KTH2502 Series

Automotive Digital-Latch Hall Effect Sensor

1 Features

- KTH2502 Qualified for Automotive Applications:
  - Device HBM ESD Level 4000V
  - Device CDM ESD Level 500V
  - Grade Q: TA = –40°C to 125°C
- Digital Bipolar-Latch Hall Sensor
- Superior Temperature Stability
  - B_{RP} ±10% Over Temperature
- Multiple Sensitivity Options (B_{OP} / B_{RP})

  A：Bop=±15Gauss Brp=∓15 Gauss

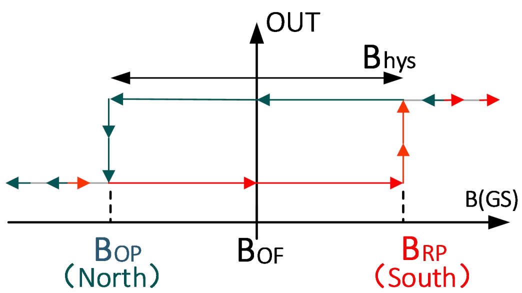
  B：Bop=±30 Gauss Brp=∓30Gauss

  C：Bop=±60 Gauss Brp=∓60Gauss

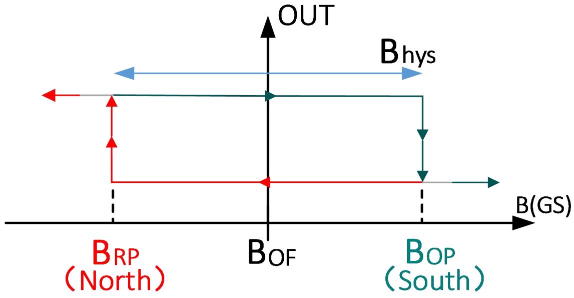
  D：Bop=±120 Gauss Brp=∓120Gauss
- Supports a Wide Voltage Range

  – 2.7 to 32 V

  – No External Regulator Required
- Open-Drain Output (30-mA Sink)
- Fast 35-μs Power-On Time
- Small Package and Footprint
  - Surface Mount 3-Pin SOT23 and SOT-23-3L
  - Through-Hole 3-Pin TO-92S
- Protection Features
  - Reverse Supply Protection (up to –32 V)
  - Supports up to 36V Load Dump
  - Output Short-Circuit Protection
  - Output Current Limitation



SOT-23-3L package product output curve



SOT23, TO-92S package product output curve

2 Applications

- Power Tools
- Flow Meters
- Valve and Solenoid Status
- Brushless DC Motors
- Proximity Sensing
- Tachometers

3 Typical Application Circuit

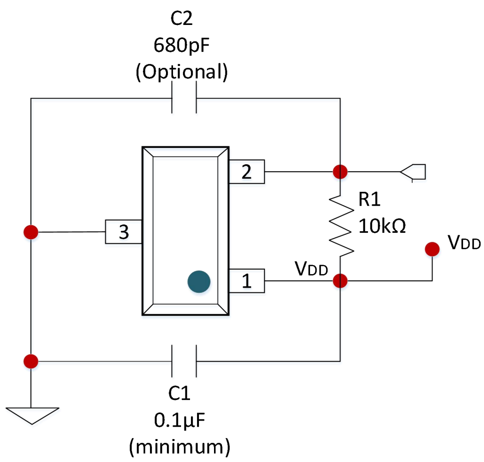


Figure 1. Typical Application Circuit

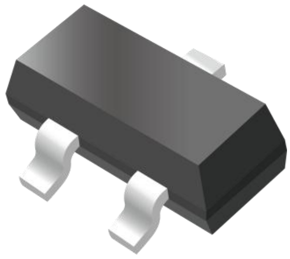
Table of Contents

4 Order information

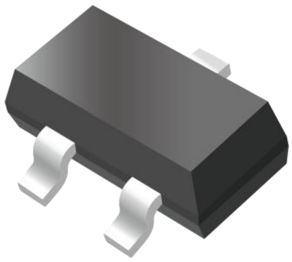
Model	Number of pins	Package form	temperature	MSL Level	SPQ
KTH2502QA-SS3	3	SOT23	-40℃~125℃	1	3000
KTH2502QA-ST3	3	SOT-23-3L	-40℃~125℃	1	3000
KTH2502QA-TO3	3	TO-92S	-40℃~125℃	NA	1000
KTH2502QB-SS3	3	SOT23	-40℃~125℃	1	3000
KTH2502QB-ST3	3	SOT-23-3L	-40℃~125℃	1	3000
KTH2502QB-TO3	3	TO-92S	-40℃~125℃	NA	1000
KTH2502QC-SS3	3	SOT23	-40℃~125℃	1	3000
KTH2502QC-ST3	3	SOT-23-3L	-40℃~125℃	1	3000
KTH2502QC-TO3	3	TO-92S	-40℃~125℃	NA	1000
KTH2502QD-SS3	3	SOT23	-40℃~125℃	1	3000
KTH2502QD-ST3	3	SOT-23-3L	-40℃~125℃	1	3000
KTH2502QD-TO3	3	TO-92S	-40℃~125℃	NA	1000

5 Descriptions

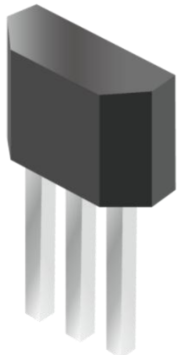
The KTH2502 device is a chopper-stabilized Hall Effect Sensor that offers a magnetic sensing solution with superior sensitivity stability over temperature and integrated protection features.
The magnetic field is indicated via a digital bipolar latch output. The IC has an open-drain output stage with 30-mA current sink capability. A wide operating voltage range from 2.7 to 32 V with reverse polarity protection up to -32 V makes the device suitable for a wide range of automotive applications.
Internal protection functions are provided for reverse supply conditions, load dump, and output short circuit or over current.



SOT23



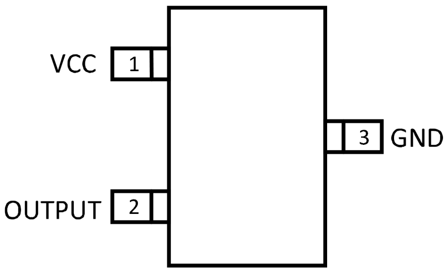
SOT-23-3L

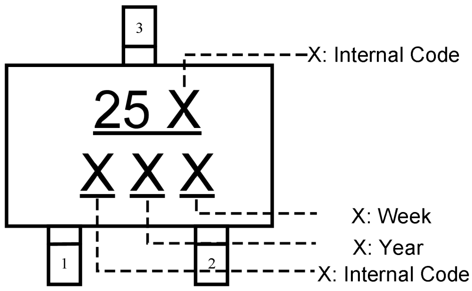


TO-92S

6 Pin Descriptions

SOT23

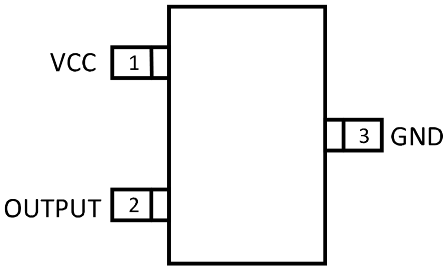


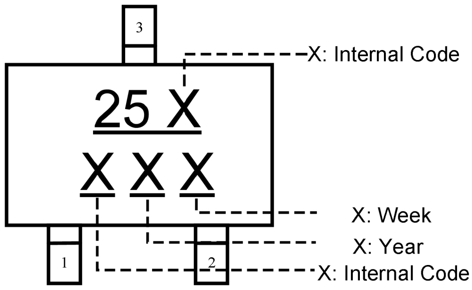


Top view

Pin Name	Pin Number	Function
VCC	1	Power Supply Input
OUTPUT	2	Output pin
GND	3	Ground Pin

