

## Single-Port IEEE 802.3af/at PSE Controller

### 1. Description

The MK3614H is a high-density integrated autonomous single Ethernet port power sourcing equipment (PSE) controller designed for use in IEEE 802.3af/at Power over Ethernet (PoE) systems. The device provides powered device (PD) detection, classification, current limit, load disconnect detection, and operating current levels. The device features intelligent protection circuitry and allows the delivered to PD power up to 50W. The device integrates a 0.3Ω power MOSFET and a current-sensing resistor, which enables the non-PoE protocol adapter to be feasibly retrofitted into a PSE adapter with the PoE protocol only requiring a few external components.

The MK3614H's LED pin is an open-drain output. The pin outputs simple digital logic signals, which indicate various operating statuses and fault conditions. The device supports Midspan or Endpoint mode. The Midspan mode function has a longer detection back-off timer..

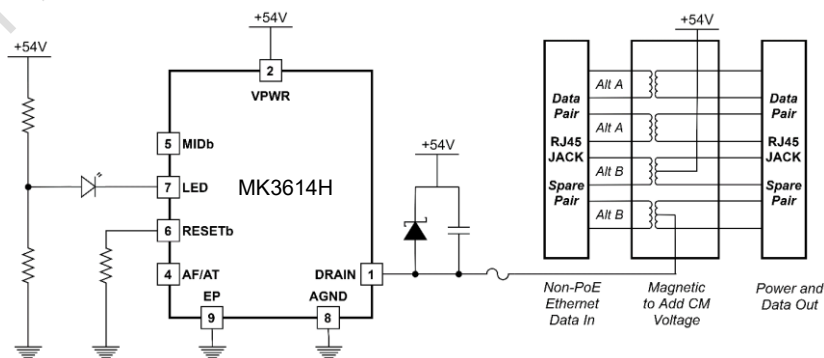
### 2. Applications

- IEEE 802.3af and 802.3at Power-Sourcing Equipment (PSE)
- Power over Ethernet Switches/Routers
- IP Phone Systems
- IP Camera Systems
- 5G Small Cells

### 3. Features

- IEEE 802.3af and 802.3at compatible
- Fully autonomous operation, no external controller required
- Up to 50W for PSE Applications
- 0.2mA standby current (Midspan mode)
- Integrated an 80V 0.3Ω power MOSFET and current-sensing resistor
- Multi-point detection
- Class 3 and Class 4 configuration
- Supports reset operation
- LED status indication
- Supports Midspan and Endpoint modes
- 8-pin ESOP-8 package with thermal pad

### 4. Typical Application

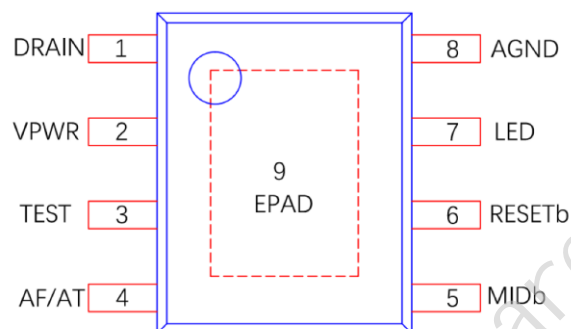


**Figure 1. Typical Application Diagram for 802.3at Midspan Configuration**

## 5. Order Information

Order Part Number	Descriptions
MK3614HGAD	ESOP-8, tape, 4k/reel

## 6. Pin Configuration and Functions



**Figure 2. Pin Function (top view)**

**Table 1. Pin Functions**

Pin		I/O	Description
NO.	Name		
1	DRAIN	Analog Power Output	MOSFET drain output.
2	VPWR	Analog Power Input	Positive PoE voltage (+44V to 57V) relative to AGND.
3	TEST	—	Connect to AGND.
4	AF/AT	Digital Input	Pull up to internal VDD rail with 10 $\mu$ A current. Connect to AGND for AF configuration, leave floating for AT configuration.
5	MIDb	Digital Input	Pull up to internal VDD rail with 10 $\mu$ A current. Connect to AGND to set 2.7 seconds detection backoff timing (Midspan), leave floating for Endpoint configuration.
6	RESETb	Digital Input	Pull up to internal VDD rail with 20 $\mu$ A current. Active low device reset input. Connect a 120k $\Omega$ to 200k $\Omega$ resistor to AGND.
7	LED	Digital Output	Open drain output pin, turn on an external LED when a PoE PD is connected and powered. Refer to LED section for more details.
8	AGND	Analog Ground	Analog ground.
9	EPAD	—	Exposed pad, it should be connected to AGND, connect to power ground plane for better thermal performance.

## 7. Specifications

### 7.1 Absolute Maximum Ratings <sup>(1)</sup>

		MIN	MAX	Units
Input voltages	VCC VPWR, DRAIN to AGND	-0.3	80	V
	LED to AGND	-0.3	35	
	TEST, AF/AT, RESETb, MIDb to AGND	-0.3	7	
Operating Junction Temperature, T <sub>J</sub>		-40	150	°C
Storage Temperature, T <sub>stg</sub>		-65	160	
Soldering Temperature (10 second), T <sub>sld</sub>			260	

**Notes:**

- (1) Stresses beyond the "ABSOLUTE MAXIMUM RATINGS" may cause permanent damage to the device. These are stress ratings only, which do not imply functional operation of the device at these or any other conditions beyond those indicated in "RECOMMENDED OPERATING CONDITIONS". Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

### 7.2 ESD Ratings

		Value	Units
Electrostatic discharge V <sub>ESD</sub>	Human body model (HBM), per ANSI/ESDA/JEDEC JS-001 <sup>(1)</sup>	500	V
	Charged device model (CDM), per JEDEC specification JESD22-C101 <sup>(2)</sup>	2000	V

**Notes:**

- (1) JEDEC document JEP155 states that 500V HBM allows safe manufacturing with a standard ESD control process
- (2) JEDEC document JEP157 states that 250V CDM allows safe manufacturing with a standard ESD control process

### 7.3 Recommended Operating Conditions

		MIN	MAX	Units
Recommended Operation Conditions	VPWR, DRAIN to AGND	32	60	V
	LED to AGND	0	30	
	TEST, AF/AT, MIDb, RESETb, MIDb to AGND	0	5.5	
	Junction Temperature	-40	+125	°C

### 7.4 Thermal Information

		Value	Units
Package Thermal Resistance	$\theta_{JA}$ (Junction to ambient)	30	°C/W
	$\theta_{JC}$ (Junction to case)	10	

## 7.5 Electrical Characteristics

Conditions are  $-40^{\circ}\text{C} < T_J < 125^{\circ}\text{C}$ ,  $V_{PWR} = 54\text{ V}$  unless otherwise noted. Typical values are at  $25^{\circ}\text{C}$ . All voltages are with respect to AGND unless otherwise noted.

