

**Analog/Digital Highend Data - Acquisition Card  
with 16 bits and 8 independent channels**





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## Overview

Our objective was to develop a data acquisition card, based on our practical experience, that met the following requirements:

- **High Noise Immunity**
- **Polling Unnecesary**
- **Automatic Record of all the Data in a Block with a Timestamp**
- **High Sampling Rate (195 kHz per Channel, 8 Channels) with High Accuracy (16 bit)**
- **Support for 2 Encoder Inputers**
- **1 Timer**
- **Easy to Program**

We purposely excluded a processor on the **XADIO 8** to spare the end-user from having to learn a manufacturer-proprietary processor architecture and development environment. So the **XADIO 8** is driven by the processor in the PC and can be integrated into a completely normal project environment. A prerequisite for this was that the data acquisition card must independantly record all of the data and copy the records into the main memory of the computer.

### analog input:

- 8 analog differential inputs
- 16Bit bipolar or unipolar switchable
- Input resistance > 20 k $\Omega$  100V dielectric strength

### Input Regions:

The DIL-switches are individually configurable in the range of  $\pm 10V$ .  
See the Table under [Calibrating XADIO](#).

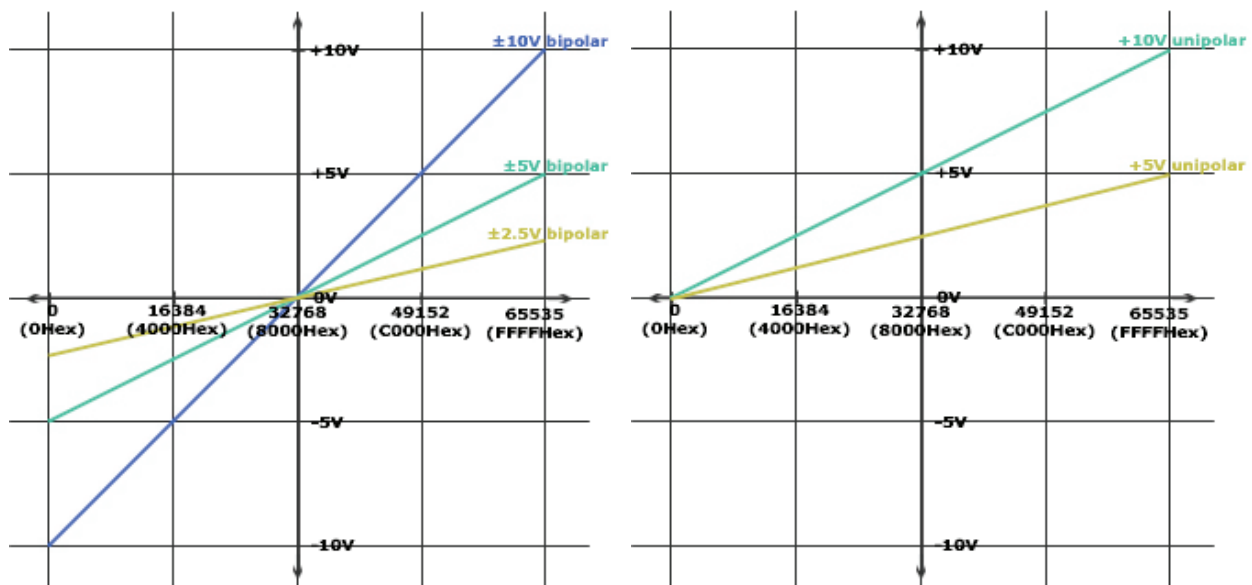
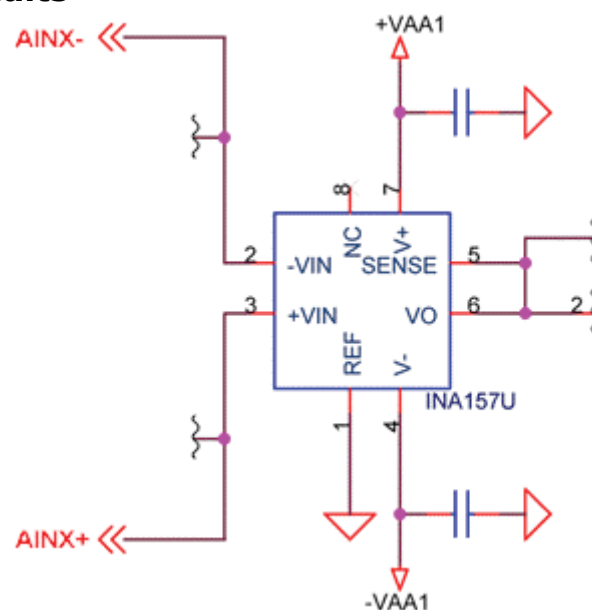


Fig.: ADC Value Range

### Analog Input Circuits

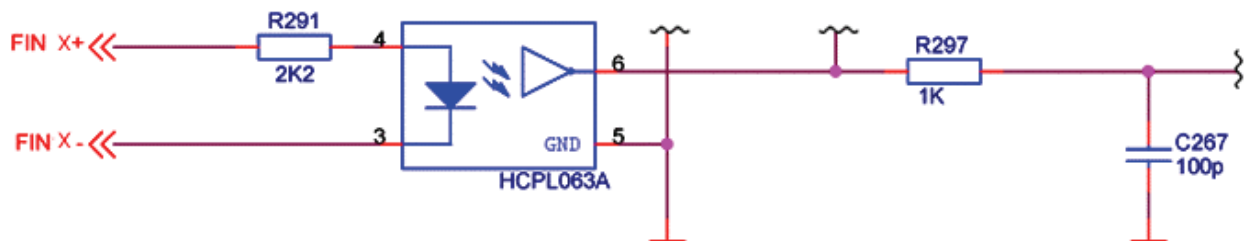


More specific information is available on datasheet for the [INA157](#) courtesy of Texas Instruments .

## digital input:

- 14 Digital Inputs Optocoupled HTL (6 can be used for the Encoder)
- 2 Encoders (each using 3 digital inputs)
- The digital inputs are debounced in the FPGA so that the noise pulses  $< 1\text{ms}$  will be suppressed

## Digital Input Circuit



More specific information is available on datasheet for the [HCPL-063A](#) from Agilent Technologies.

