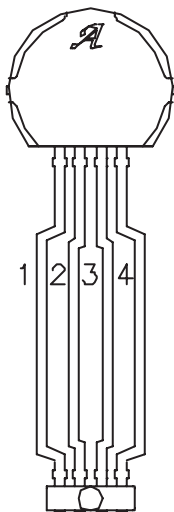


# ATS635LSE and ATS636LSE

## Programmable Back Biased Hall-Effect Switch with TPOS Functionality

### PACKAGE DIAGRAM



Pin 1 = VCC  
 Pin 2 = VOUT  
 Pin 3 = No Connect  
 Pin 4 = GND

### ABSOLUTE MAXIMUM RATINGS

Supply Voltage, $V_{CC}$ .....	<b>28 V*</b>
Reverse Supply Voltage, $V_{RCC}$ .....	<b>-18 V</b>
Overvoltage Supply Current, $I_{CC}$ .....	<b>100 mA</b>
Output Off Voltage, $V_{OUT}$ .....	<b>26.5V</b>
Output Sink Current, $I_{OUT}$ .....	<b>20 mA</b> <sup>†</sup>
Magnetic Flux Density, $B$ .....	<b>Unlimited</b>
Package Power Dissipation, $P_D$ .....	<b>See Graph</b>
Operating Temperature Range, $T_A$	
Suffix "L".....	<b>-40 °C to +150 °C</b>
Junction Temperature, $T_J$ .....	<b>165 °C</b>
Storage Temperature Range	
$T_S$ .....	<b>-65 °C to +170 °C</b>

\*Fault conditions that produce supply voltage transients will be clamped by an internal Zener diode. These conditions can be tolerated but should be avoided.

<sup>†</sup> Internal current limiting is intended to protect the device from output short circuits, but is not intended for continuous operation.

The ATS635LSE and ATS636LSE programmable, true power-on state (TPOS), sensors are an optimized Hall-effect IC and magnet combination that switch in response to magnetic signals created by ferrous targets in gear-tooth sensing and proximity applications.

The devices are externally programmable. A wide range of programmability is available on the magnetic operate point ( $B_{OP}$ ) while the hysteresis remains fixed. This advanced feature allows for optimization of the sensor switch point and can drastically reduce the effects of mechanical placement tolerances found in production environments.

A proprietary dynamic offset cancellation technique, with an internal high-frequency clock, reduces the residual offset voltage, which is normally caused by device overmolding, temperature dependencies, and thermal stress. Having the Hall element and amplifier in a single chip minimizes many problems normally associated with low-level analog signals.

This sensor system is ideal for use in gathering speed or position information using gear-tooth-based configurations, or for proximity sensing with ferrous targets.

The ATS635LSE switches HIGH in the presence of a ferrous target or tooth and switches LOW in the presence of a target valley, window, or when the ferrous target is removed. The ATS636LSE has the opposite polarity and switches LOW in the presence of a ferrous target or tooth and switches HIGH in the presence of a target valley, window, or when the ferrous target is removed.

These devices are available in lead (Pb) free versions, with 100% matte tin leadframe plating.

### FEATURES

- Chopper Stabilization
  - Extremely low switch-point drift over temperature
- On-chip Protection
  - Supply transient protection
  - Output short-circuit protection
  - Reverse-battery protection
- True Zero-Speed Operation
- True Power-On State
- Single-chip Sensing IC for High Reliability
- Optimized Magnetic Circuit
- Wide Operating Voltage Range
- Internal Regulator



Use the following complete part numbers when ordering:

Part Number	Pb-Free	Output (Tooth)	Packing*
ATS635LSETN-T	Yes	High	13-in. reel, 450 pieces/reel
ATS636LSETN-T	Yes	Low	13-in. reel, 450 pieces/reel

\*Contact Allegro for additional packing options.

# ATS635LSE and ATS636LSE

## PROGRAMMABLE TRUE POWER-ON HALL-EFFECT GEAR-TOOTH SWITCHES

### CHARACTERISTICS

#### ELECTRICAL CHARACTERISTICS over operating voltage and junction temperature range (unless otherwise noted)

Characteristics	Symbol	Test Conditions	Limits			
			Min.	Typ.	Max.	Units
Supply Voltage <sup>1</sup>	V <sub>CC</sub>	Operating	4.2	–	24	V
Power-Up State	POS	After programming V <sub>CC</sub> = 0 → V <sub>CC(min)</sub> , t > t <sub>ON</sub> : B < B <sub>OP</sub> ATS636	HIGH	HIGH	HIGH	–
		B < B <sub>OP</sub> ATS635	LOW	LOW	LOW	–
Low Output Voltage	V <sub>OUT(SAT)</sub>	Output on, I <sub>OUT</sub> = 20 mA	–	175	400	mV
Output Current Limit <sup>2</sup>	I <sub>OUTM</sub>	Pulse test method Output on	30	50	90	mA
Output Leakage Current	I <sub>OFF</sub>	Output off, V <sub>OUT</sub> = 24 V	–	–	10	μA
Supply Current	I <sub>CC</sub>	Output off (HIGH)	–	2.5	5.5	mA
		Output on (LOW)	–	2.5	5.5	mA
Reverse Supply Current	I <sub>RCC</sub>	V <sub>RCC</sub> = -18V	–	–	-5	mA
Power-On Delay <sup>3</sup>	t <sub>ON</sub>	Output off; V <sub>CC</sub> > V <sub>CC(min)</sub>	–	35	50	μs
Output Rise Time	t <sub>r</sub>	R <sub>L</sub> = 820 Ω, C <sub>L</sub> = 10 pF	–	1.2	5	μs
Output Fall Time	t <sub>f</sub>	R <sub>L</sub> = 820 Ω, C <sub>L</sub> = 10 pF	–	1.2	5	μs
Sampling Frequency	f <sub>Sample</sub>	–	–	250	–	kHz
Supply Zener Voltage	V <sub>Zsupply</sub>	I <sub>CC</sub> = I <sub>CC(max)</sub> + 3 mA T <sub>A</sub> = 25°C	28	–	–	V
Output Zener Voltage	V <sub>ZOutput</sub>	I <sub>OUT</sub> = 3 mA T <sub>A</sub> = 25°C	30	–	–	V
Supply Zener Current <sup>4</sup>	I <sub>Zsupply</sub>	V <sub>S</sub> = 28 V	–	–	8.5	mA
Output Zener Current	I <sub>ZOutput</sub>	V <sub>O</sub> = 30 V	–	–	3	mA

Note: Typical data is at V<sub>CC</sub> = 12 V and T<sub>A</sub> = +25°C.

