AKM Semiconductor Inc
www.akm.com

AKM Magnetic Sensors
Engineering Development Kits
Demonstration Modules
Application Case Studies

Lou Law
May 2011

GMW Associates www.gmw.com 650-802-8292
AKM Engineering Development Kits
and Product Support Documents

1 - AKM Hall Element KITs
   AN_161KITs
   AN_160KIT Universal Hall Interface Amplifier
2 - Gapped Core Current Sensor KITs using the AKM EQ-73XL Series Linear ICs
   AN_130KIT EQ-730L
   AN_131KIT EQ-731L
   AN_135KIT EQ-733L
   AN_136KIT EQ-733L
3 - CQ-121/131 Series Current Sensors KITS
   AN_165KIT
4 - CQ-20XX Series Current Sensors KITs
   AN_170KIT
5 - EM3242 Non-Contact Angle Sensor IC KITs
   AN_133KIT
   Reference Design RD101-EM3242
   AN_134KIT
   Reference Design RD102-EM3242
6 - Case Studies of Application using the AKM sensors
   AKMCS-001 Non Contact Remote ON-OFF
   AKMCS-002 Flow Meter using EM3242 Angle Sensor
   AKMCS-003- Flow Meter using AKM Encoder IC’s
   AKMCS-004 Accurate Position Sensing using AKM Hall Switches
7 - Demonstrators
   AK8775/6 Encoder ICs
UHIM Features

- Terminals for all I/O connections
- User Selectable I/V drive levels
- User Selectable I/V Ranges
- User Selectable Coarse Gain
- Fine Gain Adjustment
- Offset Adjustment
- Compatible with Types 1-4 PCBs and SIP packages

ASAHI Hall Element Evaluation Boards

AN_160KIT (UHIM)

GMW Associates  www.gmw.com   650-802-8292
DESCRIPTION

The AN_161KIT series of kits are PCB assemblies which provide an easy means to evaluate the Asahi Hall elements for magnetic field, electric current or position sensing applications. These kits can be used independently by themselves or with the GMW AN_160KIT, Universal Hall Interface Module (UHIM). There are two basic connection schemes depending on the kit part number as shown below. See the AN_160KIT specification sheet for details on the use of these kits with the UHIM.


<table>
<thead>
<tr>
<th>AN_161KIT Series</th>
<th>AN_162KIT Extension Cable (Required)</th>
<th>Connection Scheme</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Connection Diagram</td>
</tr>
</tbody>
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<table>
<thead>
<tr>
<th>AN_161KIT Series</th>
<th>AN_161KIT Series</th>
<th>AN_162KIT Extension Cable (Optional)</th>
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<tbody>
<tr>
<td></td>
<td></td>
<td>Connection Diagram</td>
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</table>

Revision Date: Feb 17, 2011
DESCRIPTION

The AN_160KIT is a Universal Hall Interface Module (UHIM) which provides an easy means to evaluate the Asahi Hall elements for magnetic field, electric current or position sensing applications.

The UHIM consists of a differential amplifier, a voltage drive circuit for Hall elements requiring a voltage drive, a current drive circuit for Hall elements requiring current drive, and two analog output circuits to provide the standard 2.5V+/-2.5V signal and a 1.5V+/-1.5V signal for 0-3V input level A/D circuits.

The kit provides selector switches to configure the UHIM to optimize the parameters for the various Asahi Hall elements and both a gain adjustment potentiometer and an offset adjustment potentiometer. The UHIM will interface with GWM’s Asahi element test PCB kits (AN_161 series) and the SIP element packages.

Features:
- Terminal strips for all input/output connections
- User selectable current drive or voltage drive
- User selectable current or voltage drive ranges (10/1/5) mA or volts
- User selectable coarse gain ranges (1-10, 10-100, 100-1000)
- Fine Gain adjustment (1-10X)
- Offset adjustment
- Two Analog outputs (2.5+/-2.5V and 1.5V+/-1.5V for 0-3V ADCs)
- Compatible with all Asahi/GMW Element test PCB KITS and SIP devices

AN_160KIT

Fig 1. AN_160KIT Outline
Universal Hall Interface Module - AN_160KIT

SPECIFICATIONS

Absolute Maximum Ratings

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Parameter</th>
<th>Min.</th>
<th>Typ.</th>
<th>Max.</th>
<th>Unit</th>
<th>Remarks</th>
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<td>TSTG</td>
<td>Storage Temperature</td>
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<td></td>
<td>100</td>
<td>°C</td>
<td></td>
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<tr>
<td>TA</td>
<td>Ambient Temperature</td>
<td>-10</td>
<td></td>
<td>85</td>
<td>°C</td>
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<td>VDD</td>
<td>Supply Voltage</td>
<td>-0.5</td>
<td></td>
<td>+16.0</td>
<td>V</td>
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Recommended Operating Conditions

<table>
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<tr>
<th>Symbol</th>
<th>Parameter</th>
<th>Min.</th>
<th>Typ.</th>
<th>Max.</th>
<th>Unit</th>
<th>Remarks</th>
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<tr>
<td>VDD</td>
<td>Supply Voltage</td>
<td>5.5</td>
<td>5.5</td>
<td>16</td>
<td>V</td>
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<tr>
<td>A1</td>
<td>Analog Output 1</td>
<td>0.05</td>
<td>2.5</td>
<td>4.95</td>
<td>V</td>
<td></td>
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<tr>
<td>A2</td>
<td>Analog Output 2</td>
<td>0.05</td>
<td>1.5</td>
<td>2.95</td>
<td>V</td>
<td>For 0-3 V A/D’s</td>
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Table 2. Asahi Hall Element Test Kit Selection and UHIM Configuration table