Parameter		Test Conditions	MIN	TYP	MAX	UNIT
Power Supply Voltages						
V <sub>UVLO_ON</sub>	V <sub>PWR</sub> UVLO Input Voltage		25.5	28	—	V
V <sub>UVLO_OFF</sub>	V <sub>PWR</sub> UVLO Input Voltage		—	31	33.5	V
Power Supply Currents <sup>(1)</sup>						
I <sub>PWR</sub>	V <sub>PWR</sub> Supply Current	During normal operation (Detection + Idle), MIDb=Float	—	0.45	—	mA
		During normal operation (Detection + Idle), MIDb=GND	—	0.2	—	mA
Detection Specifications						
I <sub>DET_SC</sub>	Detection Short Circuit Current	Measured when DRAIN is shorted to V <sub>PWR</sub>	—	1.5	5	mA
V <sub>PORT</sub>	Detection Voltage When R <sub>DET</sub> = 24 kΩ	V <sub>PWR</sub> - V <sub>DRAIN</sub> , primary detection voltage	2.8	4	—	V
		V <sub>PWR</sub> - V <sub>DRAIN</sub> , secondary detection voltage	—	8	10	V
T <sub>DET</sub>	Detection Time		—	320	—	ms
T <sub>IDLE</sub>	Detection Idle Time	MIDb=Float	—	315	—	ms
		MIDb=GND	—	2700	—	ms
R <sub>GOOD</sub> <sup>(1)</sup>	Signature Resistance		—	25	—	kΩ
R <sub>DET_MIN</sub> <sup>(1)</sup>	Minimum Signature Resistance @ PD		15	17	19	kΩ
R <sub>DET_MAX</sub> <sup>(1)</sup>	Maximum Signature Resistance @ PD		26.5	30	33	kΩ
C <sub>REJECT</sub>	Reject Signature Capacitance		—	2.2	10	μF
Classification Specifications						
V <sub>CLASS</sub>	Class Event Voltage	V <sub>PWR</sub> - V <sub>DRAIN</sub> , Class current between 0 and 51 mA	15.5	—	20.5	V

$I_{CLASS\_LIM}$	Class Event Current Limitation	Measured when DRIAN is shorted to VPWR	51	—	95	mA
$T_{CLE}$	Class Event Timing	Assigned PD Class 0, 1, 2, 3, 4	6	—	30	ms
$I_{CLASS\_REGION}$	Classification Current Region	Class Signature 0	0	—	5	mA
		Threshold between Class Signature 0 or 1	5	—	8	mA
		Class Signature 1	8	—	13	mA
		Threshold between Class Signature 1 or 2	13	—	16	mA
		Class Signature 2	16	—	21	mA
		Threshold between Class Signature 2 or 3	21	—	25	mA
		Class Signature 3	25	—	31	mA
		Threshold between Class Signature 3 or 4	31	—	35	mA
		Class Signature 4	35	—	45	mA
		Threshold between Class Signature 4 or invalid Class	45	—	51	mA
Classification Mark Specifications						
$V_{MARK}$	Mark Event Voltage	$V_{PWR} - V_{DRAIN}$ , Mark current between 0 and 5 mA	7	—	10	V
$I_{MARK\_LIM}$	Mark Event Current Limitation	Measured when $V_{DRIAN}$ is shorted to $V_{PWR}$	51	—	95	mA
$T_{ME}$	Mark Event Timing	Assigned PD Class 4	6	—	12	ms
Current Limit and Overcurrent						
$I_{CUT}$	Overcurrent Threshold	TA=25°C, AF/AT=0b		560		mA
		TA=25°C, AF/AT=1b		950		mA
$T_{CUT}$	Overcurrent Time Limit		50	—	75	ms
$I_{INRUSH}$	Output Current in POWER_UP State	TA=25°C, all assigned PD classes, $V_{PORT} > 30$ V	—	635	—	mA
$I_{LIM}$	Current Limit	TA=25°C, Power-on, assigned PD Class 0, 1, 2, 3	—	635	—	mA
		TA=25°C, Power-on, assigned PD Class 4	—	1100	—	mA

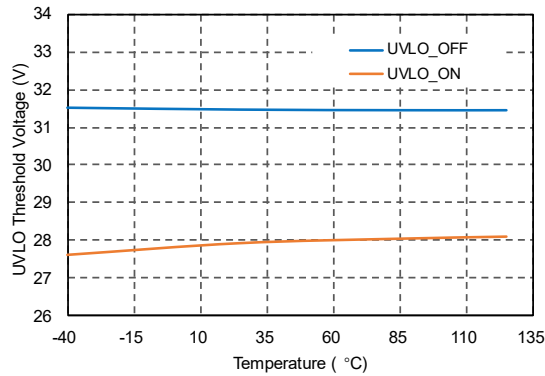
$T_{LIM}$	Short Circuit Time Limit	Power-on, assigned PD Class 0, 1, 2, 3	50	—	75	ms
		Power-on, assigned PD Class 4	10	—	75	ms
Load Disconnect						
$I_{PORT\_DIS}$	DC MPS Current	Current per pairset	—	7.5	10	mA
$T_{MPDO}$	PD MPS Dropout Time Limit		300	—	400	ms
MOSFET On Resistance						
$R_{DSON}$	FET Resistance	100mA drain to source current		290		mΩ
Digital Pin Characteristics						
$V_{IL}$	Input Low Voltage	AF/AT, RESETb, MIDb			1	V
$V_{IH}$	Input High Voltage	AF/AT, RESETb, MIDb	2			V
$I_{LK}$	Input Leakage	AGND < VIN < VDD, AF/AT, RESETb, MIDb	-1	—	1	μA
$I_{PU}$	Pullup Current to VDD	AF/AT, MIDb = 0V	-13	-10	-7	μA
$I_{PU}$	Pullup Current to VDD	RESETb = 0V	-26	-20	-14	μA
Over Temperature Protection <sup>(1)</sup>						
$T_{RISE}$	Rising Threshold		—	150	—	°C
$T_{FALL}$	Recover Threshold		—	130	—	°C

**Note:**

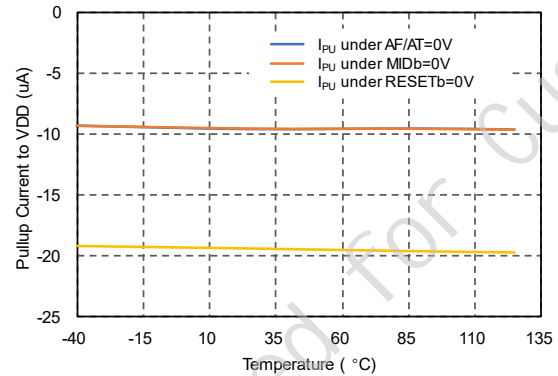
(1) Values are verified by characterization on bench, not tested in production.

