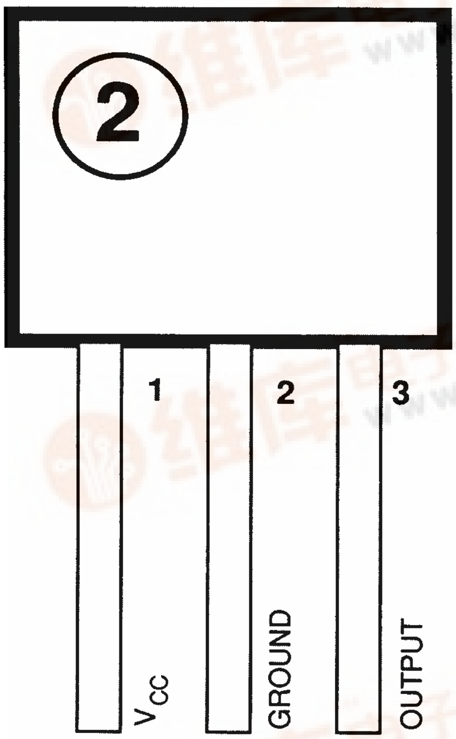
Sensor
Integrated Circuits

UGN3056U AND UGS3056U

Data Sheet
27612

HALL EFFECT DIGITAL GEAR-TOOTH SENSORS WITH ZERO-RPM CAPABILITY



The Sprague Types UGN3056U and UGS3056U Hall effect digital gear-tooth sensors are bipolar integrated circuits that switch ON and OFF in response to sufficiently large magnetic field differences created by passing ferrous targets. The sensor *operates down to zero rpm* over a wide range of air gaps and temperatures. When combined with a back-biasing magnet and a pole piece, either device can be configured to switch on either the leading or trailing edge of a passing gear tooth or slot. On-chip temperature compensation circuitry minimizes shifts in effective working air gaps and switch points over temperature, making these devices ideal sensors for ignition timing, anti-lock brake systems and speed measurement in hostile automotive and industrial environments.

Each Hall effect digital gear-tooth sensor IC includes a voltage regulator, two quadratic Hall effect sensing elements, temperature compensating circuitry, an amplifier, a Schmitt trigger and an open-collector output — all on a single monolithic chip. The on-board regulator permits IC operation with supply voltages of 4.5 V to 18 V. The output stage can switch up to 20 mA at conservatively specified repetition rates to 100 kHz, and is compatible with current bipolar and MOS logic circuits.

The two devices provide a choice of temperature ranges. The UGN3056U operates within specifications between −20°C and +85°C, the UGS3056U between −40°C and +125°C. Both device types are furnished in an environmentally rugged 3-pin plastic SIP. Other magnetic and temperature specifications are available upon request to the factory.

ABSOLUTE MAXIMUM RATINGS at T_A = +25°C

Supply Voltage, V_{CC} . . . . **18 V**
Magnetic Flux Density, B . . . . **Unlimited**
Output OFF Voltage . . . . **24 V**
Output ON Current, I_{SINK} . . . . **25 mA**
Operating Temperature, T_A
UGN3056U . . . . **−20°C to +85°C**
UGS3056U . . . . . **−40°C to +125°C***
Storage Temperature,
T_S . . . . **−55°C to +125°C**
Package Power Dissipation,
P_D . . . . **500 mW**
Reverse Battery . . . . **−30 V**

***Selected devices available with T_A range of −55°C to +170°C**

FEATURES

- Senses Ferrous Targets Down to Zero RPM
- Large Effective Air Gaps
- Wide Operating Temperature Range
- 4.5 V to 18 V Supply Voltage Range
- Fast Operation (100 kHz)
- Output Compatible with all Logic Families
- Ideal for Automotive, Consumer and Industrial Applications
- Integrated Reverse Battery Protection

UGN3056U and UGS3056U
HALL EFFECT DIGITAL GEAR TOOTH SENSOR

ELECTRICAL CHARACTERISTICS at T_A = +25°C, V_{CC} = 4.5 V to 18 V (unless noted)