<table>
<thead>
<tr>
<th>Hall Elements</th>
<th>Element Kit Type</th>
<th>Hall Element Kit P/N (Ordered separately)</th>
<th>Extension Cable</th>
<th>UHIM Configuration</th>
<th>Drive Select</th>
<th>Drive Range (V) or (mA)</th>
<th>Coarse Gain Range</th>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>I (current)</td>
<td>I</td>
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<td>AN_161-xx-xxxx (1)</td>
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<td>AN_161-xx-xxxx (1)</td>
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<td>HS-0111</td>
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<td>HG-106C, HG-106A</td>
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<td>AN_161-xx-xxxx (1)</td>
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<td>HG-176A, HG-186A</td>
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<td>HW-101A</td>
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<td>X</td>
<td>X</td>
<td>X</td>
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<tr>
<td>HW-300B, HW-302B, HW-322B</td>
<td>N/A</td>
<td>SIP (no kit required)</td>
<td>Optional</td>
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<td>HG-302C, HG-302A</td>
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<td>SIP (no kit required)</td>
<td>Optional</td>
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<td>X</td>
<td>X</td>
<td>X</td>
</tr>
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Note: 1) Example: For a kit with the HG-0111 device the Hall element kit number would be AN_161-HG-0111

Revision Date: Feb 17, 2011

GMW Associates: 955 Industrial Road, San Carlos, CA 94070, USA. www.gmw.com. +1 (650) 802-8292
Fig. 2  Schematic, AN_160KIT

Current Drive or Voltage Drive Select switch

Drive Range Select switch - When I/V Sel Switch is in I, range is 10mA, 1mA or 5mA. When I/V Sel switch is in V, range is 10V, 1V or 5V

Analog Output Fine Gain adjustment 11 turn potentiometer

Hall Element Input or AN_161KIT Connection

Analog Outputs coarse Gain Range selection switch - 10X, 1X, 100X

Analog Outputs Offset voltage adjustment- 11 turn potentiometer

Fig. 3 - AN_160KIT Controls and Interconnect Layout
Application Notes:

Connect the Hall element kit (AN_161-xx-xxx) or SIP Hall element to the AN_160KIT as shown in the above Figures (4 thru 7).

- Configure the AN_160KIT Module “Drive Sel” and “Drive Range” for the device being tested per the criteria shown in Table 2.
- Apply power (5.5V to 16VDC) to the terminals shown in Figure 3.
- Monitor the output(s) shown in Fig 3 with respect to common.
- Set the “GAIN RANGE” switch, and adjust the “GAIN” and “OFFSET” potentiometers as needed.
Features

- Low Noise-Wide Dynamic Range
- 3 to 5.5V Operation
- 4 Sensitivity ranges (20, 40, 65, 130 mV/mT)
- SIP and SMD Packages
- Fast response time < 2.5us
- DC to 100kHz

Core Selections for Nom Hall IC Sensitivity @ 5V

<table>
<thead>
<tr>
<th>IC</th>
<th>Peak Current (A)</th>
<th>Current Resolution (mA/p-p)</th>
<th>Kolektor Magma (mm)</th>
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<tr>
<td></td>
<td></td>
<td></td>
<td>OD</td>
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<tr>
<td>EQ-730L</td>
<td>17</td>
<td>7</td>
<td>10.0</td>
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<tr>
<td>EQ-731L</td>
<td>35</td>
<td>13</td>
<td></td>
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<tr>
<td>EQ-732L</td>
<td>55</td>
<td>22</td>
<td>14.0</td>
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<tr>
<td>EQ-733L</td>
<td>110</td>
<td>44</td>
<td>22.1</td>
</tr>
</tbody>
</table>

Gapped Core Current Sensors Kits using Asahi Low Noise Linear Hall Effect Sensor IC

GMW Associates  www.gmw.com  650-802-8292
**General Description**

The AN_130KIT provides an easy method of evaluating the Asahi EQ-730L Linear Hall sensor IC in a “gapped core” current sensor application. The AN_130KIT includes the Asahi EQ-730L linear IC mounted in the nominal 1.25mm wide gap cut into a 10mm x 6 mm x 4mm Ferrite core. This configuration produces a nominal output sensitivity of 120mV/A. The full scale current range is 12Arms or 17A peak. The kit includes a +5V regulator, however the circuit will work down to 2.7VDC. With the input voltage below 5V, the Hall IC supply is no longer regulated and the sensitivity, supply current and full scale output range will reduce by an amount directly proportional to the supply voltage. For example; at 3V, the sensitivity is 3/5 of 120mV/A will be equal to 73mV/A.

The Asahi EQ-730L has a very fast response time, < 5uS, thereby making it very useful for over current applications. The Asahi EQ-730L broadband output noise characteristic is low, < 5mVpp, to give an operating range of about 2000mV/2.5mV or about 800:1.

Included in the kit is a mating connector

**Features**

- Measures AC or DC currents in wires up to 14AWG
- Nominal Sensitivity: 120 ±35 mV/A for 5V Supply and 73 ±22 mV/A for 3V Supply
  (EQ-730L Magnetic Sensitivity of 130 ±30 mV/mT)
- Nominal Quiescent Output Voltage: 2.5V +/- 0.20V @ Iprimary = 0A
- Fast response time: <5uS
- Wide bandwidth: DC to 300kHz (-3dB)
- Low noise:< 5mVpp
- Large Dynamic range > 800:1
- Full scale output linear of 2.5V +/- 2.0V (With input supply voltage of 5.0 to 15VDC)
- Supply current: ≈ 8mA
- Supply voltage range of 2.7V to 15V (Below 5.0V, the voltage to the EQ-730L is unregulated)
- Galvanic isolation between primary conductor and sensor
- Interface Connector - 4 Pin 0.100” centers (Mating connector included)
- Bi-directional sensing
- Regulated Voltage Output (+5V) Pin (available for external use- up to 20mA)

**References:**

- Hall IC Specification EQ-730L
- Ferrite Core Specification T 22G 10 06 04-02

GMW Associates: 955 Industrial Road, San Carlos, CA 94070, USA. www.gmw.com. +1 (650) 802-8292

Revision Date: Feb 17, 2011
AN_130KIT - Asahi EQ-730L Hall Sensor
Gapped Core, Open Loop, Current Sensor Application

