MicroGyro
MG1101

Consumer Grade
Dual Axis Gyroscope
with Digital Output

A THOMSON COMPANY
Gyration

The MG1101 MicroGyro by Gyration, Inc. is a low-cost, fully integrated miniature gyroscope that is ideally suited for human input devices such as computer mice, remote controls and game controllers.

Features

- Integrated analog-to-digital converters
- Two-axis sensing
- Low cost
- Miniature size
- Extremely lightweight
- 2-wire Serial interface
- Low drift
- Internal shock mounting
- Low voltage
- 1K of usable EEPROM
- High temperature stability
- PCB-mountable
- Integrated digital temperature and voltage level sensors

1.0 General Description

The MG1101 is a low-cost, dual-axis miniature rate gyroscope that is fully self-contained for easy integration into human input devices such as computer mice or remote controls. Its unique tri-axial vibratory structure offers high reliability and low manufacturing cost. Internal mounting isolates the vibrating elements, greatly decreasing drift and improving shock resistance. The module can be mounted directly to a printed circuit board, without additional shock mounting.

A unique electromagnetic transducer design and a single etched beam structure utilize the Coriolis effect to sense rotation in two axes simultaneously. The MG1101 includes an integrated analog-to-digital converter (ADC) and communicates via a conventional 2-wire serial interface bus allowing a user or OEM to connect the device directly to a microcontroller with no additional hardware. The MicroGyro is well suited for low voltage products operating between 2.3 and 3.6 volts. Its low current consumption is enhanced by a low current sleep mode. A temperature sensor is provided for the most demanding applications and a voltage sensor allows simple detection of a low battery condition for battery powered applications. The MG1101 further includes 1K of available EEPROM storage on board.

Suggested applications are human motion tracking, computer pointers, TV remote controllers, game controllers, robotics, factory automation, antenna stabilization and auto navigation.

2.0 Patent Information

Gyration has been awarded several patents, both in the United States and internationally. These patents cover the proprietary mechanical design of Gyration's miniature gyroscopes.

Additionally, Gyration has been awarded broad application patents that restrict the use of any type of sensor, gyroscope or other device, to detect the rotational motion of any part of the human body to move a graphic or cursor on any type of monitor, television, or display. Several more patents pertaining to the introduction of MG1101 are pending.

3.0 Absolute Maximum Ratings

Parameter	MIN	NOM	MAX	UNITS
Storage Temperature	-30	-	+85	°C
Voltage on Vcc Pin with respect to Ground	-0.3	-	4.6	V
Voltage on either of serial bus pins, SCL, SDA with respect to Ground	-0.3		6.0	V
ESD Rating, HBM			2	kV
Shock Survivability			500	G

NOTICE: Stresses beyond those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. This is a stress rating only and functional operation of the device at these or any other conditions beyond those indicated in the operational sections of this specification are not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

CAUTION: This device is sensitive to ESD (electrostatic discharges). Although this device incorporates circuitry to protect against ESD, permanent damage may occur if subjected to high energy electrostatic discharges. It is thus recommended that appropriate ESD precautions are implemented when handling this device.

4.0 Recommended Operating Conditions

Parameter	Conditions	Symbol	MIN	NOM	MAX	UNITS
Supply Voltage		V_{CC}	2.3	2.7	3.6	V_{DC}
Power Supply Ripple		V_{RIPPLE}	-	-	50	mVpp
Power Supply Impedance		R_{SOURCE}			2	ohm
Operating Temperature		T_{AM}	-5	25	55	°C
Serial Clock Frequency, for MG1101 Gyro Functions	$V_{CC,MIN} < V_{CC} < V_{CC,MAX}$	CLK1	-	-	400	kHz
Serial Clock Frequency, for MG1101 EEPROM Functions	$2.7V < V_{CC} < V_{CC,MAX}$ $V_{CC,MIN} < V_{CC} < 2.7V$	CLK1 CLK2	- -	- -	400 100	kHz kHz
Digital Input Low Level, SDA / SCL		V_{IL}	-	-	Vcc*0.35	V
Digital Input High Level, SDA / SCL		V_{IH}	Vcc*0.65	-		V
Two Wire Serial Bus Voltage		V_{BUS}	V_{CC}	V_{CC}	5.0	V

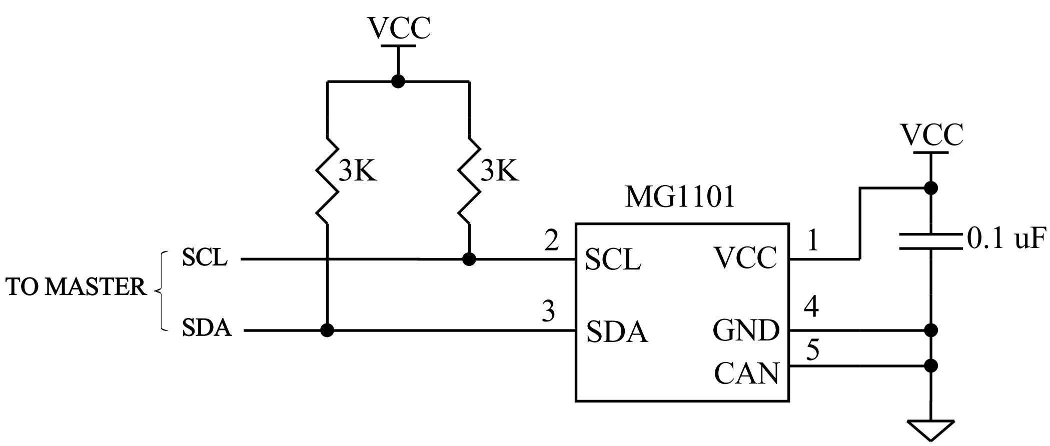


Figure 4-1 MG1101 TEST CIRCUIT

5.0 Specifications

Unless otherwise noted, these specifications are valid for the following conditions: V_{CC} =2.3 to 3.6V, T_{AM} =-5ºC to +55ºC, Rotational Rate Input = -MAV to +MAV, Serial interface bitrate for Gyro function = 400kHz, Serial interface bitrate for EEPROM function = 400kHz for $V_{CC} \geq 2.7V$ and 100KHz for $V_{CC}<2.7V$. Serial Bus Pull-up voltage = V_{CC}. Characteristics refer to both Axis A and Axis B unless otherwise specified.

