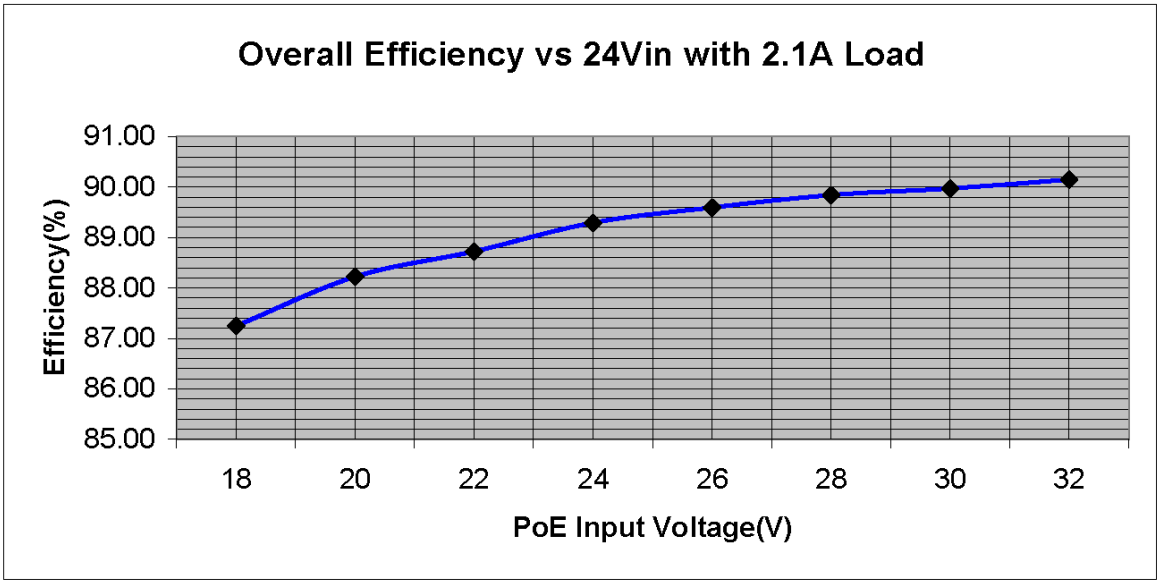


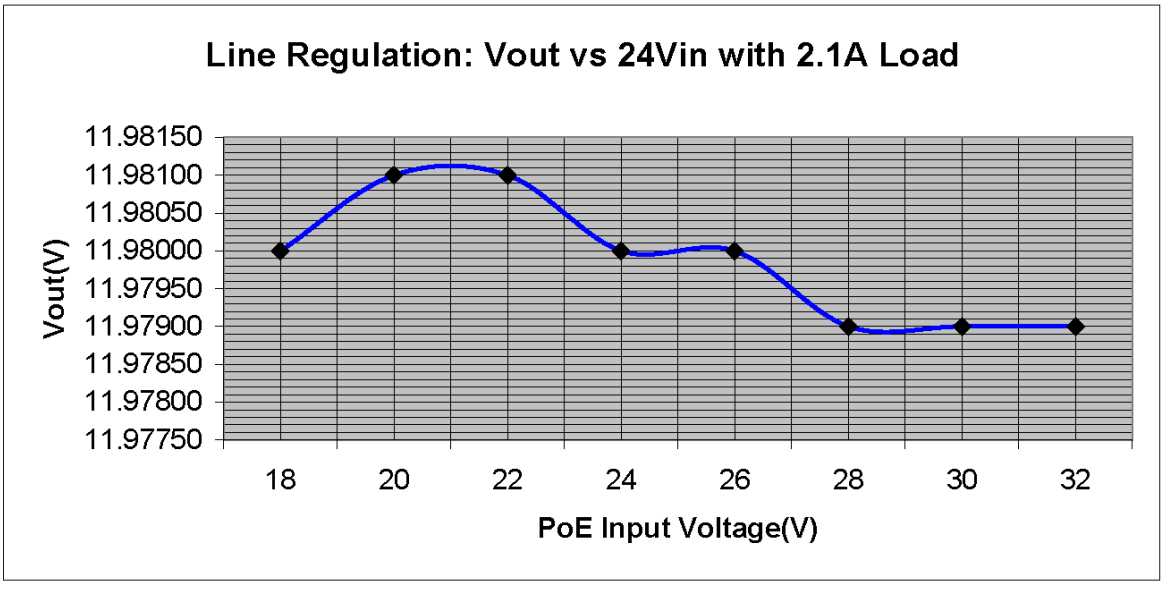
waveform2

FIGURE 8. DC to DC Converter Efficiency at 24V AUX Input

Overall Efficiency vs 24Vin with 2.1A Load(Including the Oring diode)