<sup>1</sup> Do not exceed the maximum thermal junction temperature: see power de-rating curve.

<sup>2</sup> Short circuit protection is not intended for continuous operation and is tested using pulses.

<sup>3</sup> The power on delay is the time that is necessary before the output signal is valid

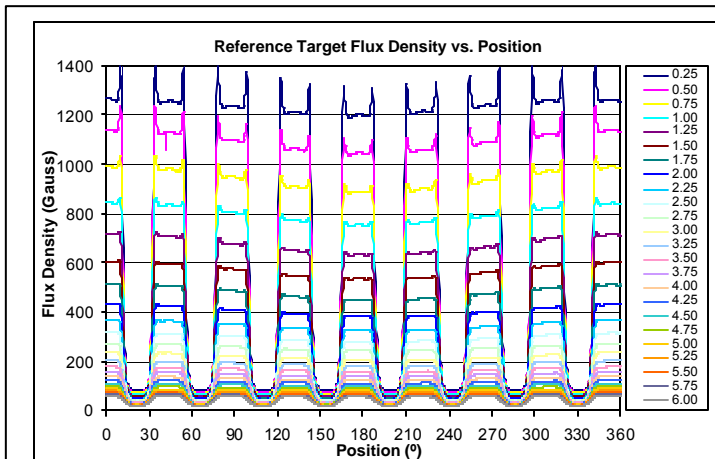
<sup>4</sup> The maximum spec limit for this parameter is equivalent to I<sub>CC(max)</sub> + 3 mA

# ATS635LSE and ATS636LSE

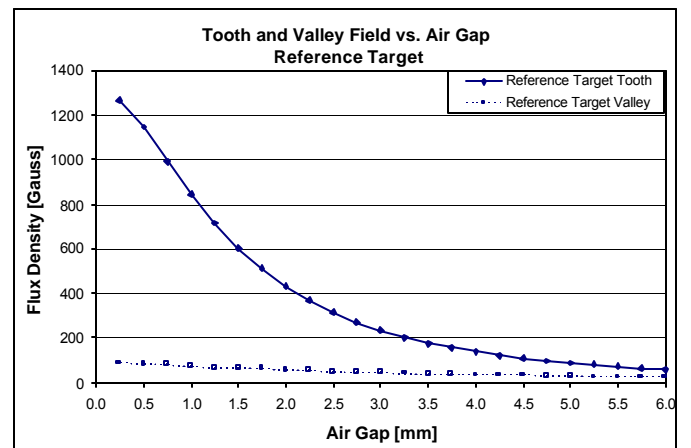
## PROGRAMMABLE TRUE POWER-ON HALL-EFFECT GEAR-TOOTH SWITCHES

### MAGNETIC CHARACTERISTICS over operating voltage and junction temperature range using reference target (Unless otherwise noted)

Characteristics	Symbol	Test Conditions	Limits			Units
			Min.	Typ.	Max.	
Number of Programming Bits	-	Switch Point	-	7	-	Bit
		Switch Point Polarity	-	1	-	Bit
		Programming Lock	-	1	-	Bit
<b>Gear Tooth Sensor / Proximity Sensing Characteristics (Low Switchpoint Only)</b>						
<sup>1</sup> Programming Air Gap Range	AG <sub>Range</sub>	Temp: 25°C Code -127	2.5	-	-	mm
		Temp: 25°C Code +127	-	-	1.5	mm
Programming Resolution	AG <sub>Res</sub>	Temperature: 25°C Program Air Gap = 2.5 mm	-	0.05	-	mm
<sup>2</sup> Air Gap Drift Over Full Temperature Range	AG <sub>Drift</sub>	Device Programmed to 2.5 mm	-	0.2	-	mm
Polarity	P	Over Tooth (ATS635LSE)	-	HIGH	-	-
		Over Valley (ATS635LSE)	-	LOW	-	-
		Over Tooth (ATS636LSE)	-	LOW	-	-
		Over Valley (ATS636LSE)	-	HIGH	-	-



Reference Target Flux Density vs. Position: Typical



Reference Target Tooth and Valley Field vs. Air Gap

<sup>1</sup> The switch point will vary over temperature. A sufficient margin obtained through customer testing is required to guarantee functionality over temperature. Programming at larger air gaps leaves no safety margin for switchpoint drift. See the applications note: "Proximity Sensing Programming Technique" [http://www.allegromicro.com/techpub2/proximity\\_sensing/](http://www.allegromicro.com/techpub2/proximity_sensing/) or visit the Allegro website at <http://www.allegromicro.com> for additional information.

<sup>2</sup> The switch point will vary over temperature, proportionally to the programmed air gap. This parameter is based on characterization data and is not a tested parameter in production. Switch point air gap generally drifts downward as temperature increases.

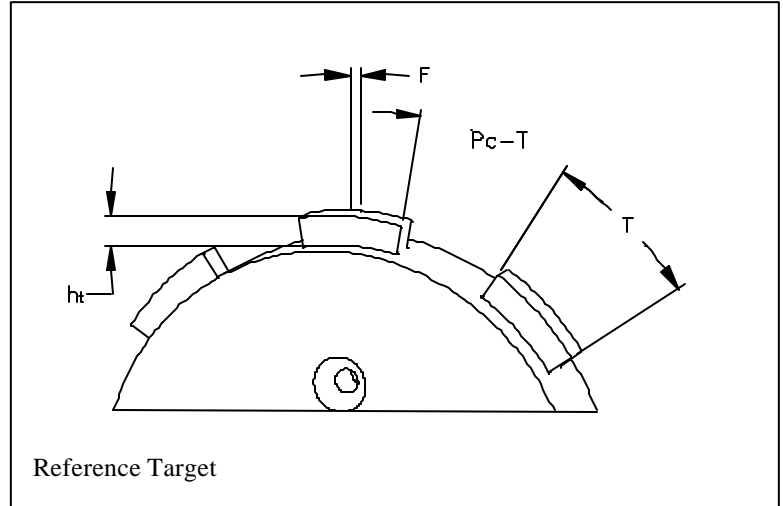
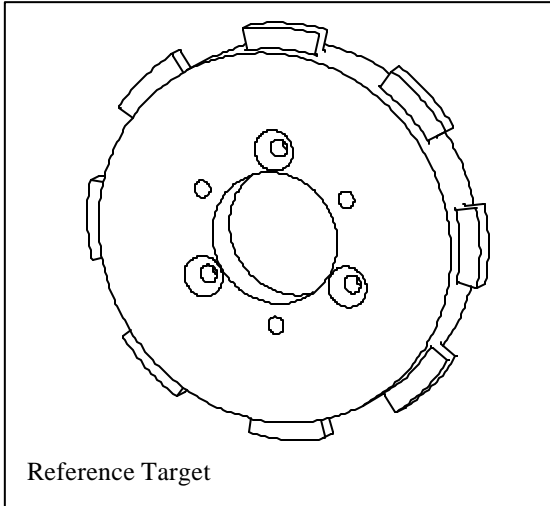