SOT-23-3L





Top view

Pin Name	Pin Number	Function
VCC	1	Power Supply Input
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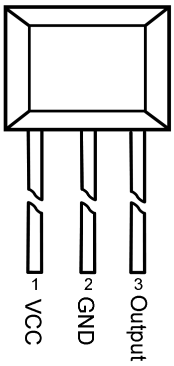
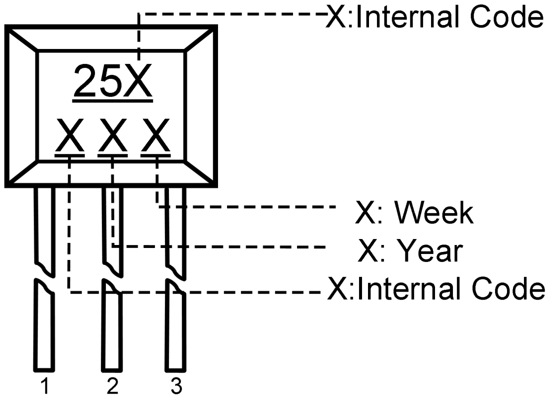
GND	3	Ground Pin

TO-92S

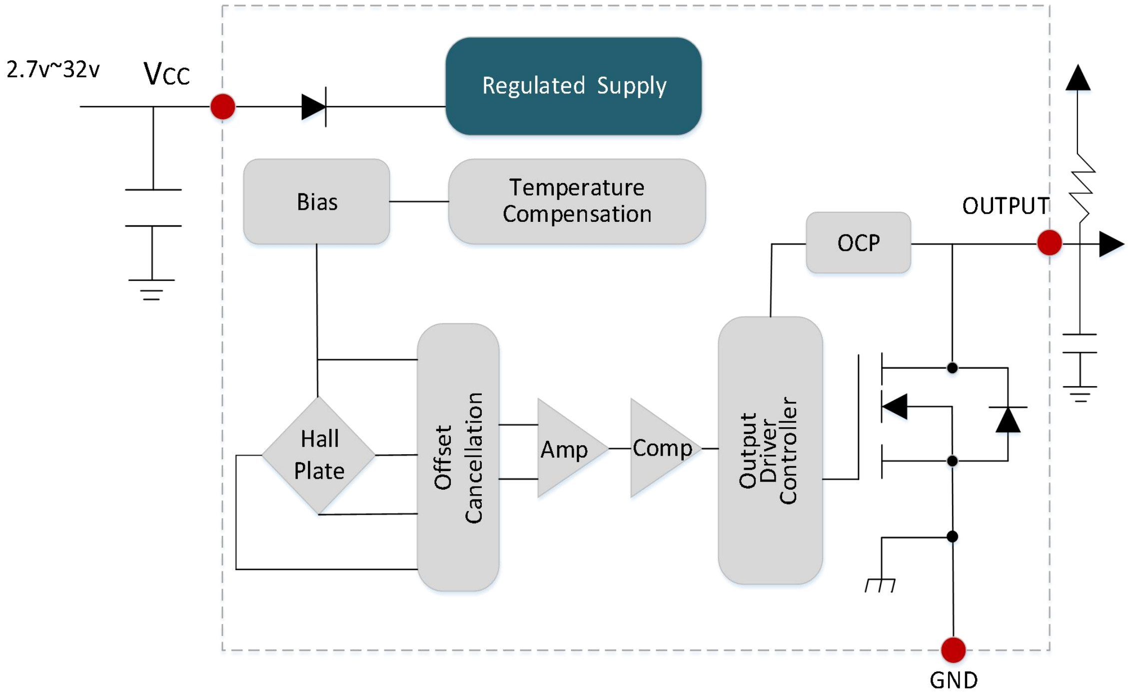




Top view

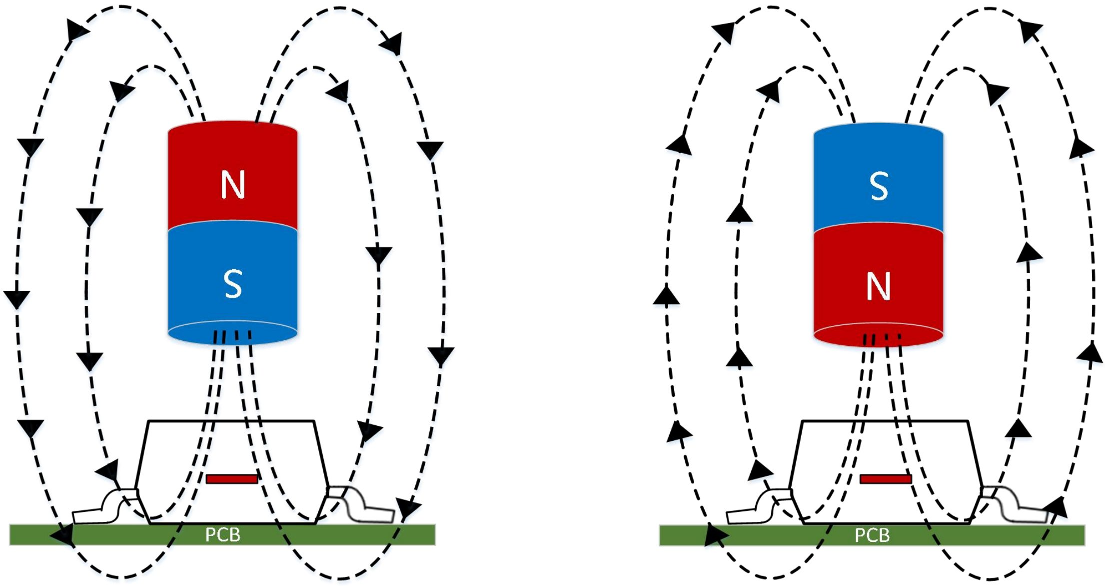
Pin Name	Pin Number	Function
VCC	1	Power Supply Input
GND	2	Ground Pin
OUTPUT	3	Output Pin