Parameter	Conditions	Symbol	MIN	NOM	MAX	UNITS
Dynamic Range		MAV	-500		+500	deg/sec
Offset	No rotation applied	OFF	-180	0	+180	deg/sec
Offset Temperature Coefficient	Measured at 10ºC Intervals	OFF_TC		± 0.25	± 1.0	deg/sec / ºC
Offset Supply Voltage Coefficient	Measured from 2.3V to 3.6V	OFF_VC		0	± 0.5	deg/sec / V
Rate Sensitivity	Measured at Full Scale Rate	SF		32.0		LSB / deg/sec
Rate Sensitivity Temperature Coefficient	% change from SF at T_{AM}=25°C	SF_TC	-0.12	-0.04	+0.01	% / ºC
Cross Axis Coupling Rotation on Axis B, change in A output Rotation on Axis A, change in B output		CAXA CAXB	-3 -3	0 0	3 3	% of applied rotation rate
Drift	Measured from 1 to 180 seconds after power up	TOD	-2.0		2.0	deg/sec
Power on Reset threshold (Brown out detection)		V_{POR}	1.5		1.75	V
Power Up Time		t_{GRNR}		55	150	msec
Power On Settling Time		t_{POST}		800	1000	msec
Rotational Rate Nonlinearity		NLIN		± 0.05	± 0.5	% FS
Gyro Digital Output Report Rate (refresh of rotation rate output after new ADC conversion)			26.7	29	31.3	Hz
Rotational Rate Input Bandwidth	3dB attenuation, 45 deg phase shift input to output	BW	13.4	14.5	15.7	Hz
Noise floor: Axis A Axis B	No vibration applied	NZ_A NZ_B		0.18 0.25	0.35 0.40	deg/sec (rms) deg/sec (rms)
Sleep Mode Current	With serial bus idle, after <Init> Bit is set.	I_{SLEEP}		3.0	10	uA
Steady State Supply Current	Full Mode, Normal Operation	I_{FULL}		7.5	10.0	mA
Temperature Sensor Sensitivity		T_{SLOPE}	4.757	5.115	5.500	LSB / Kelvin
Voltage Sensor Sensitivity		V_{SLOPE}	200.0	204.7	210.0	LSB / V
Mass		M		6.8		g

6.0 Two Wire Serial Bus Interface Architecture

The MG1101 uses a two-wire serial bus interface that is compatible with other two-wire serial interfaces devices such as EEPROMs, DACs, data converters, etc. The two-wire interface comprises a master-slave architecture and is capable of both READ and WRITE data transfers. Each data transfer has a basic unit of a byte (8-bit), although multiple data units may be combined for larger transfers.

Master - The master is typically a microcontroller or similar device. The master is responsible for selecting the data transfer direction, initiating all data transactions, and generating all START and STOP condition, addressing the slave target of interest, and performing all SCL clocking operations.

Slave – The MG1101 acts as a serial bus slave in response to transaction initiated by the master. It has two unique slave addresses that can perform many different functions, depending on the slave address, the data direction, and memory location accessed by the master. The MG1101 can share a two-wire serial bus with other devices that have compatible interfaces, provided that the total bus capacitance is not exceeded.

Each MG1101 serial transaction requires a START condition followed by an 8-bit slave device address word specifying a read or write operation (refer to Figure 6-1 MG1101 SLAVE ADDRESSES). The device address word consists of a mandatory seven bit slave address followed by the eighth bit which specifies data direction. A read operation is initiated if the eighth bit of the slave address is high and a write operation is initiated if the eighth bit is low. Upon recognizing a matching slave address, the MG1101 will output a zero (ACK). If the slave address does not match one of the two MG1101 internal slave addresses, it will ignore the remainder of the serial transaction.

Function	**Slave Device Address**								**Allowable SCL Clock Rate (kHz)**	**Allowable SCL Clock Rate (kHz)**
	MSB							LSB	$V_{CC} \geq 2.7V$	$V_{CC} < 2.7V$
MG1101 Gyro Control	1	0	1	0	1	1	1	R / W	400	400
MG1101 EEPROM Control	1	0	1	0	0	0	0	R / W	400	100

Figure 6-1 MG1101 SLAVE ADDRESSES AND FUNCTIONS

Information regarding operation of the two-wire serial bus protocol is detailed in section 11.0 Two Wire Serial Interface Operation.

7.0 MG1101 Memory Maps

The MG1101 acts as two different serial slave devices, each with different functions.

Gyro Function – The Gyro function controls the vibrating inertial structure of the MG1101, and automatically converts each axis's rotational rate into digital samples. The Gyro device is initially configured by writing calibration constants into the first 16 memory locations ($00 thru $0F) of the Gyro function memory via the two-wire serial interface. If the supply voltage V_{CC} is maintained above $V_{CC,MIN}$ then the calibration constants need only to be loaded once. Because the Gyro function memory is volatile, the calibration constants need to be reloaded if V_{CC} drops below $V_{CC,MIN.}$ After initial setup, the rotational rate data samples, the voltage and temperature sensor information, and the Gyro function STATUS register can be read by a master using READ commands from the Gyro Function RAM.

EEPROM function – The primary purpose of the MG1101 EEPROM function is to provide permanent, nonvolatile storage location for the factory calibration constants. Because the EEPROM total capacity is larger than the calibration constants require, a full 1K (memory addresses $80 thru $FF) of the EEPROM is available for general use.

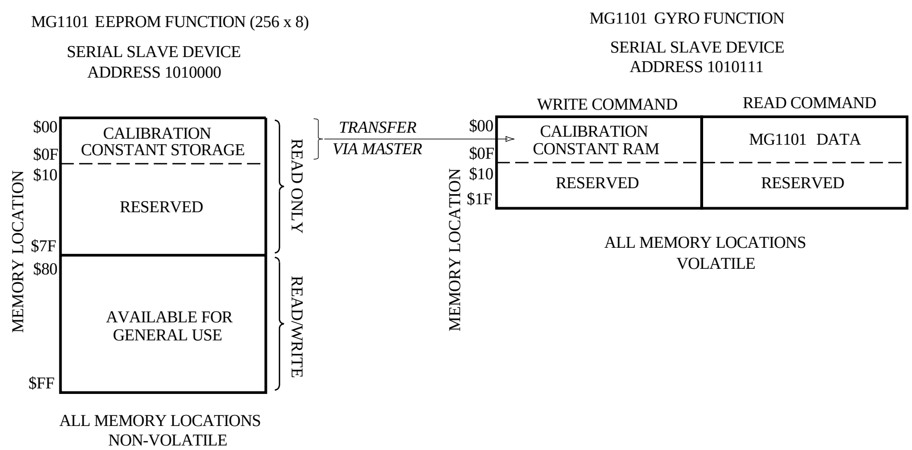


Figure 7-1 Memory Map Overview of the two MG1101 functions

7.1 MG1101 Gyro Function - Write Memory Map

The Write Memory Page consists of 16 bytes of addressable memory ranging from address $00 to $0F. The lower byte of the write memory map (Address $0F) is the write register intended for use during normal operation of the devices. The remainder of the write memory map is intended to transfer Factory Calibration Values to the device at power-up as detailed in section 8.2 Power-Up Procedure. The lower byte of the Gyro Function Write Memory Map is as follows:

Addr.	(msb) Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	(lsb) Bit 0	Byte Name	Description
$0F	0	INIT	0	0	Rsv	PMD2	PMD1	PMD0	<CNTRL>	Control Register

Note: Rsv bits which are in the above memory map will be ignored by the MG1101. It is recommended for the application firmware to use 1's when writing to these bits.