Properties

> Outputs

## analog output:

- 2 analog outputs 18 bit  $-10 \dots +10\text{V}$

## digital output:

- 10 digital outputs optocoupled HTL

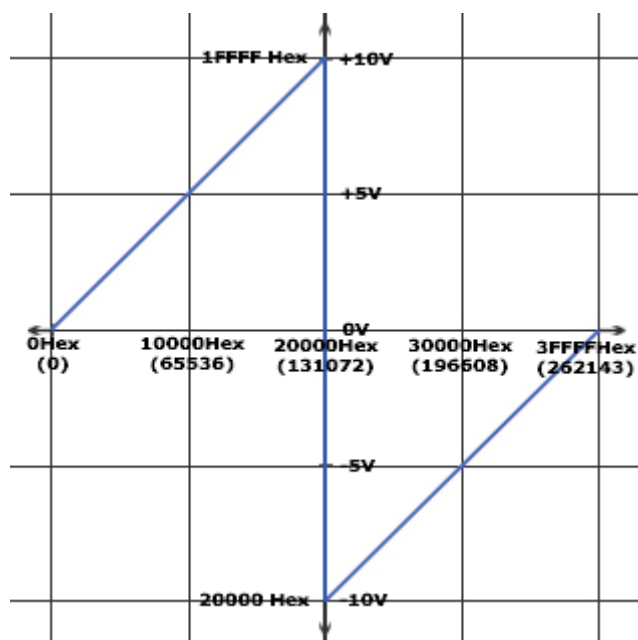


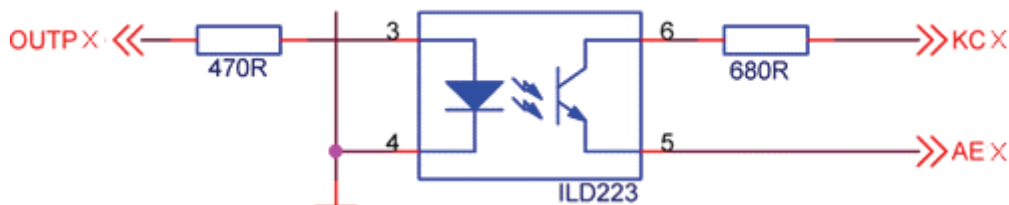
Fig.: DAC Value Range

## Analog Output Circuit: OPA2132U

In normal mode, the inner resistance amounts to  $\sim 1\Omega$  ( $< 30\text{mA} = 1\Omega$ )

More specific information is available on datasheet for the [OPA2132](#) from Agilent Technologies.

## Digital Output Circuit

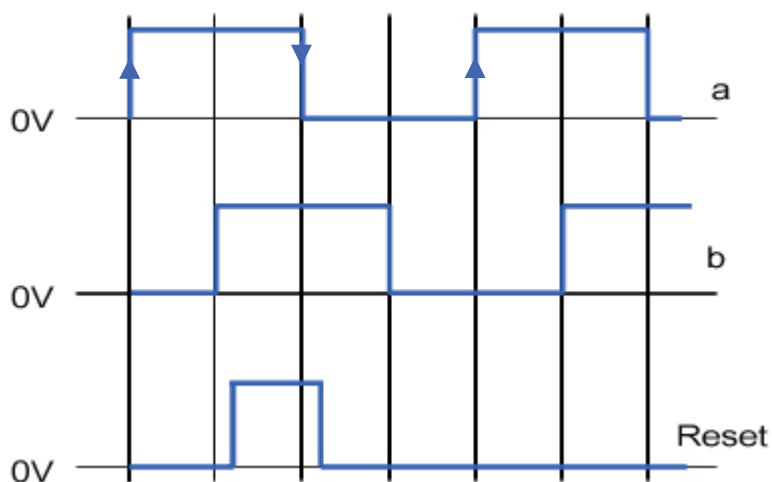


More specific information is available on datasheet for the [ILD223](#) from Siemens.

## Properties > Encoder Signal Processing

There are 4 modes:

- low- or highactive reset with respective normal or double counting.



**counter** 0 = normal  
1 = double  
**reset** 0 = low  
1 = high

0	0	0
1	0	1
2	1	0
3	1	1

Fig.: HTL – Level

**Properties****> Sampling**

- All inputs and outputs are synchronously sampled and recorded.
- All outputs are recorded with a timestamp
- Each analog input has its own AD converter. Thus, a multiplexer is unnecessary and a high sampling rate can be realized.
- Sampling occurs continuously. A sample (xadio\_record) occupies 64 bytes in memory..
- The samples are written in main memory using DMA and are stored in a ring-buffer. The buffer can be accessed by the user under Linux as a file in the /proc filesystem.
- The sampling rate is configurable from 3051 Hz to 195 kHz.

**Properties****> Frequency**

<b>kHz</b>
195,312
130,208
97,656
78,125
65,104
55,803
48,828
43,402
.
.
.
3,051

Tab.: Frequency Examples

Field	Content	32 Bit
adc0	analog input 0	
adc1	" "	1
adc2	" "	2
adc3	" "	3
adc4	" "	4
adc5	" "	5
adc6	" "	6
adc7	" "	7
digio	24 channel bit by bit	
inc0	Encoder 0 Position	
dac0	analog output 0	
dac1	analog output 1	
timer	Counter, running sample number (by a sample rate of 195kHz, 5.128 $\mu$ s interval between Samples)	
inc1	Encoder 1 Position	
fi1	RESERVED	
fi2	RESERVED	

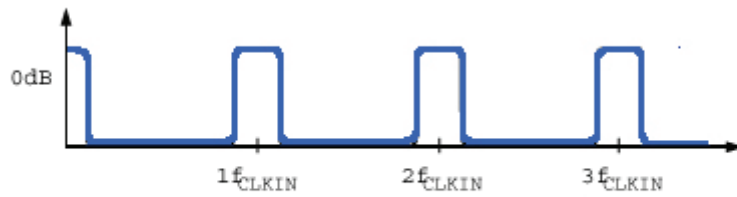
Bit 0	IO0
Bit 1	IO1
"	"
"	"
Bit 23	IO23

The conversion principle of the A/D converter (64-fold oversampling) results in an automatic filtering with a digital filter of at least the 8th order and a linear phase shift.

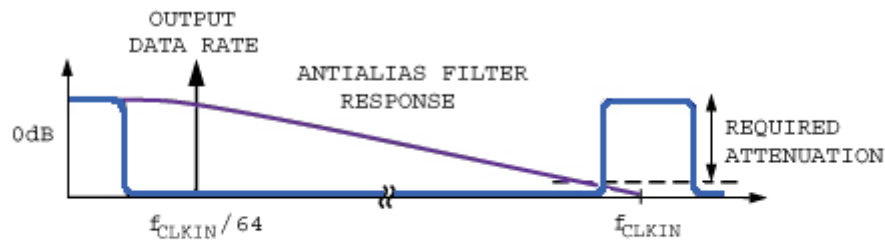
The cut-off frequency changes automatically with the sampling rate (cutoff = 90 db by sampling rate /2)

**Passband:** 0.05 db Ripple

**Cutt-Off Band :** 96 db Attenuation



**Figure a: Digital Filter Frequency Response**



**Figure b: Frequency Response of Antialias Filter**

From the AD Converter manual.

## Properties > Bus Interface Logic

**The XADIO 8 logic is programmed in a FPGA (VHDL) and therefore adaptable to customer needs, i.e. different digital input/outputs allocation.**

PCI Slot

PCI Busmaster DMA

Interrupt options: (32-bit register enabled interrupt generation)