7 Block Diagram

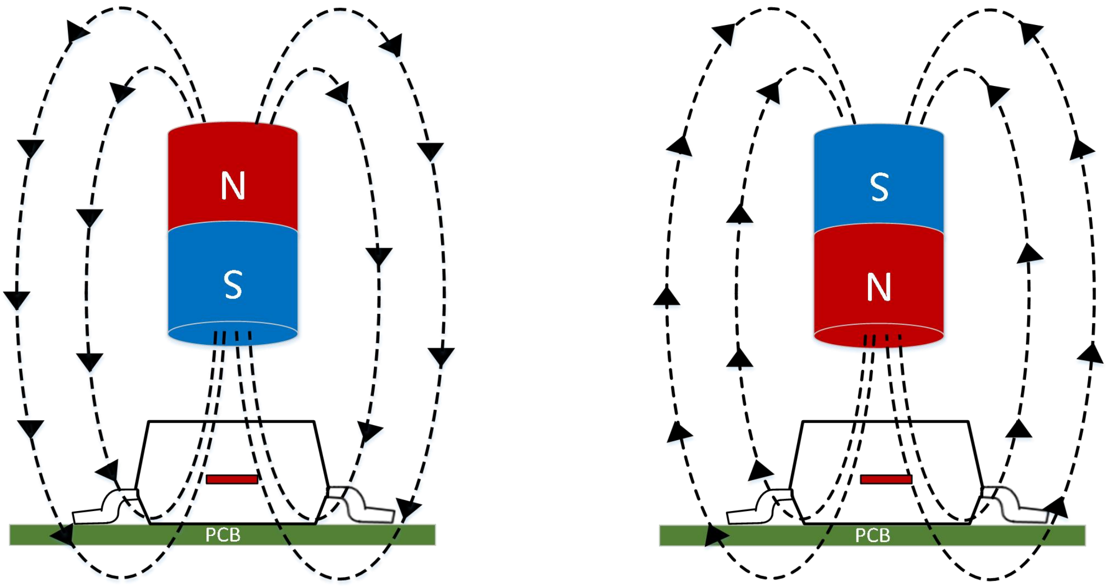


8 Output Switching Characteristics

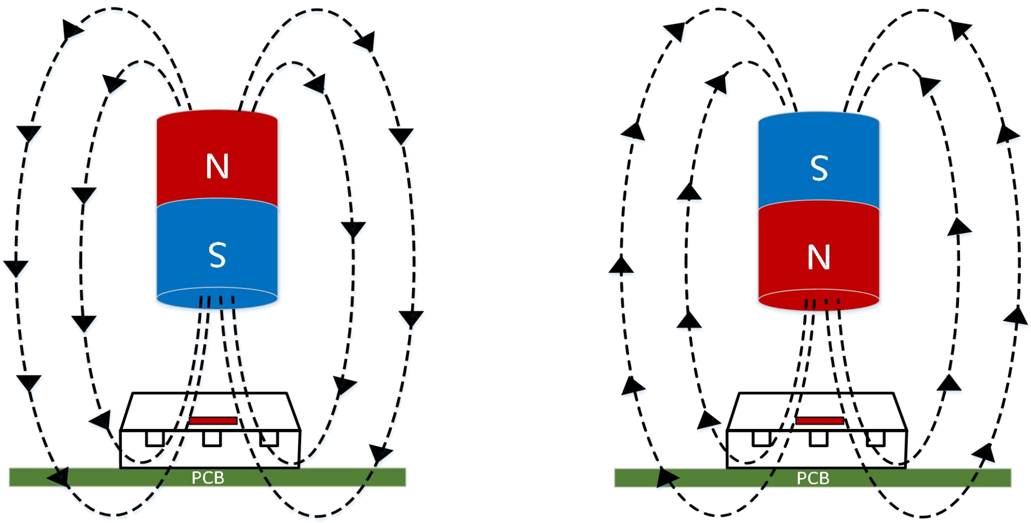
As shown in the figure below, when the South Pole of the magnet is near the top of the chip, the magnetic induction line passes from the bottom of the chip to the top. It is considered that the magnetic induction intensity B is positive at this time.When the North Pole of the magnet is near the top of the chip, the magnetic induction line passes from the top of the chip to the bottom, and the magnetic induction intensity B is considered to be negative.



SOT23

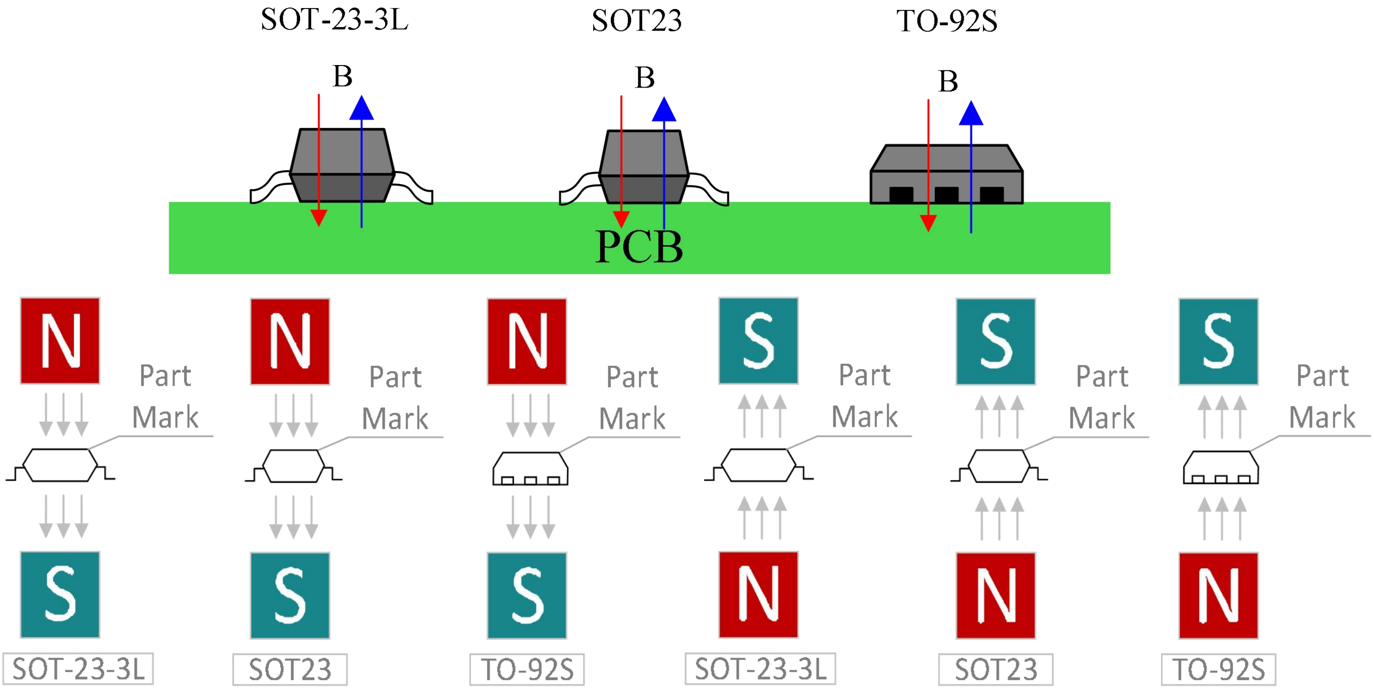


SOT-23-3L



TO-92S

As shown in the figure below, KTH2502 can detect the magnetic fields of the South Pole and the North Pole.



9 Product Name Structure

KTH2502 X X-XXX

- Package abbreviation：ST3：SOT-23-3L ; SS3：SOT23
  TO3：TO-92S
- Magnetic sensitivity：A: B_{OP}=15GS; B: B_{OP}=30GS
  C: B_{OP}=60GS ;D: B_{OP}=120GS
- Grade：Q：125℃ Vehicle grade

10 Absolute Maximum Ratings

over operating free-air temperature range (unless otherwise noted)(1)

		MIN	MAX	UNIT
Power supply voltage	VCC	–32(2)	36	V
	Voltage ramp rate (V_{CC}), V_{CC} < 5 V	Unlimited		V/µs
	Voltage ramp rate (V_{CC}), V_{CC} > 5 V	0	2	
Output pin voltage		–0.5	36	V
Output pin reverse current during reverse supply condition		0	100	mA
Magnetic flux density, B_{MAX}		Unlimited		
Operating junction temperature, T_J	Q	–40	150	°C
Storage temperature, T_{stg}		–65	150	°C

(1) Stresses beyond those listed under 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 under Recommended Operating Conditions. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

(2) Ensured by design.