Schematic, AN_130KIT

Parts List, AN_130KIT

<table>
<thead>
<tr>
<th>Item</th>
<th>Qty</th>
<th>P/N</th>
<th>Title</th>
<th>Reference(m)</th>
<th>Vendor</th>
<th>Vendor P/N</th>
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<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>12900-2426-0</td>
<td>IC, Linear Hall Effect, +/-130mV/mT, EQ-710L</td>
<td>IC1</td>
<td>GMW Associates</td>
<td>Asahi EQ-710L</td>
</tr>
<tr>
<td>2</td>
<td>1</td>
<td>12900-2413-0</td>
<td>IC REG LDO MICROPOWER SOT23-5</td>
<td>IC2</td>
<td>Digi-Key Corporation</td>
<td>LP2980IMS-5.0CT-ND</td>
</tr>
<tr>
<td>3</td>
<td>1</td>
<td>12900-2201-3</td>
<td>CAP CER, 10UF 50V Y5V 0603</td>
<td>C1</td>
<td>Digi-Key Corporation</td>
<td>445-1324-2-ND</td>
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<tr>
<td>4</td>
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<td>12900-2302-0</td>
<td>Diode, Zener, 5.6V, SMD</td>
<td>D1/D2</td>
<td>Digi-Key Corporation</td>
<td>AZ23C5V6-FDITR-ND</td>
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<td>5</td>
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<td>12900-2213-0</td>
<td>CAP TANTALUM 10UF 6.3V 10% SMD</td>
<td>C2</td>
<td>Digi-Key Corporation</td>
<td>495-2180-1-ND</td>
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<td>6</td>
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<td>12900-2709-0</td>
<td>Conn Header 4POS 0.100 RIA Tin</td>
<td>J1</td>
<td>Digi-Key Corporation</td>
<td>WM6004-ND</td>
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<tr>
<td>7</td>
<td>1</td>
<td>12900-2812-0</td>
<td>Core, Ferite, 10mm x 6mm x 4mm 1.25mm Gap</td>
<td>T1</td>
<td>Ceramic Magnetics, Inc.</td>
<td>T22G 10 06 04-02</td>
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</table>
General Description

The AN_131KIT provides an easy method of evaluating the Asahi EQ-731L Linear Hall sensor IC in a “gapped core” current sensor application. The AN_131KIT includes the Asahi EQ-731L linear IC mounted in the nominal 1.25mm wide gap cut into a 10mm x 6 mm x 4mm Ferrite core. This configuration produces a nominal output sensitivity of 60mV/A. The full scale current range is 25Arms or 35A peak. The kit includes a +5V regulator, however the circuit will work down to 2.7VDC. With the input voltage below 5V, the Hall IC supply is no longer regulated and the sensitivity, supply current and full scale output range will reduce by an amount directly proportional to the supply voltage. For example; at 3V, the sensitivity is 3/5 of 60mV/A will be equal to 36mV/A.

The Asahi EQ-731L has a very fast response time, < 5uS, thereby making it very useful for over current applications. The Asahi EQ-731L broadband output noise characteristic is low, < 5mVpp, to give an operating range of about 2000mV/2.5mV or about 800:1.

Included in the kit is a mating connector.

Features

- Measures AC or DC currents in wires up to 12AWG
- Nominal Sensitivity: 63 ±20 mV/A for 5V Supply and 36 ±12 mV/A for 3V Supply
  (EQ-731L Magnetic Sensitivity of 65 ±15 mV/mT)
- Nominal Quiescent Output Voltage: 2.5V+/− 0.15V @ Iprimary = 0A
- Fast response time: <5uS
- Wide bandwidth: DC to 300kHz (-3dB)
- Low noise: < 5mVpp
- Large Dynamic range > 800:1
- Full scale output linear of 2.5V+/− 2.0V (With input supply voltage of 5.0 to 15VDC)
- Supply current: ≈ 8mA
- Supply voltage range of 2.7V to 15V (Below 5.0V, the voltage to the EQ-731L is unregulated)
- Galvanic isolation between primary conductor and sensor
- Interface Connector - 4 Pin 0.100” centers (Mating connector included)
- Bi-directional sensing
- Regulated Voltage Output (+5V) Pin (available for external use- up to 20mA)

AN_131KIT with mating connector

AN_131KIT Electrical Block Diagram

References:

- Hall IC Specification EQ-731L
- Ferrite Core Specification T 22G 10 06 04-02
AN_131KIT - Asahi EQ-731L Hall Sensor
Gapped Core, Open Loop, Current Sensor Application

Schematic, AN_131KIT

Parts List, AN_131KIT

<table>
<thead>
<tr>
<th>Item</th>
<th>Qty</th>
<th>P/N</th>
<th>Title</th>
<th>Reference(m)</th>
<th>Vendor</th>
<th>Vendor P/N</th>
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<td>12900-2427-0</td>
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<td>IC1</td>
<td>GMW Associates</td>
<td>EQ-711L</td>
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<td>2</td>
<td>1</td>
<td>12900-2413-0</td>
<td>IC REG LDO MICROPOWER SOT23-5</td>
<td>IC2</td>
<td>Digi-Key Corporation</td>
<td>LP2980IM5-5.0CT-ND</td>
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<td>12900-2201-0</td>
<td>CAP .1UF 50V CERAMIC XTR 0805</td>
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<td>PCC1840TR-ND</td>
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<td>Diode, Zener, 5.6V, SMD</td>
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<td>C2</td>
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<td>12900-2709-0</td>
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<td>J1</td>
<td>Digi-Key Corporation</td>
<td>WM6004-ND</td>
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<td>T1</td>
<td>Ceramic Magnetics, Inc.</td>
<td>T22G 10 06 04-02</td>
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</table>
General Description

The AN_135KIT provides an easy method of evaluating the Asahi EQ-732L Linear Hall sensor IC in a “gapped core” current sensor application. The AN_135KIT includes the Asahi EQ-732L linear IC mounted in the nominal 1.25mm wide gap cut into a 14mm x 9 mm x 5mm Ferrite core. This configuration produces a nominal output sensitivity of 37mV/A. The full scale current range is 40Arms or 57A peak. The kit includes a +5V regulator, however the circuit will work down to 2.7VDC. With the input voltage below 5V, the Hall IC supply is no longer regulated and the sensitivity, supply current and full scale output range will reduce by an amount directly proportional to the supply voltage. For example; at 3V, the sensitivity is 3/5 of 37mV/A will be equal to 22mV/A.