## 7.6 Typical Characteristics

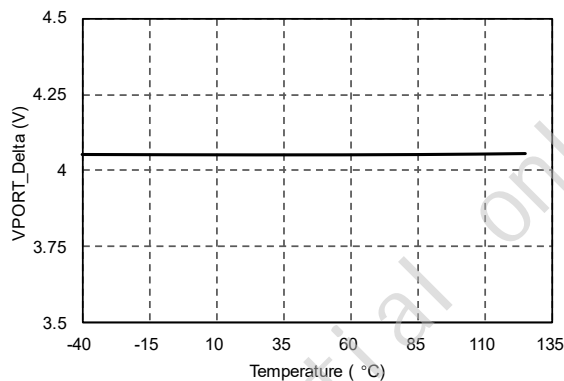
Typical values are at  $V_{PWR} = 54V$ ,  $T_A = 25^{\circ}C$ , Endpoint mode with a Class 0 PD, unless otherwise noted



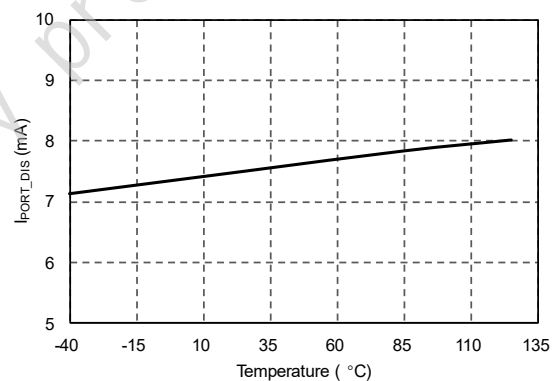
**Figure 3.  $V_{PWR}$  UVLO Threshold Voltage vs. Temperature**



**Figure 4. Digital Pin Pullup Current to VDD**

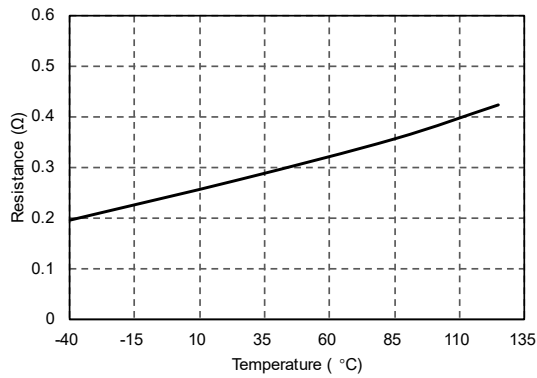


**Figure 5. Voltage Difference Between Detection Points vs. Temperature**

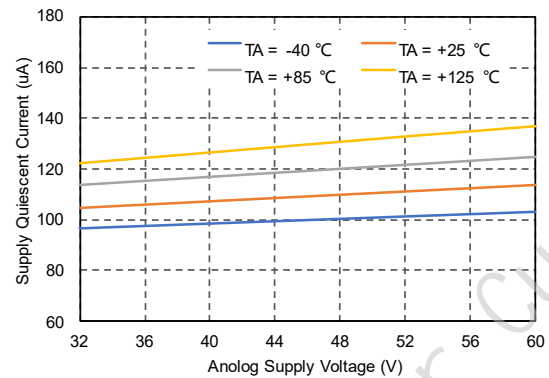


**Figure 6. DC Maintain Power Signature**

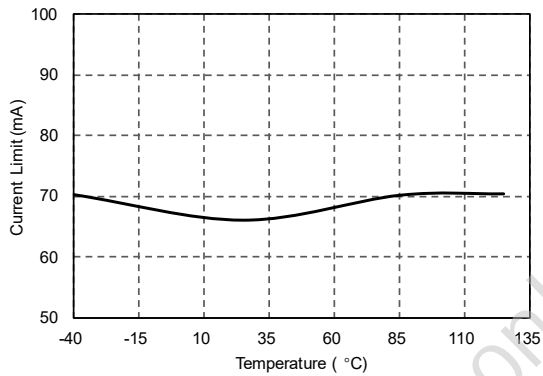




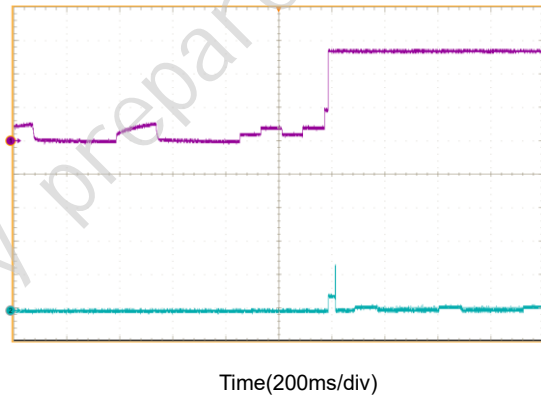
**Figure 7. Internal FET Resistance vs. Temperature**



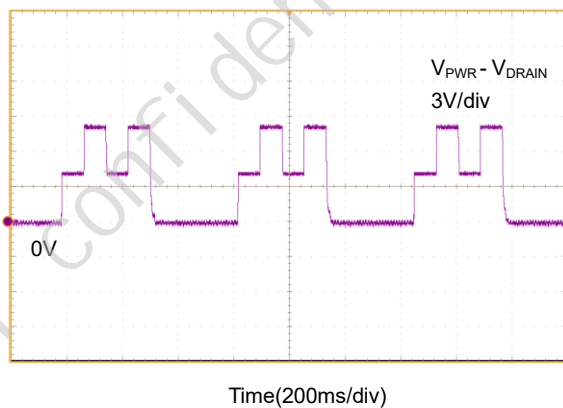
**Figure 8. VPWR Current vs. Temperature (RESETb = 0V)**



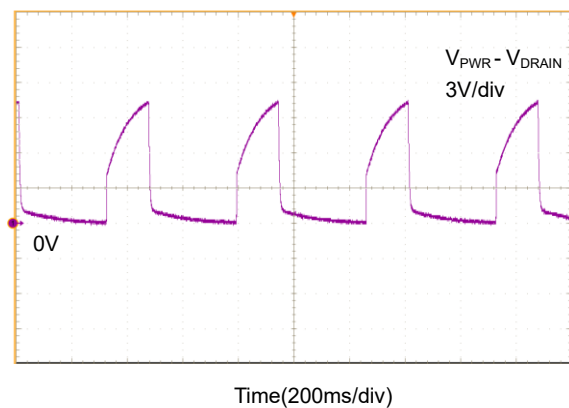
**Figure 9. Classification and Mark Current Limit vs. Temperature**



