

## Introduction

This application note provides detailed information and circuitry design guidelines for the implementation of a single port Power over Ethernet (PoE) system, based on Microsemi's™ 1-port PSE PoE controller, the PD69101. This system operates as a standalone system.

This document enables the designer to integrate PoE capabilities, as defined by IEEE standard 802.3af-2003, into an Ethernet switch or a router.

A PD69101 based design is intended for low cost applications where PoE implementation is required but there is no need for more sophisticated features such as power management.

For easier design and development of an Ethernet Switch using the PD69101, an evaluation board (P/N PD-IM-7401) can be ordered.

## Applicable Documents

- IEEE 802.3af-2003 standard, DTE Power via MDI
- IEEE802.3at-2009 standard, DTE Power via MDI
- PD69101 Data Sheet, Catalogue Number 06-0076-058
- PD-IM-7401 Evaluation Board User Guide Catalogue Number 06-0471-056

## Background

This application note defines the stand-alone operation for a 1-port system. In this configuration, the PD69101 operates without any communication to the host.

The PD69101 PSE PoE controller implements real time functions according to IEEE 802.3af-2003 including detection, classification and port-status monitoring. The PoE controller is designed to detect and disable disconnected PDs (Powered Devices), using the DC disconnection method, as defined by the standard. Using two PoE controllers enables driving 4-pairs ports.

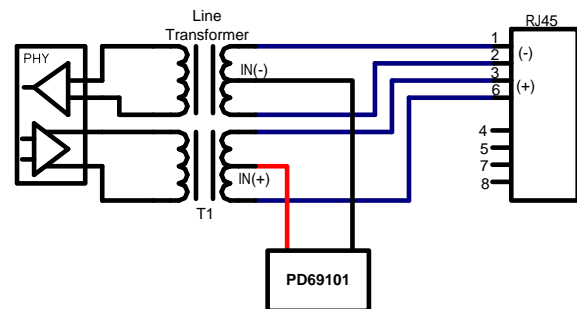
## Features

- ♦ Fully IEEE802.3af-2003 compliant
- ♦ Supports IEEE802.3at, including two-event classification
- ♦ Supports Cisco devices detection
- ♦ Supports pre-standard PD detection
- ♦ Drives independent 2-pairs power ports or synchronized 4-pairs ports (with two PD69101)
- ♦ Each PD69101 drives two direct LEDs
- ♦ Includes On/Off command pin
- ♦ Configurable load current setting
- ♦ Configurable AT/AF modes
- ♦ Each PD69101 has built in 3.3 VDC regulator
- ♦ Thermal protection
- ♦ DC disconnection method
- ♦ Voltage monitoring/protection
- ♦ Optional continuous port monitoring and system data
- ♦ RoHS compliant

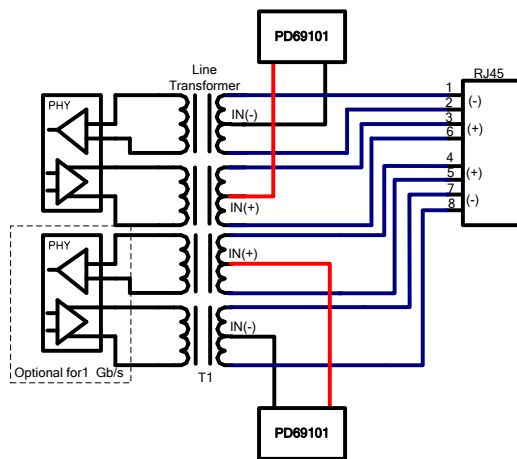
## Overall Description

The system has two main modes of operation:

- 2-pairs PoE port, based on one PD69101 controller (see Figure 1)
- 4-pairs PoE port, based on two PD69101 controllers (see Figure 2)



**Figure 1: 2 Pairs Mode**


**Figure 2: 4 Pairs Mode**

## General Circuit Description

The 1-port, 2-pair configuration shown in Figure 1 comprises one PoE manager circuit (PD69101), acting as alternative-A feeding power over the data lines. It is important to configure the PD69101 as a Master to achieve proper operation.