The Asahi EQ-732L has a very fast response time, < 5µS, thereby making it very useful for over current applications. The Asahi EQ-732L broadband output noise characteristic is low, < 5mVpp, to give an operating range of about 2000mV/2.5mV or about 800:1.

Included in the kit is a mating connector.

Features

- Measures AC or DC currents in wires up to 8AWG
- Nominal Sensitivity: 37 ±10 mV/A for 5V Supply and 22 ±7 mV/A for 3V Supply
- (EQ-732L Magnetic Sensitivity of 40 ±10 mV/mT)
- Nominal Quiescent Output Voltage: 2.5V+/− 0.10V @ Iprimary = 0A
- Fast response time: <5µS
- Wide bandwidth: DC to 300kHz (-3dB)
- Low noise:< 5mVpp
- Large Dynamic range > 800:1
- Full scale output linear of 2.5V+/− 2.0V (With input supply voltage of 5.0 to 15VDC)
- Supply current: ≈ 8mA
- Supply voltage range of 2.7V to 15V (Below 5.0V, the voltage to the EQ-732L is unregulated)
- Galvanic isolation between primary conductor and sensor
- Interface Connector - 4 Pin 0.100” centers (Mating connector included)
- Bi-directional sensing
- Regulated Voltage Output (+5V) Pin (available for external use- up to 20mA)

AN_135KIT Electrical Block Diagram

References:

- Hall IC Specification EQ-732L
- Ferrite Core Specification T 22G 14 09 05-02
AN_135KIT - Asahi EQ-732L Hall Sensor
Gapped Core, Open Loop, Current Sensor Application

Schematic, AN_135KIT

Parts List, AN_135KIT

<table>
<thead>
<tr>
<th>Item</th>
<th>Qty</th>
<th>Title</th>
<th>Reference (Vendor)</th>
<th>Vendor</th>
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<tr>
<td>1</td>
<td>1</td>
<td>IC, Linear Hall Effect, +/- 40mV/mT, EQ-712L</td>
<td>IC1</td>
<td>GMW Associates EQ-712L</td>
</tr>
<tr>
<td>2</td>
<td>1</td>
<td>IC, REG LDO MICROPOWER SOT23-5</td>
<td>IC2</td>
<td>Digi-Key Corporation LP2800M5-5.0CT-ND</td>
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<td>C1</td>
<td>Digi-Key Corporation PCC1840TR-ND</td>
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<td>D1/D2</td>
<td>Digi-Key Corporation AZ23C5V6-FD/TR-ND</td>
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Revision Date: Feb 17, 2011
**General Description**

The AN_136KIT provides an easy method of evaluating the Asahi EQ-733L Linear Hall sensor IC in a “gapped core” current sensor application. The AN_136KIT includes the Asahi EQ-733L linear IC mounted in the nominal 1.25mm wide gap cut into a 22mm x 14 mm x 7mm Ferrite core. This configuration produces a nominal output sensitivity of 37mV/A. The full scale current range is 40Arms or 57A peak. The kit includes a +5V regulator, however the circuit will work down to 2.7VDC. With the input voltage below 5V, the Hall IC supply is no longer regulated and the sensitivity, supply current and full scale output range will reduce by an amount directly proportional to the supply voltage. For example, at 3V, the sensitivity is 3/5 of 37mV/A will be equal to 22mV/A.

The Asahi EQ-733L has a very fast response time, < 5μS, thereby making it very useful for over current applications. The Asahi EQ-733L broadband output noise characteristic is low, < 5mVpp, to give an operating range of about 2000mV/2.5mV or about 800:1.

Included in the kit is a mating connector.

**Features**

- Measures AC or DC currents in wires up to 4AWG
- Nominal Sensitivity: 18 ±6 mV/A for 5V Supply and 11 ±3.5mV/A for 3V Supply
  (EQ-733L Magnetic Sensitivity of 20 ±5 mV/mT)
- Nominal Quiescent Output Voltage: 2.5V+/− 0.05V @ Iprimary = 0A
- Fast response time: <5μS
- Wide bandwidth: DC to 300kHz (-3dB)
- Low noise:< 5mVpp
- Large Dynamic range > 800:1
- Full scale output linear of 2.5V+/− 2.0V (With input supply voltage of 5.0 to 15VDC)
- Supply current: ≈ 8mA
- Supply voltage range of 2.7V to 15V (Below 5.0V, the voltage to the EQ-733L is unregulated)
- Galvanic isolation between primary conductor and sensor
- Interface Connector - 4 Pin 0.100” centers (Mating connector included)
- Bi-directional sensing
- Regulated Voltage Output (+5V) Pin (available for external use- up to 20mA)

**References:**

Hall IC Specification EQ-733L
Ferrite Core Specification T 22G 22 14 07-05
AN_136KIT - Asahi EQ-733L Hall Sensor
Gapped Core, Open Loop, Current Sensor Application

Schematic, AN_136KIT

Parts List, AN_1356KIT

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Features

- Very Low Noise
- High Isolation Voltage
- DC AC Operation
- Large Dynamic Range
- 3 to 5.5V Operation
- DC to 100kHz

Components

- CQ-121E 25A
- CQ-121E 50A

Engineering Kits

- AN_165KIT 25A
- AN_165KIT 50A

ASAHI Current Sensor and Engineering Development Kits

GMW Associates  www.gmw.com  650-802-8292
General Description
The AN_165KIT-25A and AN_165KIT-50A engineering development kits provide an easy method of evaluating the Asahi CQ-121E and CQ-131E linear Hall current sensors. The AN_165KIT-25A demonstrates the Asahi CQ-121E sensor and has a current range of +/-25A. The AN_165KIT-50A demonstrates CQ-131E and has a range of +/-50A. The CQ Series incorporates the Asahi EQ-711L Linear Hall IC and a custom ferrite core.

