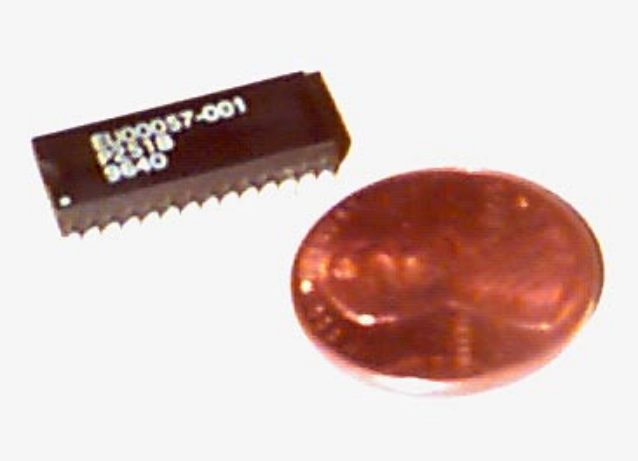
Gyration

GyroPoint ASIC

Integrated circuitry saves board space and money



Gyration's GyroPoint® ASIC is a highly integrated circuit design — so no matter what your application, from a multi-button remote control to a hand-held cordless mouse to a CD player or Internet TV — if you plan to integrate a pointing device, with Gyration you will save both design time and money.

The GyroPoint ASIC provides all of the necessary sub-circuits to connect a miniature, solid-state gyroscope to a microprocessor. It neatly replaces as many as fourteen components, freeing up valuable board space.

In addition, our GyroPoint ASIC provides buffers for interfacing with a number of platforms — including PS/2, Serial and Macintosh ADB.

It also includes 4-channel, 12-bit A/D converter, which saves you money.

Features

2 differential analog inputs for gyro signals	12 bit dual slope ADC w / SPI-compliant serial interface	Internal voltage reference
2 single ended analog inputs for general use	Open collector outputs for host interface	
Quad-input analog multiplexor.	Power-down mode with a switched VCC output to control external circuits	

SPECIFICATIONS

Pin Definitions

The part is supplied in a 28 pin plastic SOIC package (EU00051-001). The following shows the pin-out for the device:

Pin # (28 pin package)	Pin name	Pin function
1	AGND	Ground reference for the analog circuitry
2	ID1	Single ended analog input number 1
3	ID2	Single ended analog input number 2
4	MBUF_OUT	Buffered output from multiplexer. Connects to one end of integration resistor
5	NEG1	Integrator input. Junction point for integration resistor and integration capacitor
6	ISIG	Output of integrator. Connects to one end of integration capacitor
7	IO1	Host i/f data line #1
8	IO2	Host i/f data line #2
9	SEND1	General Purpose Buffer #1 (can be used for USB)
10	SEND2	General Purpose Buffer #2 (can be used for USB)
11	DEC	Reference decoupling
12	DATA_OUT	Serial data out to microprocessor
13	MSTR_CLK	Master clock in
14	SIO_CLK	Serial data shift clock
15	DGND	Ground reference for the digital circuitry
16	DATA_IN	Serial data in
17	ENABLE	Serial port enable
18	HI_Z	N/C
19	DIGIN2	Digital transmit input #2
20	DIGIN1	Digital transmit input #1
21	INB+	Non-inverting analog input B
22	INB-	Inverting analog input B
23	OUTB	Filter tap for analog input B
24	INA+	Non-inverting analog input A
25	OUTA	Filter tap for analog input A
26	INA-	Inverting analog input A
27	VCC_OUT	Switched VCC output
28	VCC	Positive supply

Maximum Ratings

Parameter	Symbol	Value	Unit
Supply voltage	V_{CC}	-0.5 - +7.0	V
Input voltage, any pin	V_I	-0.5 - (V_{CC}+0.5)	V
Junction temperature	T_J	150	°C
Operating ambient temperature	T_A	-0 - +70	°C
Storage temperature	T_S	-25 - + 85	°C