11 ESD Ratings

		VALUE	UNIT
$V_{(ESD)}$ Electrostatic discharge	Human-body model (HBM)	±4000	V
	Charged-device model (CDM)	±500	

12 Recommended Operating Conditions

over operating free-air temperature range (unless otherwise noted)

			MIN	MAX	UNIT
VCC	Power supply voltage		2.7	32	V
V_O	Output pin voltage (OUT)		0	VCC	V
I_{SINK}	Output pin current sink (OUT)[1]		0	30	mA
T_A	Operating ambient temperature	Q	–40	125	°C

(1) Power dissipation and thermal limits must be observed

13 Electrical Characteristics

over operating free-air temperature range (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
POWER SUPPLIES (VCC)						
VCC	V_{CC} operating voltage		2.7		32	V
ICC	Operating supply current	V_{CC} = 2.7 to 32 V, T_A = 25°C		2.7		mA
		V_{CC} = 2.7 to 32 V, T_A = 125°C		2.7	4.5	
t_{on}	Power-on time	A, B, C,D versions		35	50	μs
OPEN DRAIN OUTPUT (OUT)						
$r_{DS(on)}$	FET on-resistance	V_{CC} = 3.3 V, I_O = 10 mA, T_A = 25°C		11		Ω
		V_{CC} = 3.3 V, I_O = 10 mA, T_A =125°C		15	20	
$I_{lkg(off)}$	Off-state leakage current	Output Hi-Z		500		nA
PROTECTION CIRCUITS						
V_{CCR}	Reverse supply voltage			–32		V
I_{OCP}	Overcurrent protection level	OUT shorted V_{CC}	20	30	40	mA

(1)Switching Characteristics

over operating free-air temperature range (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
OPEN DRAIN OUTPUT (OUT)						
t_d	Output delay time	B = B_{RP} +10 mT to B_{OP} - 10 mT in 1 μs (@SOT-23-3L)		10	25	μs
		B = B_{RP} -10 mT to B_{OP} + 10 mT in 1 μs (@SOT23&TO-92S)		10	25	
t_r	Output rise time (10% to 90%)	R1 = 1 kΩ, C_O = 50 pF, V_{CC} = 3.3 V		160		ns
t_f	Output fall time (90% to 10%)	R1 = 1 kΩ, C_O = 50 pF, V_{CC} = 3.3 V		80		ns

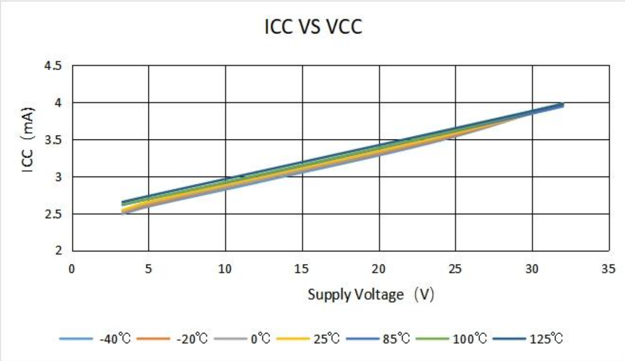
14 Magnetic Characteristics

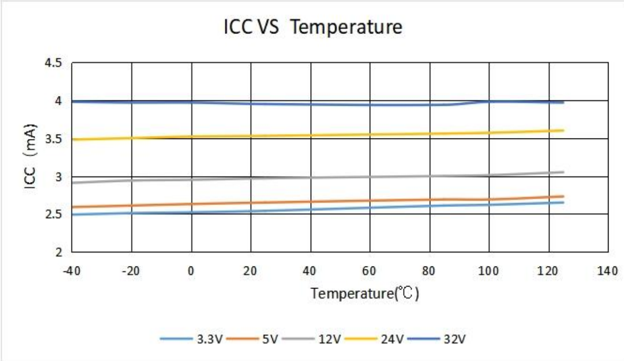
over operating free-air temperature range (unless otherwise noted)

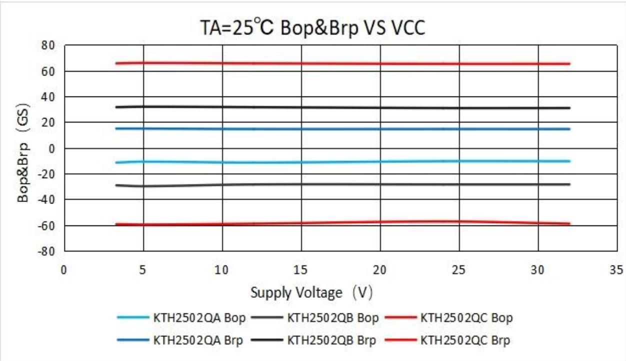
PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
f_{BW}	Bandwidth [1]		20	30		kHz
KTH2502QA: 15 / –15 GS						
B_{OP}	Operate point;	T_A = –40°C to 125°C	-25	-15	-5	GS
B_{RP}	Release point;		5	15	25	GS
B_{hys}	Hysteresis; $B_{hys} = (\|B_{OP} – B_{RP}\|)$			30		GS
B_O	Magnetic offset; $B_O = (B_{OP} + B_{RP}) / 2$		-10	0	10	GS
KTH2502QB: 30 / –30 GS						
B_{OP}	Operate point;	T_A = –40°C to 125°C	-40	-30	-20	GS
B_{RP}	Release point;		20	30	30	GS
B_{hys}	Hysteresis; $B_{hys} = (\|B_{OP} – B_{RP}\|)$			60		GS
B_O	Magnetic offset; $B_O = (B_{OP} + B_{RP}) / 2$		–10	0	10	GS
KTH2502QC: 60 / –60GS						
B_{OP}	Operate point;	T_A = –40°C to 125°C	-80	-60	-40	GS
B_{RP}	Release point;		40	60	80	GS
B_{hys}	Hysteresis; $B_{hys} = (\|B_{OP} – B_{RP}\|)$			120		GS
B_O	Magnetic offset; $B_O = (B_{OP} + B_{RP}) / 2$		–20	0	20	GS
KTH2502QD: 120 / –120GS						
B_{OP}	Operate point;	T_A = –40°C to 125°C				GS
B_{RP}	Release point;					GS
B_{hys}	Hysteresis; $B_{hys} = (\|B_{OP} – B_{RP}\|)$					GS
B_O	Magnetic offset; $B_O = (B_{OP} + B_{RP}) / 2$					GS

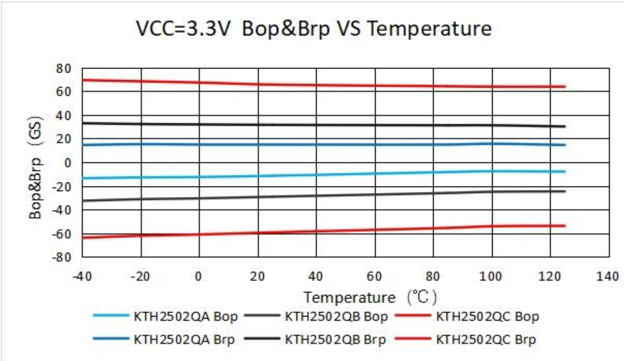
(1) Bandwidth describes the fastest changing magnetic field that can be detected and translated to the output.