The 1-port configuration shown in Figure 2, comprises two PoE manager circuits (PD69101), acting as Master and Slave. The PD69101 devices are synchronized via a Sync pin connected between them. To avoid abnormal operation, set-up one circuit as a Master, with the other acting as a Slave. The device that is connected to the data lines (1, 2, 3, and 6) should be configured as the Master. This Master/Slave configuration only affects the device behavior.

### Main Supply

The PoE system operates within a range of 44 to 57 VDC. To comply with UL SELV regulations, maximum output voltage should not exceed 60 VDC.

This power must be isolated from the Switch supply and chassis by 1500 Vrms.

### Grounds

The system utilizes several grounds: chassis, digital and analog.

The **chassis ground** is connected to the switch's chassis ground. This ground plane should be 1500 Vrms isolated from the PoE circuitry.

The **digital and analog grounds** are electrically the same ground. However, to reduce noise coupling, the grounds are physically separated and connected only at a single point.

### 3.3 V and 5V Regulators

Each PD69101 includes a 3.3 VDC and 5 VDC regulator (VAUX3P3 & DRV\_VAUX3P3, VAUX5), providing up to 10mA. This current is utilized for powering the PD69101 itself and an additional 2 mA for components external to the PoE domain. Those components must also be isolated by 1500 Vrms from the switch circuitry.

### Control

A reset control signal is utilized to reset the PoE circuit and disable the port.

### Indications

The PD69101 produces a direct 2 x LED indication, utilized to indicate PoE events.

### Monitoring Mode - Communication Interface

In the monitoring mode, the PD69101 transmits out (continuously and repeatedly) the port status, current and voltage (option).

- Data Out stream is transmitted through LED 1 (pin 14)
- Clock Out stream is transmitted through LED 0 (pin 13)
- Data stream is shifted out with a 1 MHz clock (1  $\mu$ sec).

## Detailed Circuit Description

### 2 Pair Application Circuit

Refer to Figure 3.

### Mode Configuration

Set by the Mode0 and Mode1 lines (pins 21 and 22), tied to GND or 3.3 VDC. In this application the PD69101 is configured to work in the following modes:

- Master only
  - Master/Slave (pin 23) connected to 3.3 VDC
  - Apply PoE on data lines
  - SYNC (pin 18) is pulled down to AGND with a 4.7 K $\Omega$  resistor (R9)
- PoE Configuration:
  - Standard AT (AF/AT (pin 2) = 3.3 VDC, Current\_Set (pin 1) = GND)
  - IEEE802.3af/at compliant resistor detection only

- Direct LEDs drive indication (pins 13, 14)
  - The LEDs are driven from the Vmain supply.
  - MODE0, 1 (pin 21, 22) connected to DGND.

For different configurations refer to the *PD69101 Data Sheet, Catalogue Number 06-0076-058*.

### **Control Signals**

The RESET\_N line (pin 20) can be driven by the Host CPU to the PD69101 to disable the PoE port. When the PD69101 detects low level voltage at pin 20, it immediately enters RESET mode and disables the port.

When driving this line by the HOST CPU, use an opto-coupler to isolate it 1500 VDC from the Switch domain.

When using the RESET\_N pin use a 10 K $\Omega$  pull-up resistor to DVDD.

### **Indication Signals**

When Mode0 and Mode1 input pins are configured to Serial Monitoring Mode ("01"), the LED 0 and LED 1 signals can be utilized to provide the Host CPU with the following event indications (instead of direct LEDs indication):

- Port status
- Vmain measurement
- Vport measurement
- Iport measurement

To use LED 1 and LED 0 to communicate and monitor transmissions, use a 1 K $\Omega$  pull-up resistor to the DVDD. When connecting these lines to the HOST CPU, use an opto-coupler to isolate it 1500 VDC from the Switch domain.

### **VAUX3P3**

The PD69101 provides 3.3 VDC operating potential. Connect this line to the DRV\_VAUX3P3 and use 4.7 uF coupling capacitor to AGND.