Electrical Characteristics

Parameter	Symbol	Min	Typ	Max	Unit
Supply voltage	V_{CC}	4.0		5.5	V
Supply current operating	I_{CC}	0.5	0.65	1.0	mA
Supply current power-down	I_{OFF}		25		µA
Differential Amplifiers					
Common mode rejection ratio [1]	CMRR	34			dB
Reference voltage input range (INA+, INB+)	V_{REF}	0.85		2.45	V
Signal voltage input range (INA-, INB-)	V_G	V_{REF}-0.375		V_{REF}-0.375	V
Output resistance (OUTA, OUTB)	R_O	160	200	250	kΩ
Multiplexor/ ADC					
Resolution			12		bits
Output data size [4]		12			bits
Integral non-linearity		0		5	%
Differential non-linearity				±1/2	LSB
Noise				±2	LSB_{peak}
Input range (ID1, ID2)		0.5		2.0	V
Differential input range (INA+/-, INB+/-)		-0.375		+0.375	V
Absolute error (ID1, ID2)				256	LSB
Absolute error (INA+/-, INB+/-)				±128	LSB
Clock frequency (MSTR_CLK)		3.0		4.1	MHz
Max sample rate @4.0MHz clock [3]		400			Samples/sec
Conversion time				8192	clock cycles
Serial port					
Shift clock rate (SIO_CLK)				500	kHz
Setup time, data to clock in		500			nS
Hold time, clock to data in		500			nS
Output delay, clock in to data out				500	nS
Logic threshold, all digital inputs			2		V
Switched power output					
Output voltage @ 15mA		Vcc - 100mV		Vcc	V
Open collector buffers					
Input low voltage		0		0.3 Vcc	V
Input high voltage		0.7 Vcc		Vcc	V
Output low voltage @ 12mA sink		0		0.4	V
Output high source current @ 0.8V		1.0	1.2	1.4	mA
Output high voltage @ 100µA source		Vcc-500mV		Vcc	V

Note:

1. For any input voltage between 0.7V and 2.9V.
2. The theoretical output of the ADC is (Vin - Vmin) / (Vmax - Vmin) * 4095, where Vmax and Vmin represent the input voltage range. Absolute error is the maximum deviation from the theoretical value, including gain-errors, offset errors and linearity errors in amplifiers, multiplexer ADC and reference.
3. Derate proportionally with clock frequency.
4. Output is 12 bit two's complement format. If more then 12 bits are shifted out, data will be padded with the MSB to form a valid two's complement number.

1. Functional Description and Notes

1.1 Function and Benefit

The MG100 provides analog rate outputs giving precise two-axis motion tracking. In order for these rate signals to be easily integrated into a larger, more intelligent system, these analog signals usually must be converted into digital signals.

The GyroPoint ASIC was specifically designed to accomplish this task. The GyroPoint ASIC provides all of the necessary circuit elements necessary to interface the gyro's analog rate signals with a microprocessor. The entire ASIC typically uses only 650 microamps and it can be put into a "power-down" mode where it draws only 25 microamps making it perfectly suited for use in low power devices.

The GyroPoint ASIC combines the following circuit functions into a single package.

1. 4- Channel 12 bit Dual Slope Analog-to-digital converter
2. Serial Interface for controlling input commands and extracting digital data from the ASIC
3. Buffers for interfacing with a number of platforms, including PS/2, Serial Port, and Macintosh ADB
4. Very low-current "power-down" mode

1.2 Electrical Issues

1.2.1 Minimum Connections

Figure 1 below shows the basic connections for using the GyroPoint ASIC:

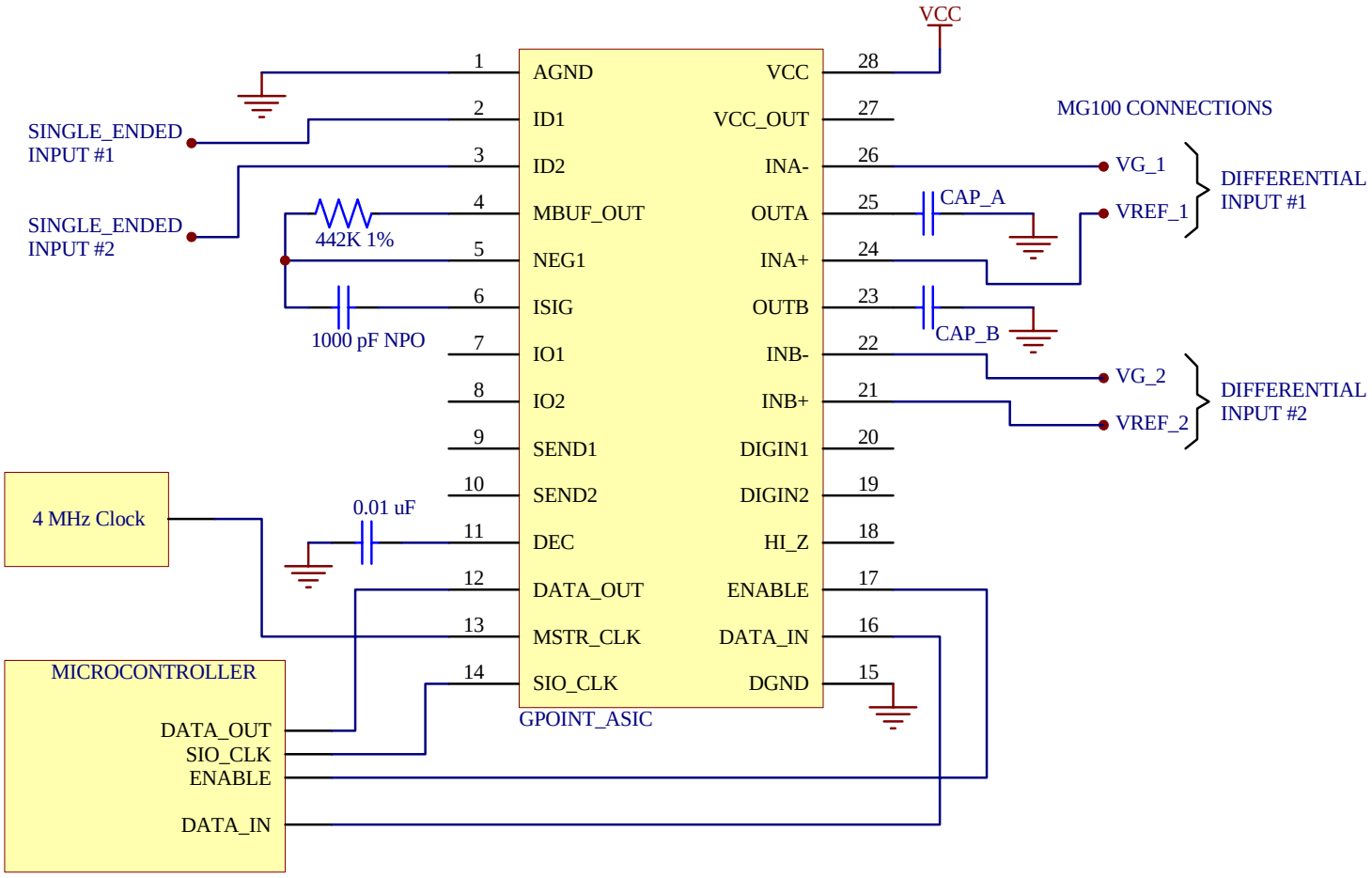


Figure 1: GyroPoint ASIC Hookup Diagram

Note that the 442K and the 1000 pF capacitor provide the time constant for the Full Scale resolution of the A/D converter when running the master clock at 4MHz. The values of these two components may be changed slightly but the product of R and C must remain a constant for the ASIC to work properly. If the master clock runs at a lower frequency, then the RC time constant should be increased using a linear scale to adjust for the slower clock operation. Also, for the best performance of the GyroPoint ASIC over temperature, you should use resistors and capacitors with low temperature coefficients.

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1.2.2 Signals

The GyroPoint ASIC allows you connect up to four analog inputs that will then be available for digital conversion. Please refer to Figure 2 below which shows the layout of the GyroPoint ASIC in block form.