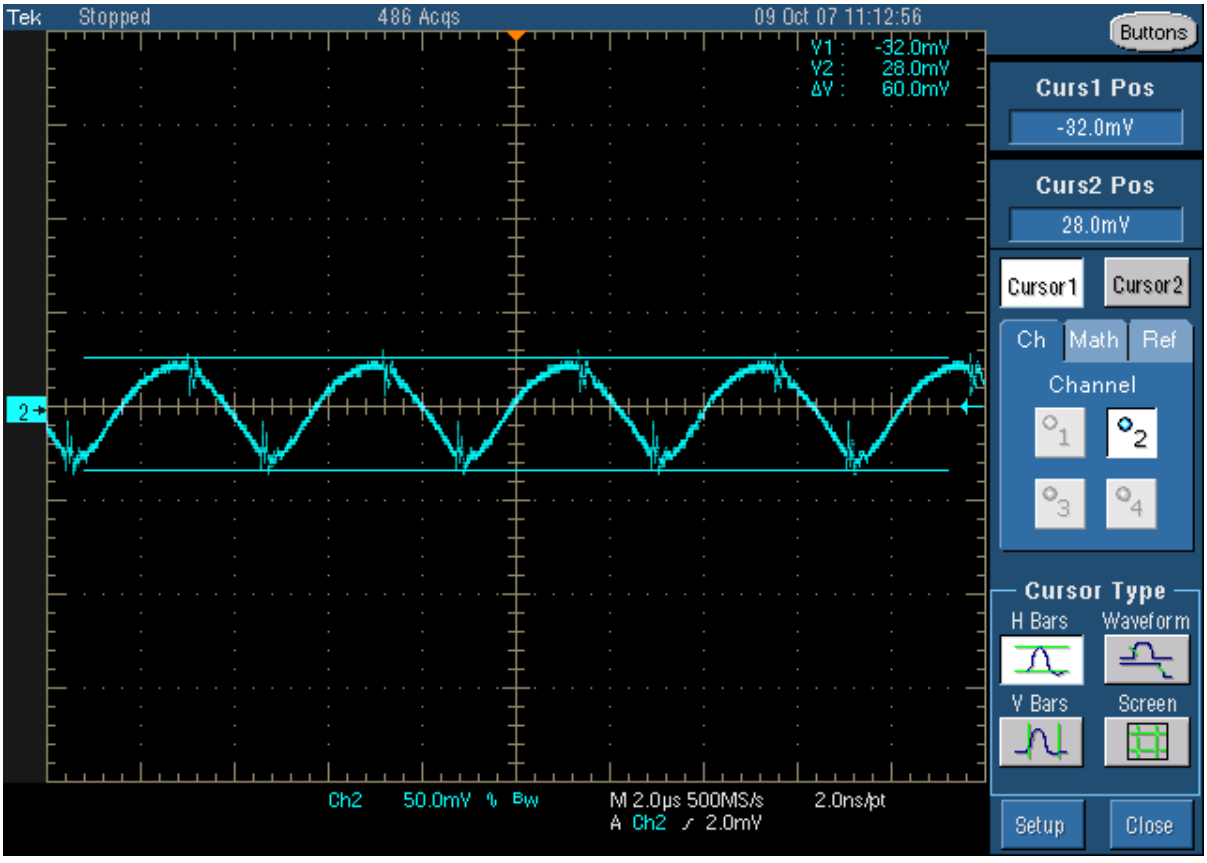
Vin (V)	Iin (A)	Pin (W)	Vout (V)	Iout (A)	Pout (W)	Ploss (W)	Efficiency (%)	Remark
18	1.602	28.836	11.98	2.1	25.1580	3.6780	87.25	
20	1.426	28.520	11.981	2.1	25.1601	3.3599	88.22	
22	1.289	28.358	11.981	2.1	25.1601	3.1979	88.72	
24	1.174	28.176	11.98	2.1	25.1580	3.0180	89.29	
26	1.080	28.080	11.98	2.1	25.1580	2.9220	89.59	
28	1.000	28.000	11.979	2.1	25.1559	2.8441	89.84	
30	0.932	27.960	11.979	2.1	25.1559	2.8041	89.97	
32	0.872	27.904	11.979	2.1	25.1559	2.7481	90.15	