The PD69101 performs a multitude of internal operations and PoE functions, requiring a bare minimum of external components. Each PD69101 handles 1 port. Figure 4 illustrates the PD69101 with related components for a 1-port configuration.

**Note** For a solution of more than one port described in this application note, multiple the circuitry shown in Figure 3.

### **Reference Current Source**

Reference for internal voltages within the PD69101 is set by a precision resistor (R4).

### **Sense Resistors**

A 0.499  $\Omega$  (1%) sense resistor is connected to the port output line. The voltage dropped over this resistor represents the port's current.

### **Front-end Circuitry**

This circuit is the PoE manager analog front end of a port.

### **Output Port**

The output port circuitry is supplied with voltage. Terminal validity is established by comparing the load resistance of the PD attached to the port (meaning the voltage transmitted at the port) to pre-defined thresholds in the PD69101.

Additional components are used for the following:

- D3 is a polarity reversal diode used to prevent the application of reversed external voltage.
- C2 is a noise suppression component.
- D4 is a pre-emption immunity protection diode.

## **4 Pair Application Circuit**

See Figure 3.

### **Mode Configuration**

Set by MODE0 and MODE 1 lines (pins 21 and 22) tied to GND or 3.3 VDC. In this application two PD69101s are configured to work in the following modes:

- Master Slave
  - Master/Slave (pin 23) connected to 3.3 VDC on the Master PD69101 and to DGND on the Slave PD69101.
  - Applies PoE on data and spear lines
  - SYNC (pin 18) pins of the Master and the Slave are connected together and pulled up to the DVDD with 4.7 K $\Omega$  resistor (R6)
- PoE Configuration:
  - Standard AT (AF/AT (pin 2) = 3.3 VDC, Current\_Set (pin 1) = GND
  - IEEE802.3af/at compliant resistor detection only

**Note** Connect Master and Slave PoE configuration must be the same for proper circuit operation.

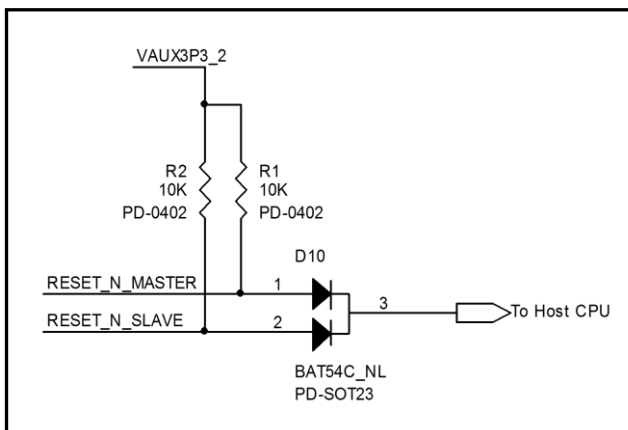
- Direct LEDs drive indication (pins 13 and 14) from the Master PD69101
  - The LEDs are driven from the Vmain supply.
  - Mode0 and Mode1 (pins 21 and 22) are connected to DGND.

For different configuration refers to PD69101 Data Sheet, Catalogue Number 06-0076-058.

### **Control Signals**

The Master RESET\_N pin is connected via a 10 K $\Omega$  pull-up resistor to the Slave 3.3 VDC ensuring that the Master does not initialize before the Slave voltage stabilizes.

The RESET\_N line (pin 20) can be driven by the Host CPU to both PD69101s to disables the PoE port (see Figure 2).



**Figure 3: PD69101 4 Pair RESET\_N**

When the PD69101 detects low level voltage at pin 20, it immediately enters the RESET mode and disables the port.

When driving this line by the HOST CPU use an opto-coupler to isolate it 1500 VDC from the Switch domain. When using the RESET\_N pin use a 10 K $\Omega$  pull-up resistor to DVDD.

### **Indication Signals**

When Mode0 and Mode1 Input pins are configured to Serial Monitoring Mode ("01") the LED0 and LED1 signals can be utilized to provide the Host CPU with the following event indications (instead of direct LEDs indication):

- Port Status
- Vmain measurement

- Vport measurement
- Iport measurement

To use LED1 and LED0 to communicate and monitor transmissions, use a 1 K $\Omega$  pull-up resistor to the DVDD.