# ATS635LSE and ATS636LSE

## PROGRAMMABLE TRUE POWER-ON HALL-EFFECT GEAR-TOOTH SWITCHES

### REFERENCE TARGET DIMENSIONS

Target	Outside Diameter ( $D_o$ )	Face Width ( $F$ )	Circular Tooth Length ( $T$ )	Circular Valley Length ( $P_c - T$ )	Tooth Whole Depth ( $h_t$ )
Reference Target	120mm	6mm	23.5mm	23.5mm	5mm



### GEAR PARAMETERS FOR CORRECT OPERATION

Characteristic	Description	Limits			
		Min.	Typ.	Max.	Units
Tooth Whole Depth ( $h_t$ )	Depth of Target Valley	5	–	–	mm
Circular Valley Length ( $P_c - T$ )	Length of Target Valley	13	–	–	mm
Circular Tooth Length ( $T$ )	Length of Target Tooth	5	–	–	mm
Face Width ( $F$ )	Thickness or Width of Target Tooth	5	–	–	mm

**MATERIAL:** CRS 1018

# ATS635LSE and ATS636LSE

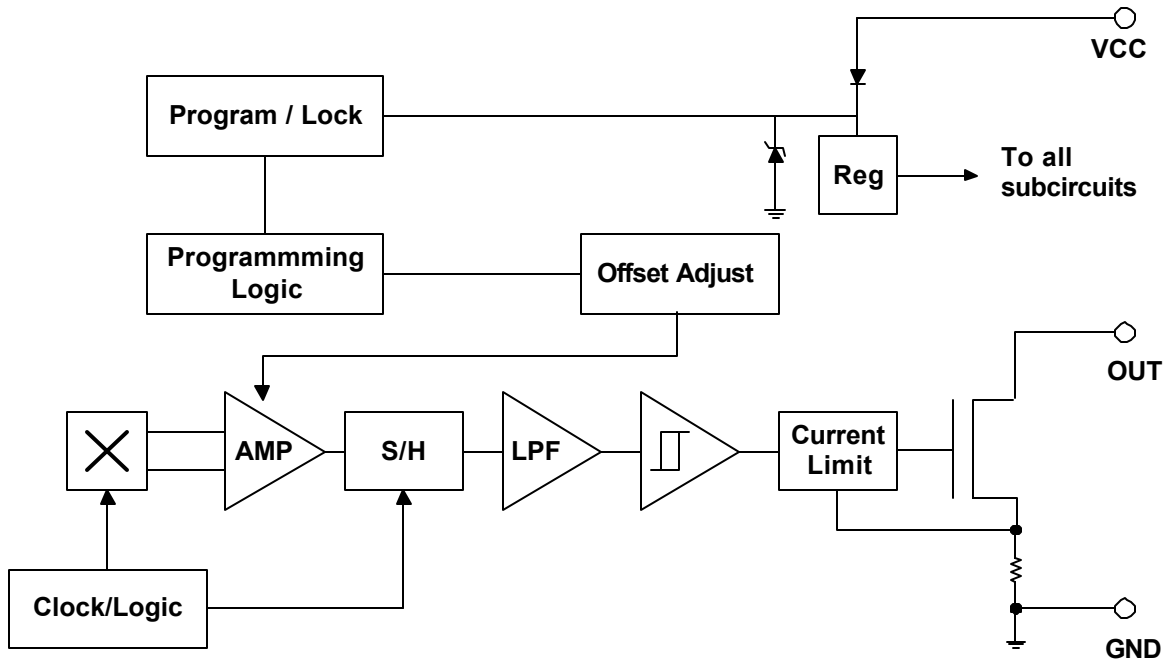
## PROGRAMMABLE TRUE POWER-ON HALL-EFFECT GEAR-TOOTH SWITCHES

### ELECTROMAGNETIC CAPABILITY (EMC) PERFORMANCE

Please contact Allegro MicroSystems for EMC performance

Test Name	Reference Specification
ESD – Human Body Model	AEC-Q100-002
ESD – Machine Model	AEC-Q100-003
Conducted Transients	ISO 7637-1
Direct RF Injection	ISO 11452-7
Bulk Current Injection	ISO 11452-4
TEM Cell	ISO 11452-3

### FUNCTIONAL BLOCK DIAGRAM



# ATS635LSE and ATS636LSE

## PROGRAMMABLE TRUE POWER-ON HALL-EFFECT GEAR-TOOTH SWITCHES

### FUNCTIONAL DESCRIPTION

**Chopper-Stabilized Technique.** The basic Hall sensor is a small sheet of semiconductor material in which a constant bias current will flow when a constant voltage source is applied. The output will take the form of a voltage measured across the width of the sheet and will have negligible value in the absence of a magnetic field. When a magnetic field with flux lines at right angles to the Hall current is applied, a small signal voltage directly proportional to the strength of the magnetic field will occur at the output terminals.

This signal voltage is proportionally small relative to the offset produced at the input of the chip. This makes it very difficult to process the signal and maintain an accurate, reliable output over the specified temperature and voltage range. Therefore, it is important to reduce any offset on the signal that could be amplified when the signal is processed.

Chopper Stabilization is a unique approach used to minimize input offset on the chip. This technique removes a key source of output drift with temperature and stress, and produces a 3X reduction in offset over other conventional methods.

This offset reduction Chopping Technique is based on a signal modulation-demodulation process. The undesired offset signal is separated from the magnetically induced

signal in the frequency domain. The offset (and any low frequency noise) component of the signal can be seen as signal corruption added after the signal modulation process has taken place. Therefore, the DC offset is not modulated and remains a low frequency component. Consequently, the signal demodulation process acts as a modulation process for the offset causing the magnetically induced signal to recover its original spectrum at baseband while the DC offset becomes a high frequency signal. Then, using a low pass filter the signal passes while the modulated DC offset is suppressed.

The advantage of this approach is significant offset reduction, which de-sensitizes the chip against the effects of temperature and stress. The disadvantage is that this technique features a demodulator that uses a sample and hold block to store and recover the signal. This sampling process can slightly degrade the Signal-to-Noise Ratio (SNR) by producing replicas of the noise spectrum at the baseband. The degradation is a function of the ratio between the white noise spectrum and the sampling frequency. The effect of the degradation of the SNR is higher jitter, a.k.a. signal repeatability. In comparison to a continuous time device, the jitter spec can be increased by a factor of five.