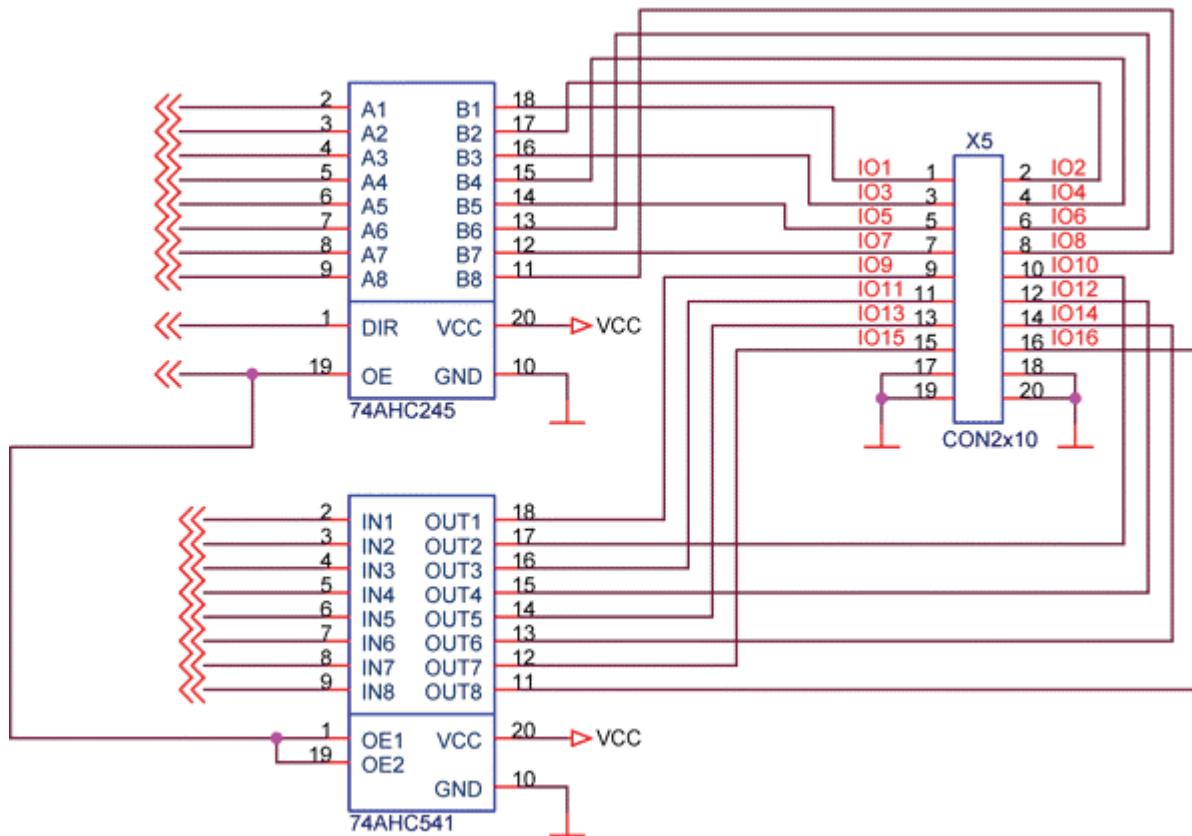
- by each measurement in the register
- by reaching a timer value
- by change of a digital value
- by a filled buffer in main-memorz (copy out of the register)
- by zero-crossing of the encoder

Power Supply 5V, 2.5A

**The number of cards that can be cascaded is limited only by the PCI bus.**

## Expansion Interface Circuit

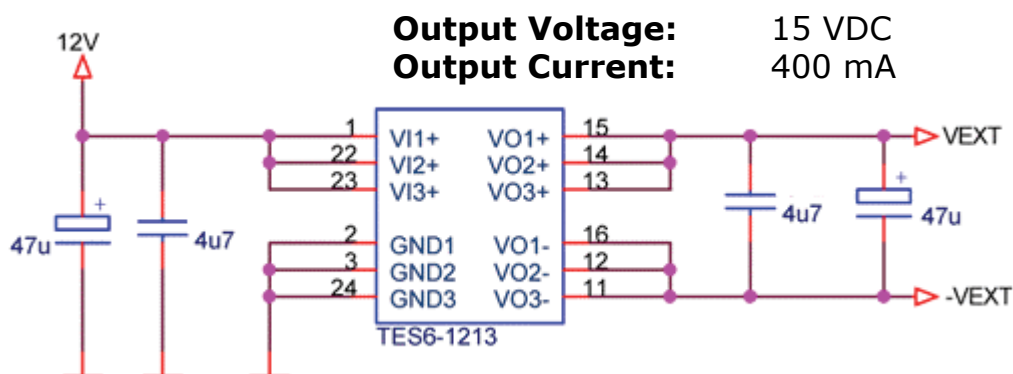
The expansion interface can be extended per customer request.



More specific information is available on datasheet for the [74AHC541](#) from Philips Semiconductors.

## External Power Supply

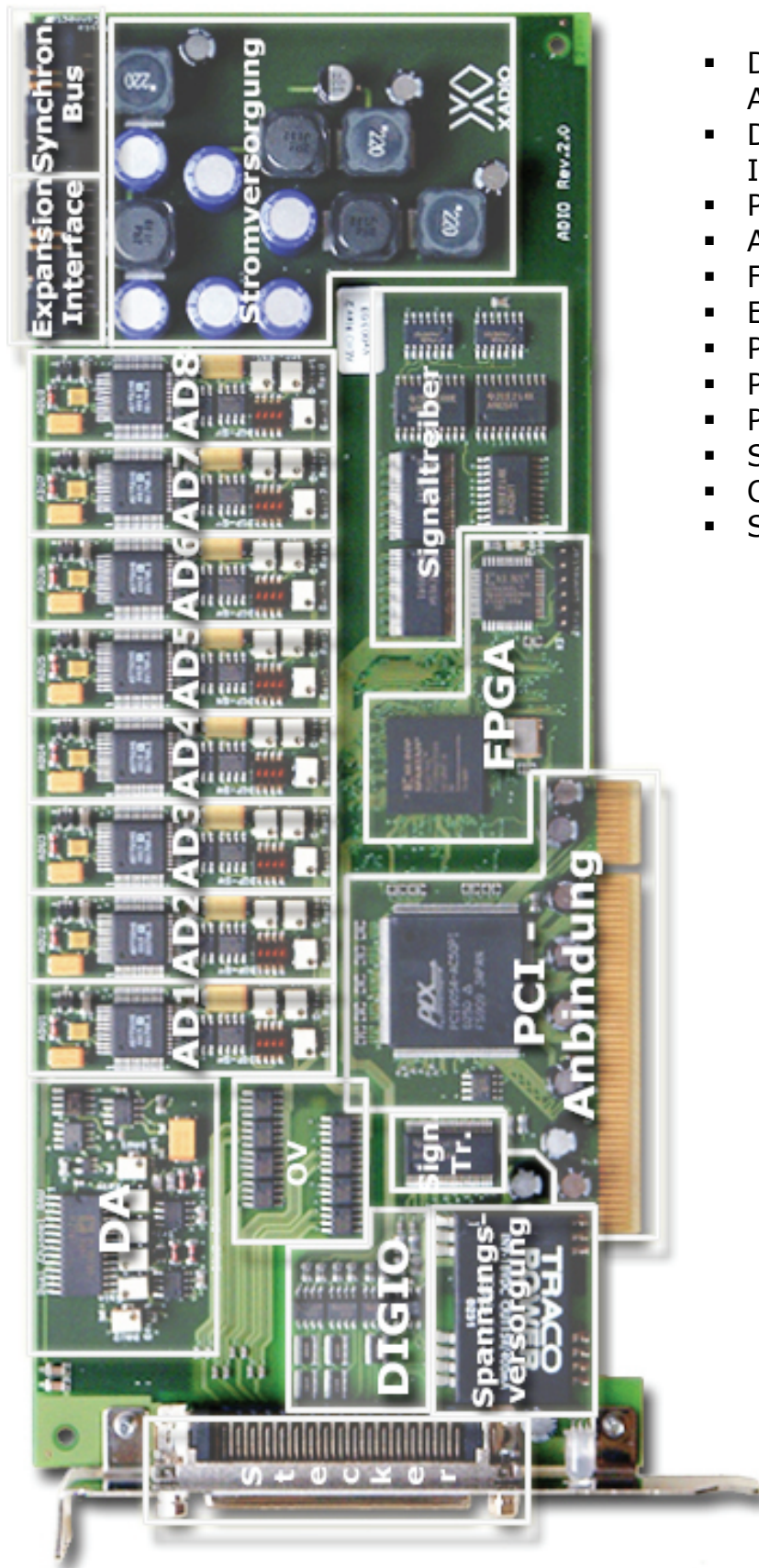
External logic provides a potential-controlled power supply.