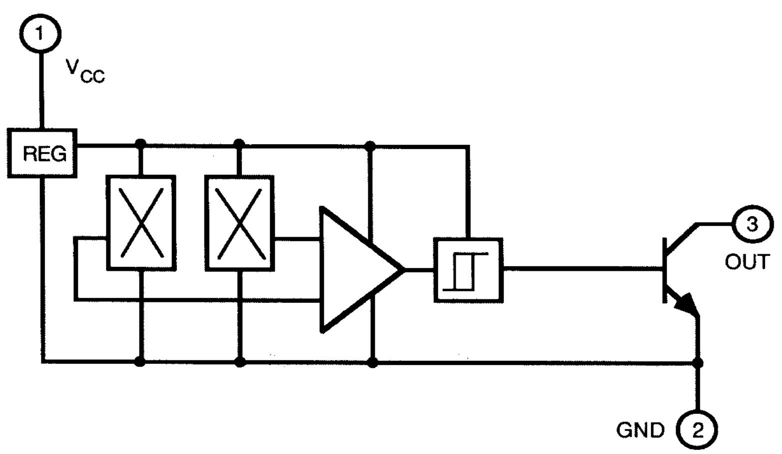
Characteristic	Symbol	Test Conditions	Min.	Typ.	Max.	Units
Supply Voltage	V_{CC}		4.5	—	18	V
Output Saturation Voltage	$V_{CE(SAT)}$	V_{CC} = 18 V, I_{SINK} = 20 mA, ΔB > 100 G	—	160	400	mV
Output Leakage Current	I_{OFF}	V_{OUT} = 18 V, V_{CC} = 18 V, ΔB < −200 G	—	0.01	10	μA
Supply Current	I_{CC}	V_{CC} = 18 V, Output Open	—	8.0	20	mA
Output Rise Time	t_r	V_{CC} = 14 V, R_L = 820 Ω, C_L = 20 pF	—	15	400	ns
Output Fall Time	t_f	V_{CC} = 14 V, R_L = 820 Ω, C_L = 20 pF	—	15	400	ns

MAGNETIC CHARACTERISTICS*

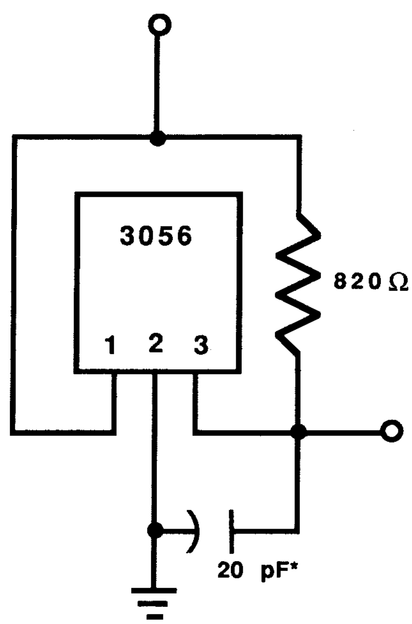
Characteristic	Device	Test Conditions	Min.	Max.	Units
Operate Point, B_{OP}	All	T_A = +25°C	−100	+100	G
	UGN	T_A = −20°C to +85°C	−150	+120	G
	UGS	T_A = −40°C to +125°C	−150	+120	G
Release Point, B_{RP}	All	T_A = +25°C	−200	−5	G
	UGN	T_A = −20°C to +85°C	−250	−5	G
	UGS	T_A = −40°C to +125°C	−250	−5	G
Hysteresis, B_H	All	T_A = +25°C	20	120	G
	UGN	T_A = −20°C to +85°C	20	120	G
	UGS	T_A = −40°C to +125°C	20	120	G

*Differential flux values

FUNCTIONAL BLOCK DIAGRAM



TEST CIRCUIT



*Includes probe and test fixture capacitance.

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HALL EFFECT DIGITAL GEAR TOOTH SENSOR

APPLICATIONS NOTES

A gear tooth sensing system consists of the sensor IC, a back-biasing magnet and pole piece, and a target (Fig. 1). The system requirements are usually specified in terms of the effective working air gap between the IC and the target (the gear teeth), the number of switching events per rotation of the target, temperature and speed ranges, minimum pulse width or duty cycle, and switch point accuracy. Careful choice of the sensor IC, magnet, and target promotes achievement of large working air gaps and good switch point accuracy over the system operating temperature range.

System Operation

The IC output normally assumes a LOW state at power-up, and remains LOW when placed in the magnet/pole-piece assembly. The sensor measures differential flux by means of two Hall effect elements, Sensor 1 and Sensor 2, located 17 mils (0.43 mm) below the front surface of the IC package.