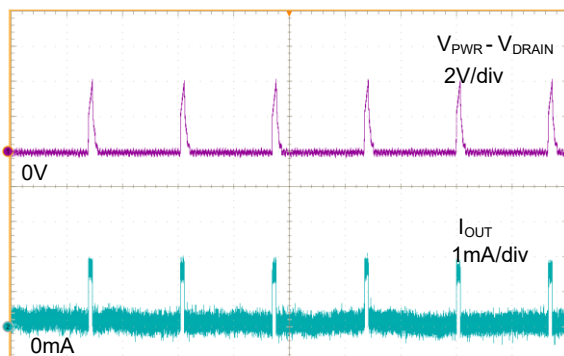
**Figure 10. Startup with a valid PD**



**Figure 11. Detection with invalid PD (33kΩ)**

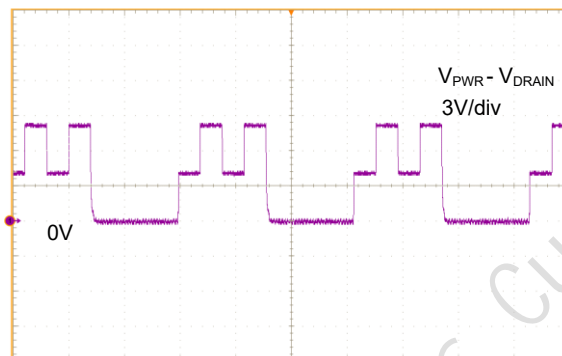


**Figure 12. Detection with invalid PD (Open)**



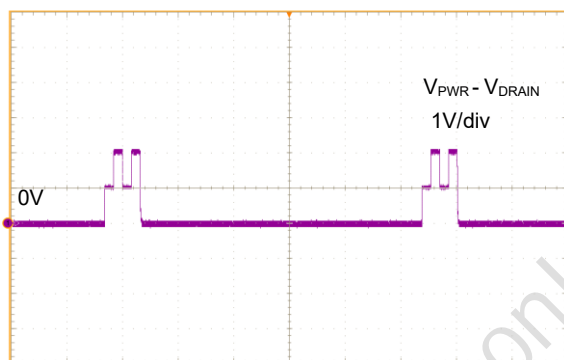
Time(200ms/div)

**Figure 13. Detection with invalid PD (24k $\Omega$  and 10 $\mu$ F)**



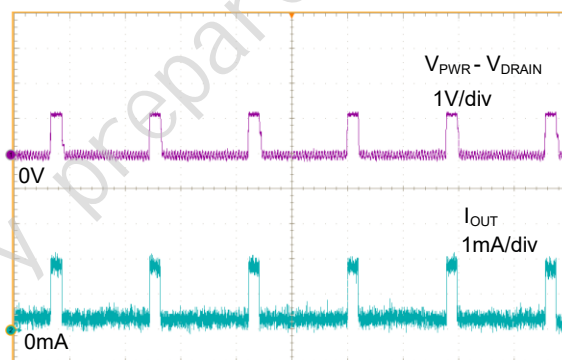
Time(200ms/div)

**Figure 14. Detection with invalid PD (15k $\Omega$ )**



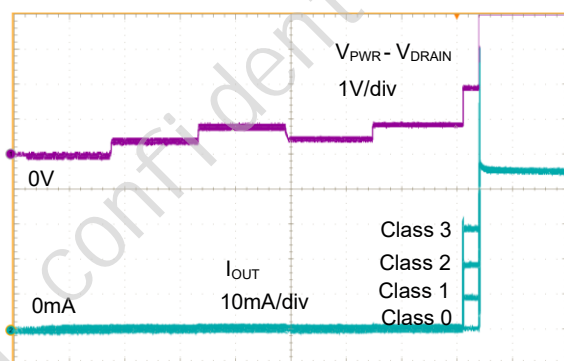
Time(500ms/div)

**Figure 15. Detection in Midspan with invalid PD (15k $\Omega$ )**



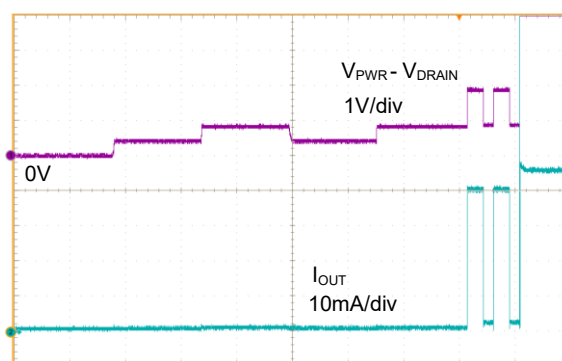
Time(200ms/div)

**Figure 16. Detection with output shorted**



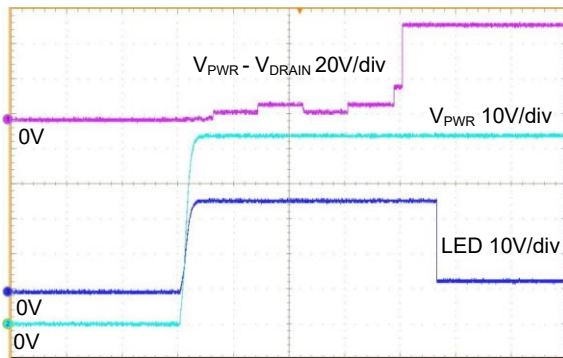
Time(200ms/div)

**Figure 17. Classification with different PD classes (0 to 3)**



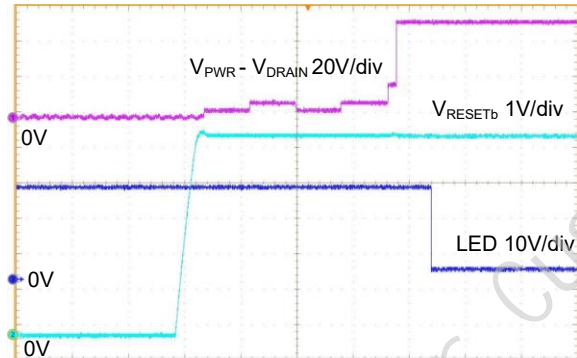
Time(200ms/div)

**Figure 18. Classification with PD Class 4**



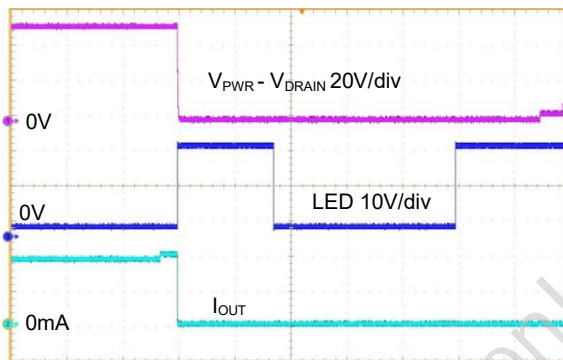
Time(100ms/div)