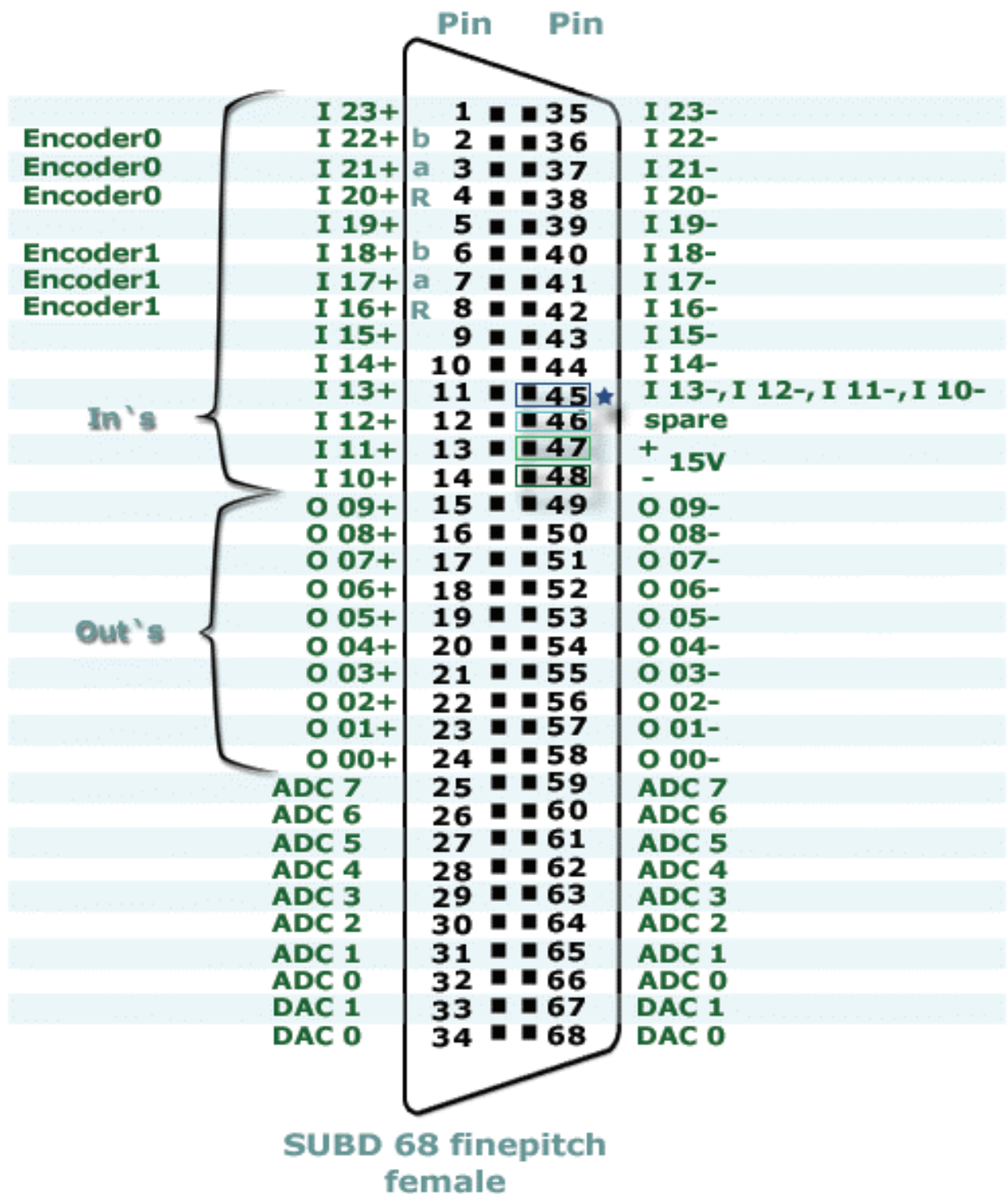
More specific information is available on datasheet for the [TES6-1213](#) from Traco Electronic AG.

## View of the XADIO 8

Overview over the individual areas of the card:



- DA - digital/analog Acquisition
- DIGIO – digital Input/Output
- PCI – Binding
- AD1 ... AD8
- FPGA
- Expansions-Interface
- Power supply (extern)
- Power supply
- Plug
- Signal driver
- OV – analog Inputs
- Synchronisation-Bus



- ★ Pin 45 is responsible for the pins 10 through 13.
- Pin 46 is free.
- Pin 47 is+ (positive) and Pin 48 is- (negative).
- The voltage difference between the pins is 15 V.

## Connection > Cable

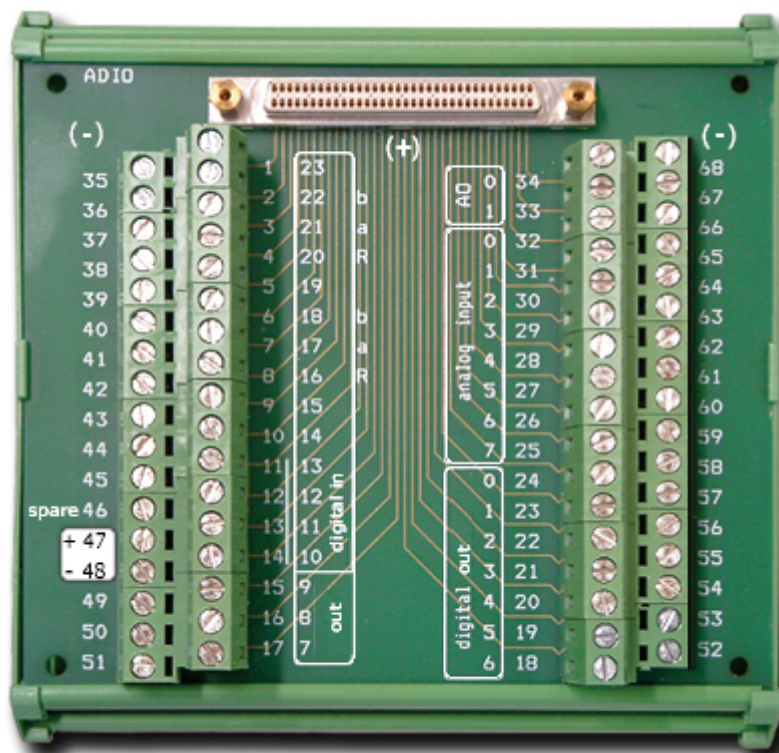
The connection cable is a SCSI3 cable with the following properties:

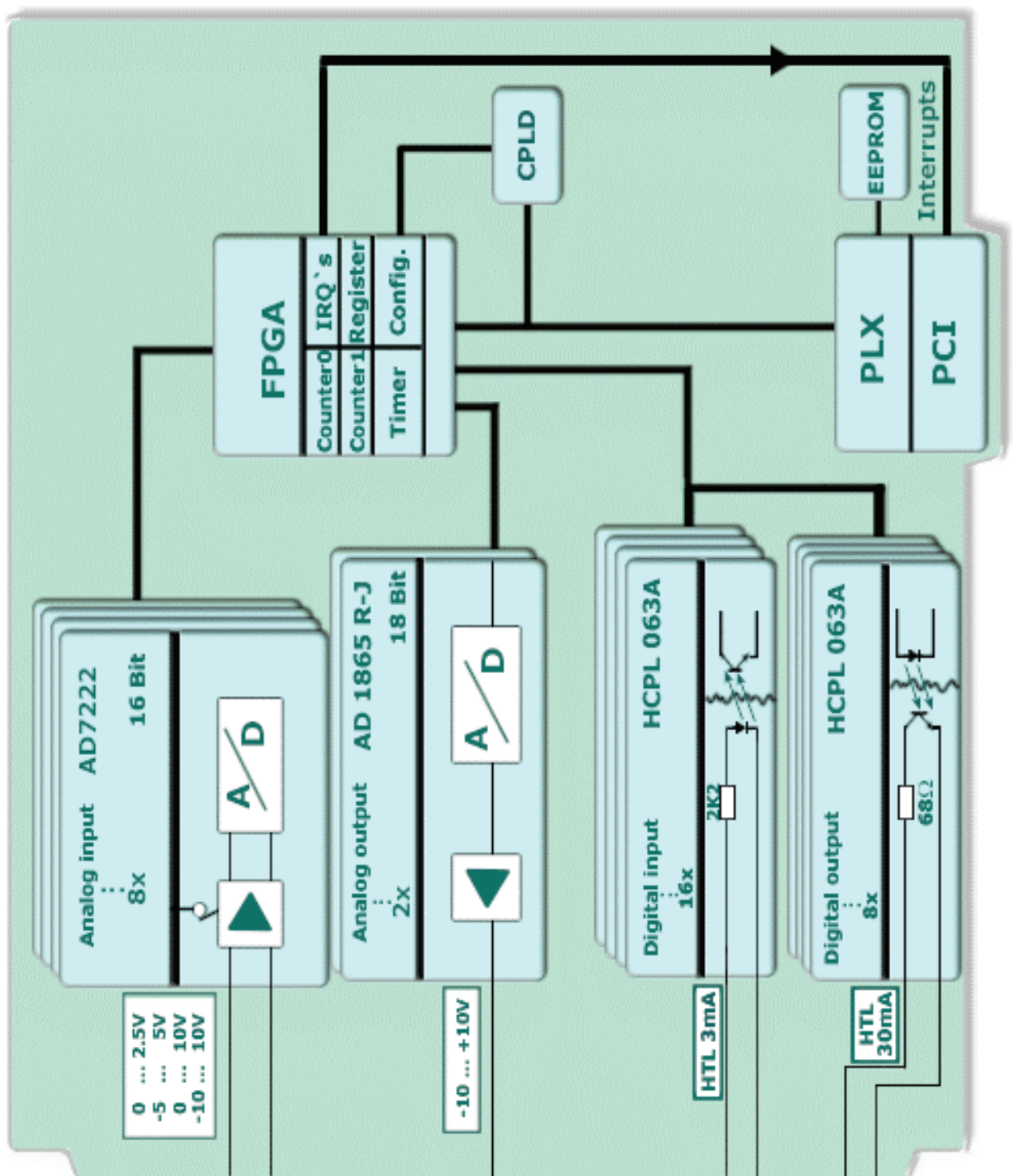
- 100MHz digital suitable
- 68 pins
- 34 data wires
- twisted core-pairs

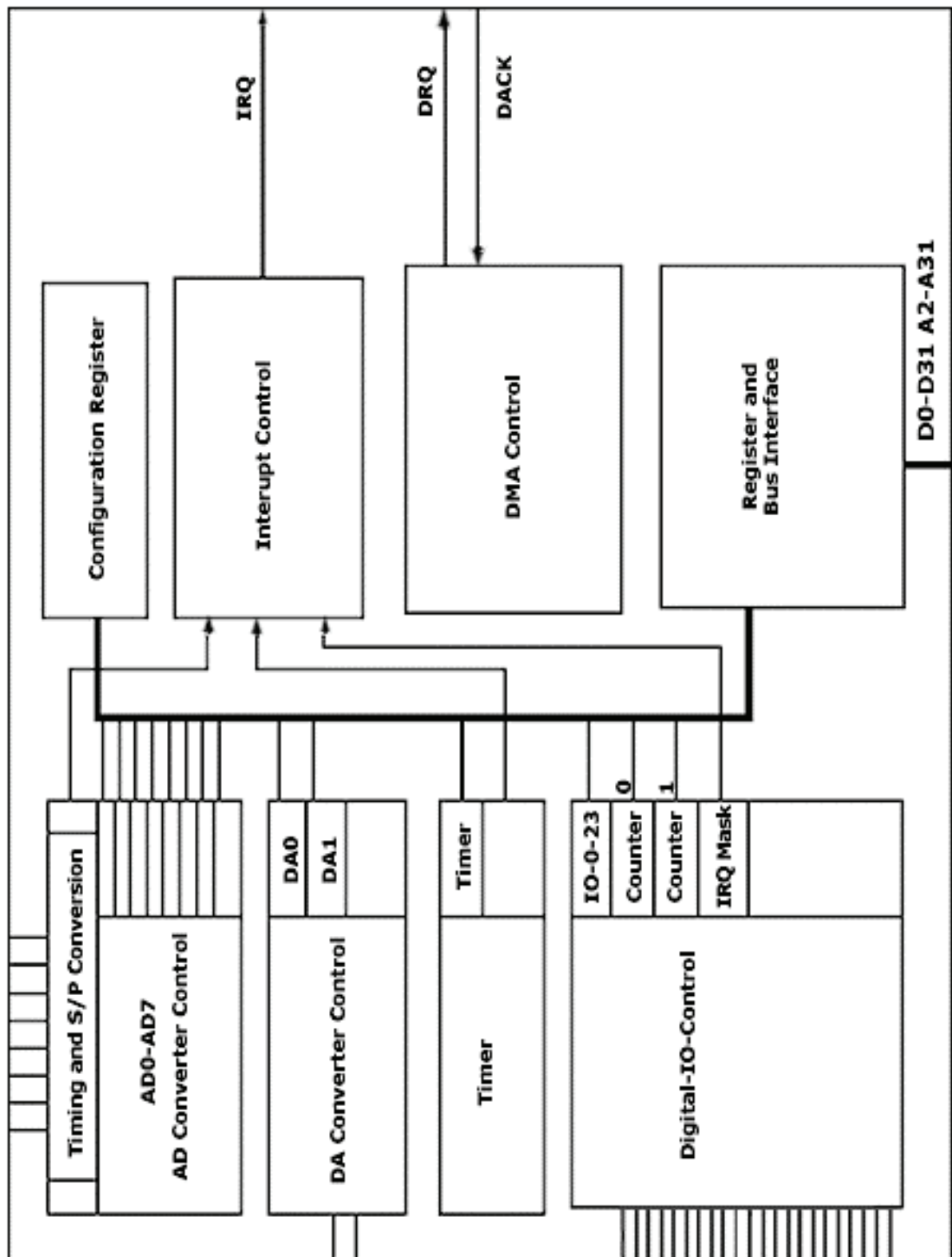
### Advantages :