Bit Names	Description
INIT	Gyro Initialization Bit. This bit must be set in order to initialize the MG1101. Please see section 8.2 Power-Up Procedure. Note: Until the <INIT> bit is set, all reads from MG1101 Gyro Function will output 1's in every bit location.
PMD2…PMD0	Power Mode Control bits used to put the MG1101 into various operational modes in order to conserve power consumption. For mode description see section 8.1 Gyro Function Power Mode Control Bits.

7.2 MG1101 Gyro Function - Read Memory Map

The Gyro Function Read Memory Page consists of 16 bytes of readable memory ranging from address $00 to $0F. The register names and locations are as follows:

Addr.	(msb) Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	(lsb) Bit 0	Byte Name	Description
$00	AR15	AR14	AR13	AR12	AR11	AR10	AR9	AR8	<HAR>	High Byte Axis A result
$01	AR7	AR6	AR5	AR4	AR3	AR2	AR1	AR0	<LAR>	Low Byte Axis A result
$02	BR15	BR14	BR13	BR12	BR11	BR10	BR9	BR8	<HBR>	High Byte Axis B result
$03	BR7	BR6	BR5	BR4	BR3	BR2	BR1	BR0	<LBR>	Low Byte Axis B result
$04							VR9	VR8	<HVR>	High Byte Voltage result
$05	VR7	VR6	VR5	VR4	VR3	VR2	VR1	VR0	<LVR>	Low Byte Voltage result
$06							TR9	TR8	<HTR>	High Byte Temp. result
$07	TR7	TR6	TR5	TR4	TR3	TR2	TR1	TR0	<LTR>	Low Byte Temp. result
$08				Rsv	TRNR	Rsv	GRNR	PC	<STATUS>	Status Register
$09 - $0F									(unused)	

Note: The MG1101 memory map will return a 1 when the application attempts to read any bit which is left blank in the above memory map table. Rsv bits are reserved bits that are not applicable to normal operation of the device.

Bit Name	Description
AR15…AR0	Axis A Rotational Rate Sensor result register
BR15…BR0	Axis B Rotational Rate Sensor result register
VR9…VR0	Supply Voltage Sensor result register
TR9…TR0	Temperature Sensor result register
PC	Power Cycle Bit. Flag indicating that an internal power cycle has occurred This bit is set to 1 in the following situations • Initial Power Up • Low voltage/brownout detection ($V_{CC} < V_{POR}$) • Power Mode Control bits are changed to a Reset Command. (see Section 8.0) This bit is cleared only when the <INIT> bit has been set to by a WRITE command. For usage see Section 8.2 Power-Up Procedure
GRNR	Gyro Not Ready Bit. This bit is cleared when the vibrating beam element of the MG1101 is stable and the Rotational Rate Sensors are ready for operation. For usage see Section 8.3 Start-Up Procedure
TRNR	Transition Not Ready. This bit is set to 1 after a certain Power Mode commands are initiated in order to indicate that the MG1101 is in transition. The bit is automatically cleared when the device is stable and ready to provide output data.

8.0 Device Operation

8.1 Gyro Function Power Mode Control Bits

<PMD> (binary)	Description	Details and Intention
000	Sleep Mode	All main functions are disabled except for the serial interface circuitry. The MG1101 is not being used and has essentially been turned off in order to conserve power. The serial interface is operational so that the user may send a command that will change the mode of the MG1101 to something other than Sleep Mode.
001	Full Operation	All blocks are powered and fully operational. The MG1101 is being used to detect Rotational Rate information, and provide Temperature and Voltage information.
010	Temp/Voltage	MG1101 is being used solely for the purpose of providing Temperature and Voltage sensor information.
011	Waiting for Motion	The MG1101 is expecting that the sensor will be used to detect Rotational Rate motion within a short period of time. In this mode the Vibrating Beam Oscillator is sustained, but the Rate Sensing circuitry is disabled in order to conserve power.
100	Reserved	This mode is used for internal testing and calibration and is not designed for use by the end user. If you enter this mode, you may see degraded performance on the gyro function. You can restore proper operation by resetting the MG1101 and reloading the calibration constants from the EEPROM into Gyro Function RAM.
101 – 110		Remain in Sleep Mode
111	Reset	Full reset of all hardware functions, including Read and Write RAM to default power on state. Equivalent to cycling VCC to zero and back.

8.2 Power-Up Procedure

Each MG1101 unit requires certain unique factory calibration constants to be written to the MG1101 Gyro Function RAM registers in order for the device to function correctly. The required calibration constants are stored in the EEPROM that is integrated into the MG1101 device and needs to be transferred to the MG1101 Gyro Function registers by an external master device (such as a microcontroller) whenever the MG1101 is powered up. The Power Up procedure is listed below:

Step	Procedure
1	Supply power to the Vcc Pin
2	Read the calibration constants from the EEPROM function addresses $00-$0F to a temporary storage location (typically within the master) by performing a Page Read.
3	Write these calibration constants from the temporary storage to the MG1101 Gyro Function memory locations $00-$0F by performing a Page Write. (There is a direct mapping of values. EEPROM Memory Location $00 maps to MG1101 Gyro Function Memory $00. EEPROM Memory Location $01 maps to MG1101 Gyro Function Memory $01, etc.)
4	Set the Gyro Initialize bit <INIT>.

Note: The MG1101 will maintain the calibration constants as long as power is maintained to the MG1101 device. If a power fail occurs, or a Reset command is initiated, the calibration constants need to be reloaded from the EEPROM function to the Gyro Function memory locations. The application can detect a Power fail by periodically checking the PC bit in the Gyro Function <STATUS> register.

8.3 Start-Up Procedure

Step	Procedure
1	Set the Power Mode to Full Operation, <PMD> to B001
2	Poll the Gyro Not Ready bit, <GRNR>, and wait till this bit is cleared
3	For best performance, wait a fixed time delay of t_{POST} for the inertial vibratory structure to settle.
4	The MG1101 is now ready for operation.

8.4 Rotational Rate Sensor Output

Data from the two Rotational Rate Sensors are outputted via the 16 bit unsigned numbers stored in Gyro Function RAM registers <AR> and
.