waveform3

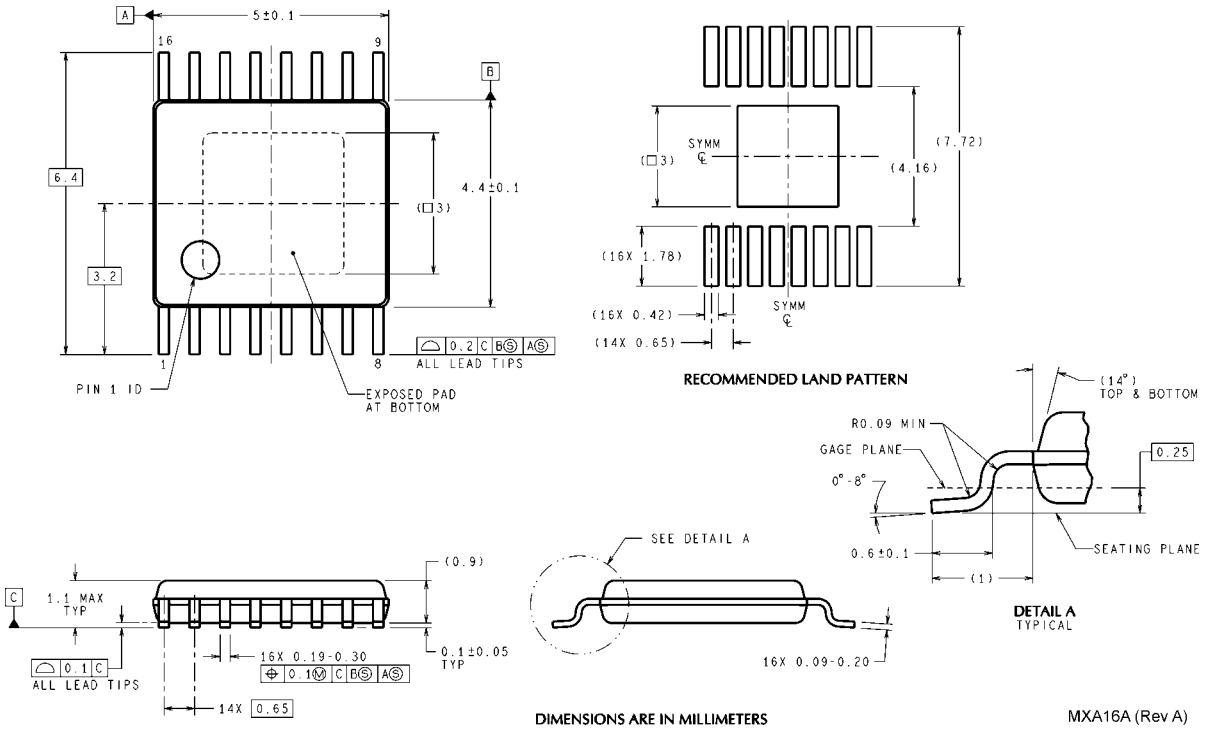
FIGURE 9. Overall Efficiency at 24V AUX Input