Referring to Fig. 2, the output switches HIGH when the magnetic flux "seen" by Sensor 1 drops below the flux at Sensor 2 by a value less than the sensor IC Release Point, B_{RP}. The IC output returns to the LOW state when the flux difference between sensors exceeds the Operate Point, B_{OP}. The difference between B_{RP} and B_{OP} is the hysteresis of the device, which affects the duty cycle or pulse width the IC can generate.

Fig. 3 relates the output state of the sensor IC to the target (gear tooth) profile and position, as well as the magnetic field and its changes at the sensor locations. The IC output switches to the HIGH state whenever Sensor 1 faces a (ferrous) gear tooth and Sensor 2 faces air, ie., whenever the negative value of the magnetic field at Sensor 1 exceeds that at Sensor 2 by B_{RP}. The output returns to the LOW state when both sensors simultaneously face a gear tooth or air, ie., when the magnetic field at both sensors approach equality or their difference equals or exceeds B_{OP}.

On-chip temperature compensation circuitry minimizes switch point drift over temperature. At the system level, this translates into minimal shifts in effective working air gap and higher switch-point stability over the full operating temperature range.

GEAR TOOTH SENSING SYSTEM

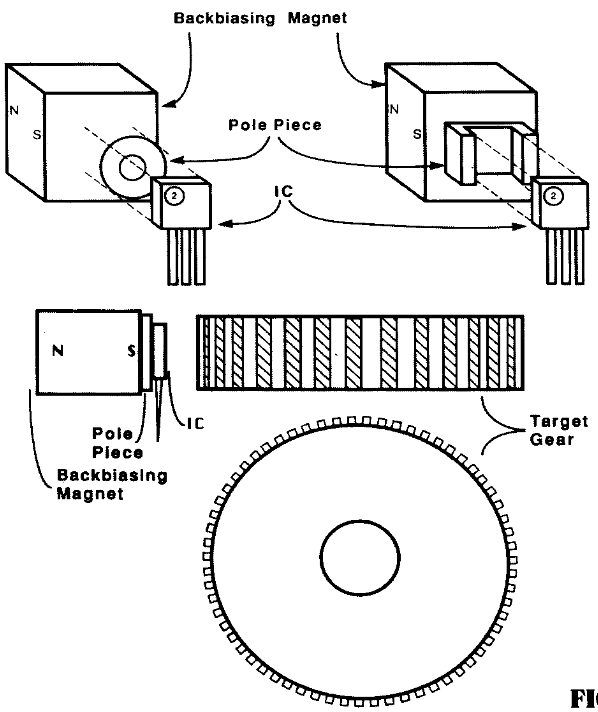

FIGURE 1

UGN/UGS3056
HYSTERESIS CHARACTERISTICS

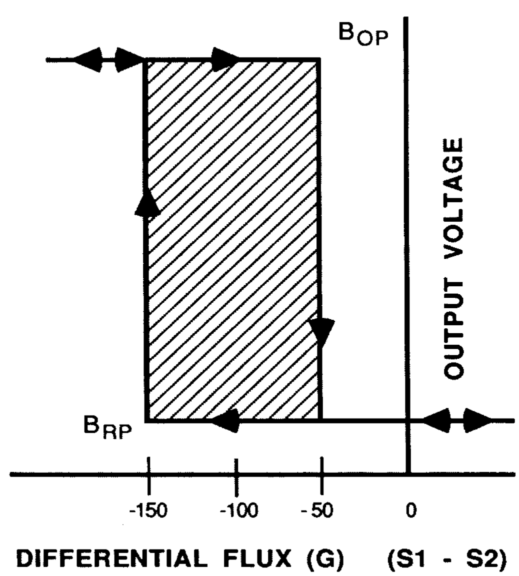

FIGURE 2

Pole Piece Design

For optimal IC operation, the back-biasing magnet must provide the same amount of ambient flux to the pair of sensing elements, which are spaced 88 mils apart. However, rare earth magnets (samarium cobalt and neodymium iron boron) and, to a lesser extent, Alnico-8 magnets do not generate uniform flux across their pole faces; the distribution of flux and its peak value at the magnet pole face is highly unpredictable. Along with this, placing the sensor IC directly on the magnet pole face can, and usually does, result in a large difference of flux density passing through Sensors 1 and 2. This error can produce a "flipped" output signal and/or a greatly reduced effective working air gap.