Included in the kit is a mating connector

References:
Asahi Sensor Specification  CQ-121E/CQ-131E
Asahi Linear Hall Specification  EQ-711L

KIT Part Numbers
AN_165KIT-25A
AN_165KIT-50A

Features
Small-sized open loop current transducer using Linear Hall Effect IC
Galvanic isolation between the primary conductor and the Hall Effect IC.
Sensitivity range: 63 +/- 8mV/A
Analog output voltage range: 1/2Vcc +/- 95% Vcc
Offset voltage: 1/2Vcc +/- 6%
Supply voltage range: 3-5.5V
Ratiometric analog output
Quick response: Typ. 3μs
Supply current: Typ.9mA
Operating Temperature Range:-30 to +80
Components

CQ-2092 +/-21A, 20Arms
CQ-2093 +/-35A, 20Arms

CQ-2063 +/-35A, 50Arms
CQ-2094 +/-54A, 50Arms
CQ-2063 +/-85A, 50Arms
CQ-2094 +/-130A, 50Arms

Engineering Kits

AN_170KIT
For the CQ-2092

Features

• 2.5V+/−2.4V signal
• Ratiometric output
• DC & AC operation
• Very low noise <2mVrms
• Large dynamic range: 1000:1
• High isolation voltage
• Single 5.0V supply
• DC to 400kHz
• 1μS response time
• +/-2% accuracy

AKM Current Sensor and Engineering Development Kits

GMW Associates  www.gmw.com  650-802-8292
General Description

The AN_170KIT engineering development kit provides an easy method of evaluating the AKM CQ-2092 linear Hall current sensor. The AN_170KIT demonstrates the AKM CQ-2092 sensor and has a current range of +/-20A. The CQ-2092 current sensor incorporates the AKM EQ-950L factory programmed Linear Hall IC and a custom ferrite core. The kit includes a 5V regulator for the CQ-2092 and will operate with an input Vcc voltage of 5V to 24Vdc.

Features

- Small-sized open loop current transducer using a factory programmed Linear Hall Effect IC
- Galvanic isolation between the primary conductor and the Hall Effect IC: >2.5kV
- Sensitivity range: 100 +/- 2mV/A (+/-2%)
- Analog output voltage range: 2.5V +/- 2.4V
- Offset voltage: 2.50V +/- 110mV
- Kit supply voltage range: 5V to 24Vdc
- Supply current: Typ. <9mA
- Large BW: dc to 400kHz (-3db)
- Fast response: Typ. 1μs delay
- Ratiometric analog output
- Operating temperature range:-40 to +90 °C
- Very low output noise: <2.5mVrms
- Large Dynamic Range 1000:1

References:
AKM Sensor Specification: CQ-2092 Linear Current Sensor

KIT Part Number
AN_170KIT

AN_170KIT with mating connector and pigtail

AN_170KIT Outline Drawing (all dimensions in mm)
Schematic, AN_170KIT

AN_170KIT

AKM CQ-2092

Molex WM4302

Molex WM2002

Current IN

Current OUT

AKM CQ-2092

2.2μF

0.1μF

+5V Reg

Vcc 5 to 24Vdc @9mA

+5V Out

 COM

 Analog Out

GMW Associates: 955 Industrial Road, San Carlos, CA 94070, USA. www.gmw.com. +1 (650) 802-8292
EM-3242 Features

- Non-Contact Angle Sensing
- 3 to 5.5V Operation
- 360 Degree Range
- Very small 6 Pin SMD
- High Speed Operation
- Large Air-Gap

ASahi EM-3242 360 Degree Non-Contact Angle Sensing IC with Pre-Engineered Reference Designs and Development Kits
ASAHI KASEI EMD - EM3242 Non-Contact Angle Sensor

Engineer Evaluation Kit

FEATURES of the EM3242 Non-Contact Angle Sensor

- Non-Contact Angle Sensing
- Senses magnetic field orientation of a small permanent magnet
- Small Size 3.6 x 3.0 x 0.8 mm - 6pin SOIC
- Resolution of up to 10 bits (0.35 deg)
- Non-linearity - 1%
- Low Power -Typ. 10mA @3.0V
- Sleep Mode - 1uA current draw
- Linear ratio-metric analog output voltage proportional to 0-360deg
- Single supply (2.7 to 5.25 V operating)
- Only one external part required - 0.1uF Capacitor
- Very High Speed > 8K RPM

GENERAL DESCRIPTION
The AN_133KIT consists of a EM3242 angle sensor mounted on a small 0.25” square PCB with a 2 inch flat cable. Also included in kit are two SmCo24 magnets compatible with the angle sensor, a 0.25” dia. magnet and a 0.25” square magnet. The sensor works well with smaller magnets but with less air gap. This kit eliminates the need to design a PCB for testing which makes it convenient to evaluate the EM3242 for compatibility to the user’s applications. See EM3242 specification for details.

Magnet Field Orientation
“0” Degrees
Clockwise rotation increases the output voltage.

Air Gap range for standard RD and SQ magnets

EM3242 Angle Sensor, Output vs Angle

Vcc = 3.0V
Note: Output is proportional to Vcc

Connection Diagram - AN_133KIT
The RD101-EM3242 is a reference design for the AKM EM-3242 Non-Contact Angle Position Sensing IC. The EM-3242 senses the angle of magnetic field component in the top plane of the device package. The EM-3242 provides an analog output voltage of 10% to 90% of the supply voltage for a mechanical angle range of 360 degrees of rotation. The EM-3242 has two operating modes. One with the “In Range” detector enabled and one with the “In Range” detector disabled. The “In Range” detector includes internal circuitry which causes the output voltage to drop to 0V whenever the magnetic field level at the EM-3242 is greater than 60mT or less than 10mT. This reference design illustrates the operating mode which has the “In-Range” detector disabled. Please note that the PDN (Power Down) function is also disabled in this mode.

GMW offers a development kit that can be used to demonstrate this reference design. The kit P/N is AN_133KIT

RD102-EM3242 details the design for an angle sensor that has the “In Range” detector enabled and the PDN (Power Down) enabled.