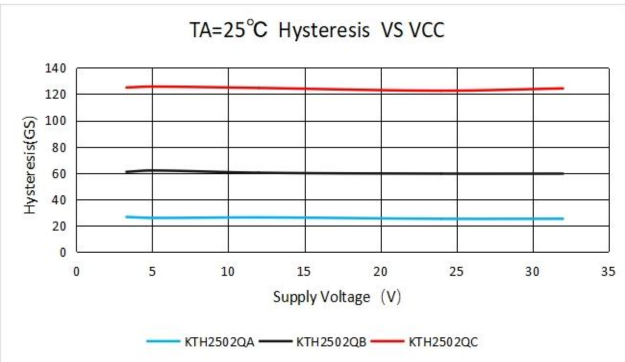
15 Typical Characteristics

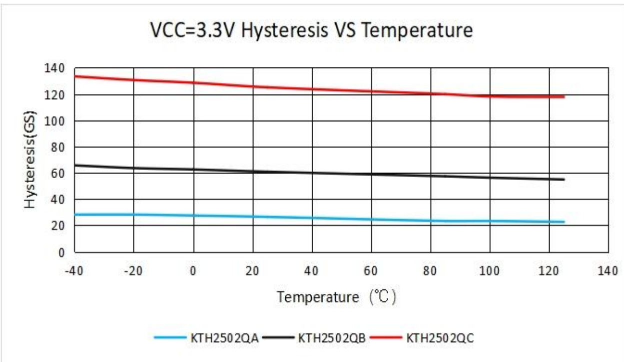












16 Power-On Time

After applying VCC to the KTH2502 device, t_{on} must elapse before the OUT pin is valid. During the power-up sequence, the output is Hi-Z. This pulse can allow the host processor to determine when the KTH2502 output is valid after startup. In Case 1and Case 2 , the output is defined assuming a constant magnetic field B > B_{OP} and B < B_{RP}.

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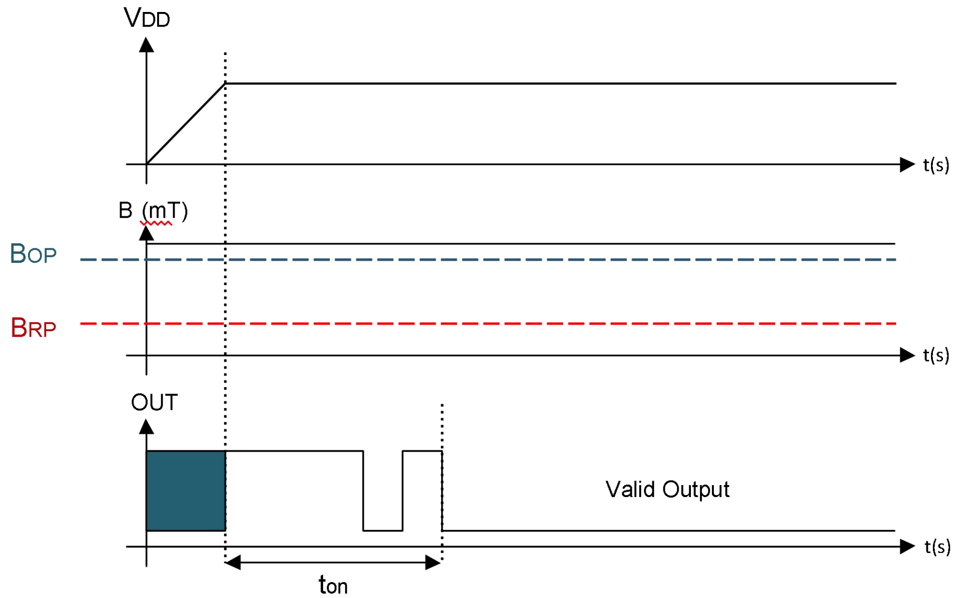
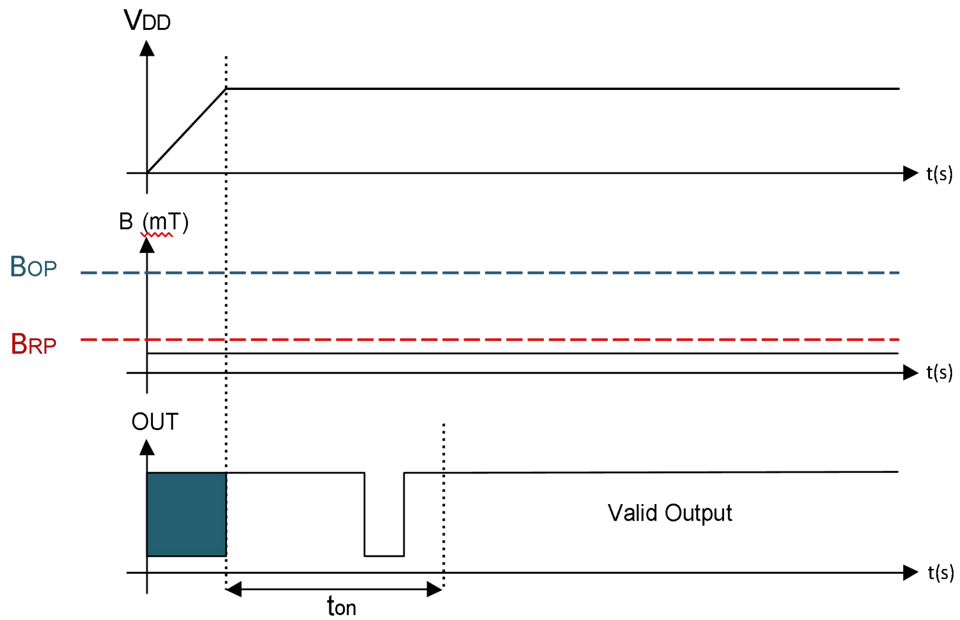
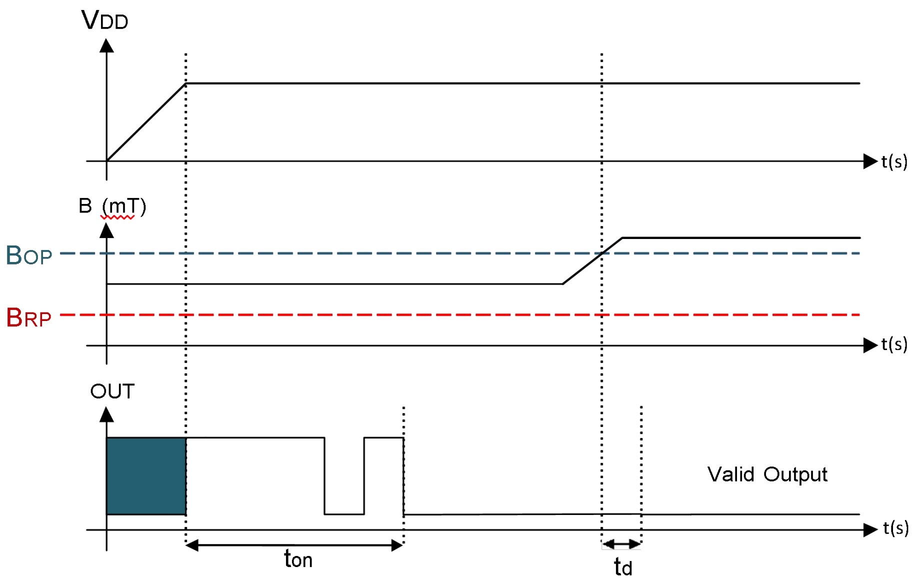