With the gyro held motionless, read the <AR> and
 registers which give the binary code which corresponds to zero rotational rate

A_OFFSET = <AR> (with the gyro motionless)
B_OFFSET =
 (with the gyro motionless)

These two offset values are 16 bits long each and will typically be stored by the application in a nonvolatile memory location.

The following convention is used for the values of <AR> and

- An ideal Offset of 0 deg/sec corresponds to a value of $8000
- The lowest possible output of each rate sensor is $0000
- The highest possible output of each rate sensor is $FFFE
- An output of $FFFF is not a valid sample of rotational rate, and occurs when the Gyro Function is not ready to deliver data (such as in sleep mode or if the <INIT> bit has not been set)

Actual rate output is attained by subtracting these above offset values from the current value of the <AR> and
 register result values according to the following formula:

For Axis A:

$$RotationalRate[\mathrm{deg/sec}] = \frac{<\mathrm{AR}> - \mathrm{A\_OFFSET}}{\mathrm{SF}\,[\mathrm{LSB/deg/sec}]}$$

For example for the Axis A Channel,

(a) Suppose the <AR> value with no motion = $81E2. This is the A_OFFSET value. [Note this corresponds to an A_OFFSET of about +15.1 deg/sec for typical SF = 32 LSB/deg/sec].
(b) Now suppose the <AR> value read during rotation is <AR> = $C062
Subtracting (a) from (b) gives a result of $3E80 due to rotational motion.
And dividing by the nominal sensitivity parameter SF = 32 LSB/deg/sec, we calculate that the unit was rotated around the A axis at a rotational rate of +500 deg/sec.

Since the Offset value can shift under different operating conditions, for optimal results, the application firmware should update the A_OFFSET and B_OFFSET values whenever the MG1101 is known to be motionless.

The same equations apply to the Axis B Channel.

8.5 *Digital Voltage Sensor*

The supply voltage to the MG1101 can be measured using the integrated voltage sensor which has 10 bits of resolution and produces accurate results in the range 1.8 V < V_{CC} < $V_{CC,MAX}$.

The voltage sensor obeys the following equation:

$$V_{RESULTS}(LSB) = V_{SLOPE} * V_{CC}$$

Where

- $V_{RESULTS}$ is the 10 bit binary result that is read from the MG1101 voltage results RAM registers.
- V_{SLOPE} is the voltage sensitivity parameter defined in section 5.0 Specifications
- V_{CC} is the supply voltage for the MG1101

V_{CC} (V)	Voltage Results Min (HEX)	Voltage Results Nom (HEX)	Voltage Results Max (HEX)
1.80	$168	$170	$17A
2.20	$1B8	$1C2	$1CE
2.50	$1F4	$200	$20D
2.70	$21C	$229	$237
3.30	$294	$2A4	$2B5
3.60	$2D0	$2E1	$2F4

8.6 *Digital Temperature Sensor*

The temperature inside the MG1101 can be measured using the integrated temperature sensor which has 10 bits of resolution and produces accurate results in the entire range of operating temperatures.

The temperature sensor obeys the following equation:

$$T_{RESULTS}(LSB) = T_{SLOPE} * T_{ACTUAL}(K) - 1023$$

Where

- $T_{RESULTS}$ is the 10 bit binary result that is read from the MG1101 temperature results RAM registers.
- T_{SLOPE} is the temperature sensitivity parameter as defined in section 5.0.Specifications
- $T_{ACTUAL}(K)$ is the actual temperature inside the MG1101 [in Kelvin]

T_{ACTUAL} (ºC)	T_{ACTUAL} (K)	Temp. Results Min (HEX)	Temp. Results Nom (HEX)	Temp. Results Max (HEX)
-5	268	$0FC	$15C	$1C3
5	278	$12B	$18F	$1FA
15	288	$15B	$1C2	$231
25	298	$18B	$1F5	$268
35	308	$1BA	$228	$29F
45	318	$1EA	$25C	$2D6
55	328	$219	$28F	$30D

9.0 Typical Performance Characteristics

Figure 9-1 Offset Settling Time

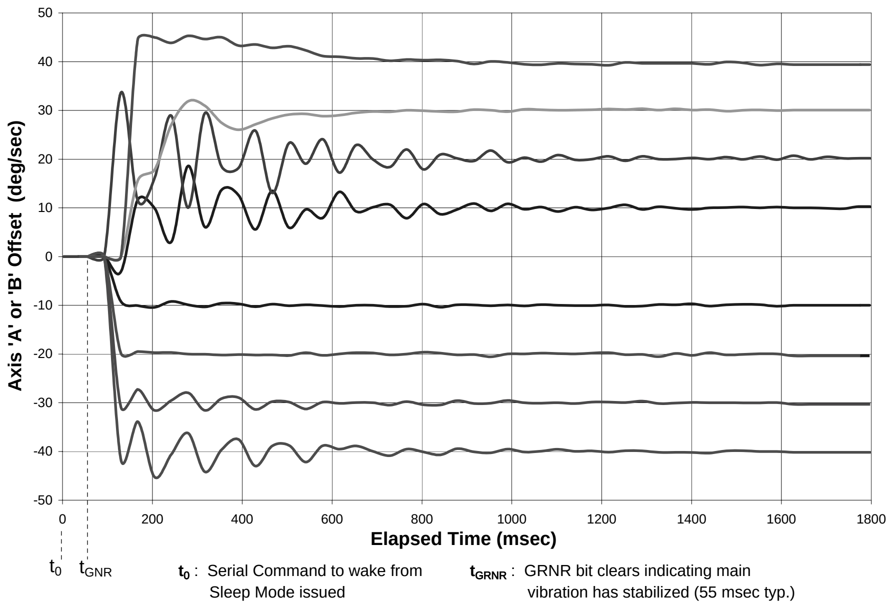
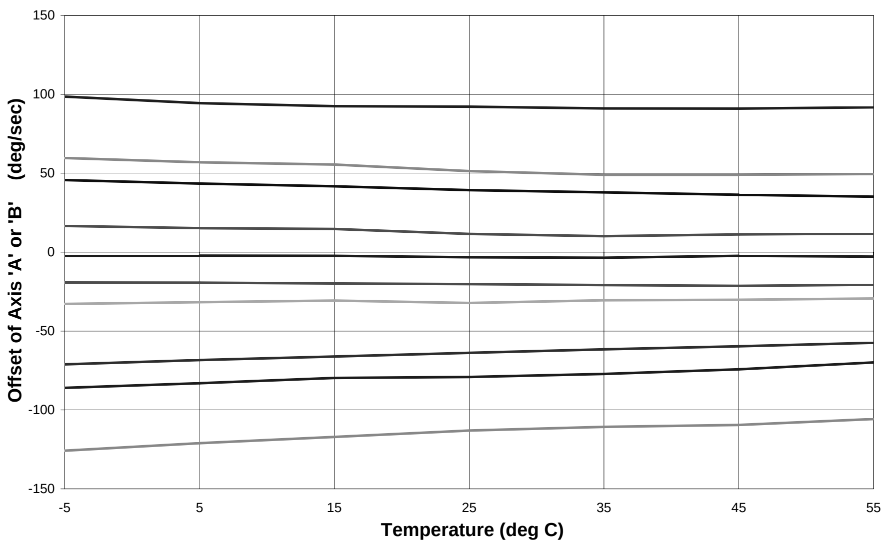
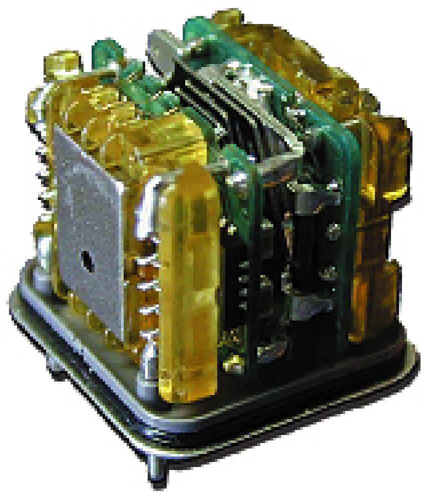