waveform4

FIGURE 10. Ripple and Noise

10.0 Physical Dimensions inches (millimeters) unless otherwise noted



11.0 Appendix

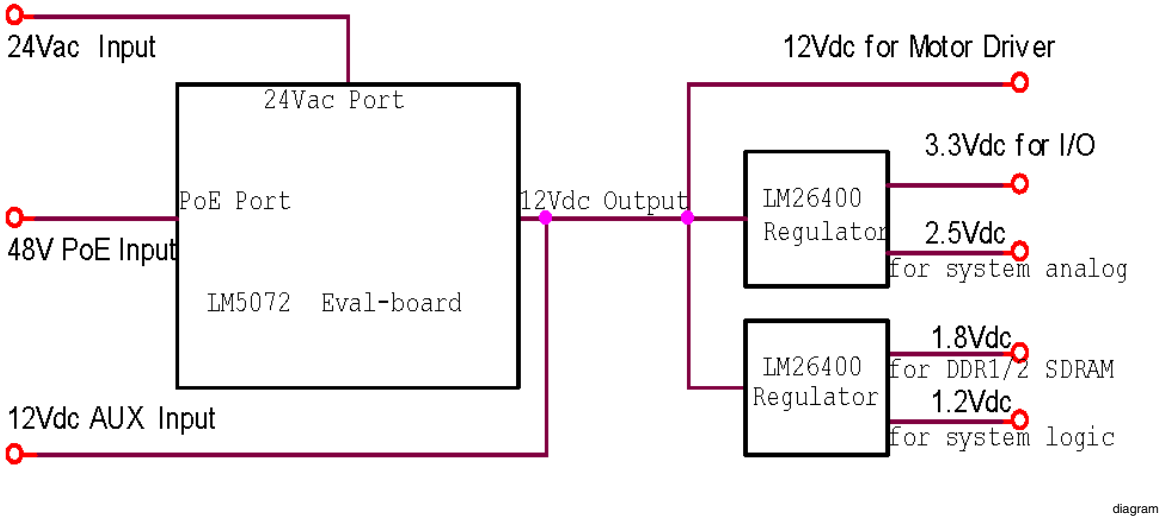


FIGURE 11. Power Block Diagram for IP Camera

Notes

National Semiconductor Americas Customer Support Center
Email: new.feedback@nsc.com
Tel: 1-800-272-9959

National Semiconductor Europe Customer Support Center
Fax: +49 (0) 180-530-85-86
Email: europe.support@nsc.com
Deutsch Tel: +49 (0) 69 9508 6208
English Tel: +49 (0) 870 24 0 2171
Français Tel: +33 (0) 1 41 91 8790

National Semiconductor Asia Pacific Customer Support Center
Email: ap.support@nsc.com

National Semiconductor Japan Customer Support Center
Fax: 81-3-5639-7507
Email: jpn.feedback@nsc.com
Tel: 81-3-5639-7560

STANDARD TERMS AND CONDITIONS FOR EVALUATION MODULES

1. *Delivery:* TI delivers TI evaluation boards, kits, or modules, including any accompanying demonstration software, components, or documentation (collectively, an “EVM” or “EVMs”) to the User (“User”) in accordance with the terms and conditions set forth herein. Acceptance of the EVM is expressly subject to the following terms and conditions.

   1.1 EVMs are intended solely for product or software developers for use in a research and development setting to facilitate feasibility evaluation, experimentation, or scientific analysis of TI semiconductors products. EVMs have no direct function and are not finished products. EVMs shall not be directly or indirectly assembled as a part or subassembly in any finished product. For clarification, any software or software tools provided with the EVM (“Software”) shall not be subject to the terms and conditions set forth herein but rather shall be subject to the applicable terms and conditions that accompany such Software

   1.2 EVMs are not intended for consumer or household use. EVMs may not be sold, sublicensed, leased, rented, loaned, assigned, or otherwise distributed for commercial purposes by Users, in whole or in part, or used in any finished product or production system.

2 *Limited Warranty and Related Remedies/Disclaimers*:

   2.1 These terms and conditions do not apply to Software. The warranty, if any, for Software is covered in the applicable Software License Agreement.

   2.2 TI warrants that the TI EVM will conform to TI's published specifications for ninety (90) days after the date TI delivers such EVM to User. Notwithstanding the foregoing, TI shall not be liable for any defects that are caused by neglect, misuse or mistreatment by an entity other than TI, including improper installation or testing, or for any EVMs that have been altered or modified in any way by an entity other than TI. Moreover, TI shall not be liable for any defects that result from User's design, specifications or instructions for such EVMs. Testing and other quality control techniques are used to the extent TI deems necessary or as mandated by government requirements. TI does not test all parameters of each EVM.

   2.3 If any EVM fails to conform to the warranty set forth above, TI's sole liability shall be at its option to repair or replace such EVM, or credit User's account for such EVM. TI's liability under this warranty shall be limited to EVMs that are returned during the warranty period to the address designated by TI and that are determined by TI not to conform to such warranty. If TI elects to repair or replace such EVM, TI shall have a reasonable time to repair such EVM or provide replacements. Repaired EVMs shall be warranted for the remainder of the original warranty period. Replaced EVMs shall be warranted for a new full ninety (90) day warranty period.