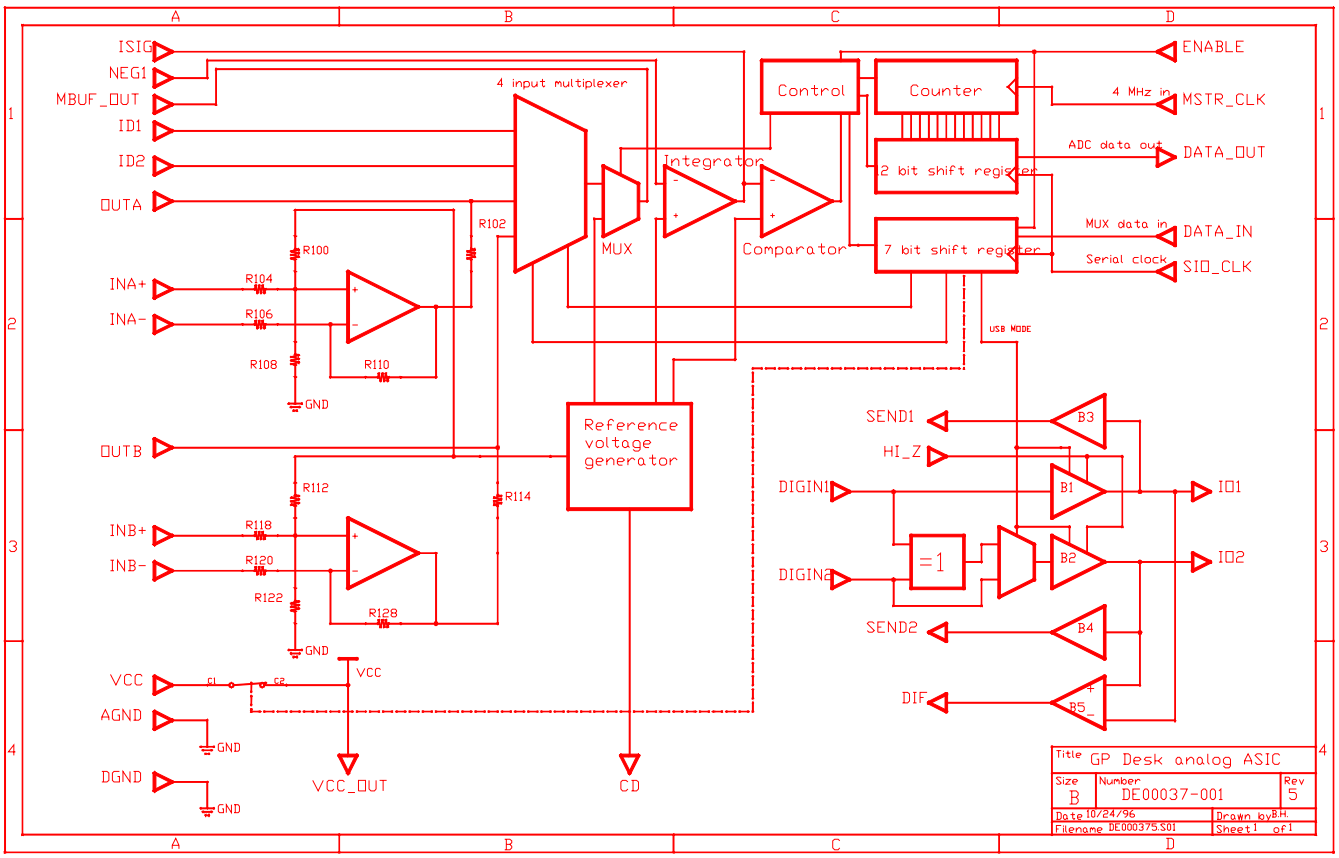

Figure 2: GyroPoint ASIC Block Diagram

There are two different types of analog inputs that the GyroPoint ASIC can accept.

1. **Differential Analog Inputs** (**INA+/-** , **INB+/-**) - These inputs have a differential input range of ±0.375 V and are amplified and buffered inside the ASIC. These two differential input pairs are specifically designed for connecting to the two MG100 analog rate outputs. You can connect the two differential outputs of the MicroGyro 100 directly into these inputs.
   - The **INA+** and **INB+** inputs are designed to accept fixed reference voltages only. To avoid amplifier non-linearity, please connect only the MG100 **VREF_1 and VREF_2** outputs to these pins.
   - The dynamically varying gyroscope ouputs **VG_1** and **VG_2** should connect to either the **INA-** or **INB-** input.
   - The **OUT_A** and **OUT_B** pins are filter taps on the INA+/- and INB+/- channels after analog amplification but before digital conversion. The series resistors on the amplifier output (R114 and R102 shown in Figure 2) are 100K. By attaching capacitors to the **OUT_A** and **OUT_B** pins you can provide additional filtering to the analog signals, thereby greatly improving the signal-to-noise ratio of your data.

2. **Single Ended Analog Inputs** (**ID1**, **ID2**) - these inputs have an input range of 0.5 - 2.0 Volts and are not amplified or buffered.

The single-ended inputs are intended for general use to allow you to acquire other analog information along with the MicroGyro 100 outputs. For example, the MicroGyro100's built-in temperature sensor can be connected to one of these inputs if you want to collect and store the temperature as a part of your application.

1.3 ASIC Control

The GyroPoint ASIC has a four-wire serial interface for controlling its functions. To control the GyroPoint ASIC's internal circuits, you shift in a 7 bit control word into the **DATA_IN** pin on the ASIC. However, since most microprocessors work in units of 8 bits (or more), one will usually add additional bit(s) to the least significant bit (LSB) position of the control word and set those bit(s) to zero. For Figure 3 below, we have added to single bit to the LSB side, making our input an 8-bit control word.