Figure 9-2 Offset vs. Temperature



10.0 Theory of Operation



The MG1101 operates on the principle of the Coriolis effect, where velocity in one reference frame is detected as acceleration by a rotating reference frame. An etched metal structure is designed and assembled so that it has three orthogonal modes of resonance: one primary and two secondary. A set of electromagnetic transducers creates a sustained oscillation on the structure's primary resonance, while additional sets of electromagnetic sensors are capable of picking up motion on the other two secondary resonant modes. As the entire structure is rotated, the velocity from the primary resonance is detected as acceleration on the corresponding secondary mode. Each of the two secondary mode's transducer outputs change proportionally to the rate of rotation around its axis, resulting in a dual axis rate sensor. The low level signal picked up by the secondary mode transducers is internally amplified, demodulated, filtered, and converted to digital outputs using dual integrated Σ-Δ type converters. A two-wire serial interface allows access to the most recent digital conversion for each axis.

11.0 Two Wire Serial Interface Operation

CLOCK and DATA TRANSITIONS: The SDA pin is normally pulled high with an external device such as a pull-up resistor. Data on the SDA pin may change only during SCL low time periods (refer to Figure 11-1 Data Validity). Logic level transitions on SDA during SCL high periods do not transfer data but will indicate a START or STOP condition as defined below.

START CONDITION: A high-to-low transition of SDA with SCL high is a start condition which must precede any other command (refer to Figure 11-2 Start and Stop Condition).

STOP CONDITION: A low-to-high transition of SDA with SCL high is a STOP condition. Stop conditions are used to terminate all data transfers (refer to Figure 11-2 Start and Stop Condition).

ACKNOWLEDGE: All memory locations and data words are serially transmitted to and from the MG1101 in 8-bit words. The MG1101 sends a zero to acknowledge (ACK) that it has received each word. This happens during the ninth clock cycle. (Refer to Figure 11-3 Output Acknowledge)

SERIAL INTERFACE RESET: After an interruption in protocol, power loss or system reset, any slave on the serial bus can be reset by a master following these steps: (a) Check SDA. If it is being held low, use SCL to clock cycles (9 cycles would be the maximum required to force a slave devices to let SDA go high) (b) in each cycle, look for SDA high while SCL is high. When this condition is found (c) create a start condition.

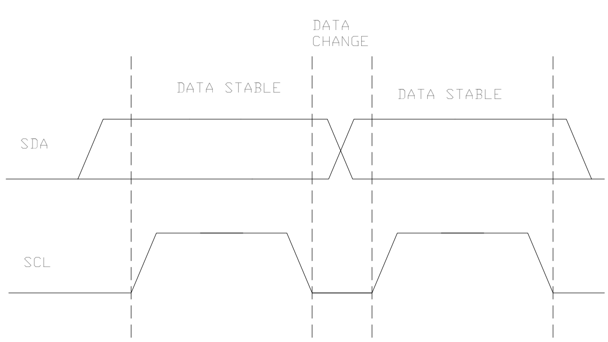


Figure 11-1 Data Validity

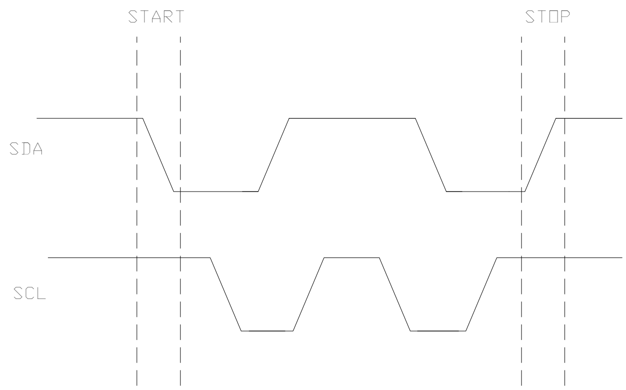


Figure 11-2 Start and Stop Condition

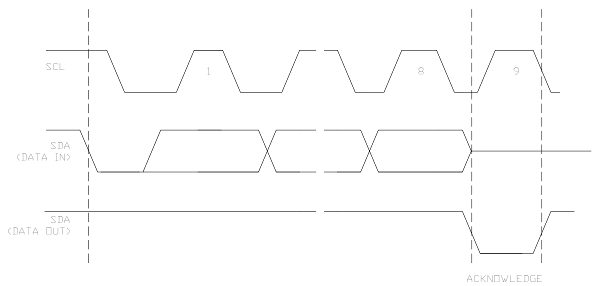
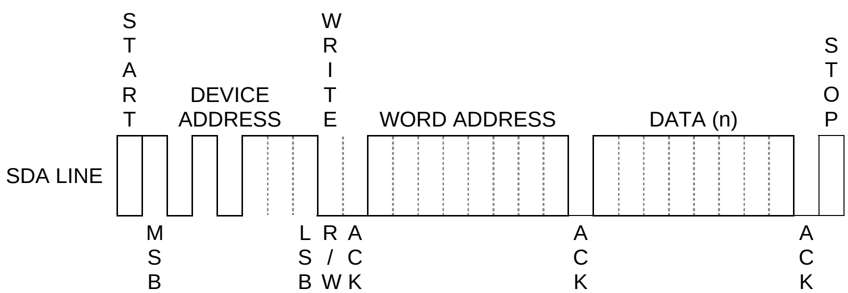


