The Embedded I/O Company

TEWS TECHNOLOGIES

TIP840

16 / 8 Channel 12 Bit ADC

Version 1.2

User Manual

Issue 1.2.10

March 2009

D75840800

TEWS TECHNOLOGIES GmbH
Am Bahnhof 7
25469 Halstenbek, Germany
www.tews.com
Phone: +49-(0)4101-4058-0
Fax: +49-(0)4101-4058-19
e-mail: info@tews.com

TEWS TECHNOLOGIES LLC
9190 Double Diamond Parkway,
Suite 127, Reno, NV 89521, USA
www.tews.com
Phone: +1 (775) 850 5830
Fax: +1 (775) 201 0347
e-mail: usasales@tews.com

TIP840-10

8 single-ended channel 12 bit ADC (gain 1, 10, 100)

TIP840-11

8 single-ended channel 12 bit ADC (gain 1, 2, 4, 8)

TIP840-20

16 single-ended / 8 differential channel 12 bit ADC (gain 1, 10, 100)

TIP840-21

16 single-ended / 8 differential channel 12 bit ADC (gain 1, 2, 4, 8)

Style Conventions

Hexadecimal characters are specified with prefix 0x, i.e. 0x029E (that means hexadecimal value 029E).

For signals on hardware products, an 'Active Low' is represented by the signal name with # following, i.e. IP_RESET#.

Access terms are described as:

W	Write Only
R	Read Only
R/W	Read/Write
R/C	Read/Clear
R/S	Read/Set

Issue	Description	Date
1.0	First Issue	June 1994
1.1	Change of settling time	December 1994
1.2	Change of settling time	February 1996
1.3	General Revision	April 2003
1.4	Addition “Technical Specification”	April 2003
1.5	Correction Offset I/O Addressing	October 2003
1.6	New Hardware Version 1.2	November 2003
1.7	Addition “Technical Specification”	April 2004
1.8	Added Programming Note and Installation Note	October 2004
1.9	New address TEWS LLC	September 2006
1.2.10	New notation of User Manual Issue	March 2009

Table of Contents

List of Figures

List of Tables

1 Product Description

The TIP840 is an IndustryPack® compatible module and provides 8 (16) single-ended channels of 12 bit A/D conversion. The data acquisition and conversion time is up to 10µs without channel / gain change and up to 62µs with channel / gain change.

The input multiplexer offers analog overvoltage protection of up to 70Vpp. A programmable gain amplifier allows gains of 1, 10, 100 or 1, 2, 4, 8. The full-scale input range is +/-10V. An interrupt can be generated at end-of-conversion supporting an 8 bit vector.

Each TIP840 is factory calibrated. The calibration information is stored in the Identification-ROM unique to each IP.