Pole pieces made of soft iron or low carbon steel materials can greatly minimize this magnetic offset error. The two most successful pole-piece shapes appear in Figs. 3d and 3e. The toroidal form should have an outer diameter equal to that of the magnet, and an inner diameter slightly larger than the device package width. The second pole piece shape should be the same height as the device package, and should wrap tightly around the back and sides of the IC package.

Magnet Selection

Alnico-8 and the rare earths are the materials of choice for this system. The Alnico-8 and the samarium cobalt magnets perform well over a temperature range of −40°C to +150°C. At this time, neodymium iron boron is not a proven high-temperature performer; at temperatures above +150°C it may lose magnetic strength irreversibly.

Either cylindrical or cube-shaped magnets can be used so long as the magnet pole face at least equals the facing surface(s) of the IC package and the pole piece. Choose the length of the magnet to obtain a length-to-width ratio of at least 1:1 for rare earths and 2:1 for Alnico-8. Any added magnet length will incrementally improve the maximum air gap. Figs. 4-7 illustrate the differences in nominal air gap with equal volumes of Alnico-8 and samarium cobalt magnets.

Ferrous Targets

The best ferrous targets are made of cold-rolled low-carbon steel. Sintered metal targets are also usable, but care must be taken to ensure uniform material composition and density.

The teeth or holes of the target should be square cut, if possible, to maximize the abruptness of transition from metal to air as the target passes by the sensor. Figures 4-7 can be used to estimate a nominal working air gap for a particular target configuration. Generally, larger teeth and slots allow a larger air gap.