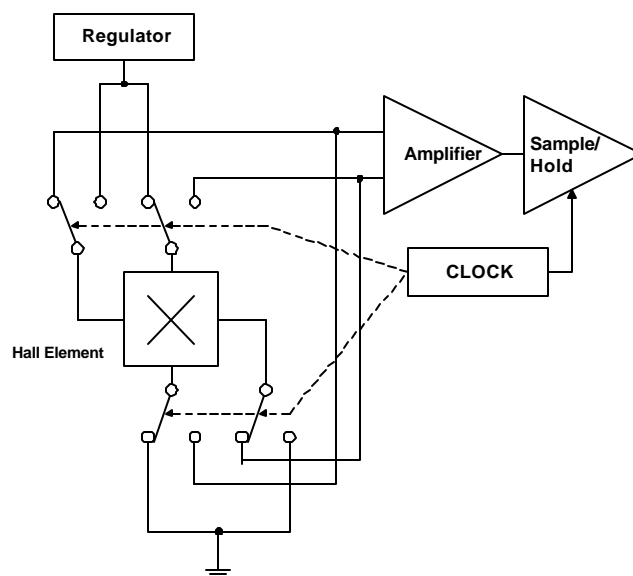


Figure 1 – Concept of Chopper-Stabilization Algorithm

# ATS635LSE and ATS636LSE

## PROGRAMMABLE TRUE POWER-ON HALL-EFFECT GEAR-TOOTH SWITCHES

### FUNCTION DESCRIPTION: ADDRESSING / PROGRAMMING PROTOCOL

The ATS635LSE and ATS636LSE magnetic operate point ( $B_{OP}$ ) is programmed by serially addressing the devices through the supply terminal (1). After the correct operate point is determined, the device programming bits are selected and blown, then a lock bit is selected and blown to prevent any further (accidental) programming.

**Addressing:** Bop is programmable in both the positive and negative direction from its initial value. Addressing is used to determine the desired code, while programming is used to lock the code. A unique key is needed to blow fuses, while addressing as described below does not allow for the device to be programmed accidentally.

**Addressing with positive polarity.** The magnetic operate point ( $B_{OP}$ ) is adjustable using 7 bits or 128 addresses. The Addresses are sequentially selected (Figure 2) until the required operate point is reached. The first address must be selected with a High voltage pulse ( $V_{PP}$ ), while the remaining pulses should be  $V_{PH}$  Pulses. Note that the difference between  $B_{OP}$  and the magnetic release point ( $B_{RP}$ ), the Hysteresis ( $B_{HYS}$ ), is fixed for all addresses.

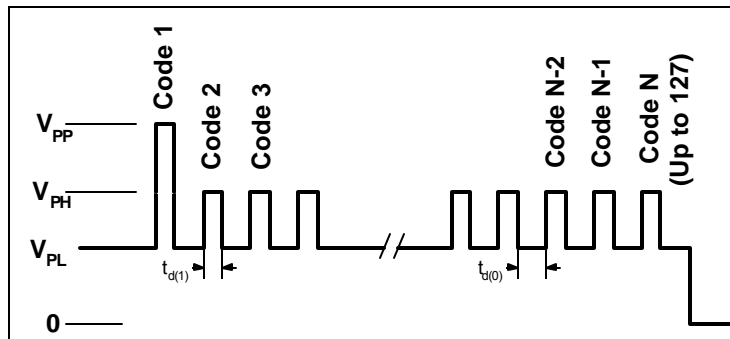


Figure 2 – Addressing Pulses: Positive Polarity

**Addressing with negative polarity.** The magnetic operate point ( $B_{OP}$ ) is adjustable with negative polarity using 7 bits or 128 addresses. To invert the polarity it is necessary to first apply a keying sequence (Figure 3). The polarity key contains a  $V_{PP}$  pulse and at least 1  $V_{PH}$  pulse, but no more than 6  $V_{PH}$  pulses; the key in Figure 3 shows 2  $V_{PH}$  pulses. The addresses are then sequentially selected until the required operate point is reached. The first address must be selected with a High voltage pulse ( $V_{PP}$ ), while the remaining pulses should be  $V_{PH}$  Pulses.

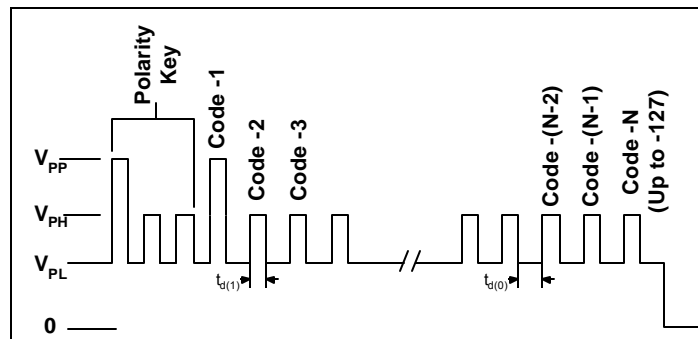


Figure 3 – Addressing Pulses: Negative Polarity

# ATS635LSE and ATS636LSE

## PROGRAMMABLE TRUE POWER-ON HALL-EFFECT GEAR-TOOTH SWITCHES

**Program Enable.** To program the device, a keying sequence is used to activate / enable the programming mode as shown in Figure 4. This program key sequence consisting of a  $V_{PP}$  pulse, at least seven  $V_{PH}$  pulses, and a  $V_{PP}$  pulse with no supply interruptions. The sequence is designed to prevent the device from being programmed accidentally (e.g., as a result of noise on the supply line).

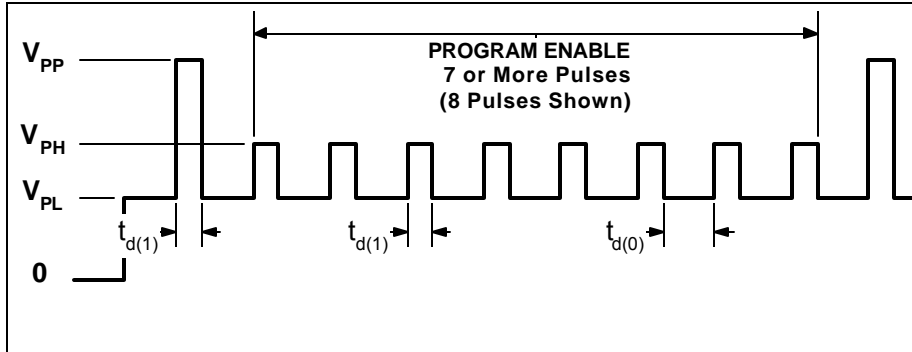


Figure 4 – Program Enable Pulse Sequence

**Code Programming.** After the desired switch point code is selected (0 through 127), each bit of the corresponding binary address should be programmed individually, not at the same time. For example, to program code 5 (binary 000101), bits 1 and 3 need to be programmed. A bit is programmed by addressing the code and then applying a  $V_{PP}$  pulse, the programming is not reversible. An appropriate sequence for blowing code 5 is shown in Figure 5.