Case 1: Power On When B > B_{OP}

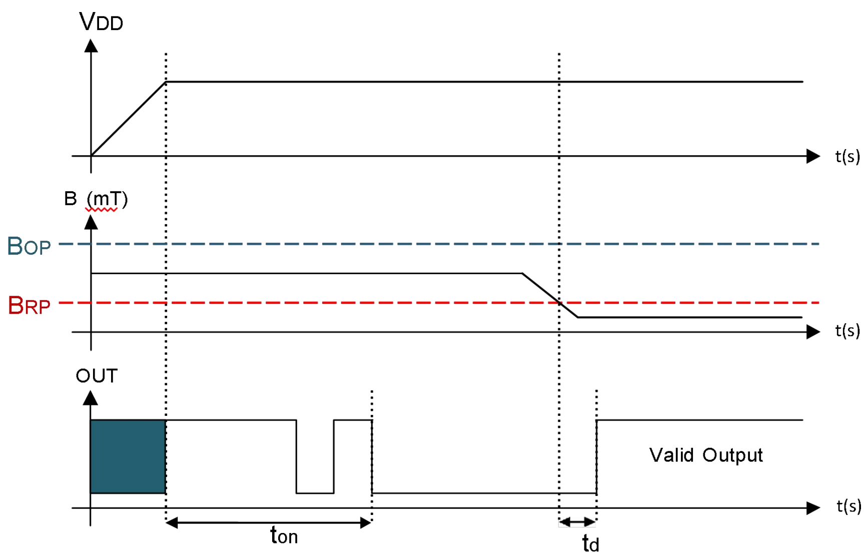


Case 2: Power On When B < B_{RP}

If the device is powered on with the magnetic field strength $B_{RP} < B < B_{OP}$, then the device output is pulled low. During the power-up sequence, the output is held Hi-Z until t_{on} has elapsed. At the end of t_{on}, a pulse is given on the OUT pin to indicate that ton has elapsed. After ton, if the magnetic field changes such that $B < B_{RP}$, the output is released. Case 3 and Case 4 show examples of this behavior.



Case 3: Power On When $B_{RP} < B < B_{OP}$, Followed by $B > B_{OP}$



Case 4: Power On When $B_{RP} < B < B_{OP}$, Followed by $B < B_{RP}$

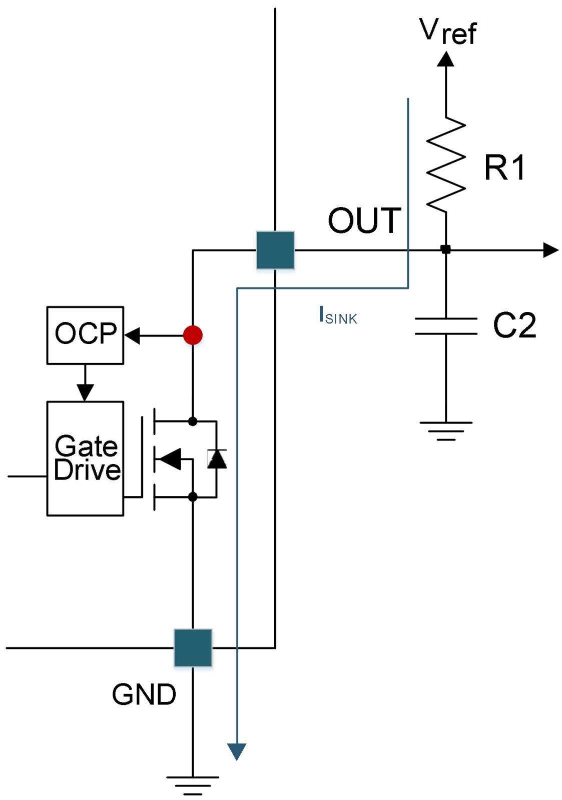
17 Output Stage

The KTH2502 output stage uses an open-drain NMOS, and it is rated to sink up to 30 mA of current. For proper operation, calculate the value of the pullup resistor R1 using Equation 1.

$$\frac{V_{\text{ref}}\,\text{max}}{30\ \text{mA}} \leq R1 \leq \frac{V_{\text{ref}}\,\text{min}}{100\ \mu\text{A}} \qquad (1)$$

The size of R1 is a tradeoff between the OUT rise time and the current when OUT is pulled low. A lower current is generally better, however faster transitions and bandwidth require a smaller resistor for faster switching. In addition, ensure that the value of R1 > 500 Ω to ensure the output driver can pull the OUT pin close to GND.

NOTE
Vref is not restricted to VCC. The allowable voltage range of this pin is specified in the Absolute Maximum Ratings.



Select a value for C2 based on the system bandwidth specifications as shown in Equation 2.

$$2\times f_{BW}\ (\text{Hz}) < \frac{1}{2\pi \times R1 \times C2} \qquad (2)$$

18 Protection Circuits

The KTH2502 device is fully protected against overcurrent and reverse-supply conditions.

19 Overcurrent Protection (OCP)

An analog current-limit circuit limits the current through the FET. The driver current is clamped to I_{OCP}. During this clamping, the $r_{DS(on)}$ of the output FET is increased from the nominal value.

20 Load Dump Protection

The KTH2502 device operates at DC VCC conditions up to 32 V nominally, and can additionally withstand VCC = 36 V. No current-limiting series resistor is required for this protection.

21 Reverse Supply Protection

The KTH2502 device is protected in the event that the VCC pin and the GND pin are reversed (up to –32 V).

Table 1.

FAULT	CONDITION	DEVICE	DESCRIPTION	RECOVERY
FET overload (OCP)	$I_{SINK} \geq I_{OCP}$	Operating	Output current is clamped to I_{OCP}	$I_O < I_{OCP}$
Load dump	32 V < V_{CC} < 36 V	Operating	Device will operate for a transient duration	V_{CC} ≤ 32 V
Reverse supply	–32 V < V_{CC} < 0 V	Disabled	Device will survive this condition	V_{CC} ≥ 2.7 V

22 Device Functional Modes

The KTH2502 device is active only when VCC is between 2.7 and 32 V.

When a reverse supply condition exists, the device is inactive.

23 Application and Implementation

NOTE

Information in the following applications sections is not part of the CONNTEK component specification, and CONNTEK does not warrant its accuracy or completeness. CONNTEK customers are responsible for determining suitability of components for their purposes. Customers should validate and test their design implementation to confirm system functionality.

24 Application Information

The KTH2502 device is used in magnetic-field sensing applications.

25 Design Requirements

For this design example, use the parameters listed in Table 2 as the input parameters.

Table 2. Design Parameters

DESIGN PARAMETER	REFERENCE	EXAMPLE VALUE
Supply voltage	VCC	3.2 to 3.4 V
System bandwidth	fBW	10 kHz

26 Detailed Design Procedure

Table 3. External Components

COMPONENT	PIN 1	PIN 2	RECOMMENDED
C1	VCC	GND	A 0.1-μF (minimum) ceramic capacitor rated for V_{CC}
C2	OUT	GND	**Optional**: Place a ceramic capacitor to GND
R1	OUT	REF(1)	Requires a resistor pullup

(1) REF is not a pin on the KTH2502 device, but a REF supply-voltage pullup is required for the OUT pin; the OUT pin may be pulled up to VCC.