Each PD69101 transmits its own port indications.

When connecting these lines to the HOST CPU, use an optocoupler to isolate it 1500 VDC from the Switch domain.

### **VAUX3P3**

3.3V operating potential is provided by the PD69101.

Connect this line to the DRV\_VAUX3P3 and connect a 4.7 uF coupling capacitor to AGND.

The PD69101 performs a multitude of internal operations and PoE functions, requiring a bare minimum of external components. Each PD69101 handles one port. Figure 5 shows the PD69101 with related components for a 1-port configuration.

**Note** For the solution of more than one port described in this application note, multiply the circuitry shown in Figure 5.

### **Reference Current Source**

Reference for internal voltages within the PD69101 is set by a precision resistor (R4, R7).

### **Sense Resistors**

A 0.499  $\Omega$ , (1%) sense resistor is connected to port output line. The voltage dropped over this resistor represents the port's current.

### **Front-end Circuitry**

This circuit is the PoE manager analog front end of a port.

### **Output Port**

The output port circuitry is supplied with a voltage. Terminal validity is established by comparing the load resistance of the PD attached to the port (meaning the voltage transmitted at the port) to pre-defined thresholds in the PD69101.

Additional components are used for the following:

- D3 and D5 are polarity reversal diodes, used to prevent application of reversed external voltage.
- C2 and C6 are noise suppression components.
- D4 and D6 are provision immunity protection diodes.