**FEATURES**

- 360 Degree Non-Contact Magnetic Angle Position Sensing
- Analog Output 10% to 90% of VDD
- Nonlinearity less than 3.5 deg at 3V
- Magnetic to EM-3242 separation of 0.120” to 0.190” (55B0082 magnet)
- Tolerant of mechanical misalignment
- Expanded Magnet to IC separation with increased non-linearity

**Reference Documents**

- 55B0082 Spec Sheet (0.25”dia. x 0.15”T SmCo24 Magnet)
- 55B0081 Spec Sheet (0.15”dia. x 0.15”T SmCo24 Magnet)
- 55C0126 Spec Sheet (0.25”Sq. x 0.10”T SmCo24 Magnet)
- AN_133KIT- Eng Development Kit
- RD102-EM3242 Ref Design for Angle sensing with “In Range” Detector

**Magnetic flux density (Magnetic Field)**

units of Gauss and Tesla

1G=100uT or 0.1mT
10G =1mT
100G =10mT

**Bill of Material**

- IC-1 EM-3242 IC
- C1- 0.1uF Ceramic cap-0603 SMD +/-10%
- PCB FR-4, 0.8mm thick, 0.5 oz copper
- 55B0082 Cylindrical Magnet or
- 55B0081 Cylindrical Magnet or
- 55C0126 Square Magnet
Magnet Orientation

Output increases as magnet is rotated Counterclockwise. See output curve, next page

Zero Degrees occurs when the South Pole of the magnet is in line with pin 6 of the IC.
360 to 0 Degree Transition
When the Angle of rotation approaches the 360 degree position, the output will approach 90% of the supply voltage and then abruptly change to 10% of VDD and then start increasing again as the angle increases. This transition can be a wide as 0.5deg. If the position of the magnet is held steady at a point within the 0.5 deg. range, there is a possibility that the output will randomly switch between the 90% level and the 10% level. Both levels represent the same angle of 0 deg. If the output is filtered with a low pass filter, the average voltage output could be approximately 50% of VDD, thus creating an error in the reading. This can be avoided by not using a low pass filter. If a uP is used to sample the output, it can simply register a 10%VDD reading and a 90%VDD reading as the same angle (zero degrees).

Non-Linearity Specifications.
The EM-3242 is specified to operate within +/-6 degrees of non-linearity when the supply is 3V over the magnetic field range of 20mT to 40mT. With the "In Range” detector disabled, as in this case, the sensor will continue to function normally over a wider range, but with an increased angle error. The following graphs show the relationship between the non-linearity range and the air gap between the magnet and sensor for the 55B0082 magnet.
Expanded Range Operating Mode
Angle Error vs Air Gap for the 55B0082 Magnet
VDD = 3.0V
ASAHI KASEI EMD - EM-3242 Non-Contact Angle Sensor without “In Range” Detection Engineering Development Kit

FEATURES of the EM-3242 Non-Contact Angle Sensor
- Non-Contact Angle Sensing
- Senses magnetic field orientation of a small permanent magnet
- Small Size 3.6 x 3.0 x 0.8 mm - 6 pin SOIC
- Resolution of up to 10 bits (0.35 deg)
- Non-linearity - 1% (at 3V)
- Low Power -Typ. 9mA
- Sleep Mode - 1uA current draw
- Linear ratio-metric analog output voltage proportional to 0-360deg
- Single supply (2.7 to 5.5V operating)
- Only one external part required - 0.1uF Capacitor
- Very High Speed > 8K RPM
- “Out of Range” Detection

GENERAL DESCRIPTION
The AN_134KIT consists of a EM-3242 angle sensor mounted on a small 0.25” square PCB with a 6 inch flat cable. Also included in kit are three SmCo24 magnets compatible with the angle sensor, a 0.25” dia. magnet, a 0.15” dia magnet and a 0.25” square magnet. The sensor works well with smaller magnets but with less air gap. The Sensor incorporates a “Out or Range “ detector circuit and will fault the output to zero volts when the magnet’s strength is either too weak or too strong. See RD102-EM3242 for details.
This kit eliminates the need to design a PCB for testing which makes it convenient to evaluate the EM-3242 for compatibility to the user’s applications. See EM-3242 specification for details.
The RD102-EM3242 is a reference design for the AKM EM-3242 Non-Contact Angle Position Sensing IC. The EM-3242 senses the angle of magnetic field component in the top plane of the device package. The EM-3242 provides an analog output voltage of 10% to 90% of the supply voltage for a mechanical angle range of 360 degrees of rotation. The EM-3242 has two operating modes. One with the “In Range” detector enabled and one with the “In Range” detector disabled. The “In Range” detector includes internal circuitry which causes the output voltage to drop to 0V whenever the magnetic field level at the EM-3242 is greater than 60mT or less than 10mT. This reference design illustrates the operating mode which has the “In-Range” detector enabled. Please note that the PDN (Power Down) function is also enabled in this mode.

GMW offers an engineering development kit that can be used to evaluate this reference design. The P/N is AN_134KIT

RD101-EM3242 details the design for a angle sensor that has the “In Range” detector enabled and the PDN (Power Down) enabled.

**FEATURES**

- 360 Degree Non-Contact Magnetic Angle Position Sensing
- Analog Output 10% to 90% of VDD
- Nonlinearity less than 3.5 deg at 3V
- Magnetic to EM-3242 separation of 0.100’ to 0.250”
- Tolerant of mechanical misalignment
- Expanded Magnet to IC separation with increased non-linearity
- Out of Range Detection (Faults to 0V when Magnetic Field is >60mT or <10mT.
- Power Down (PDN) option reduces current draw to <10uA.

**Reference Documents**

- 55B0082 Spec Sheet (0.25”dia. x 0.15”T SmCo24 Magnet)
- 55B0081 Spec Sheet (0.15”dia. x 0.15”T SmCo24 Magnet)
- 55C0126 Spec Sheet (0.25”Sq. x 0.10”T SmCo24 Magnet)
- AN_134KIT- Eng Development Kit
- RD101-EM3242 Ref Design for Angle sensing without “In Range” Detector

**Magnetic flux density (Magnetic Field)**

- units of Gauss and Tesla
  - 1G=100uT or 0.1mT
  - 10G =1mT
  - 100G =10mT

**Bill of Material**

- IC-1 EM-3242 IC
- C1- 0.1uF Ceramic cap-0603 SMD +/-10%
- PCB FR-4, 0.8mm thick, 0.5 oz copper
- 55B0082 Cylindrical Magnet or
- 55B0081 Cylindrical Magnet or
- 55C0126 Square Magnet

**Operating Note:**

Power Down (PDN) is enabled when PDN is tied to VSS (COM). Tie PDN to +VDD activate the sensor for normal operation

**Revision Date:** 7 Jan 2009
**Magnet Orientation**

Output increases as magnet is rotated CounterClockwise. See output curve, next page.