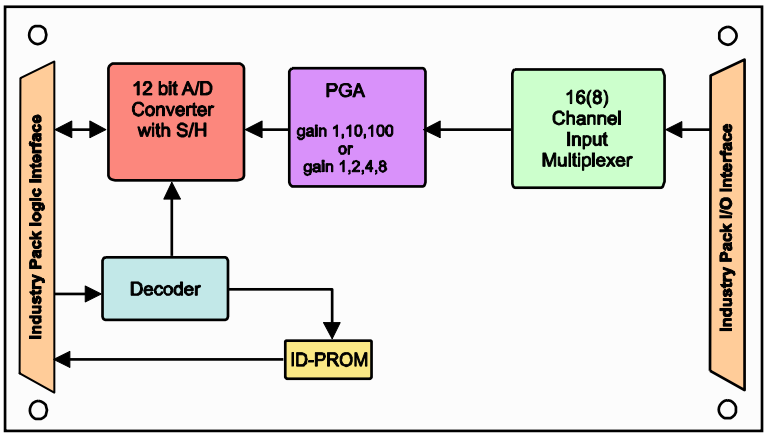

Figure 1-1 : Block Diagram

2 Technical Specification

IP Interface		
Interface	Single Size IndustryPack® Logic Interface compliant to ANSI/VITA 4-1995	
ID ROM Data	Format I	
I/O Space	Used with no wait states	
Memory Space	Not used	
Interrupts	INTREQ0# used by A/D conversion	
DMA	Not supported	
Clock Rate	8 MHz	
Module Type	Type I	
I/O Interface		
Analog Inputs	TIP840-20/-21: 16 single-ended channels or 8 differential channels TIP840-10/-11: 8 single-ended channels	
Input Gain Amplifier	TIP840-10/-20: programmable for gain 1, 10, 100 TIP840-11/-21: programmable for gain 1, 2, 4, 8	
Input Voltage Range	for TIP840-10/-20 : ±10V (gain = 1) ±1V (gain = 10) ±0.1V (gain = 100)	for TIP840-11/-21: ±10V (gain = 1) ±5V (gain = 2) ±2.5V (gain = 4) ±1.25V (gain = 8)
	Note: The module accuracy is guarantied at the ±10V input voltage range only for voltage range of ±9.6V.	
Input Overvoltage	Protection up to 70Vpp	
Input ADC	12 bit, 10µs sampling time (ADS7804)	
Input Path Settling Time	52µs appr.	
Calibration Data	Gain and offset correction values stored in ID ROM space	
Wait States	ID ROM: No wait states	
Interface Connector	50-conductor flat cable	
Physical Data		
Power Requirements	180mA typical @ +5V DC 10mA typical @ +12V DC -10mA typical @ -12V DC	
Temperature Range	Operating Storage	-40 °C to +85 °C -40°C to +125°C
MTBF	TIP840-10/-11: 638000 h TIP840-20/-21: 579000 h	
Humidity	5 – 95 % non-condensing	
Weight	28 g	

Table 2-1 : Technical Specification

3 Functional Description

The TIP840-20 and TIP840-21 board options provide 16 single-ended or 8 differential multiplexed analog inputs. The desired input channel and the mode (single-ended or differential) are selected by programming the input multiplexer.

The TIP840-10 and TIP840-11 board options provide 8 single-ended multiplexed analog inputs as a low cost option.

A software programmable gain amplifier with gain settings of 1, 10 and 100 for the TIP840-10 and TIP840-20, and 1, 2, 4 and 8 for the TIP840-11 and TIP840-21 allows a direct connection of a wide range of sensors and instrumentation. The maximum analog input voltage range is ±10V at a gain of 1.

The ADC is a 12 bit ADS7804 with a minimum sampling rate of 100 kHz. The 12 data bit are aligned in the least significant 12 bit of a 16 bit data word. The sign bit is extended by hardware into the upper 4 bit of the 16 word. For this reason the data value can be directly used in 16 bit integer arithmetic as two's complement value.

In multiplexed analog input systems a settling time must expire before the data can be converted after the change of the input channel. This settling time depends on the programmed gain. The TIP840 module has an Automatic Settling Time Control mode. If this mode is enabled, a write to the ADC Control and Status Register for changing the input channel or gain, initiates a data conversion automatically after the settling time has expired.

The absolute accuracy of the module is increased by the possibility of software correction using factory calibration factors, stored in the individual ID ROM space of the module.

3.1 Data Correction

The basic formula for correcting any ADC reading is:

$$\mathbf{Value = Reading * (1 - Gain_{err} / 8192) - Offset_{corr} /4}$$

Value is the corrected result.

Reading is the data read from the ADC Data Register.

$Gain_{err}$ and **$Offset_{corr}$** are the correction factors from the boards ID ROM space. They are stored for each for the possible gains.

Floating point arithmetic or scaled integer arithmetic is necessary to avoid rounding error while computing above formula.

4 ID ROM Content

Offset	Function	Contents
0x01	ASCII 'I'	0x49
0x03	ASCII 'P'	0x50
0x05	ASCII 'A'	0x41
0x07	ASCII 'C'	0x43
0x09	Manufacturer ID	0xB3
0x0B	Model Number	0x0D
0x0D	Revision	0x10
0x0F	Reserved	0x00
0x11	Driver-ID Low - Byte	0x00
0x13	Driver-ID High - Byte	0x00
0x15	Number of bytes used	0x15
0x17	CRC	Board dependent
0x19	Board Option	0x0A (TIP840-10) 0x0B (TIP840-11) 0x14 (TIP840-20) 0x15 (TIP840-21)
0x1B	ADC Offset (gain = 1)	Board dependent
0x1D	ADC Offset (gain = 2,10)	Board dependent
0x1F	ADC Offset (gain = 4, 100)	Board dependent
0x21	ADC Offset (gain = 8)	Board dependent
0x23	ADC Gain (gain = 1)	Board dependent
0x25	ADC Gain (gain = 2, 10)	Board dependent
0x27	ADC Gain (gain = 4, 100)	Board dependent
0x29	ADC Gain (gain = 8)	Board dependent