SYSTEM OPERATION

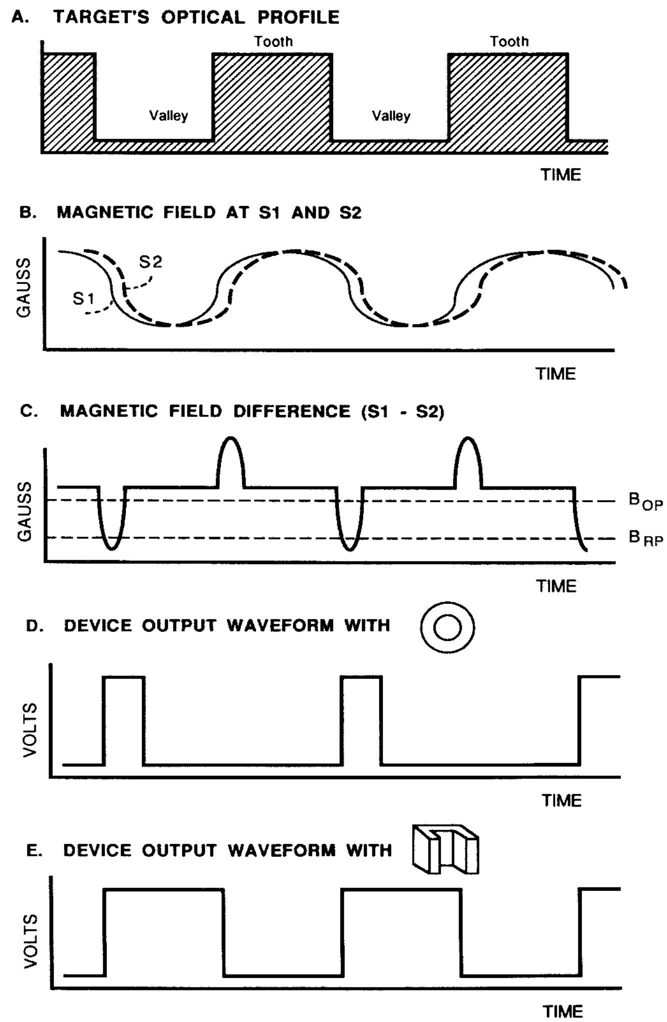

FIGURE 3

UGN3056U and UGS3056U
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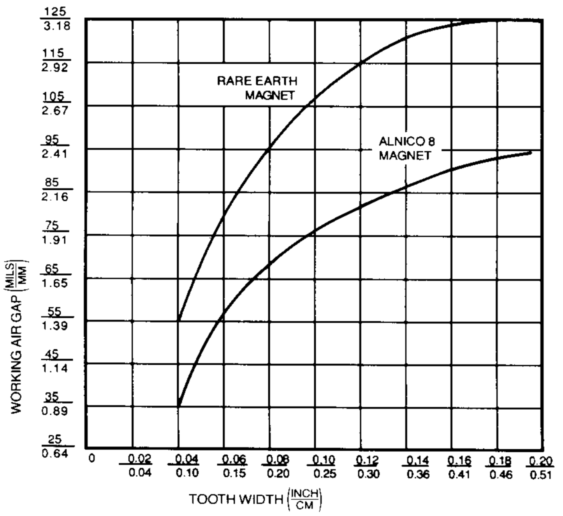
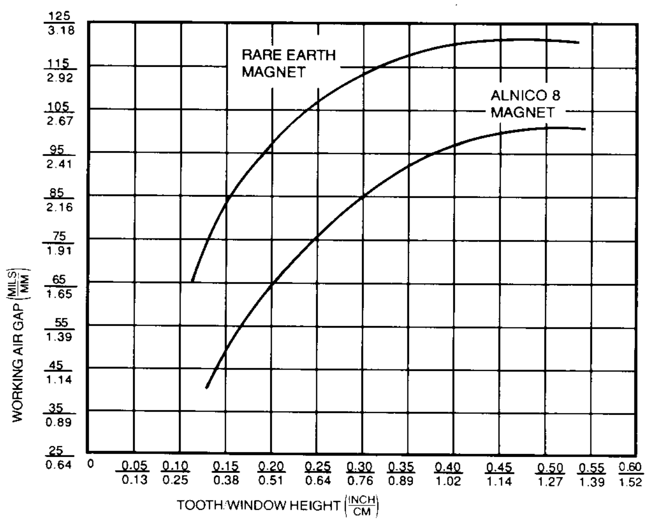
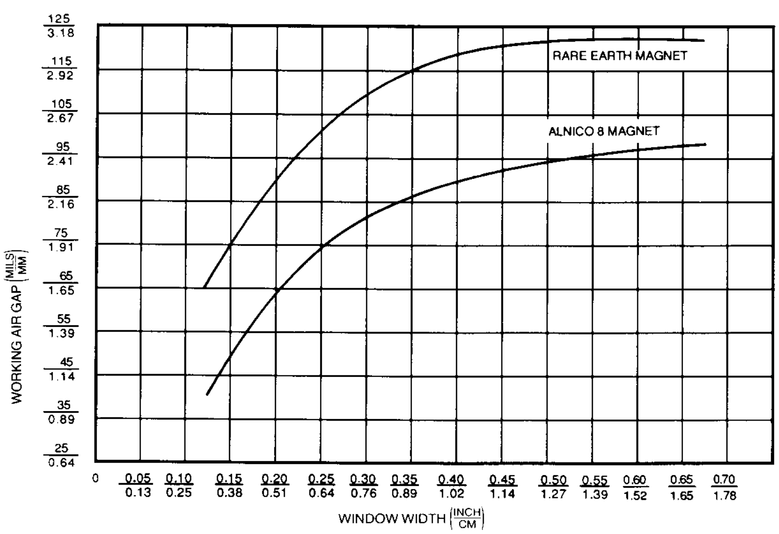
WORKING AIR GAP vs TOOTH WIDTH
FIGURE 4



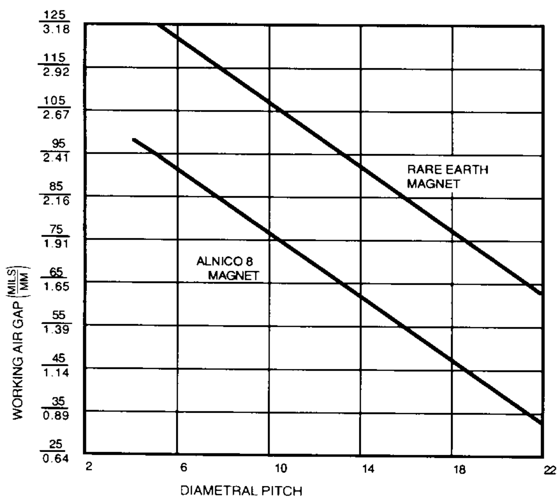
WORKING AIR GAP vs TOOTH WINDOW HEIGHT
FIGURE 5