**Figure 19. LED function of the PD powered from  $V_{PWR}$**



Time(100ms/div)

**Figure 20. LED function of the PD powered from  $V_{RESETb}$**



Time(200ms/div)

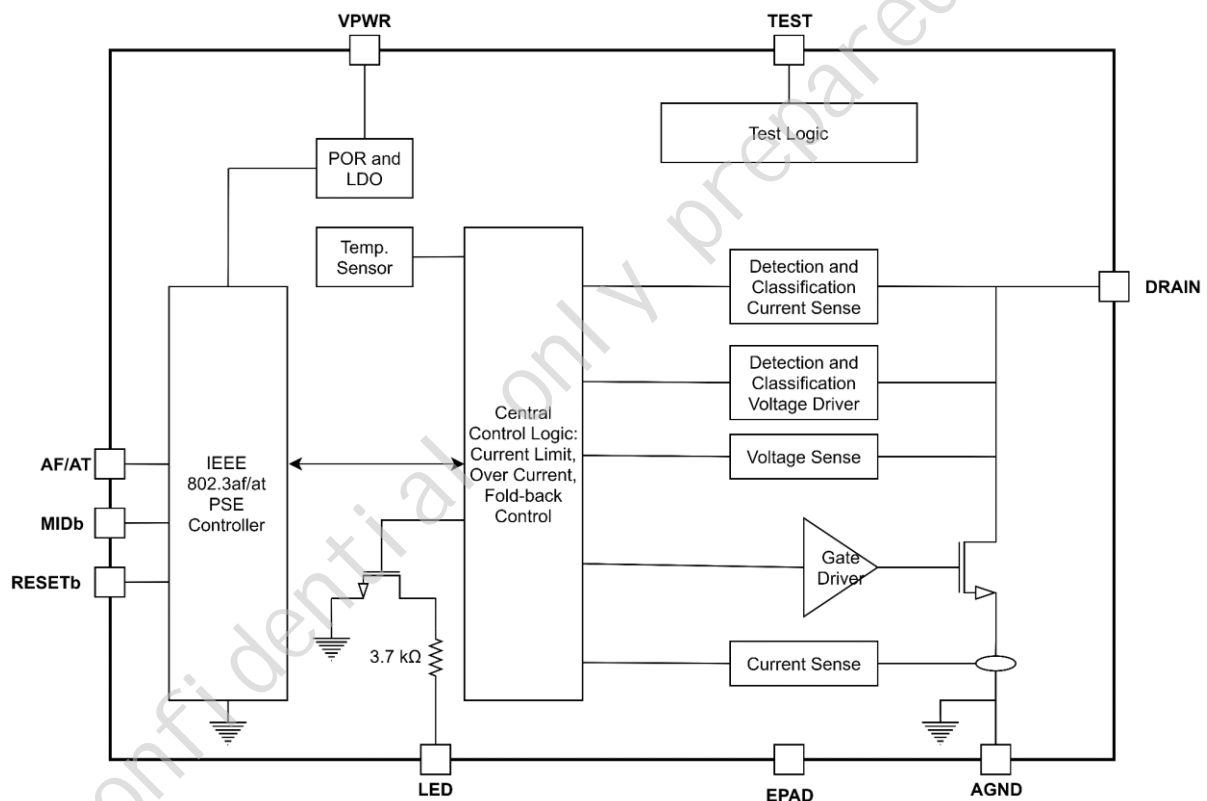
**Figure 21. LED function of ICUT**

## 8. Detailed Description

### 8.1 Overview

The MK3614H is a high-density integrated autonomous single-port PSE controller designed for use in IEEE 802.3af/at PoE systems. The device provides PD detection, classification, current limit, load disconnect detection and operating current levels. The MK3614H provides up to 50W to the Ethernet port. Besides, the MK3614H features intelligent protection circuitry including input undervoltage lockout, over-temperature protection, overcurrent timeout, port short protection, load-disconnect detection timeout, port voltage slew-rate limit during startup, operating status, fault conditions indicated by LED.

### 8.2 Functional Block Diagram



**Figure 22. Block Diagram**

## 8.3 Feature Description

### 8.3.1 Reset

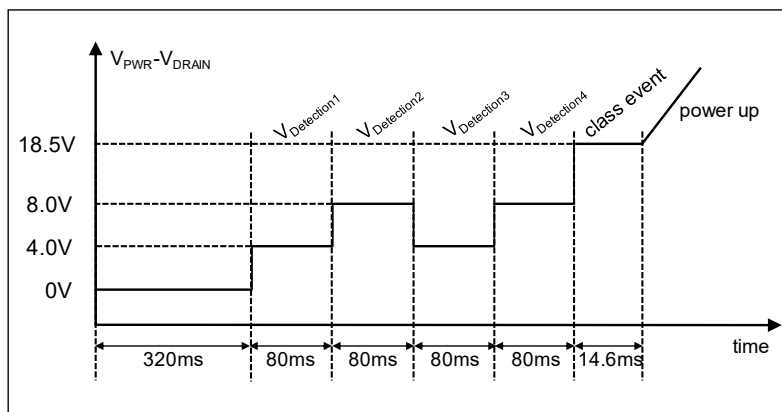
The MK3614H is reset by power-up and hardware reset. Reset condition is cleared once  $V_{PWR}$  rises above the UVLO threshold. The MK3614H's RESETb pin is tied to internal VDD through a pull-up resistance. In a typical application, connect a 120k $\Omega$  to 200k $\Omega$  resistor to AGND. However, if the RESETb pin is driven low ( $> 110\mu s$ , typ), the MK3614H is reset. Once in the reset state, the port output and LED detection function are disabled. At the end of a reset event, the MK3614H latches in the state of AF/AT and MIDb input signals. During normal operation, changes of the AF/AT and MIDb inputs are ignored, and these inputs can only be changed at any time prior to the end of a reset state.