Table 4-1 : ID ROM Content

5 IP Addressing

5.1 I/O Addressing

The complete register set of the TIP840 is accessible in the IP I/O space.

Offset	Symbol	Description	Size (Bit)
0x00	ADC_CSR	ADC Control and Status Register	16
0x02	ADC_CON	ADC Convert Register	16
0x04	ADC_DAT	ADC Data Register	16
0x41	INT_VEC	Interrupt Vector Register	8

Table 5-1 : Register Set

5.2 ADC Control and Status Register

The ADC Control and Status Register (ADC_CSR) (bits 0:8) is used to select an input channel, the gain and the mode for the next data conversion. The status of the ADC can be obtained by reading bits 14:15.

Bit	Symbol	Description	Access
15	ADC Busy	ADC Busy Status 0 : ADC conversion is done 1 : ADC conversion is in progress If interrupt mode is disabled, this bit must be read as '0' before the data can be read from the ADC Data Register.	R
14	Settle Busy	Settling Time Busy Status 0 : Settling time is done 1 : Settling time is not yet expired after writing to the ADC_CSR If interrupt mode is disabled and automatic settling time mode is disabled, this bit must be read as '0' before the data conversion is started using the ADC Convert Register. If interrupt mode is disabled and automatic settling time mode is enabled, this bit must be read as '0' before the data can be read from the ADC Data Register.	R
13:9	-	Not used. Undefined for reads. Write as '0'.	
8	INT ENA	Interrupt Mode Control 0 : Disable interrupts 1 : Enable interrupts If automatic settling control mode is enabled, an interrupt is generated when the data conversion is done. If automatic settling control mode is disabled, an interrupt is generated when the settling time has expired, and another one when the data conversion is done.	W
7	ASTCE	Automatic Settling Time Mode Control 0 : Automatic settling time mode is disabled 1 : Automatic settling time mode is enabled If automatic settling time mode is disabled, the data conversion must be initiated by writing to the ADC Conversion Register when the settling time has expired.	W

<table>
<tr><th>Bit</th><th>Symbol</th><th>Description</th><th>Access</th></tr>
<tr><td></td><td></td><td>If automatic settling time mode is enabled, the data conversion is initiated automatically by hardware after the settling time has expired.
The settling time is required for the multiplexed analog input path and gain amplifier.</td><td></td></tr>
<tr><td>6:5</td><td>G1 G0</td><td>ADC Gain Selection for the ADC input amplifier.
<table>
<tr><th colspan="3">TIP840-10/-20</th><th colspan="3">TIP840-11/-21</th></tr>
<tr><th>G1G0</th><th>Gain</th><th>Range</th><th>G1G0</th><th>Gain</th><th>Range</th></tr>
<tr><td>00</td><td>1</td><td>+/-10V</td><td>00</td><td>1</td><td>+/-10V</td></tr>
<tr><td>01</td><td>10</td><td>+/-1V</td><td>01</td><td>2</td><td>+/-5V</td></tr>
<tr><td>10</td><td>100</td><td>+/-0.1V</td><td>10</td><td>4</td><td>+/-2.5V</td></tr>
<tr><td>-</td><td></td><td></td><td>11</td><td>8</td><td>+/-1.25V</td></tr>
</table></td><td>W</td></tr>
<tr><td>4</td><td>DIF</td><td>Differential Mode Control
0 : Single-ended mode
1 : Differential mode
TIP840-10/-11 board options only support single-ended mode.
TIP840-20/-21 board options support channels 1 to 16 in single-ended mode, and channels 1 to 8 in differential mode (channels 9 to 16 are used as - input for differential channels 1 to 8).</td><td>W</td></tr>
<tr><td>3:0</td><td>CS[3:0]</td><td>Input Channel Selection
Input channel for the next data conversion
<table>
<tr><th colspan="2">Single-Ended</th><th colspan="2">Differential</th></tr>
<tr><th>CS[3:0]</th><th>Channel</th><th>CS[3:0]</th><th>Channel</th></tr>
<tr><td>0000</td><td>1</td><td>0000</td><td>1</td></tr>
<tr><td>...</td><td>...</td><td>…</td><td>...</td></tr>
<tr><td>1111</td><td>16</td><td>0111</td><td>8</td></tr>
</table>
For TIP840-10/-11 board options, only channel 1 to 8 for single-ended mode can be selected.</td><td>W</td></tr>
</table>