WORKING AIR GAP vs WINDOW WIDTH at +25°C
FIGURE 6



EFFECTIVE WORKING AIR GAP vs DIAMETRICAL PITCH at +25°C
FIGURE 7



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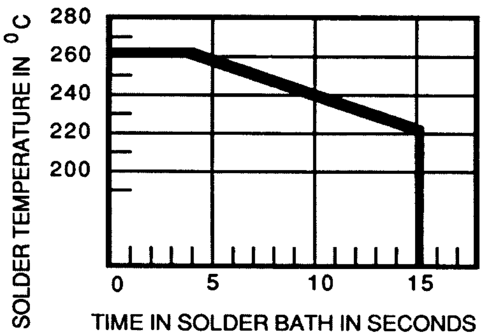
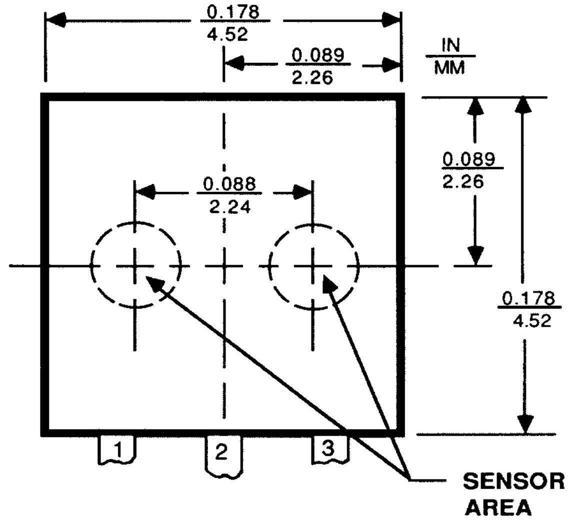
GUIDE TO INSTALLATION



1. All Hall Effect integrated circuits are susceptible to mechanical stress effects. Caution should be exercised to minimize the application of stress to the leads or the epoxy package. Use of epoxy glue is recommended. Other types may deform the epoxy package.

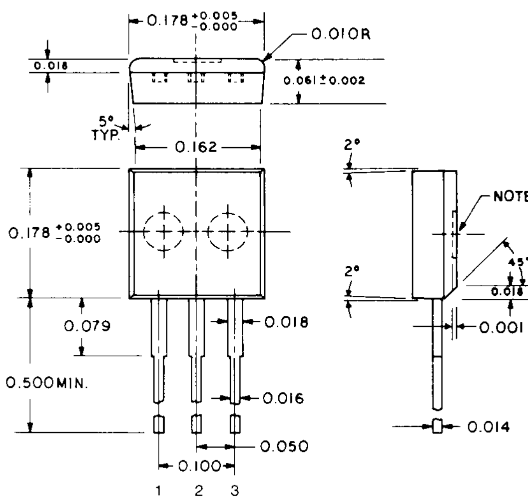
2. To prevent permanent damage to the Hall cell, heat-sink the leads during hand-soldering. Recommended maximum conditions for wave soldering are shown in the graph at right.

SENSOR LOCATION

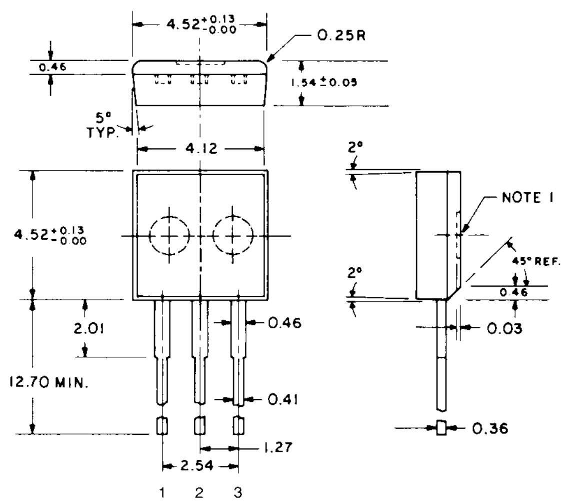


PLASTIC SIP — SPRAGUE PACKAGE DESIGNATOR 'U'

DIMENSIONS IN INCHES



DIMENSIONS IN MILLIMETERS (Based on 1" = 25.40 mm)



The Sprague Electric Company reserves the right to make, from time to time, such departures from the detail specifications as may be required to permit improvements in the design of its products. Components made under military approvals will be in accordance with the approval requirements.

The information included herein is believed to be accurate and reliable. However, the Sprague Electric Company assumes no responsibility for its use; nor for any infringements of patents or other rights of third parties which may result from its use.

NOTES:
1. Ejector pin is centrally located.
2. Tolerances on package height and width represent allowable mold offsets. Dimensions given are measured at the widest point (parting line).
3. Tolerances, unless otherwise specified, are ±0.005" (0.13 mm) and ± 1/2°.

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