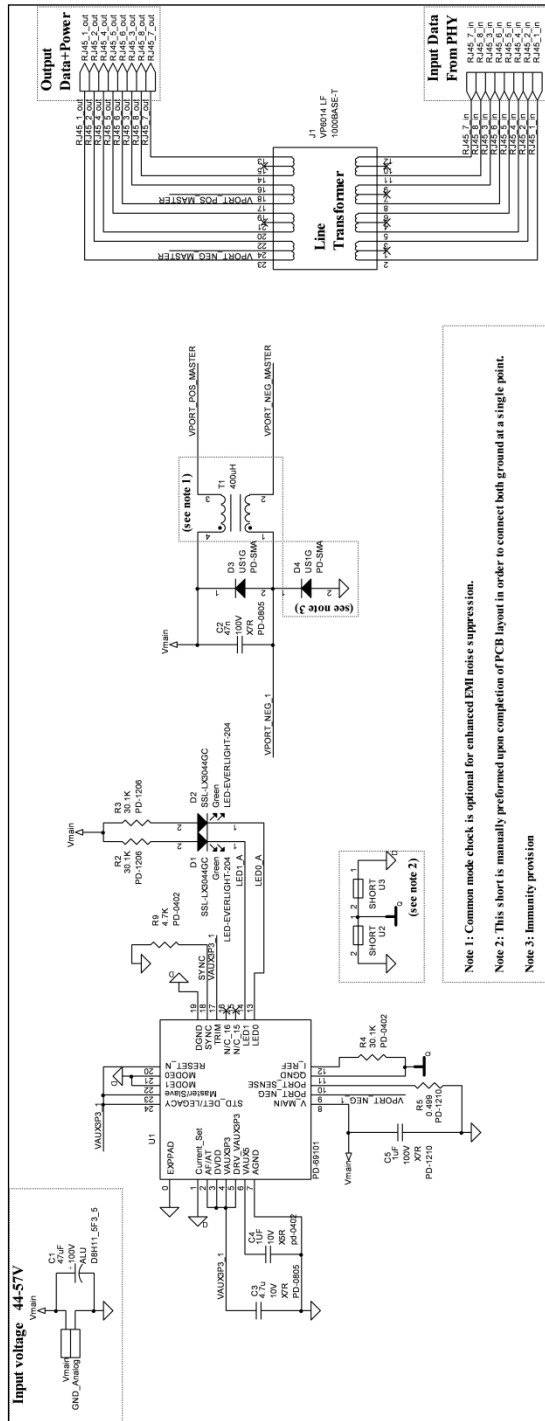


Figure 4: PD69101 2 Pair Circuitry

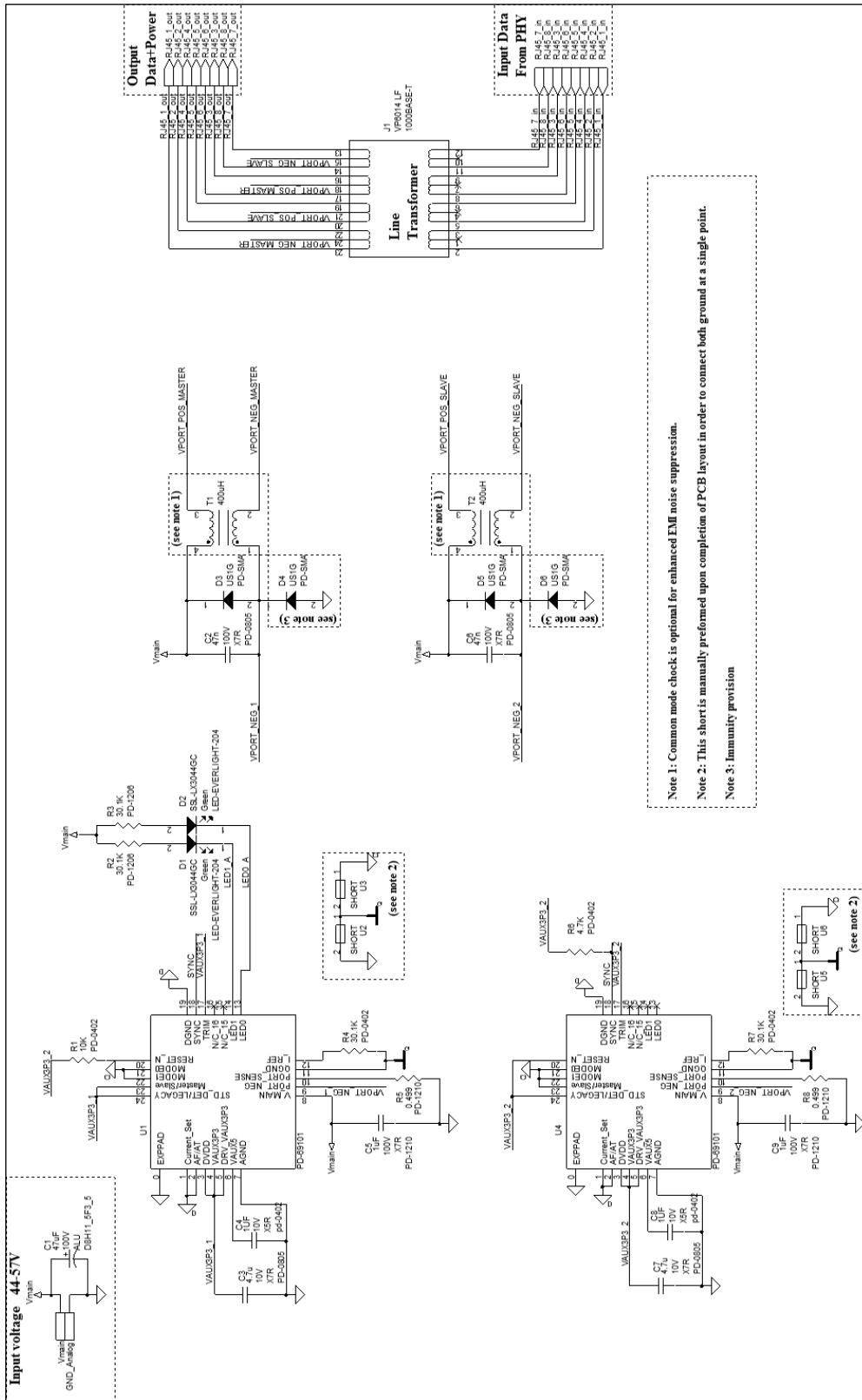


Figure 5: PD69101 4 Pair Circuitry



## Bill of Material for 2 Pair PoE Application

See Figure 4.