Table 5-2 : ADC Control and Status Register

5.3 ADC Convert Register

Bit	Symbol	Description	Access
15:0		Used to start a data conversion with automatic settling time mode disabled. By writing any value the data conversion is started. This mode is useful, if a single input channel should be sampled with a maximum data rate.	W

Table 5-3 : ADC Convert Register

In this mode it is in the responsibility of the user to make sure, that the required accuracy of the data is not affected by the required settling time after a change of gain or input channel.

5.4 ADC Data Register

The ADC Data Register (ADC_DAT) contains the converted data value.

Bit	Symbol	Description	Access
15:11	S	12 bit ADC data sign extended in 2's complement. Data bits 11:0 hold the 12 bit ADC data value. Data bit 11 (sign bit) is extended into bits 12 to 15 by hardware.	R
10:0	D		

Table 5-4 : ADC Data Register

ADC Data Register Value	Analog Input Voltage
0x0000	0 (0V)
0x07FF	2047 x 1LSB (9.99512V)
0xF800	-2048 x 1LSB (-10V)
0xFFFF	-1 x 1LSB (-4.88mV)

Table 5-5 : ADC Data Coding

5.5 Interrupt Vector Register

Bit	Symbol	Description	Access
7:0		Register must be loaded with the interrupt vector value, when interrupts shall be used with the TIP840.	R/W

Table 5-6 : Interrupt Vector Register

6 Pin Assignment – I/O Connector

6.1 Analog Input Connections

Pin	Mode Single-Ended	Mode Differential
1	ADC Input 1	ADC Input 1+
2	ADC Input 9	ADC Input 1-
3	AGND	AGND
4	ADC Input 10	ADC Input 2-
5	ADC Input 2	ADC Input 2+
6	AGND	AGND
7	ADC Input 3	ADC Input 3 +
8	ADC Input 11	ADC Input 3-
9	AGND	AGND
10	ADC Input 12	ADC Input 4-
11	ADC Input 4	ADC Input 4+
12	AGND	AGND
13	ADC Input 5	ADC Input 5+
14	ADC Input 13	ADC Input 5-
15	AGND	AGND
16	ADC Input 14	ADC Input 6-
17	ADC Input 6	ADC Input 6+
18	AGND	AGND
19	ADC Input 7	ADC Input 7+
20	ADC Input 15	ADC Input 7-
21	AGND	AGND
22	ADC Input 16	ADC Input 8+
23	ADC Input 8	ADC Input 8-
24	AGND	AGND

Table 6-1 : Analog Input Connections

The TIP840-10 and TIP840-11 board options provide 8 single-ended channels (ADC Input 1 to ADC Input 8) only.

6.2 Miscellaneous Output Connections

Pin	Function
44	GND
45	-12V
46	GND
47	+12V
48	GND
49	+5V
50	GND

Table 6-2 : Miscellaneous Output Connections

7 Programming Notes

After power up the on board ADC device is in a random state and requires two dummy conversions before operating correctly. This is based on the chip design of the ADC device.

Software should ignore the data of the first two ADC conversions after power-up.

The software drivers from TEWS TECHNOLOGIES already include these two dummy conversions.

8 Installation Notes

Make sure that all unused analog input pins are tied to the AGND signal level (or any other valid signal level within the analog input voltage range). This is required even if the unused channels are turned off by software.

If unused analog inputs are left floating, they could badly degrade the performance of the active channels.