3 *Regulatory Notices:*

   3.1 *United States*

      3.1.1 *Notice applicable to EVMs not FCC-Approved:*

      This kit is designed to allow product developers to evaluate electronic components, circuitry, or software associated with the kit to determine whether to incorporate such items in a finished product and software developers to write software applications for use with the end product. This kit is not a finished product and when assembled may not be resold or otherwise marketed unless all required FCC equipment authorizations are first obtained. Operation is subject to the condition that this product not cause harmful interference to licensed radio stations and that this product accept harmful interference. Unless the assembled kit is designed to operate under part 15, part 18 or part 95 of this chapter, the operator of the kit must operate under the authority of an FCC license holder or must secure an experimental authorization under part 5 of this chapter.

      3.1.2 *For EVMs annotated as FCC – FEDERAL COMMUNICATIONS COMMISSION Part 15 Compliant:*

      CAUTION

      This device complies with part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

      Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

      FCC Interference Statement for Class A EVM devices

      NOTE: This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense.

FCC Interference Statement for Class B EVM devices

NOTE: This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- *Reorient or relocate the receiving antenna.*
- *Increase the separation between the equipment and receiver.*
- *Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.*
- *Consult the dealer or an experienced radio/TV technician for help.*

3.2 *Canada*

3.2.1 *For EVMs issued with an Industry Canada Certificate of Conformance to RSS-210*

Concerning EVMs Including Radio Transmitters:

This device complies with Industry Canada license-exempt RSS standard(s). Operation is subject to the following two conditions: (1) this device may not cause interference, and (2) this device must accept any interference, including interference that may cause undesired operation of the device.

Concernant les EVMs avec appareils radio:

Le présent appareil est conforme aux CNR d'Industrie Canada applicables aux appareils radio exempts de licence. L'exploitation est autorisée aux deux conditions suivantes: (1) l'appareil ne doit pas produire de brouillage, et (2) l'utilisateur de l'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement.

Concerning EVMs Including Detachable Antennas:

Under Industry Canada regulations, this radio transmitter may only operate using an antenna of a type and maximum (or lesser) gain approved for the transmitter by Industry Canada. To reduce potential radio interference to other users, the antenna type and its gain should be so chosen that the equivalent isotropically radiated power (e.i.r.p.) is not more than that necessary for successful communication. This radio transmitter has been approved by Industry Canada to operate with the antenna types listed in the user guide with the maximum permissible gain and required antenna impedance for each antenna type indicated. Antenna types not included in this list, having a gain greater than the maximum gain indicated for that type, are strictly prohibited for use with this device.

Concernant les EVMs avec antennes détachables

Conformément à la réglementation d'Industrie Canada, le présent émetteur radio peut fonctionner avec une antenne d'un type et d'un gain maximal (ou inférieur) approuvé pour l'émetteur par Industrie Canada. Dans le but de réduire les risques de brouillage radioélectrique à l'intention des autres utilisateurs, il faut choisir le type d'antenne et son gain de sorte que la puissance isotrope rayonnée équivalente (p.i.r.e.) ne dépasse pas l'intensité nécessaire à l'établissement d'une communication satisfaisante. Le présent émetteur radio a été approuvé par Industrie Canada pour fonctionner avec les types d'antenne énumérés dans le manuel d'usage et ayant un gain admissible maximal et l'impédance requise pour chaque type d'antenne. Les types d'antenne non inclus dans cette liste, ou dont le gain est supérieur au gain maximal indiqué, sont strictement interdits pour l'exploitation de l'émetteur

3.3 *Japan*

3.3.1 *Notice for EVMs delivered in Japan:* Please see http://www.tij.co.jp/lsds/ti_ja/general/eStore/notice_01.page 日本国内に輸入される評価用キット、ボードについては、次のところをご覧ください。
http://www.tij.co.jp/lsds/ti_ja/general/eStore/notice_01.page

3.3.2 *Notice for Users of EVMs Considered "Radio Frequency Products" in Japan:* EVMs entering Japan may not be certified by TI as conforming to Technical Regulations of Radio Law of Japan.