Figure 11-3 Output Acknowledge

11.1 Write Operations

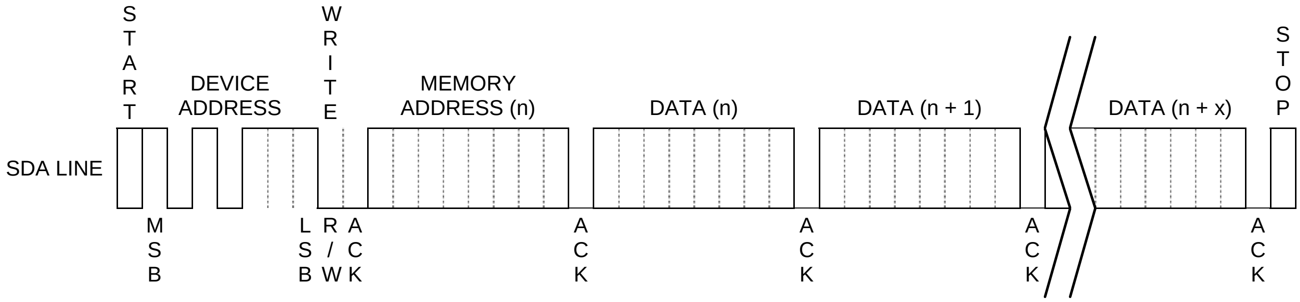
BYTE WRITE: Please refer to Figure 11-4 BYTE WRITE FIGURE. A write operation requires an 8-bit data word address following the device slave address word and acknowledgment. Upon receipt of this address, the MG1101 will again respond with a zero (ACK) and then clock in the first 8-bit data word. Following receipt of the 8-bit data word, the MG1101 will output a zero and the master device, such as a microcontroller, must terminate the write sequence with a stop condition.

Figure 11-4 BYTE WRITE FIGURE



PAGE WRITE: Please refer to Figure 11-5 PAGE WRITE FIGURE. The MG1101 is capable of 16-byte page write operations. A page write is initiated the same as a byte write, but the master does not send a stop condition after the first data word is clocked in. Instead, after the MG1101 acknowledges receipt of the first data word, the master can transmit up to fifteen more data words. The MG1101 will respond with a zero after each data word received. The master must terminate the page write sequence with a stop condition. The register memory address (four bits used to address the 16 bytes in MG1101 RAM) is internally incremented following the receipt of each data word. When the memory address reaches the end of MG1101 RAM page, the following byte is placed at the beginning of MG1101 RAM. If more than sixteen data words are transmitted to the MG1101, the previous data will be overwritten. The address "roll over" during write is from the last byte of the current page to the first byte of the same page.

Figure 11-5 PAGE WRITE FIGURE



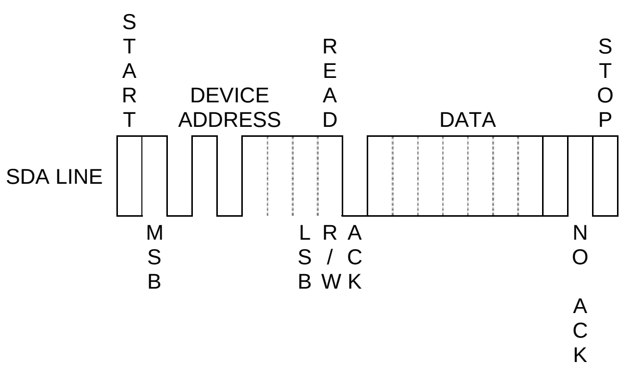
ACKNOWLEDGE POLLING: Acknowledge polling can be initiated to determine whether or not the MG1101 is ready for serial transactions. This involves sending a start condition followed by the slave device address word. The read/write bit is populated depending on the operation desired. Only if the MG1101 is ready for serial transactions will the MG1101 respond with a zero allowing the read or write sequence to continue.

11.2 Read Operations

Read operations are initiated the same way as write operations with the exception that the read/write select bit in the device address word is set to one. There are three read operations: current address read, random address read and sequential read.

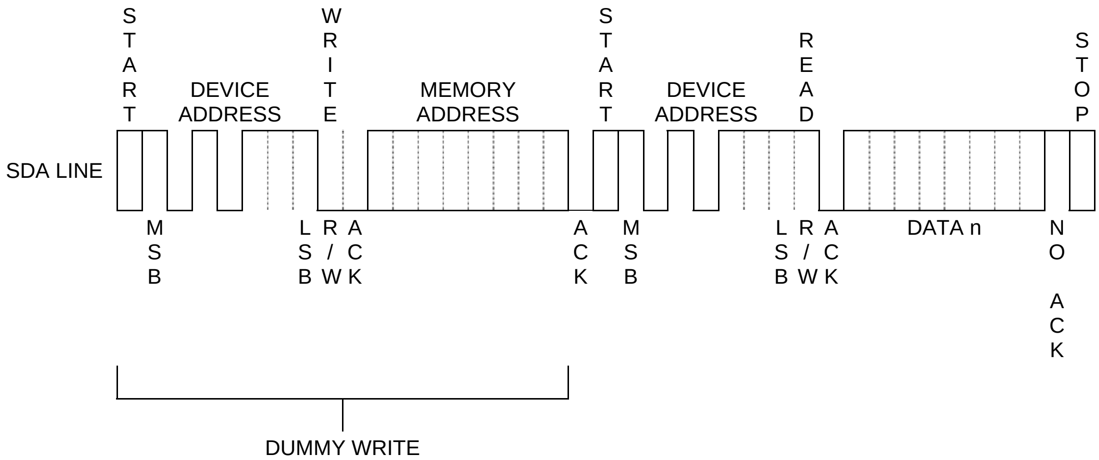
CURRENT ADDRESS READ: The internal memory address counter maintains the last address accessed during the last read or write operation, incremented by one. This address stays valid between operations as long as the device power is maintained. The address "roll over" during read is from the last byte MG1101 RAM to the first byte MG1101 RAM. Once the device address with the read/write select bit set to one is clocked in and acknowledged by the MG1101, the current data word is serially clocked out. To end the command, the master does not respond with an input zero but does generate a following stop condition.