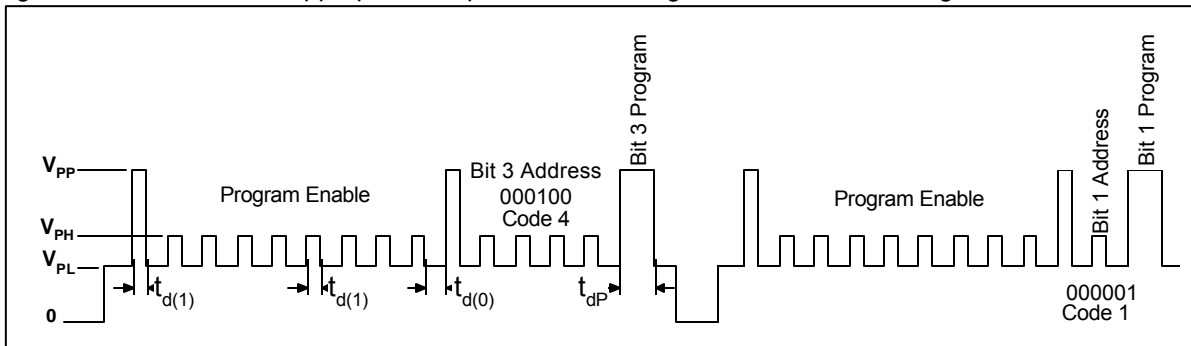


Figure 5 – Code Programming Example

**Polarity Bit Programming.** If the desired switchpoint has negative polarity, the polarity bit must be programmed. To do this it is necessary to first apply the polarity key sequence before the program key sequence (Figure 6). Finally a  $V_{PP}$  pulse of duration  $t_{dP}$  must be applied to program this bit, the programming is not reversible. The polarity bit is for adjusting programming range only and will not affect the output polarity. The proper output polarity device is determined by ordering the correct part number (ATS635 or ATS636), as they are different ICs.

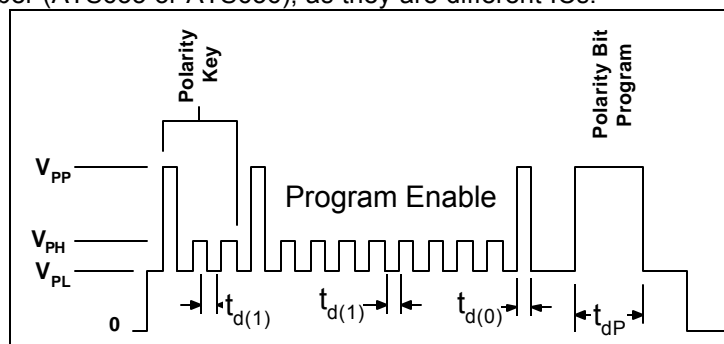


Figure 6 – Polarity Bit Programming



# ATS635LSE and ATS636LSE

## PROGRAMMABLE TRUE POWER-ON HALL-EFFECT GEAR-TOOTH SWITCHES

**Lock-Bit Programming.** After the desired code is programmed, the lock bit (code 128), can be programmed (figure 7) to prevent further programming of the device. Again; programming is not reversible.

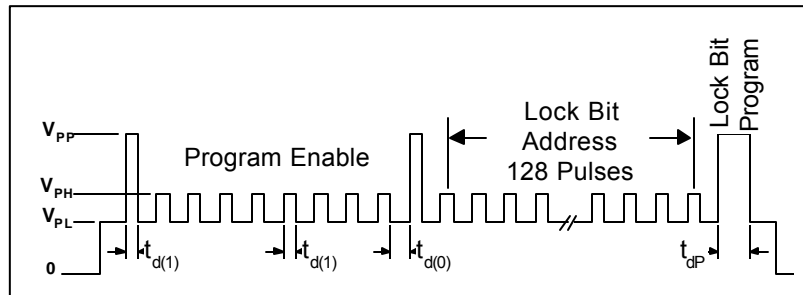


Figure 7 – Lock-Bit Programming Pulse Sequence

See Allegro website at <http://www.allegromicro.com> for extensive information on device programming as well as programming products. Programming hardware is available for purchase and programming software is available for free.

**Valid over operating temperature range unless otherwise noted.**

Part Number	Characteristics	Symbol	Test Conditions	Limits			
				Min.	Typ.	Max.	Units
<b>PROGRAMMING PROTOCOL (T<sub>A</sub> = +25°C)</b>							
ATS635 / ATS636	<sup>5,6</sup> Programming Voltage	V <sub>PL</sub>	Minimum voltage range during programming	4.5	5	5.5	V
		V <sub>PH</sub>		8.5	–	15	V
		V <sub>PP</sub>		25	–	27	V
	Programming Current	I <sub>PP</sub>	Maximum supply current during programming	–	500	–	mA
	Pulsewidth	t <sub>d(0)</sub>	OFF time between bits	20	–	–	µs
		t <sub>d(1)</sub>	Enable, address, program, or lock bit ON time	20	–	–	µs
		t <sub>dP</sub>	Program pulse ON time	100	300	–	µs
	Pulse Rise Time	t <sub>r</sub>	V <sub>PL</sub> to V <sub>PH</sub> or V <sub>PP</sub>	–	–	11	µs
Pulse Fall Time	t <sub>f</sub>	V <sub>PH</sub> or V <sub>PP</sub> to V <sub>PL</sub>	–	–	5	µs	

<sup>5</sup> Programming Voltages are measured at Pin 1 (V<sub>CC</sub>) of SIP. A minimum capacitance of 0.1 µF must be connected from V<sub>CC</sub> to GND of the SIP to provide the current necessary to blow the fuse.

<sup>6</sup> Testing is the only method that guarantees successful programming.