27 Configuration Example

In a 3.3 V system, 3.2 V ≤ Vref ≤ 3.4 V. Use Equation 3 to calculate the allowable range for R1.

$$\frac{V_{\text{ref}}\text{max}}{30\ \text{mA}} \leq \text{R1} \leq \frac{V_{\text{ref}}\ \text{min}}{100\ \mu\text{A}} \tag{3}$$

For this design example, use Equation 4 to calculate the allowable range of R1.

$$\frac{3.4\text{v}}{30\ \text{mA}} \leq \text{R1} \leq \frac{3.2\text{v}}{100\ \mu\text{A}} \tag{4}$$

Therefore:

$$113\ \Omega \leq \text{R1} \leq 32\ \text{k}\Omega \tag{5}$$

After finding the allowable range of R1 (Equation 5), select a value between 500 Ω and 32 kΩ for R1. Assuming a system bandwidth of 10 kHz, use Equation 6 to calculate the value of C2.

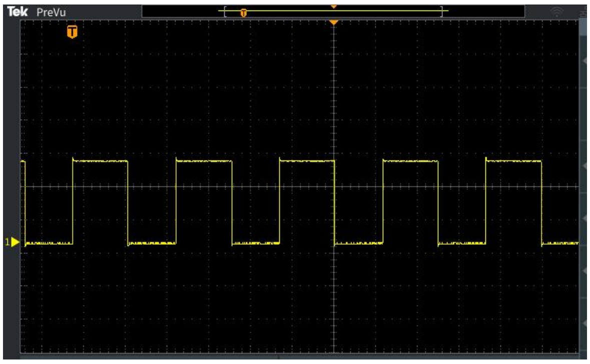
$$2 \times f_{\text{BW}}\ (\text{Hz}) \leq \frac{1}{2\pi \times \text{R1} \times \text{C2}} \tag{6}$$

For this design example, use Equation 7 to calculate the value of C2.

$$2 \times 10\ \text{kHz} \leq \frac{1}{2\pi \times \text{R1} \times \text{C2}} \tag{7}$$

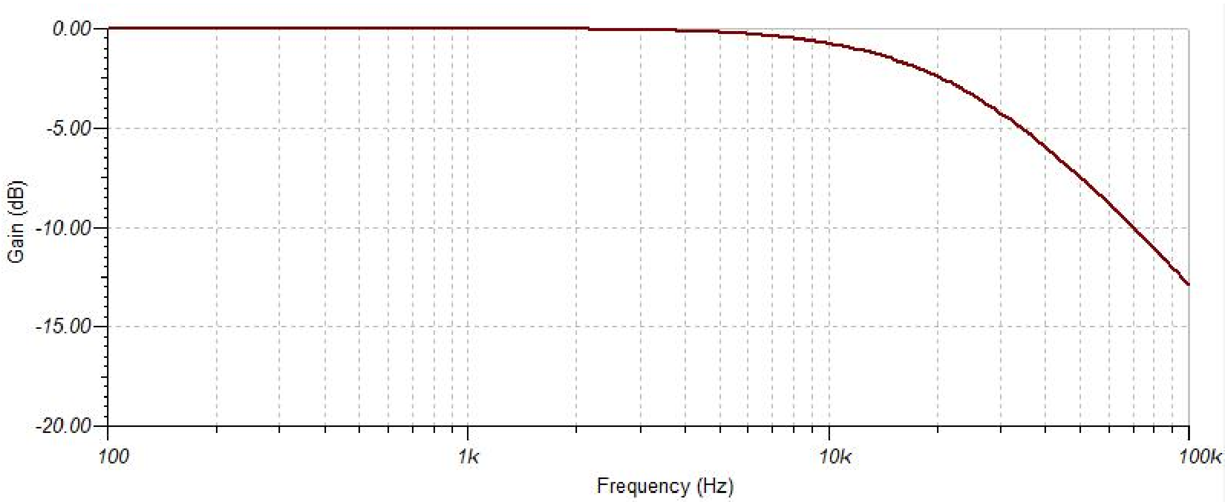
An R1 value of 10 kΩ and a C2 value less than 820 pF satisfy the requirement for a 10kHz system bandwidth. A selection of R1 = 10 kΩ and C2 = 680pF would cause a low-pass filter with a corner frequency of 23.4 kHz.

28 Application Curves



R1=10 kΩ pull-up
10kHz Switching Magnetic Field

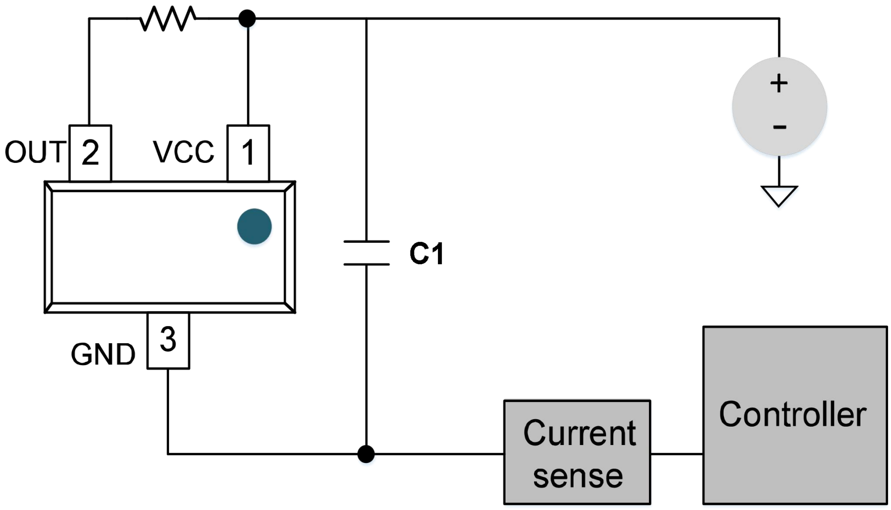
R1= 10 kΩ pull-up C2= 680pF
10kHz Switching Magnetic Field



Low-Pass Filtering

29 Alternative Two-Wire Application

For systems that require minimal wire count, the device output can be connected to VCC through a resistor, and the total supplied current can be sensed near the controller.



2-Wire Application

Current can be sensed using a shunt resistor or other circuitry.

30 Design Requirements

Table 4 lists the related design parameters,see Figure 1(when R1=1kΩ）.

Table 4. Design Parameters

DESIGN PARAMETER	REFERENCE	EXAMPLE VALUE
Supply voltage	VCC	12 V
OUT resistor	R1	1 kΩ
Bypass capacitor	C1	0.1 µF
Current when B < B_{RP}	$I_{RELEASE}$	About 3 mA
Current when B > B_{OP}	$I_{OPERATE}$	About 15 mA

31 Detailed Design Procedure

When the open-drain output of the device is high-impedance, current through the path equals the ICC of the device (approximately 3 mA).
When the output pulls low, a parallel current path is added, equal to VCC / (R1 + $r_{DS(on)}$). Using 12 V and 1 kΩ, the parallel current is approximately 12 mA, making the total current approximately 15 mA.
The local bypass capacitor C1 should be at least 0.1 μF, and a larger value if there is high inductance in the power line interconnect.