Qty	Reference	Footprint	Description	Manufacturer	Manufacturer's P/N
Qty	Reference	Footprint	Description	Mfr. Name	Mfr. Part Number
1	U1	PD-QFN24-4X5	1 Port PSE IC	Microsemi	PD69101
1	C3	PD-0805	CAP CRM 4.7 uF 10 V 10% X5R 0805 SMT	AVX	0805ZD475KAT2A
				Murata	GRM219R61A475KE19D
				Taiyo Yuden	LMK212BJ475KD-T
1	C2	PD-0805	CAP CRM 47 nF 100 V 10% X7R 0805 SMT	AVX	08051C473KAT2A
				Murata	GRM21BR72A473KA01L
				Novacap	0805B473K101CTM
				Samsung	CL21B473KCFNNNE
				TDK	C2012X7R2A473K
				Vishay	VJ0805Y473KXBAT
1	C4	pd-0402	CAP CER 1.0 UF 10V X5R 10% 0402	AVX	0402ZD105KAT2A
				Murata	GRM155R61A105KE15D
				Panasonic	ECJ-0EB1A105M
				Taiyo Yuden	LMK105BJ105KV-F
1	C5	PD-1210	CAP Cer 1 uF 100 V 10% X7R 1210 SMT	AVX	12101C105KAT2A
				Murata	GRM32ER72A105KA01L
				Samsung	CL32B105KCJNNNE
				TDK	C3225X7R2A105K
				Taiyo Yuden	HMK325B7105KN-T
1	C1	D8H11_5F3_5	CAP ALU 47 uF 100 V 20% 8X11.5 105C P = 3.5 mm T/H	Nichicon	UVY2A470MPD1CA
				Nippon Chemi-Con	EKMQ101ETD470MHB5D
				Panasonic	ECA2AM470
				Rubycon	100PX47M EFC T7 8X11.5
2	D3,D4	PD-SMA	Dio Rec UF 400 V 1.0 A 50 nS SMA SMT	Diodes Inc.	US1G-13-F
				TSC	US1G
				Vishay	US1G-E3/61T
1	J1	1000BASE-T	1000 Base ?T Single Port Voice Over IP Magnetics Module SMT	BOTHHAND	VP6014 LF
1	T1	COIL-10X5F5_2F2_5	Common Mode Choke 400 uH 150 m ohm T/H	Star Electronic	TB080402-400UHMIN-2P-F
2	D1,D2	LED-EVERLIGHT-204	T-1{3 mm} Solid State Lamp -P = 2.54 mm-TH	Kingbright	L-7104PGC
				Kingbright	WP7104PGC
				Lumex Opto	SSL-LX3044GC
1	R9	PD-0402	Resistor, SMT 4.7 K, 5%, 1/16 W 0402	ASJ	CR10-472JK
				Panasonic	ERJ-2GEJ472X
				Rohm	MCR01MZPJ472
				Vishay	CRCW0402 4K70JNED
				Yageo	RC0402JR-074K7L
1	R4	PD-0402	RES TCK FLM 30.1K 1% 62.5mW 0402 SMT	Panasonic	ERJ2RKF3012X
				Vishay	CRCW040230K1FKED
				Yageo	RC0402FR-0730K1L

Qty	Reference	Footprint	Description	Manufacturer	Manufacturer's P/N
2	R2,R3	PD-1206	*RES 30.1 K 250 mW 1% 1206 SMT MTL FLM	Bourns	CR1206-FX-3012ELF
				Samsung	RC3216F3012CS
				Yageo	RC1206FR-0730K1L
1	R5	PD-1210	RES TCK FLM 499 mOhm 100 PPM 0.5 W 1% 1210 SMT	KOA	SR732ETTDR499F
				Viking	CS13FTE499N



## Bill of Material for 4 Pair PoE Application

See Figure 5.