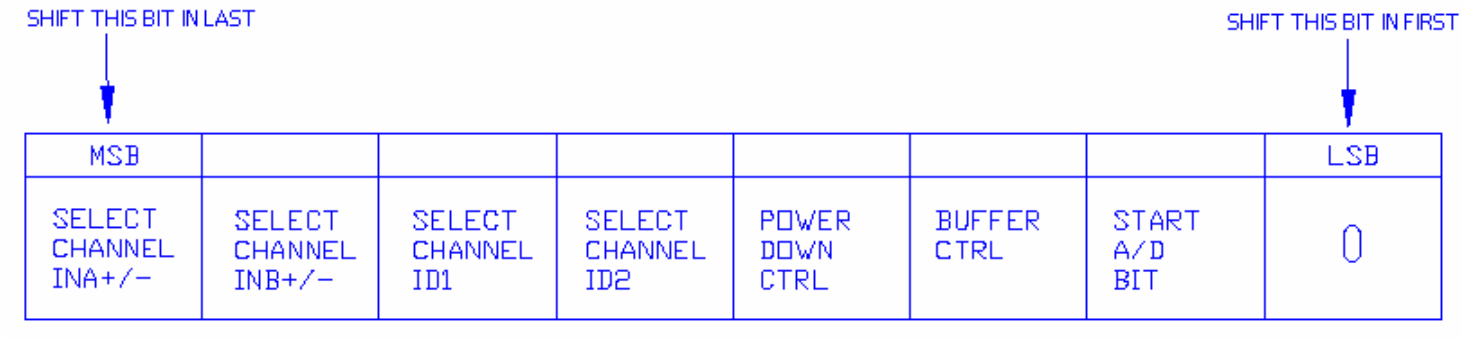

Figure 3: GyroPoint ASIC Input Control Word

1.3.1 Control Word Bit Definitions

SELECT CHANNEL INA+/-
SELECT CHANNEL INB+/-
SELECT CHANNEL ID1
SELECT CHANNEL ID2

These first four bits allow you to select which analog input is to be presented to the 12 bit converter. To select an input, set that input's select bit to '1' and the remaining 3 channel select bits to '0'.

START A/D BIT

If you wish to start an analog-to-digital conversion, this bit is set to 1.
Otherwise, set this bit to 0.

POWER-DOWN CTRL

This bit allows you to shut off the GyroPoint ASIC to minimize current consumption during times when you are not using the GyroPoint ASIC's functions.
0 = Setting during normal ASIC use
1 = Power-Down the GyroPoint ASIC

BUFFER_CTRL

0 = Setting for normal use of the ASIC's DIGIN1 and DIGIN2 buffers
1 = This bit should be set to 1 for "power-down" mode

Based on these definitions, we can make the following table showing valid command words and their functions.

8-bit Control Word Examples (x = means Don't Care)

Action	**Control Word**
Start A/D Conversion on Channel INA+/-	10000x10
Start A/D Conversion on Channel INB+/-	01000x10
Start A/D Conversion on Channel ID1	00100x10
Start A/D Conversion on Channel ID2	00010x10
Perform No Operation	00000x00
Power Down the GyroPoint ASIC	00001100
Normal Buffer Operation	xxxxx0x0

IMPORTANT NOTE :You should note that some combinations of control bits should be avoided
For example: 00110X10 will start an analog to digital conversion, but with two inputs (ID1 and ID2) shorted together at the converter's inputs, leading to unexpected results. For best results, make sure your microprocessor code does not issue such control words.

1.3.2 Timing

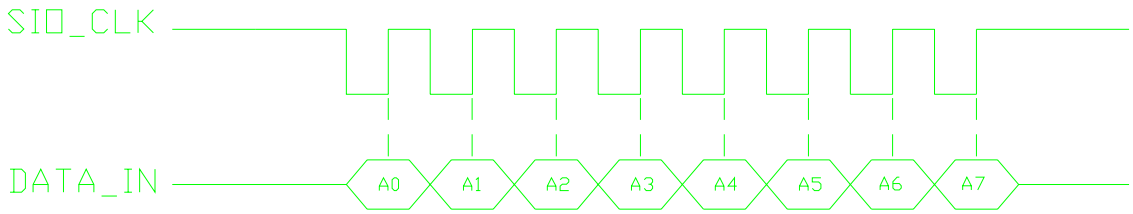

Figure 4: GyroPoint ASIC Timing Diagram

Figure 4 above shows the required timing relationship between the SIO_CLK line and the DATA_IN line when sending an 8-bit control word A ={ A7 A6 A5 A4 A3 A2 A1 A0} to the GyroPoint ASIC. Note that the DATA_IN pin is read on the RISING edge of the SIO_CLK pin.