# ATS635LSE and ATS636LSE

## PROGRAMMABLE TRUE POWER-ON HALL-EFFECT GEAR-TOOTH SWITCHES

### FUNCTIONAL DESCRIPTION (CONT.): TYPICAL APPLICATION CIRCUIT

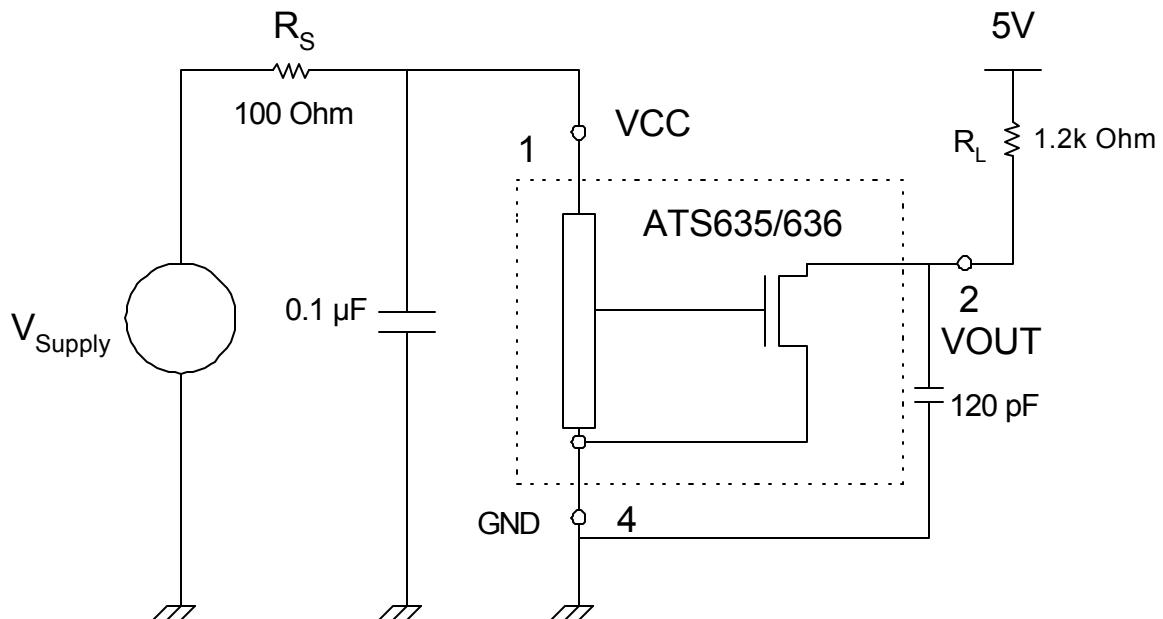
**Applications.** It is *strongly recommended* that an external ceramic bypass capacitor in the range of 0.01  $\mu\text{F}$  to 0.1  $\mu\text{F}$  be connected between the supply and ground of the device to reduce both external noise and noise generated by the chopper-stabilization technique. (The diagram below shows a 0.1  $\mu\text{F}$  bypass capacitor.)

The series resistor  $R_S$  in combination with the bypass capacitor creates a filter for EMC pulses. The series resistor will have a drop of approximately 800 mV, this must be considered for the minimum  $V_{CC}$  requirement of the ATS635LSE / ATS636LSE. The small capacitor on the output of the device improves the EMC performance of the device.

The pull-up resistor should be chosen to limit the current through the output transistor; do not exceed the maximum continuous output current of the device.

*Note: This circuit cannot be used to program the device, as the series resistance is too large, and a minimum capacitance of 0.1  $\mu\text{F}$  must be connected from  $V_{CC}$  to GND of the SIP to provide the current necessary to blow the fuse.*

#### Typical Application:



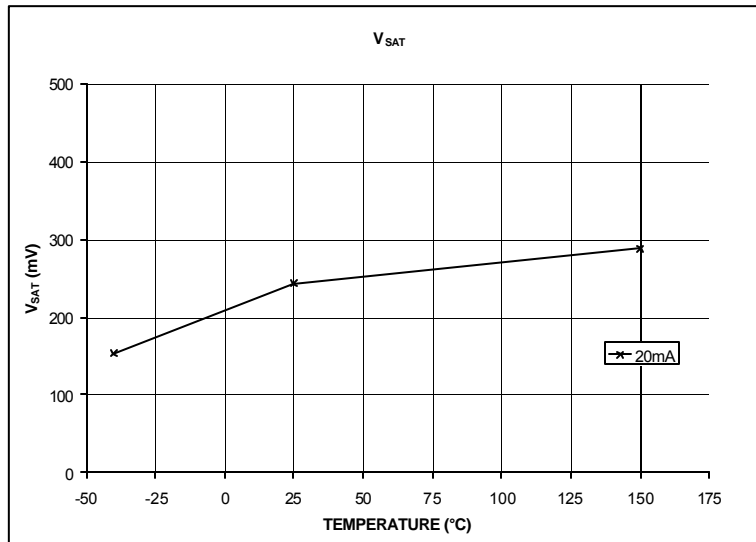
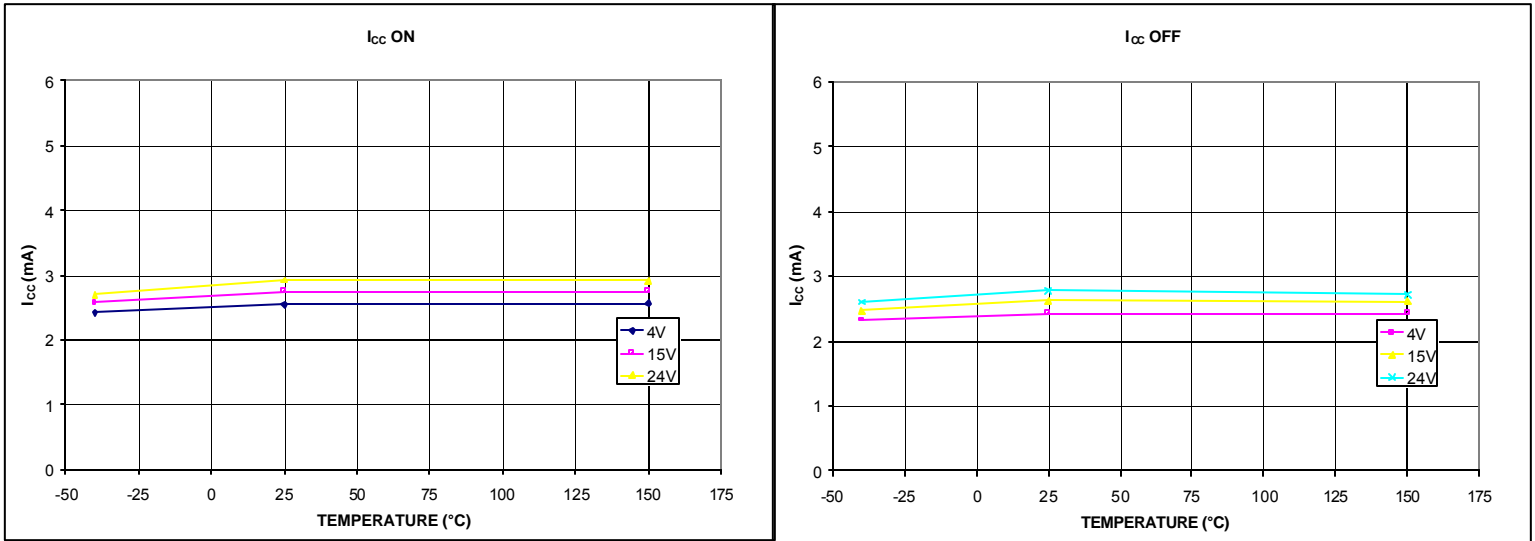
Extensive applications information on magnets and Hall-effect sensors including Chopper-Stabilization is available in the *Allegro Electronic Data Book* CD, or at the website: <http://www.allegromicro.com>.