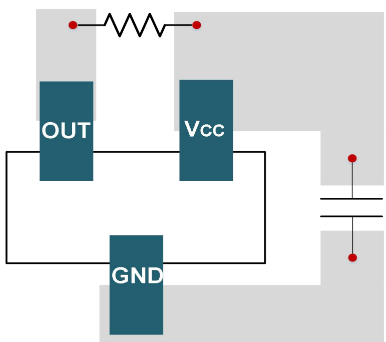
32 Power Supply Recommendations

The KTH2502 device is designed to operate from an input voltage supply (VM) range between 2.7 V and 32 V. A 0.1-μF (minimum) ceramic capacitor rated for V_{CC} must be placed as close to the KTH2502 device as possible. Larger values of the bypass capacitor may be needed to attenuate any significant high-frequency ripple and noise components generated by the power source. CONNTEK recommends limiting the supply voltage variation to less than 50 mV_{PP}.

33 Layout Guidelines

The bypass capacitor should be placed near the KTH2502 device for efficient power delivery with minimal inductance. The external pull up resistor should be placed near the microcontroller input to provide the most stable voltage at the input; alternatively, an integrated pull up resistor within the GPIO of the microcontroller can be used.
Generally, using PCB copper planes underneath the KTH2502 device has no effect on magnetic flux, and does not interfere with device performance. This is because copper is not a ferromagnetic material. However, If nearby system components contain iron or nickel, they may redirect magnetic flux in unpredictable ways.

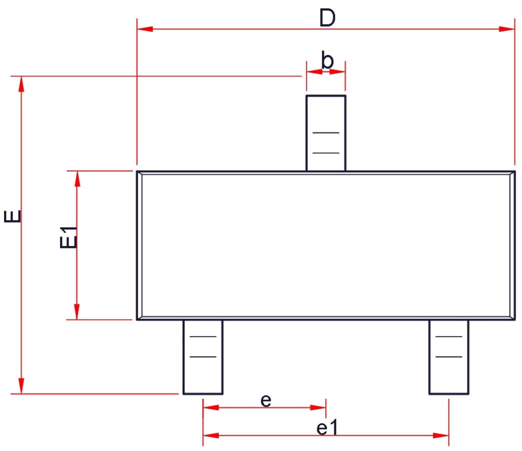
34 Layout Example

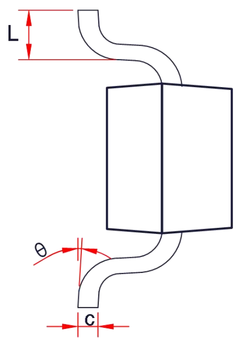


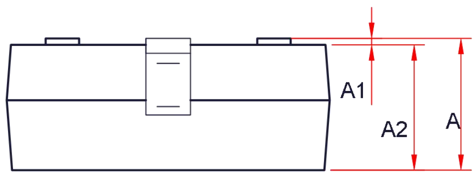
KTH2502 Layout Example

35 PACKAGE OUTLINE DIMENSIONS

SOT23

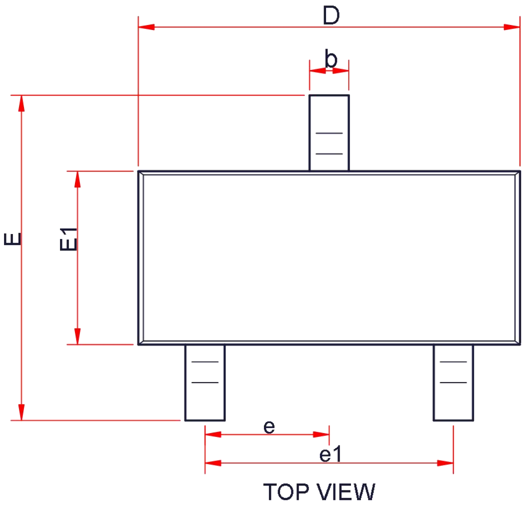


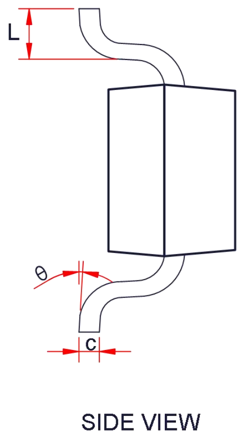


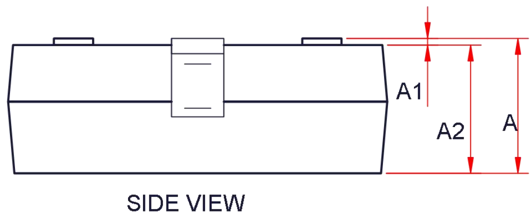


Symbol	Dimensions in Millimeters	
	Min.	Max.
A	-	1.15
A1	0.00	0.1
A2	0.9	1.1
b	0.30	0.50
c	0.132	0.202
D	2.8	3.0
E	2.25	2.55
E1	1.2	1.4
e	1.8	2.0
L	0.30	0.50
θ	0 °	8 °

SOT-23-3L

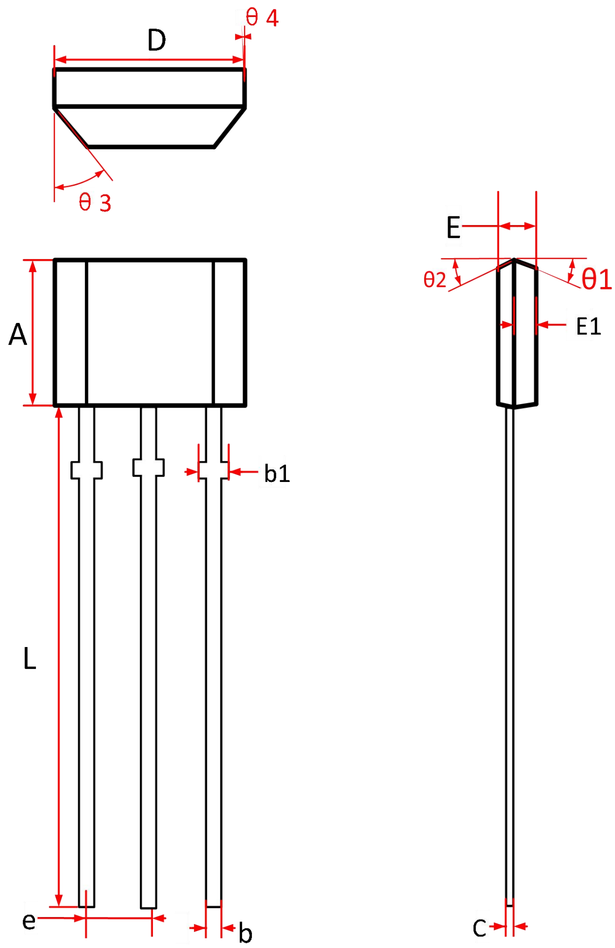






Symbol	Dimensions in Millimeters		
	Min.	Typ.	Max.
A	-	-	1.25
A1	0.00	-	0.1
A2	1.00	1.10	1.15
b	0.30	-	0.50
c	0.10	-	0.20
D	2.82	2.95	3.02
E	2.65	2.80	2.95
E1	1.50	1.65	1.70
e	0.85	0.95	1.05
e1	1.80	1.90	2.00
L	0.30	0.45	0.60
θ	0 °	-	8 °

TO-92S



Symbol	Dimensions in Millimeters		
	Min.	Typ.	Max.
A	2.90	3.00	3.10
b	0.35	0.39	0.50
b1	0.40	0.44	0.55
C	0.36	0.38	0.45
D	3.90	4.00	4.10
E	1.42	1.52	1.62
E1		0.75	
e	1.27 TYP		
L	13.50	14.50	15.50
θ 1		6°	
θ 2		3°	
θ 3		45°	
θ 4		3°	