Zero Degrees occurs when the South Pole of the magnet is in line with pin and 6 of the IC.

Air-Gap ranges to produce specified linear output. See graph on page 4 for expanded ranges.

**Air Gap Operating Range for the 55B0082 Cylindrical Magnet**

Air Gap Operating Range for the 55B0081 Cylindrical Magnet

Air Gap Operating Range for the 55C0126 Square Magnet
360 to 0 Degree Transition
When the Angle of rotation approaches the 360 degree position, the output will approach 90% of the supply voltage and then abruptly change to 10% of VDD and then start increasing again as the angle increases. This transition can be as wide as 0.5deg. If the position of the magnet is held steady at a point within the 0.5 deg. range, there is a possibility that the output will randomly switch between the 90% level and the 10% level. Both levels represent the same angle of 0 deg. If the output is filtered with a low pass filter, the average voltage output could be approximately 50% of VDD, thus creating an error in the reading. This can be avoided by not using a low pass filter. If a uP is used to sample the output, it can simply register a 10%VDD reading and a 90%VDD reading as the same angle (zero degrees).

Non-Linearity Specifications.
The EM-3242 is specified to operate within +/-3.5 degrees of non-linearity when the supply is 3V and +/-6 degrees when the supply voltage is 5V over the magnetic field range of 20mT to 50mT. With the "In Range" detector enabled, as in this case, the sensor will continue operate normally until the magnetic field strength at the sensor either exceeds 60mT or drops below 10mT. When these limits are exceeded, the output of the EM-3242 will drop to 0.2V or less. The following graphs show the relationship between the non-linearity range and the air gap between the magnet and sensor for the 55B0082 magnet.
Case Studies

AKMCS-001 Non Contact Remote ON-OFF
AKMCS-002 Flow Meter using EM3242 Angle Sensor
AKMCS-003 Flow Meter using AKM Encoder IC’s
AKMCS-004 Accurate Switching using AKM Hall devices
Problem to be solved:

Customer needs a solution for turning power ON and OFF in a sealed container (In this case, a small battery operated gastrointestinal ingestible capsule). The capsule contains sensors and telemetry circuitry that is powered by a small battery.

The customer’s needs are the following:
1) Very low operating current draw
2) Operate at low battery voltages
3) Activated with a magnet
4) Needs to be latched ON or OFF with the external magnet
5) Small size

GMW recommended solution

GMW offered the customer a solution that would use the AKM Low Power Hall switch to activate the internal circuitry with a magnet. The Hall IC recommended was the AKM EM-1712 which has the following characteristics applicable to the issue.
1) Very low operating current <60uA. This will be well suited for battery operation
2) The operating voltage is 1.6V to 5.5V
3) The IC is a Hall switch which is activated by a magnetic field, in this case from a small magnet
4) The IC is a “Latching Hall” device whose output remains in the state that it was last activated to. A North pole of a magnet will switch the output to high and a South pole will latch the output to low. This allows the customer to turn the IC on (That is: Latch it ON) and then turn it off with an external magnet. Once the capsule is assembled and just prior to shipment, it is sealed and tested by momentarily switching the device ON and OFF.
5) The EM-1712 IC comes in a very small SMT package (2.1mm square). AKM has a smaller version, the EM-0712, which comes in a leadless SON package however in this case, the customer preferred the leaded SMT package.
Below is a typical schematic of the AKM EM-1712 being used to turn power ON and OFF. This circuit shows the AKM EM-1732 being used to turn a regulator circuit ON and OFF. When the EM-1712 is in the OFF state (South Pole toward the top of the IC), the EM-1712’s output is LOW, which disables the regulator. When the EM-1712 is activated and latch to the high state with a North pole facing the top of the IC, the regulator is turned on to activate the circuitry in the capsule. Because the EM-1712 is a “Latching” Hall IC, it will remain in a given state until activated by a magnet with the opposite polarity.
Below are the technical details of the switch operation. The magnet North pole of a magnet facing the bottom of the IC will cause the output to switch “Low”. A North pole of a magnet facing the top of the IC will switch the output to the “High” state. The switch levels are well above the Earth’s magnetic fields which are typically in the range of +/- 0.5mT.

Very small magnets can be used to activate the switch. Below is a typical activation range of the AKM EM-1712 using a 6.35mm long by 3mm diameter.
Problem to be solved:

Customer needs a solution for measuring liquid flow that will be reported in Gallons. The concept is an impeller type flow meter with a magnet mounted on the end of the rotating shaft. The rotating impeller and magnet are in a sealed non magnetic housing. The rate of turning is relatively slow, so the customer need at least 8 bits of resolution for each turn.

A summary of the customer’s needs are the following:

1) Low cost sensor
2) Low operating voltage
3) Sensor that is responsive to a rotating horizontal magnetic field
4) Operate at a large gap with small magnet
5) A minimum of 8 bits of resolution per 360 degrees

GMW recommended solution

GMW offered the customer a solution that would use the AKM self contain angle sensing IC. The AKM IC recommended was the AKM EM-3242 which has the following characteristics applicable to the issue.

1) Very low cost. In the $1.00 range at 80K-100K/Yr
2) The operating voltage is 2.7V to 5.5Vdc
3) The IC measures the angle of a rotating magnetic field that is parallel (horizontal) to the IC surface.
4) The IC has a sensitivity level of 20mT min. Using a 5mm diameter Neodymium magnet, this correlates to a 3mm operating range between the magnet and the face of the IC.
5) The EM-3242 has a resolution of 10 bits (~0.35 deg) which is 4x better resolution than requested.

In a flow meter, the more resolution it has, the more precise the flow measurement can be. For example: if a given meter has an impeller that rotates one turn for every gallon of liquid and the resolution of the sensing measurement is one pulse per turn, then the measurement resolution is only 1 gallon. If there are 10 pulses per turn, then the resolution of the flow meter is 0.1 Gallons. If the measurement system has a resolution of 8 bits (or 254 counts per revolution), the precision of the measurement is 0.004 gallons. In this case, the EM-3242 is more than adequate for the meter requirements.