- ready-made cable
- ideally suited with the twisted signal-ground pairs

## Connection > Terminal Adapter



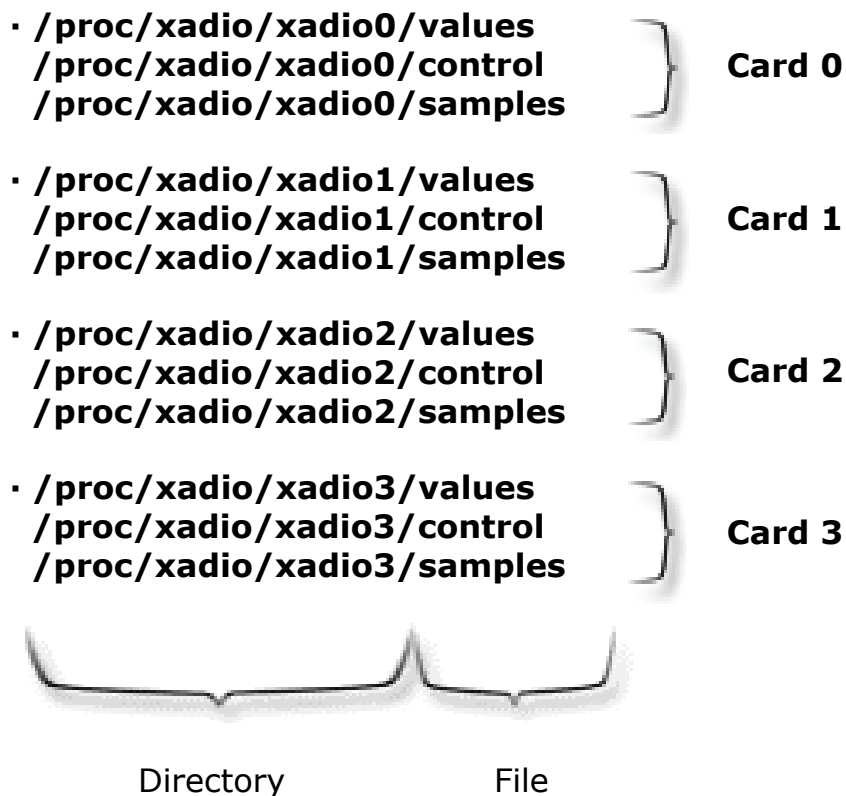




The driver is connected to the proc file-system under Linux.

Load with : **insmod xadio.o** (Driver)

For each card, the following files are created:



**control** : is a text-file for reading and writing

**samples** : is a binary-file for reading

### Output:

With help of the command:

```
cat /proc/xadio/xadio0/control  
cat /proc/xadio/xadio0/values
```

the actual card values will be shown.

For example :

Output	Description
rate 19	Index from the Frequency Table
freq 9600	Set Frequency
modeword 0x135f000	Internal Status Variable
version 81	Driver Version
brecords 1024	For Access to /proc/.../samples
bcount 3	" "
ADC0 30566	Channel 0 16 Bit Voltage Value
ADC1 30881	Channel 1 16 Bit Voltage Value
ADC2 31013	Channel 2 16 Bit Voltage Value
ADC3 30764	Channel 3 16 Bit Voltage Value
ADC4 31192	Channel 4 16 Bit Voltage Value
ADC5 31270	Channel 5 16 Bit Voltage Value
ADC6 31573	Channel 6 16 Bit Voltage Value
ADC7 31033	Channel 7 16 Bit Voltage Value
DIGIO 13631520	18 Bit digital In/Outputs
INCR0 29	Encoder 0
DAC0 253952	Analog Output 0 ... 10,24V
DAC1 253952	Analog Output 0 ... 10,17V
TIMER 771086321	Timer for the XADIO Card
INCR1 0	Encoder 1
RESETS 8399	Internal Status Variable
incmode0 1	Encoder Configuration
incmode1 1	" "
iomode 0xf000	Internal Status Variable
fpgaversion 0xadda000f	XADIO Firmware Version
tcelsius 0x157f 42.93	Measured temperature on the card, the second value is the converted first indication in degrees Celsius
frequencies {195312 ...}	frequencies

**Device Interface**

**> Windows**

Pending.

Example: Channel 0, bipolar +/-10V

**Calib 0V:**

- Connect voltmeter to DA0/1
- output 0V on DA0/1  
**echo "setda0 0" > /proc/xadio/xadio0/control**
- Set the 0V using the variable resistor (see figure)

**Calib 10,0V:**

- output 10.24V on DA0/1  
**echo "setda0 128000" > /proc/xadio/xadio0/control**
- Set the 10.24V using the variable resistor (see figure)

**Calib -10,0V:**

- output -10,24V on DA0/1  
**echo "setda0 -128000" > /proc/xadio/xadio0/control**
- set to -10,24V

***Without Calibration Program:***

Example: Channel 0, bipolar +/-10V

***Offset*****ADC0 to 0V:**

- apply 0V to ADC0  
**echo "setda0 0" > /proc/xadio/xadio0/control**
- Set the value 0x8000 (32768) on **offset1\*** using the variable resistor  
**cat /proc/xadio/xadio0/values**

## Amplification (Gain)

### ADC0 to +10V:

- apply +10V to ADC0  
**echo "setda0 128000" > /proc/xadio/xadio0/control**
- Set the value 0xFD00 oder 0xFFFF on **gain 1** using the variable resistor\*\*  
**cat /proc/xadio/xadio0/values**

\* Channel 0 correspondes to Offset 1. Channel 1 to Offset 2 and so forth.