Figure 11-6 CURRENT ADDRESS READ FIGURE



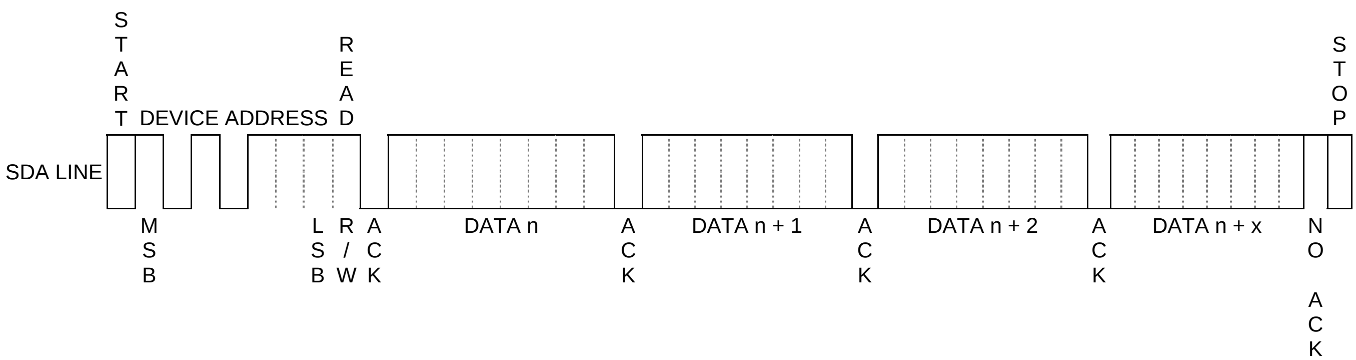
RANDOM READ: A random read requires a “dummy” byte write sequence to load in the memory address of interest. Once the device address word and memory address are clocked in and acknowledged by the MG1101, the master must generate another start condition. The master now initiates a current address read by sending a device address with the read/write select bit high. The MG1101 acknowledges the device address and serially clocks out the data word. To end the command, the master does not respond with a zero but generates a stop condition.

Figure 11-7 RANDOM READ FIGURE



SEQUENTIAL READ: Sequential reads are initiated by either a current address read or a random address read. After the master receives a data word, it responds with an acknowledge bit. As long as the MG1101 receives an acknowledge bit, it will continue to increment the memory address and serially clock out sequential data words. When the memory address limit is reached, the current memory address will “roll over” and the sequential read will continue. The sequential read operation is terminated when the microcontroller does not respond with a zero but generates a stop condition.

Figure 11-8 SEQUENTIAL READ FIGURE



11.3 Serial Bus Timing

The table below listing the timing parameters for both the EEPROM and the Gyro function unless noted otherwise. Refer to Figure 11-9 Serial Bus Timing Parameters for the corresponding timing diagram.

Symbol	Parameter	EEPROM function 2.3V to 2.7V		EEPROM function 2.7 to 3.6V		Gyro function 2.3V to 3.6V		Units
		Min	Max	Min	Max	Min	Max	
t_{LOW}	Clock Pulse Width Low	4.7		1.2		1.2		μs
t_{HIGH}	Clock Pulse Width High	4.0		0.6		0.6		μs
t_{AA}	Clock Low to Data Out Valid	0.1	4.5	0.1	0.9	0.1	0.9	μs
$t_{HD.STA}$	Start Hold Time	4.0		0.6		0.6		μs
$t_{SU.STA}$	Start Set-up Time	4.7		0.6		0.6		μs
$t_{HD.DAT}$	Data In Hold Time	0		0		0		μs
$t_{SU.DAT}$	Data In Set-up Time	4.7		0.6		0.6		μs
t_R	Inputs Rise Time		1.0		0.3		0.3	μs
t_F	Inputs Fall Time		0.3		0.3		0.3	μs
$t_{SU.STO}$	Stop Setup Time	4.7		0.6		0.6		μs
t_{DH}	Data Out Hold Time	100		50		0†		ns
C_{BUS}	Total Capacitance on SDA or SCL [each line]		400		400		400	pF

† Note: The MG1101 Gyro Function does not have an internal "hold time" delay on the SDA line relative to SCL. The master should allow SDA to remain high until SCL has fully transitioned to logic low (refer to t_F parameter) to avoid generating an unwanted START or STOP condition within the MG1101 Gyro Function slave device.

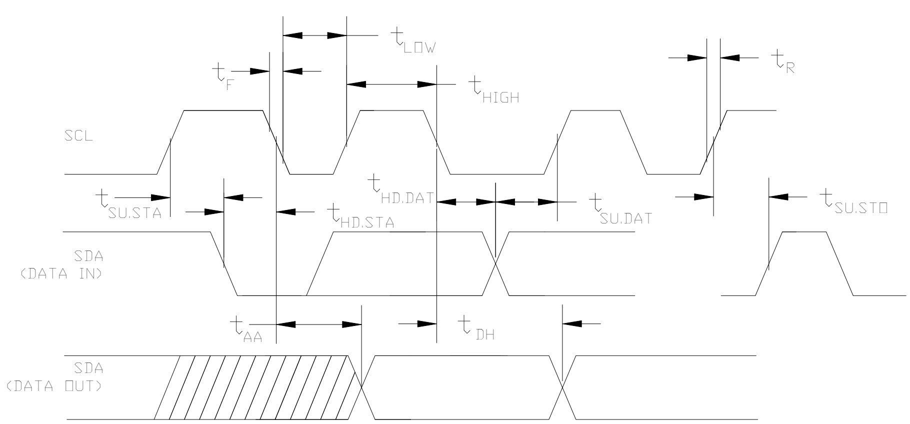
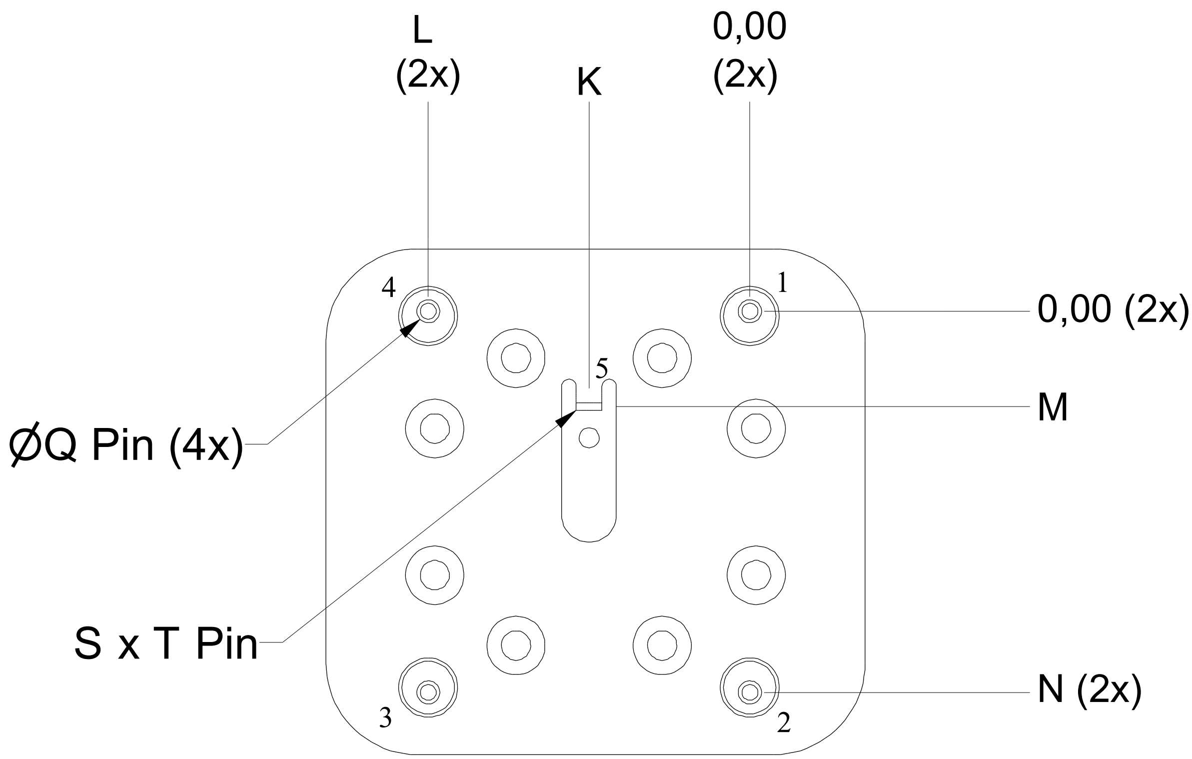