Revision Date: Jan 28 2011
AKM Case Study: AKMCS-002
Flow meter using an EM-3242 angle sensor IC

Flow meter conceptual view

Typical air gap using a 4mm dia. Neodymium magnet is approx. 3mm

AKM EM-3242 Angle Sensor

Impeller

Magnet magnetized diametrically

Top View of rotating magnetic field

Non Magnetic material

AKM EM-3242

Rotating magnet field

Revision Date: Jan 28 2011
EM-3242 Output signal. Repeating Saw Tooth waveform that starts at 10% of the supply voltage and increases linearly to 90% of Vcc. The resolution of the linear ramp is 10 bits (1024 steps). Each step updates every 40uS, therefore to maintain 10 bits of resolution, the maximum rotational speed would be approximately 1500 rpm. The EM-3242 is capable of higher speeds, but the resolution will be less, see graph below.
Problem to be solved:

Customer needs a non-contact magnet activated switch that will provide a very accurate and repeatable switch point for an end of travel application
   1) Very accurate switch point
   2) Hall based switch in SIP package
   3) Activated with a magnet
   5) Small size

GMW recommended solution

GMW presented a solution to use an AKM EW-752B Unipolar Switching IC. The EW-752B has a bipolar transistor output with an internal 5K pull up resistor. The EW-752B has a wide range operating voltage of 3 to 26V and a switch operate point Bop between 4mT and 10mT, typically = 6mT. The switch turns ON when the South pole field facing the sensor with the marking, exceeds the Bop point. See blow the basic operating characteristics.

---

EW-752B

Vout

H

1 : Vcc
2 : GND
3 : OUT

Magnetic flux density

N-pole O Brp Bop S-pole

Bh
The typical method of using a Hall switch activated by a magnet is to have the magnet approach the IC “Head ON”. The magnetic field increases exponentially as it approaches the sensor. When the field exceeds the IC switch point Bop, the IC will turn ON. The problem with this method, is the Switch ON level, Bop, can vary significantly (4mT to 10mT for the EW-752B), therefore the switch ON point can have a wide range of operation as shown below because it operates on the low slope of the magnetic field curve. This method would not provide an accurate switch point.

With a 4.7mm dia x 6.3mm long Neodymium magnet, the typical switch point variation for the EW-752B would be approx. 4.5mm to 12mm.
Below is the arrow plot as a result of magnetic modeling analysis of the magnet. The exponential curve in the plot below represents the field strength in the “X” direction as a function of distance from the magnet face.

**TECHNIQUE FOR IMPROVING SWITCHING POINT PRECISION**

The best way to create an accurate switch point with a Hall switch IC, is to operate it in “Slide-By” mode. In a “Slide-By” mode, the magnet passes by the sensor with the magnet pointing toward the top of the IC rather than the face of the IC. The illustration below shows the magnetic field as related to three different positions between the magnet and the IC. As the magnet approaches the IC, the magnetic field into the IC increases the field in the North direction (position A). As it passes over the IC, the field rapidly changes direction and passes through zero toward the South direction (Position B). As the field increases in the South direction, the IC responds to a South pole switch point, Bop and turns ON as shown in Position C. The “key” in obtaining an accurate switch point is operating the sensor in the steep portion of the field change. In this case, the variances in the Bop point from sensor to sensor, is very minimal. The stronger the magnet and the closer the sensor is to the magnet, the steeper the curve and therefore the more accurate the switch point will be.
AKM Case Study: AKMCS-004
Non-Contact Accurate Switching with Hall IC’s

4.7mm x 6.3mm Neo Magnet

Position A | Position B | Position C

Air Gap 1.5mm

AKM EW-752B

Arrow plot of magnetic field created by magnet in a “Slide-By” mode.

Variation < 0.5mm compared to 8mm variation with a “Head ON” approach.

GMW
955 Industrial Rd, San Carlos, CA 94070 Tel: (650) 802-8292 Fax: (650) 802-8298
Email: sales@gmw.com Web site: http://www.gmw.com

Revision Date: 28 Jan 2011
TOP DEAD CENTER SENSING

This technique is also very useful in creating a very narrow “Top Dead Center” timing pulse. This is accomplished by placing two EW-752B IC’s back to back and having one switch turn ON just before the other IC is Turned Off. By combining the two outputs when they are both ON using a NAND gate, a very narrow and very accurate pulse can be created. The width of the pulse is based on the distance between two sensors which is about 1mm when they are placed back to back. For a linear movement, the pulse width in seconds, would be the speed of the magnet in Sec/mm * 1mm. The physical width would be 1mm. For an angle sweep, the pulse width in degrees would be:

\[ \Delta \theta \approx \left( \frac{1\text{mm} \times 360^\circ}{\pi} \right) \times \text{D(mm)} \]

EG: for D=50mm, \( \Delta \theta \approx \left( \frac{1\text{mm} \times 360^\circ}{\pi} \right) \times 50\text{mm} \) ~ 2.3°
Demonstrator for the AKM AK8775 ands AK8776 Magnetic Encoder IC’s

Features:
- Self Contained 9V Battery Operated – Power ON/OFF switch
- Output LED indicators
- Motor driven ring magnets 4PP and 8PP
- Two Speed Switch
- Forward – Reverse Switch
- Output terminals for external connections and monitoring
Price List

AKM Hall Element KITs

AN_161KITs............................................................................................... $35
AN_160KIT Universal Hall Interface Amplifier........................................ $35

Gapped Core Current Sensor KITs using the AKM EQ-73XL Series Linear ICs

AN_130KIT EQ-730L ................................................................................ $35
AN_131KIT EQ-731L ................................................................................ $35
AN_135KIT EQ-733L ................................................................................ $35
AN_136KIT EQ-733L ................................................................................ $35

CQ-121/131 Series Current Sensors KITS

AN_165KIT................................................................................................. $35

CQ-20XX Series Current Sensors KITS

AN_170KIT................................................................................................. $35

EM3242 Non-Contact Angle Sensor IC KITs

AN_133KIT................................................................................................. $30
AN_134KIT................................................................................................. $30

Demonstrators

AK8775/6 Encoder ICs............................................................................... $375