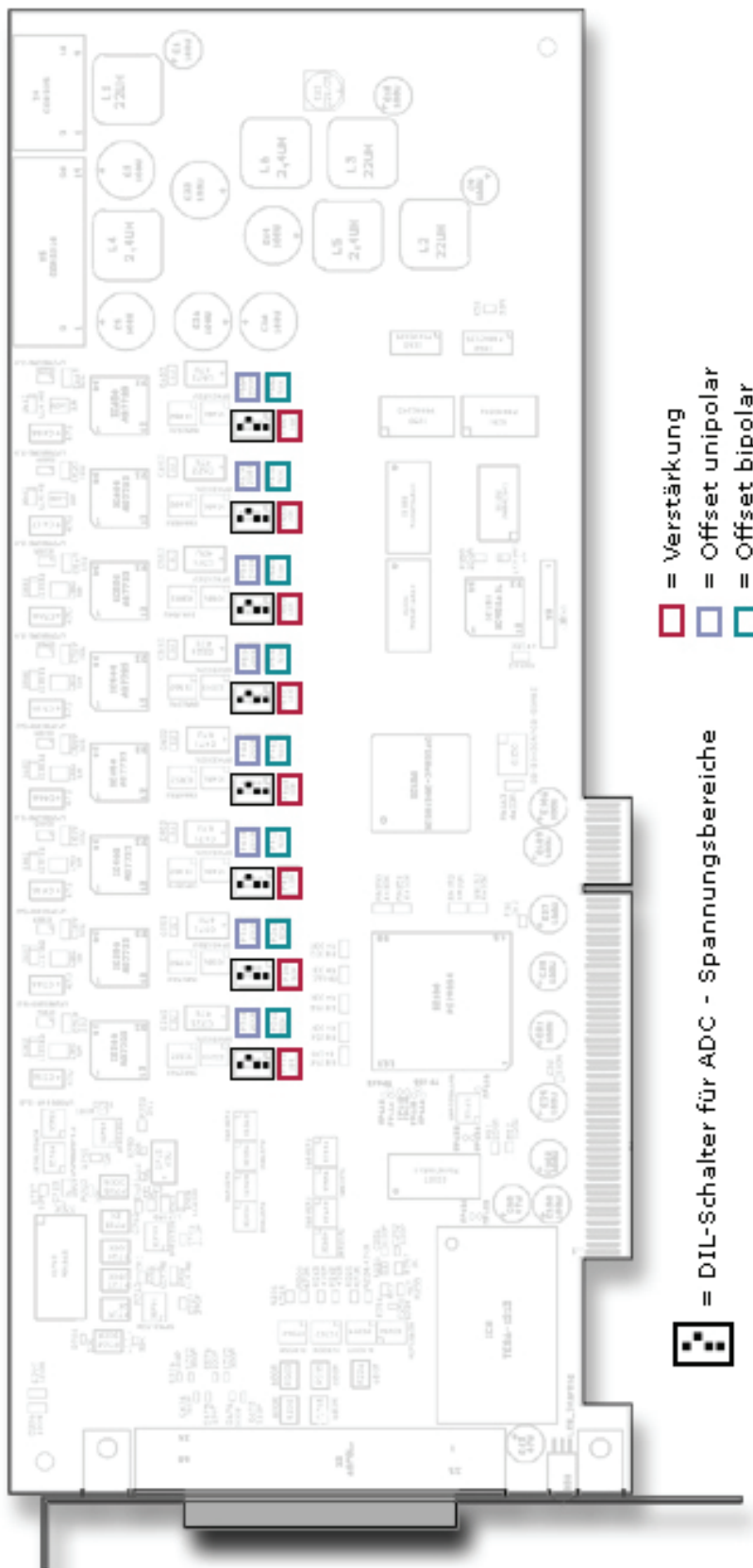
\*\* Two possible sensitives are configurable.

- The value 0xFD00 correspondes to 3200 Dig/V » is for the  $\pm 10V$  measurement range with reserve.
- The value 0xFFFF correspondes to 3276,8 Dig/V » is for the  $\pm 10V$  measurement range without reserve.

### With the Calibration Program:

This small helper application considerable eases the calibration of the card. The card can be easily, quickly, and accurately calibrated through the request of multiple selections.





\* Channel 0 corresponds to Offset 1. Channel 1 to Offset 2 and so forth,  
 » Offset 8.

## DIL-Switch for Specific Settings:







bipolar		
Voltage Range	DIL Switch	Dipcode
$\pm 10 \text{ V}$		9
$\pm 5 \text{ V}$		5
$\pm 2,5 \text{ V}$		1
unipolar		
0 ... 20 V		10
0 ... 10 V		6
0 ... 5 V		2

Table: DIL Configuration



May 2005

## LM74

# SPI/MICROWIRE™ 12-Bit Plus Sign Temperature Sensor

### General Description

The LM74 is a temperature sensor, Delta-Sigma analog-todigital converter with an SPI and MICROWIRE compatible interface. The host can query the LM74 at any time to read temperature. A shutdown mode decreases power consumption to less than 10  $\mu$ A. This mode is useful in systems where low average power consumption is critical.

The LM74 has 12-bit plus sign temperature resolution (0.0625°C per LSB) while operating over a temperature range of -55°C to +150°C.

The LM74's 3.0V to 5.5V supply voltage range, low supply current and simple SPI interface make it ideal for a wide range of applications. These include thermal management and protection applications in hard disk drives, printers, electronic

test equipment, and office electronics. The LM74 is available in the SO-8 package as well as an 5-Bump micro SMD package.

### Features

- 0.0625°C temperature resolution.
- Shutdown mode conserves power between temperature reading
- SPI and MICROWIRE Bus interface
- 5-Bump micro SMD package saves space

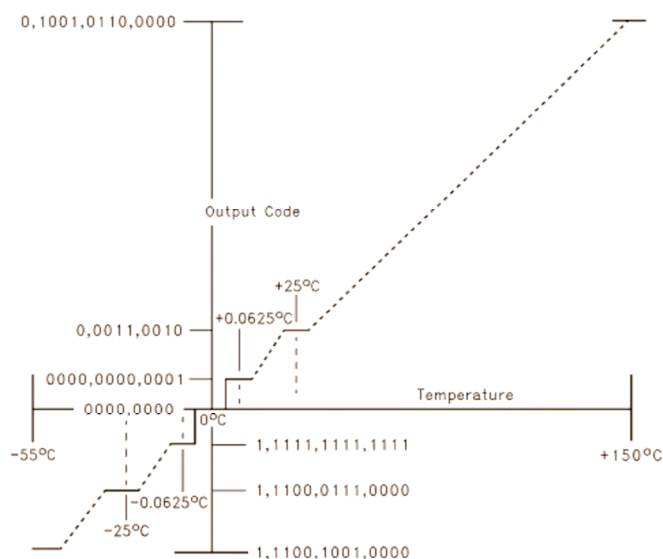
### Key Specifications

Supply Voltage		3.0V or 2.65V to 5.5V
Supply Current	operating	265 $\mu$ A (typ)
	shutdown	520 $\mu$ A (max) 3 $\mu$ A (typ)
Temperature Accuracy	-10°C to 65°C	$\pm 1.25^\circ\text{C}(\text{max})$
	-25°C to 110°C	$\pm 2.1^\circ\text{C}(\text{max})$
	-55°C to 125°C	$\pm 3^\circ\text{C}(\text{max})$

### Applications

- System Thermal Management
- Personal Computers
- Disk Drives
- Office Electronics
- Electronic Test Equipment

### Electrical Characteristics



10090908

FIGURE 5. Temperature-to-Digital Transfer Function (Non-linear scale for clarity)

**INA157**

(In the following excerpt from the data sheet "High-Speed, Precision DIFFERENCE AMPLIFIER" von Courtesy Texas Instruments)

**SPECIFICATIONS:  $V_S = \pm 15V$** 

At  $T_A = +25^\circ C$ ,  $V_S = \pm 15V$ ,  $R_L = 2k\Omega$  connected to ground, and reference pin connected to ground, unless otherwise noted.