### 8.3.2 Midspan Mode

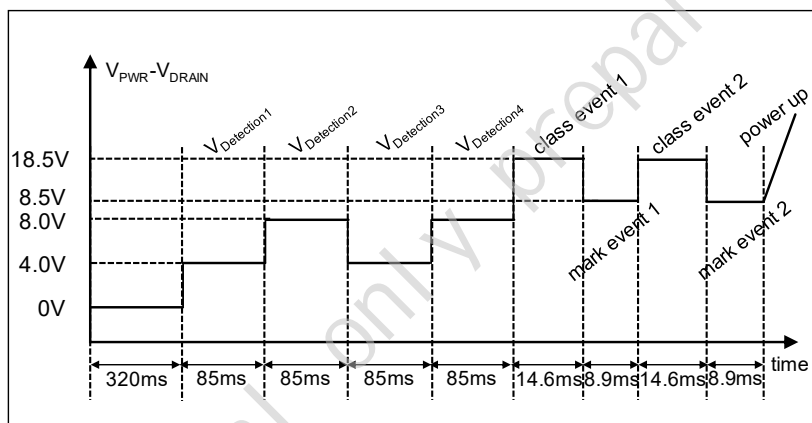
The MK3614H supports an Endpoint or Midspan PSE network configuration. In midspan mode, when failed detections occur, the device waits about 2.7s before attempting to detect again. Like the RESETb pin, MIDb pin is also tied to internal VDD through a pull-up resistance. The device is configured as Endpoint mode by default unless the MIDb pin is driven low.

### 8.3.3 PD Detection and Classification

Detection function of the MK3614H is the most important, which determines if the remote equipment connected to a PSE is capable of receiving power. To avoid false detection in noisy environments, the MK3614H detects a PD by using a robust 4-point detection algorithm to reliably determine the signature resistance of the PD. During detection phase, the MK3614H keeps the internal MOSFET off and drives probe voltages with two different levels through the DRAIN pin. The device uses a specific algorithm to calculate the PD signature resistance by sampling the current injected into the port. Once the detection result is RGOOD, the MK3614H will perform Physical Layer classification by driving a class probe to determine the PD's class signature. The number of class events and mark events determines the PD requested power. Figure 23 shows a timing diagram of PD detection and classification for a Type 1 PSE powering a Type 1 PD. In this example, the MK3614H produces one class event to a Type 1 PD without any mark event. As shown in Figure 24, two class events and two mark events are driven by the MK3614H for a Type 2 PSE powering a Class 4 PD.



**Figure 17. Type 1 Detection, Classification, and Port Power-Up Sequence**



**Figure 18. Type 2 Detection, Classification, and Port Power-Up Sequence**

### 8.3.4 Inrush

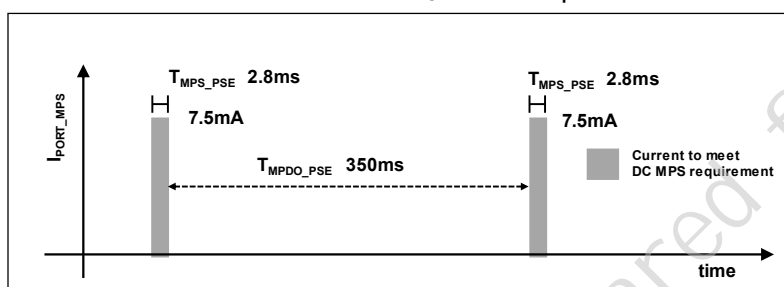
After classification, if the MK3614H decides to power the PD, it will first go through the inrush phase. During inrush, the PSE limits the amount of current being delivered for at least 60ms. Between 1ms and 60ms after power-on, the inrush current of the MK3614H is limited to no more than 700mA.

### 8.3.5 Operating Power

During a nominal powering state, the MK3614H checks for abnormal conditions, including overcurrent, PD disconnection, and short-circuits. Meanwhile, the MK3614H assigns the class required for PD to PD. The MK3614H achieves the purpose of distributing power by controlling the current called  $I_{CUT}$ . Once the current exceeds the  $I_{CUT}$  as least  $T_{CUT}$ , the MK3614H immediately cuts off the power and goes through detection phase.

### 8.3.6 Maintain Power Signature

When the MK3614H is supplying power to a PD, the MK3614H keeps on monitoring the current drawn in order to make sure that the PD is still connected. The minimum current that the PD must draw to avoid being disconnected is named the Maintain Power Signature (MPS). The MK3614H is designed to remove power when the MPS is absent for at least 350ms, ensuring that disconnected cables do not remain powered. In order to further reduce minimum standby power consumption for PoE systems, the MK3614H only requires that PD must draw a current above  $I_{PORT\_DIS}$  for at least 2.8ms with no more than  $T_{MPDO}$  between pulses.



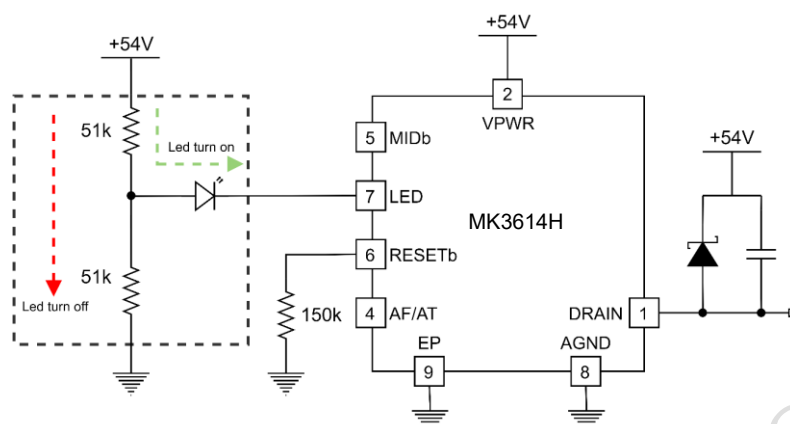
**Figure 25. The MK3614H MPS requirements**

### 8.3.7 Current Limit and Voltage Foldback

The MK3614H integrates a current-sensing resistor connected between the internal MOSFET and AGND to monitor the loop current. During normal operating conditions, the current running through the current-sensing resistor never exceeds the threshold  $ILIM$ . Otherwise, the internal feedback circuit regulates the driver voltage of the MOSFET to limit the current. Besides, the MK3614H senses the DRAIN voltage and regulates the current-limit value, which helps to reduce the internal MOSFET power dissipation.

### 8.3.8 LED Signals

The MK3614H's LED pin is open-drain output. The pin outputs FM signals with different duty ratios, which indicate various operating statuses and fault conditions. The LED pin can be directly connected to the VIN port through pull-up resistors, but an external pull-down resistor is required to reduce the voltage stress of the LED pin. As shown in Figure 22, the LED pin outputs various signals by controlling the internal MOSFET. Once the MOSFET is turned on, the current is injected to AGND through the internal integrated resistor, where its resistance value is approximately 3.7kΩ. Figure 26 shows the recommended LED connection circuit.



**Figure 26. Recommended LED connection circuit**

The following table lists LED pin states which indicate various operating statuses and fault conditions of the MK3614H.

**Table 2. LED pin functions**

LED Indication	Status	Note
LED on	Port successfully powered at requested power level	The MOSFET that controls the LED output is turned on.
LED off	Looking for a valid detection signature	The MOSFET that controls the LED output is turned off.
LED blinking only several times	Error condition, such as OCP, ICUT, port short fault, OTP	The MOSFET that controls the LED output is switched on and off several times, then off.