If User uses EVMs in Japan, not certified to Technical Regulations of Radio Law of Japan, User is required by Radio Law of Japan to follow the instructions below with respect to EVMs:

1. Use EVMs in a shielded room or any other test facility as defined in the notification #173 issued by Ministry of Internal Affairs and Communications on March 28, 2006, based on Sub-section 1.1 of Article 6 of the Ministry's Rule for Enforcement of Radio Law of Japan,
2. Use EVMs only after User obtains the license of Test Radio Station as provided in Radio Law of Japan with respect to EVMs, or
3. Use of EVMs only after User obtains the Technical Regulations Conformity Certification as provided in Radio Law of Japan with respect to EVMs. Also, do not transfer EVMs, unless User gives the same notice above to the transferee. Please note that if User does not follow the instructions above, User will be subject to penalties of Radio Law of Japan.

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1. 電波法施行規則第6条第1項第1号に基づく平成18年3月28日総務省告示第173号で定められた電波暗室等の試験設備でご使用いただく。
2. 実験局の免許を取得後ご使用いただく。
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3.3.3 *Notice for EVMs for Power Line Communication:* Please see http://www.tij.co.jp/lsds/ti_ja/general/eStore/notice_02.page

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4 *EVM Use Restrictions and Warnings:*

4.1 EVMS ARE NOT FOR USE IN FUNCTIONAL SAFETY AND/OR SAFETY CRITICAL EVALUATIONS, INCLUDING BUT NOT LIMITED TO EVALUATIONS OF LIFE SUPPORT APPLICATIONS.

4.2 User must read and apply the user guide and other available documentation provided by TI regarding the EVM prior to handling or using the EVM, including without limitation any warning or restriction notices. The notices contain important safety information related to, for example, temperatures and voltages.

4.3 *Safety-Related Warnings and Restrictions:*

4.3.1 User shall operate the EVM within TI's recommended specifications and environmental considerations stated in the user guide, other available documentation provided by TI, and any other applicable requirements and employ reasonable and customary safeguards. Exceeding the specified performance ratings and specifications (including but not limited to input and output voltage, current, power, and environmental ranges) for the EVM may cause personal injury or death, or property damage. If there are questions concerning performance ratings and specifications, User should contact a TI field representative prior to connecting interface electronics including input power and intended loads. Any loads applied outside of the specified output range may also result in unintended and/or inaccurate operation and/or possible permanent damage to the EVM and/or interface electronics. Please consult the EVM user guide prior to connecting any load to the EVM output. If there is uncertainty as to the load specification, please contact a TI field representative. During normal operation, even with the inputs and outputs kept within the specified allowable ranges, some circuit components may have elevated case temperatures. These components include but are not limited to linear regulators, switching transistors, pass transistors, current sense resistors, and heat sinks, which can be identified using the information in the associated documentation. When working with the EVM, please be aware that the EVM may become very warm.

4.3.2 EVMs are intended solely for use by technically qualified, professional electronics experts who are familiar with the dangers and application risks associated with handling electrical mechanical components, systems, and subsystems. User assumes all responsibility and liability for proper and safe handling and use of the EVM by User or its employees, affiliates, contractors or designees. User assumes all responsibility and liability to ensure that any interfaces (electronic and/or mechanical) between the EVM and any human body are designed with suitable isolation and means to safely limit accessible leakage currents to minimize the risk of electrical shock hazard. User assumes all responsibility and liability for any improper or unsafe handling or use of the EVM by User or its employees, affiliates, contractors or designees.

4.4 User assumes all responsibility and liability to determine whether the EVM is subject to any applicable international, federal, state, or local laws and regulations related to User's handling and use of the EVM and, if applicable, User assumes all responsibility and liability for compliance in all respects with such laws and regulations. User assumes all responsibility and liability for proper disposal and recycling of the EVM consistent with all applicable international, federal, state, and local requirements.

5. *Accuracy of Information:* To the extent TI provides information on the availability and function of EVMs, TI attempts to be as accurate as possible. However, TI does not warrant the accuracy of EVM descriptions, EVM availability or other information on its websites as accurate, complete, reliable, current, or error-free.

6. *Disclaimers:*

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8. *Limitations on Damages and Liability:*

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