# ATS635LSE and ATS636LSE

## PROGRAMMABLE TRUE POWER-ON HALL-EFFECT GEAR-TOOTH SWITCHES

### CHARACTERISTIC DATA

Data taken from 3 lots, 30 pieces/lot  
Reference Target 8x

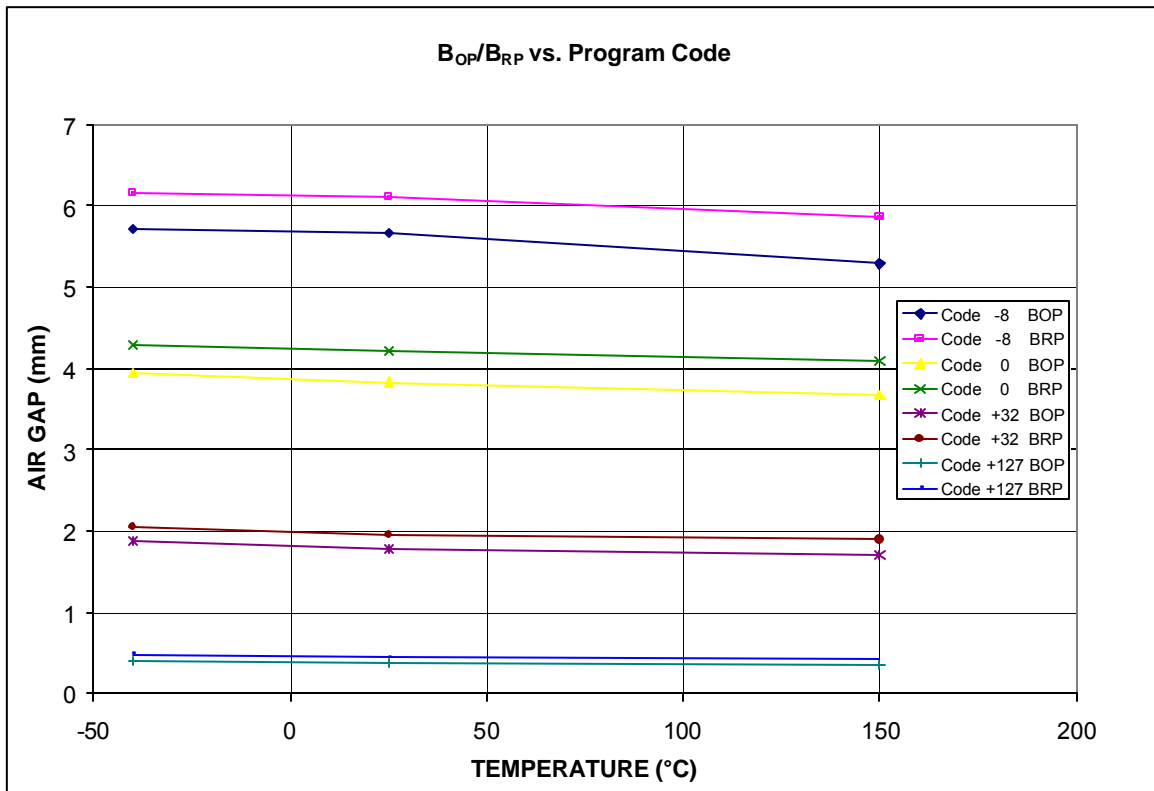


# ATS635LSE and ATS636LSE

## PROGRAMMABLE TRUE POWER-ON HALL-EFFECT GEAR-TOOTH SWITCHES

### CHARACTERISTIC DATA (continued)

Data taken from 3 lots, 30 pieces/lot  
Reference Target 8x



**Notes:**

- ♦ Air gaps for Code 127 @ 150°C are interpolated due to test limitations at minimum air gap.
- ♦ These graphs are intended to provide an understanding of how the program codes affect the switch points. In a production environment, individual devices would be programmed to individual codes to ensure all devices switch at the same air gap.

# ATS635LSE and ATS636LSE

## PROGRAMMABLE TRUE POWER-ON HALL-EFFECT GEAR-TOOTH SWITCHES

### POWER DE-RATING – SE Package

#### Power De -Rating

Due to internal power consumption, the temperature of the IC (junction temperature,  $T_J$ ) is higher than the ambient environment temperature,  $T_A$ . To ensure that the device does not operate above the maximum rated junction temperature use the following calculations:

$$\Delta T = P_D \times R_{\theta JA}$$

Where  $P_D = V_{CC} \times I_{CC}$

$$\therefore \Delta T = V_{CC} \times I_{CC} \times R_{\theta JA}$$

Where  $\Delta T$  denotes the temperature rise resulting from the IC's power dissipation:

$$T_J = T_A + \Delta T \quad R_{\theta JA} = 77^\circ\text{C/W} \quad T_{J(\text{max})} = 165^\circ\text{C}$$

#### Typical $T_J$ Calculation:

$$T_A = 25^\circ\text{C}, V_{CC} = 5 \text{ V}, I_{CC(\text{on})} = 5.5 \text{ mA}$$

$$P_D = V_{CC} \times I_{CC}$$

$$P_D = 5 \text{ V} \times 5.5 \text{ mA} = 27.5 \text{ mW}$$

$$\Delta T = P_D \times R_{\theta JA} = 27.5 \text{ mW} \times 77^\circ\text{C/W} = 2.0^\circ$$

$$T_J = T_A + \Delta T = 25^\circ\text{C} + 2.0^\circ\text{C} = 27.0^\circ\text{C}$$