Figure 11-9 Serial Bus Timing Parameters

12.0 Pin Numbering and Layout



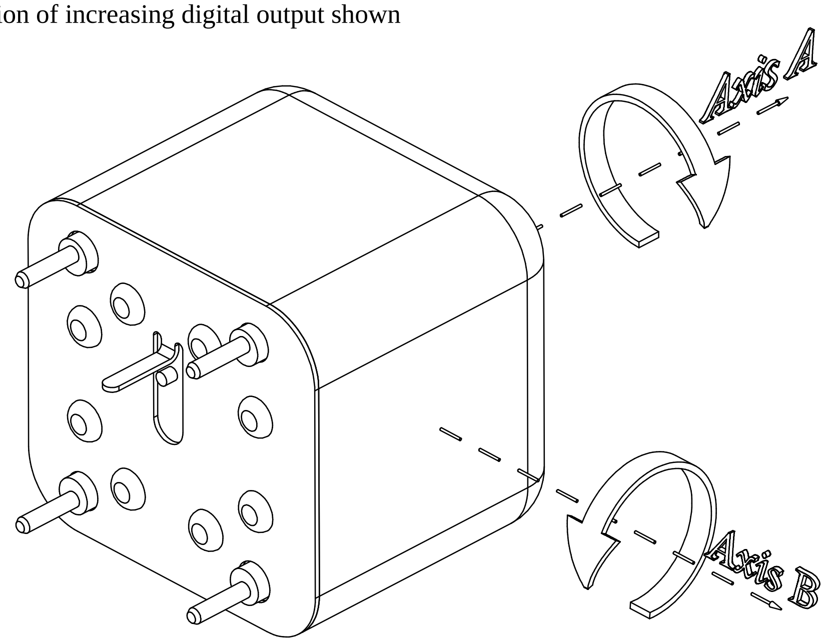
BOTTOM VIEW

Symbol	K	L	M	N	Q	S	T
Dimension	4.40	8.80	2.60	10.40	0.64	0.70	0.20
All dimensions in millimeters: .X ± 0.1 .XX ± 0.05							

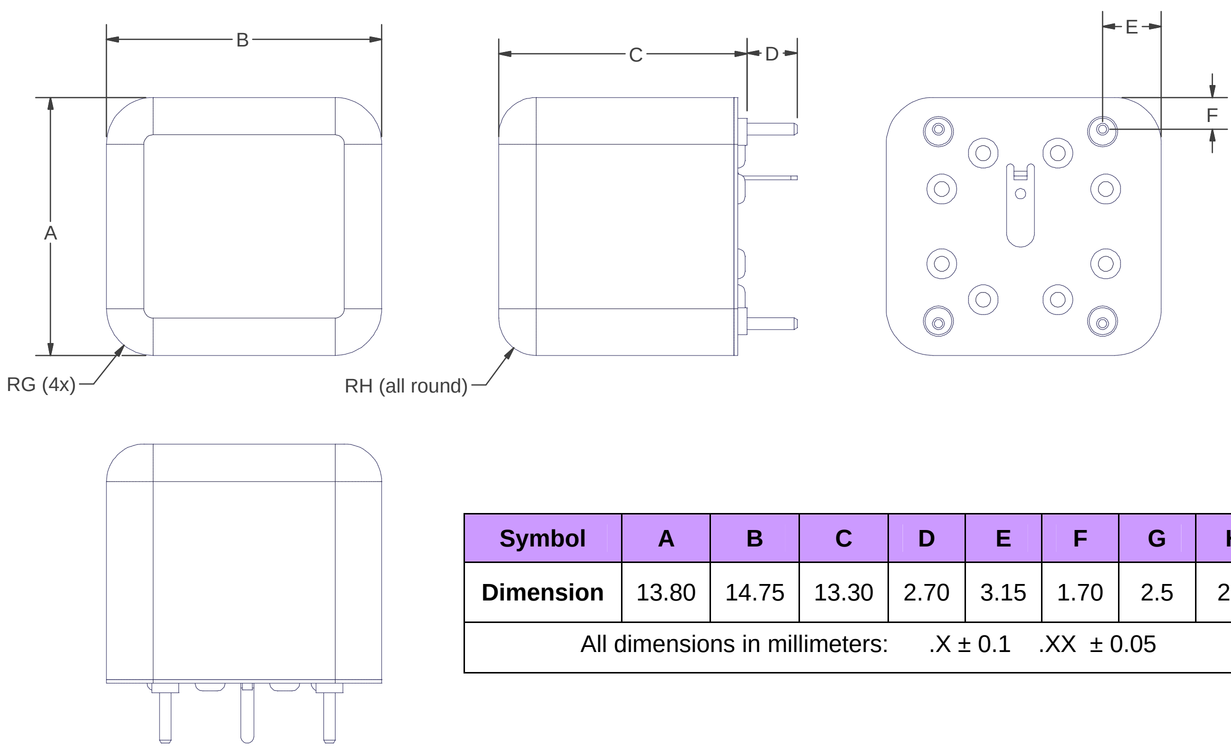
Pin	Symbol
1	VCC
2	SCL
3	SDA
4	GND
5	CAN

13.0 Axis Orientation

Direction of increasing digital output shown



14.0 Package Dimensions



Symbol	A	B	C	D	E	F	G	H
Dimension	13.80	14.75	13.30	2.70	3.15	1.70	2.5	2.0
All dimensions in millimeters: .X ± 0.1 .XX ± 0.05								

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