1.4 Completing an analog-to-digital conversion

****
***** VERY IMPORTANT *****
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Once you have started a A/D conversion, you should wait for that the conversion to finish before you issue another any new control words or try to read the conversion value. Failure to wait for the conversion to complete will result in errors in the values you read.

To complete a conversion you should use the following steps

1.) Raise the **ENABLE** input pin HIGH
2.) Apply a clocking signal on the **SIO_CLK** line, and simultaneously shift the desired control word into the **DATA_IN** pin (Remember LSB goes in first; MSB goes in last)
3.) Pull the **ENABLE** input LOW
4) Wait a minimum of 8192 Master Clock cycles (the GyroPoint ASIC Master Clock)
5.) Raise the **ENABLE** input pin HIGH
6.) Apply a clock signal to the **SIO_CLK** line, and simultaneously shift 12 bits (or more) from the **DATA_OUT** pin of the ASIC to some memory location in the microprocessor. [Optional: You can shift a new control word into DATA_IN at the same time you are shifting out the data from the last control word].
7.) Pull the **ENABLE** input LOW and go to step 1 for the next sample.

1.4.1 Output: 12-bit words

The converted data comes out of the DATA_OUT pin as a 12-bit, 2's complement binary number with its least significant bit (LSB) coming out first. The interpretation of this 12-bit number will depend on which analog input was the source of the conversion because the inputs have different input ranges. The following table summarizes how to interpret the 12-bit number.

	FullScale Negative	**MidScale**	**FullScale Positive**
DATA_OUT value (binary)	100000000000	000000000000	011111111111
Decimal Equivalent	-2048	0	+2047
Input Channel Source ID1 or ID2	2.0 V	1.25 V	0.5 V
Input Channels Source INA+/- or INB+/-	+0.375V	0	-0.375V

Note that the scaling of the differential inputs and the single-ended inputs have different polarities and the resolution is different by about a factor of 2. A few examples should help clarify these subtleties.

1.4.1.1 EXAMPLE:#1

The 12-bit DATA_OUT number read is 000100010001 (273 decimal) and the input source was the INA+/- Channel.

Thus the voltage at the INA+/- input was
= 273*(-0.375)/(2048)
= -0.050 V

1.4.1.2 EXAMPLE:#2

The 12-bit DATA_OUT number is 111111010011 (-45 decimal) and the input source was the ID2 Channel.

Thus the voltage at the ID2 input was
= 1.25 - [(-45)*(0.75)/(2048)]
= +1.266 V

1.4.2 Input / Output: 16-bit words

For maximum efficiency in your use of the GyroPoint ASIC, you should shift in the next control word as the same time you are shifting out the digital data results from the last control word. Obviously to accomplish both these tasks in the same time window requires that you modify both word sizes to become the same size.

A convenient way of achieving this is to make both input words and output data 16 bits long. Now when you shift in a control word to the DATA_IN pin, you need to add eight additional 0's to the LSB side of the control word. The previous 8-bit control word table is repeated here to show the same command set in 16-bit format.

16-bit Control Word Examples (x = means Don't Care)

Action	Control Word
Start A/D Conversion on Channel INA+/-	10000x1000000000
Start A/D Conversion on Channel INB+/-	01000x1000000000
Start A/D Conversion on Channel ID1	00100x1000000000
Start A/D Conversion on Channel ID2	00010x1000000000
Perform No Operation	00000x0000000000
Power Down the GyroPoint ASIC	0000110000000000
Normal Buffer Operation	xxxxx0x000000000

The ASIC DATA_OUT format also can use 16 bits words and the ASIC output was specifically designed to allow this flexibility. As stated previously, the converted data output of the ASIC is a 12-bit 2's complement binary number, and the ASIC *will automatically repeat the sign bit for any output word sizes larger than 12 bits.*

The net result is that the output number will always be a valid 2's complement binary number provided that you use an output word size of 12 bits or more.

SAMPLING RATES
Each analog-to-digital conversion requires a minimum of 8192 ASIC master clock cycles to complete. If you are operating the GyroPoint ASIC at a 4MHz clock speed, you can achieve sample rates on a single analog input at rates approaching 488 Hz or you can sample both gyro axes up near 244 Hz.

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