#### Maximum Allowable Power Dissipation Calculation

$$T_J = T_A + \Delta T$$

$$T_{J(\text{max})} = 165^\circ\text{C}, \text{ if } T_A = 150^\circ\text{C} \text{ then:}$$

$$165 = 150 + \Delta T$$

$$\Delta T = 15^\circ\text{C}$$

$$\Delta T = P_D \times R_{\theta JA} \quad (R_{\theta JA} = 77^\circ\text{C/W})$$

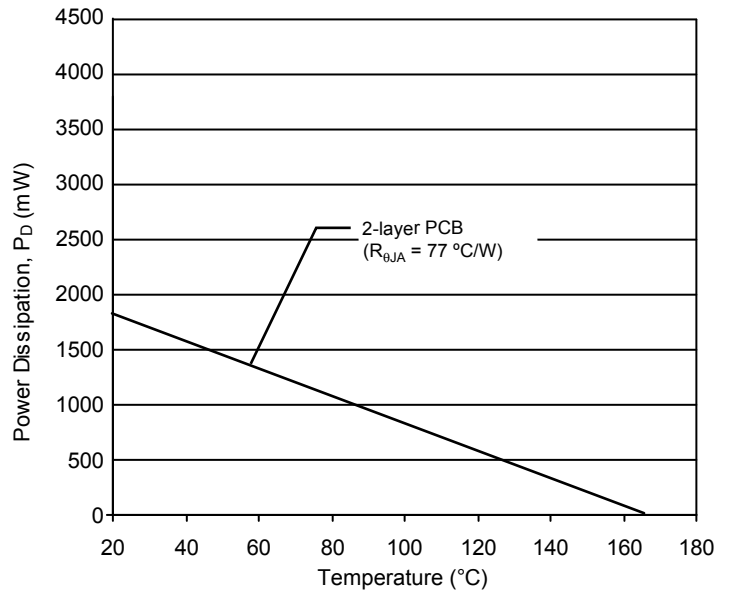
$$\therefore P_{D(\text{max})} = 15^\circ\text{C} / 77^\circ\text{C/W} = 195 \text{ mW @ } T_A = 150^\circ\text{C}$$

Maximum  $V_{CC}$  for  $P_{D(\text{max})} = 111 \text{ mW}$  at  $T_A = 150^\circ\text{C}$

$$P_D = V_{CC} \times I_{CC} \quad I_{CC} = 10 \text{ mA (max) at } 150^\circ\text{C}$$

$$V_{CC} = P_D / I_{CC} = 195 \text{ mW} / 5.5 \text{ mA} = 35.4 \text{ V}$$

**Power Dissipation versus Ambient Temperature**

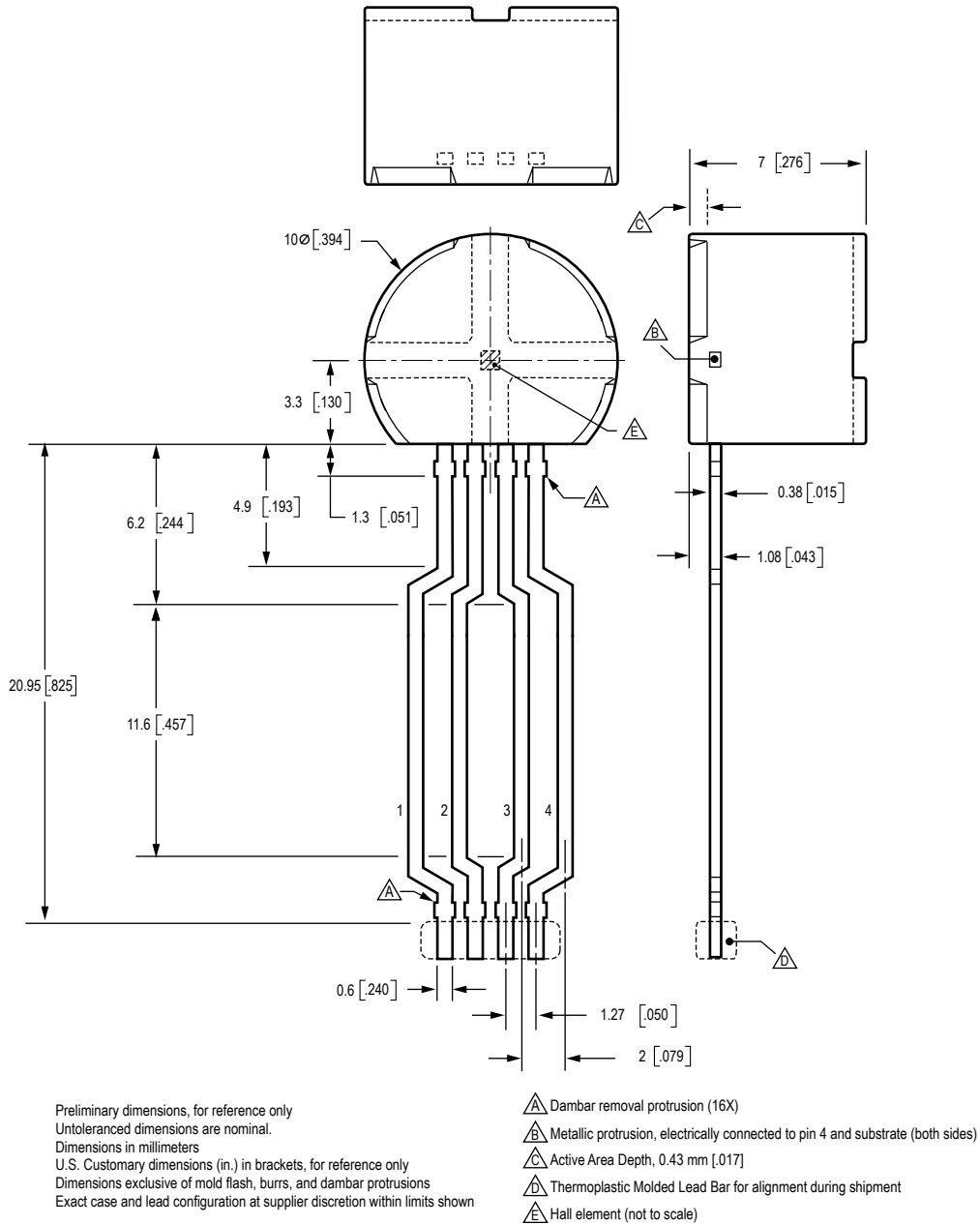


# ATS635LSE and ATS636LSE

## PROGRAMMABLE TRUE POWER-ON HALL-EFFECT GEAR-TOOTH SWITCHES

### SE PACKAGE DIMENSIONS

Reference Dimensions Only



# ATS635LSE and ATS636LSE

## PROGRAMMABLE TRUE POWER-ON HALL-EFFECT GEAR-TOOTH SWITCHES

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