QTY	Reference	Footprint	Description	Manufacturer	Manufacturer's P/N
2	U1, U4	PD-QFN24-4X5	1 Port PSE IC	Microsemi	PD69101
2	C3,C7	PD-0805	CAP CRM 4.7 uF 10V 10% X5R 0805 SMT	AVX	0805ZD475KAT2A
				Murata	GRM219R61A475KE19 D
				Taiyo Yuden	LMK212BJ475KD-T
2	C2,C6	PD-0805	CAP CRM 47 nF 100V 10% X7R 0805 SMT	AVX	08051C473KAT2A
				Murata	GRM21BR72A473KA01 L
				Novacap	0805B473K101CTM
				Samsung	CL21B473KCFNNE
				TDK	C2012X7R2A473K
				Vishay	VJ0805Y473KXBAT
2	C4,C8	pd-0402	CAP CER 1.0 UF 10V X5R 10% 0402	AVX	0402ZD105KAT2A
				Murata	GRM155R61A105KE15 D
				Panasonic	ECJ-0EB1A105M
				Taiyo Yuden	LMK105BJ105KV-F
2	C5,C9	PD-1210	CAP CER 1 uF 100V 10% X7R 1210 SMT	AVX	12101C105KAT2A
				Murata	GRM32ER72A105KA01 L
				Samsung	CL32B105KCJNNE
				TDK	C3225X7R2A105K
				Taiyo Yuden	HMK325B7105KN-T
1	C1	D8H11_5F3_5	CAP ALU 47 uF 100 V 20% 8X11.5 105C P = 3.5 mm T/H	Nichicon	UVY2A470MPD1CA
				Nippon Chemi-Con	EKMQ101ETD470MHB5 D
				Panasonic	ECA2AM470
				Rubycon	100PX47M EFC T7 8X11.5
4	D3-D6	PD-SMA	DIO REC UF 400V 1.0A 50 nS SMA SMT	Diodes Inc.	US1G-13-F
				TSC	US1G
				Vishay	US1G-E3/61T
1	J1	1000BASE-T	1000 Base ?T Single Port Voice Over IP Magnetics Module SMT	BOTHHAND	VP6014 LF
2	T1,T2	COIL- 10X5F5_2F2_5	Common Mode Choke 400uH 150 mohm T/H	Star Electronic	TB080402-400UHMIN- 2P-F
2	D1,D2	LED- EVERLIGHT- 204	T-1{3 mm} Solid State Lamp -P = 2.54 mm-TH	Kingbright	L-7104PGC
				Kingbright	WP7104PGC
				Lumex Opto	SSL-LX3044GC
1	R1	PD-0402	Res Tck FLM 10 K 1% 62.5 mW 0402 SMT	Bourns	CR0402-FX-1002GLF
				Samsung	RC1005F1002CS
				Vishay	CRCW0402-10K0 1% ET1 E3

QTY	Reference	Footprint	Description	Manufacturer	Manufacturer's P/N
				Yageo	RC0402FR-0710KL
1	R6	PD-0402	Resistor, SMT 4.7K, 5%, 1/16W 0402	ASJ	CR10-472JK
				Panasonic	ERJ-2GEJ472X
				Rohm	MCR01MZPJ472
				Vishay	CRCW0402 4K70JNED
				Yageo	RC0402JR-074K7L
2	R4,R7	PD-0402	Res Tck FLM 30.1K 1% 62.5 mW 0402 SMT	Panasonic	ERJ2RKF3012X
				Vishay	CRCW040230K1FKED
				Yageo	RC0402FR-0730K1L
2	R2,R3	PD-1206	*Res 30.1K 250 mW 1% 1206 Smt Mtl Flm	Bourns	CR1206-FX-3012ELF
				Samsung	RC3216F3012CS
				Yageo	RC1206FR-0730K1L
2	R5,R8	PD-1210	Res Tck Flm 499 mOhm 100 PPM 0.5W 1% 1210 SMT	KOA	SR732ETTDR499F
				Viking	CS13FTER499N

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## Revision History

Revision Level / Date	Para. Affected	Description
0.1 / 03/09	-	Initial release
1.0 Dec 2013	Figure 1	PD69001 changed to PD69101

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Catalogue Number 06-0079-080

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