The schematic diagram of the PoE PD module is divided into several functional blocks:

- Power Input and Regulation:** A DC 54V input is connected to a network of capacitors (C0, C01, C1, C2) and resistors (R1, R2, R3). A diode D1 (SMAJ58A) is used for protection. The microcontroller U1 (MK3614H) manages the power distribution.
- Microcontroller (U1):** The MK3614H microcontroller has pins for DRAIN, VPWR, TEST, AF/AT, EPAD, LED, RESETb, and MIDB. It is connected to various components including a pull-up resistor R3 and a capacitor C3.
- Data Interface:** RJ1 (Data Input) and RJ2 (Power Indicator) are RJ45 connectors. RJ1 is connected to the microcontroller's MIDB pin. RJ2 is connected to the power indicator's S13 and S14 pins.
- Power Indicator:** A power indicator LED is connected to the S13 and S14 pins of RJ2. The LED is also connected to the microcontroller's LED pin.
- PoE Output:** The PoE output is connected to RJ1 (Data Input) and RJ2 (Power Indicator). The output is connected to the S13 and S14 pins of RJ2.
- Optional Pull-down:** An optional pull-down network is shown for the MPS current, consisting of a diode D2 (NC/27V Zener) and resistors R8 and R9.

### Figure 27. Application Schematic Example

## 10. Power Supply Recommendations

## 11. Layout

### 11.1 Layout Guidelines

To achieve high performance of the MK3614H, the following layout tips must be followed.

1. At least one low-ESR ceramic bypass capacitor for the VPWR pin must be used. Place the capacitor as close as possible to the MK3614H VPWR pin.
2. The unidirectional TVS connected between VPWR and DRAIN must be employed to prevent an external lightning strike and surge current from damaging the chip.
3. The recommended voltage of the LED pin is not higher than 30V and the current does not exceed 1mA, otherwise it may damage the pin. The pin voltage can be reduced by a pull-down resistor divider.
4. TEST pin is recommended to be tied to GND, and thermal pad is used for chip heat dissipation.
5. Use short, wide traces whenever possible for high power paths.

### 11.2 Layout Example

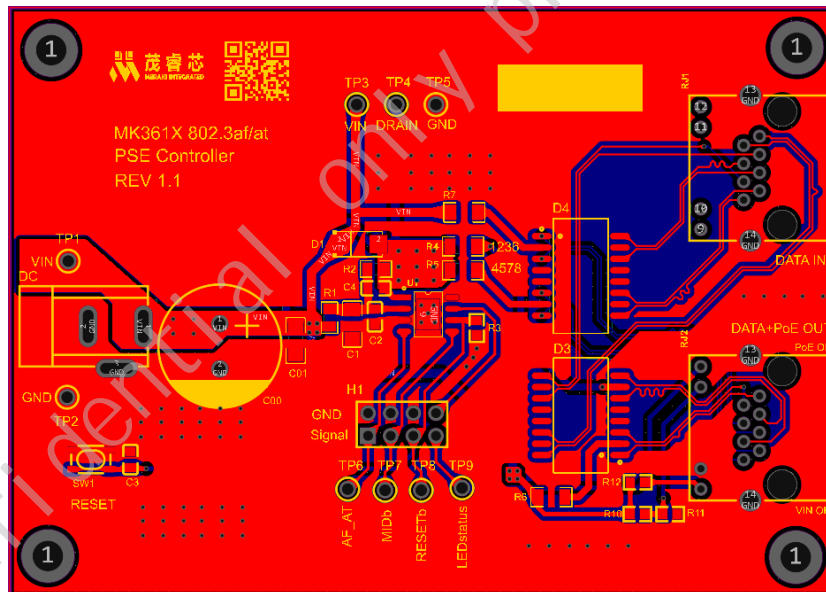
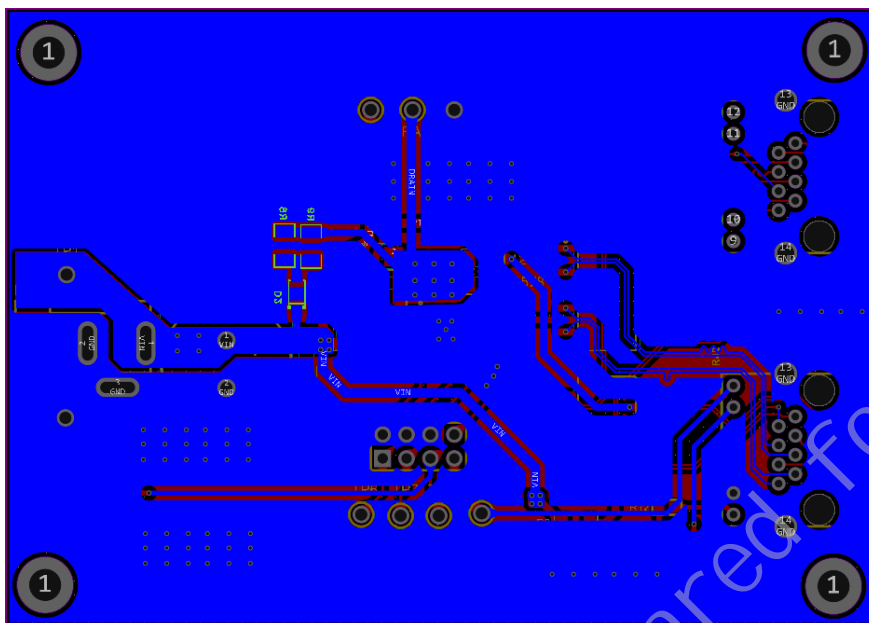


Figure 28. Evkit Layout (Top Layer)



**Figure 29. Evkit Layout (Bottom Layer)**

## **12. Device and Documentation Support**

### **12.1 Device Support**

### **12.2 Documentation Support**

### **12.3 Receiving Notification of Documentation Updates**

### **12.4 Support Resources**

### **12.5 Trademarks**

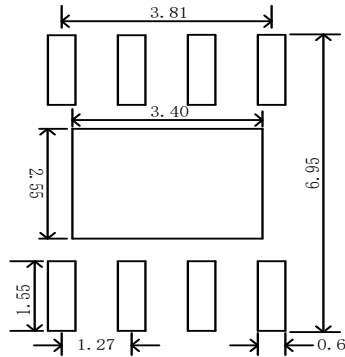
### **12.6 Electrostatic Discharge Caution**



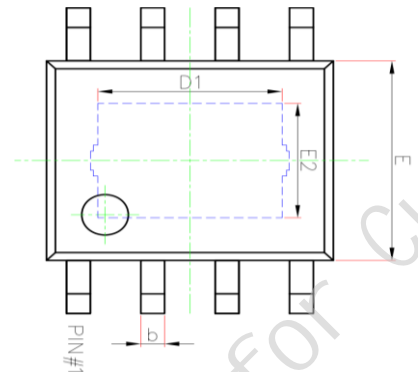
This integrated circuit can be damaged by ESD. Meraki Integrated recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage.

ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may be more susceptible to damage because very small parametric changes could cause the device to not meet its published specifications.

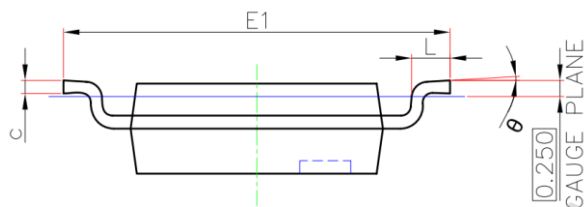
### 13. Mechanical, Packaging



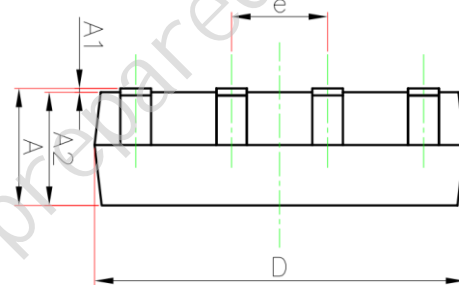
**Figure 19. Recommended Land Pattern (mm)**



**Figure 20. MK3614H Top View**



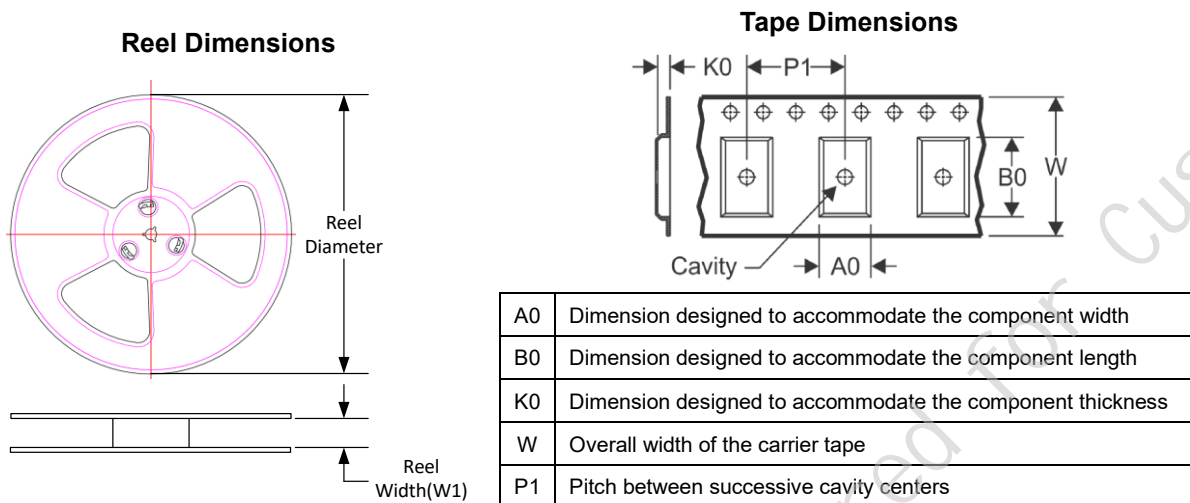
**Figure 21. MK3614H Side View**



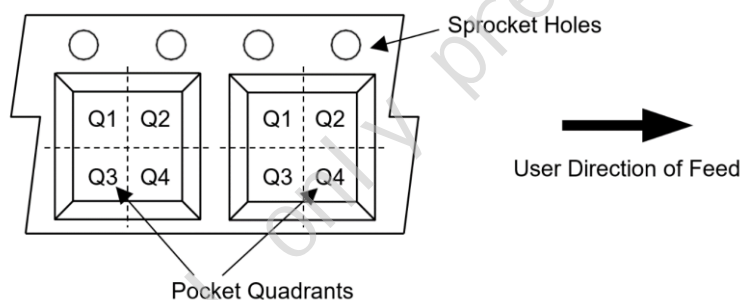
**Figure 22. MK3614H Side View**

SYMBOL	Millimeter	
	MIN	NOM
A	1.300	1.700
A1	0.000	0.100
A2	1.350	1.550
b	0.330	0.510
c	0.170	0.250
D	4.700	5.100
D1	3.050	3.250
E	3.800	4.000
E1	5.800	6.200
E2	2.160	2.360
e	1.270(BSC)	
L	0.400	1.270
θ	0°	8°

## 14. Reel and Tape Information

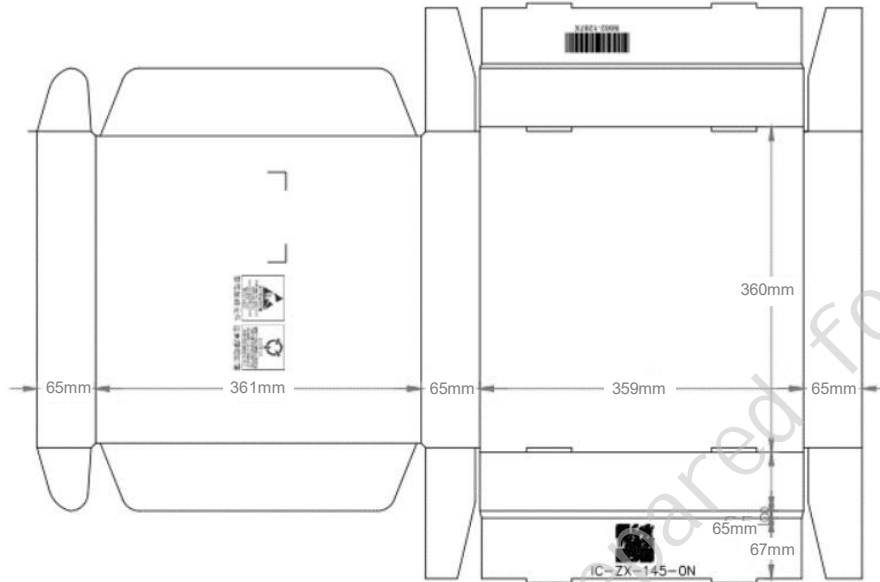


### Quadrant Assignments For Pin 1 Orientation In Tape



Device	Package Type	Pins	Quantities	Reel Diameter (mm)	Reel Width W1(mm)
MK3614H	ESOP8	8	4000	330	12.4
A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
6.4	5.4	2.1	8.0	12.0	Q1

## 15. Tape and Reel Box Dimensions



靜電敏感元件 注意靜電防護