PARAMETER	CONDITIONS	INA157U			UNITS
		MIN	TYP	MAX	
<b>OFFSET VOLTAGE<sup>(1)</sup></b> Initial <sup>(1)</sup> vs Temperature vs Power Supply vs Time	RTO  $V_S = \pm 4V$ to $\pm 18V$		$\pm 100$ $\pm 2$ $\pm 5$ 0.25	$\pm 500$ $\pm 20$ $\pm 60$	$\mu V$ $\mu V/^\circ C$ $\mu V/V$ $\mu V/mo$
<b>INPUT IMPEDANCE<sup>(2)</sup></b> Differential Common-Mode			24 18		$k\Omega$ $k\Omega$
<b>INPUT VOLTAGE RANGE</b> Common-Mode Voltage Range Positive Negative Common-Mode Rejection Ratio	$V_O = 0V$ $V_O = 0V$ $V_{CM} = -37.5V$ to $37.5V$ , $R_S = 0\Omega$	$3(V+) - 7.5$ $3(V-) + 7.5$ 86	$3(V+) - 6$ $3(V-) + 3$ 96		V V dB
<b>OUTPUT VOLTAGE NOISE<sup>(3)</sup></b> $f = 0.1Hz$ to $10Hz$ $f = 1kHz$	RTO		1.3 26		$\mu Vp-p$ $nV/\sqrt{Hz}$
<b>GAIN</b> Initial Error vs Temperature Nonlinearity	$V_O = -10V$ to $+10V$  $V_O = -10V$ to $+10V$		0.5 $\pm 0.01$ $\pm 1$ $\pm 0.0001$	$\pm 0.05$ $\pm 10$ $\pm 0.001$	V/V % ppm/ $^\circ C$ % of FS
<b>OUTPUT</b> Voltage, Positive Negative Current Limit, Continuous to Common Capacitive Load (stable operation)		$(V+) - 2$ $(V-) + 2$	$(V+) - 1.8$ $(V-) + 1.6$ $\pm 60$ 500		V V mA pF
<b>FREQUENCY RESPONSE</b> Small-Signal Bandwidth Slew Rate Settling Time: 0.1% 0.01% Overload Recovery Time	-3dB  10V Step, $C_L = 100pF$ 10V Step, $C_L = 100pF$ 50% Overdrive		4 14 2 3 3		MHz V/ $\mu s$ $\mu s$ $\mu s$ $\mu s$
<b>POWER SUPPLY</b> Rated Voltage Operating Voltage Range Quiescent Current	  $I_O = 0mA$	$\pm 4$	$\pm 15$  $\pm 2.4$	$\pm 18$  $\pm 2.9$	V V mA
<b>TEMPERATURE RANGE</b> Specified Operation Storage Thermal Resistance, $\theta_{JA}$ SO-8 Surface-Mount	   150	-40 -55 -55		+85 +125 +125	$^\circ C$ $^\circ C$ $^\circ C$ $^\circ C/W$

NOTES:

(1) Includes effects of amplifier's input bias and offset currents.

- (2) Internal resistors are ratio matched but have  $\pm 20\%$  absolute value.  
(3) Includes effects of amplifier's input current noise and thermal noise contribution of resistor network.

**ABSOLUTE MAXIMUM RATINGS <sup>(1)</sup>**

Supply Voltage, V+ to V-	40V
Input Voltage Range	$\pm 80V$
Output Short Circuit (to ground)	Continuous
Operating Temperature	$-55^{\circ}C$ to $+125^{\circ}C$
Storage Temperature	$-55^{\circ}C$ to $+125^{\circ}C$
Junction Temperature	$+150^{\circ}C$
Lead Temperature (soldering, 10s)	$+300^{\circ}C$

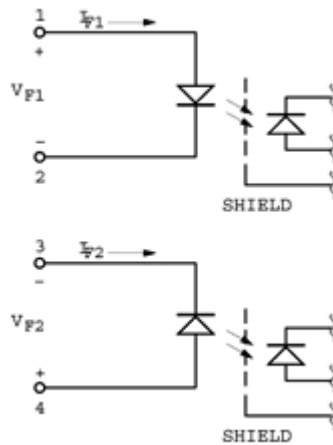
NOTE: (1) Stresses above these ratings may cause permanent damage.  
Exposure to absolute maximum conditions for extended periods may degrade device reliability.

## HPCL-063A

(In the following excerpt from the data sheet " HCMOS Compatible, High CMR, 10 MBd Optocouplers " von Agilent Technologies)

Minimum CMR		Input On-Current (mA)	Output Enable	8-Pin DIP (300 Mil)	Small-Outline SO-8
$dV/dt$ (V/ $\mu$ s)	$V_{CM}$ (V)			Dual Channel Package	Dual Channel Package
1000	50	3 3mA x 2,2k $\Omega$ = 6,6V	nein	HCPL-063A	HCPL-063A

## Schema des HPCL-063A



## Absolute Maximal Leistung

Parameter	Symbol	Min.	Max.	Units	Note
Operating Temperature	$T_A$	- 40	+ 85	°C	
Average Input Current	$I_{F(AVG)}$		10	mA	1
Reverse Input Voltage	$V_R$		3	Volts	

## Empfohlener Operations-Status

Parameter	Symbol	Min.	Max.	Units	Note
Input Voltage, Low Level	$V_{FL}$	- 3	0.8	V	
Input Current, High Level	$I_{FH}$	3.0	10	mA	
Power Supply Voltage	$V_{CC}$	4.5	5.5	Volts	
High Level Enable Voltage	$V_{EH}$	2.0	$V_{CC}$	Volts	
Low Level Enable Voltage	$V_{EL}$	0	0.8	Volts	
Fan Out (at $R_L = 1$ k $\Omega$ )	N		5	TTL Loads	
Output Pull-up Resistor	$R_L$	330	4k	$\Omega$	
Operating Temperature	$T_A$	- 40	85	°C	

### Elektrische Spezifikationen

Empfohlene Operations-Temperatur ( $T_A = -40^\circ\text{C}$  bis  $+85^\circ\text{C}$ ) außer es ist anderweitig spezifiziert.

Parameter	Symbol	Min.	Typ.*	Max.	Units	Test Conditions	Fig.	Note
High Level Output Current	$I_{OH}$		3.1	100	$\mu\text{A}$	$V_{CC} = 5.5\text{ V}$ , $V_O = 5.5\text{ V}$ , $V_F = 0.8\text{ V}$ , $V_E = 2.0\text{ V}$	4	18
Low Level Output Voltage	$V_{OL}$		0.4	0.6	V	$V_{CC} = 5.5\text{ V}$ , $I_{OL} = 13\text{ mA}$ (sinking), $I_F = 3.0\text{ mA}$ , $V_E = 2.0\text{ V}$	5, 8	4, 18
High Level Supply Current	$I_{CCH}$		7	10	mA	$V_E = 0.5\text{ V}$ $V_{CC} = 5.5\text{ V}$ $I_F = 0\text{ mA}$		4
			9	15				
Low Level Supply Current	$I_{CCL}$		8	13	mA	$V_E = 0.5\text{ V}$ $V_{CC} = 5.5\text{ V}$ $I_F = 3.0\text{ mA}$		
			12	21				
High Level Enable Current**	$I_{EH}$		- 0.6	- 1.6	mA	$V_{CC} = 5.5\text{ V}$ , $V_E = 2.0\text{ V}$		
Low Level Enable Current**	$I_{EL}$		- 0.9	- 1.6	mA	$V_{CC} = 5.5\text{ V}$ , $V_E = 0.5\text{ V}$		
Input Forward Voltage	$V_F$	1.0	1.3	1.6	V	$I_F = 4\text{ mA}$	6	4
Temperature Coefficient of Forward Voltage	$\Delta V_F / \Delta T_A$		- 1.25		mV/ $^\circ\text{C}$	$I_F = 4\text{ mA}$		4
Input Reverse Breakdown Voltage	$B_{VR}$	3	5		V	$I_R = 100\text{ }\mu\text{A}$		4
Input Capacitance	$C_{IN}$		60		pF	$f = 1\text{ MHz}$ , $V_F = 0\text{ V}$		

\*Alle Werte bei  $T_A = 25^\circ\text{C}$ ,  $V_{CC} = 5\text{ V}$

### Wechselnde Spezifikationen

Empfohlene Operations-Temperatur ( $T_A = -40^\circ\text{C}$  bis  $+85^\circ\text{C}$ ) außer es ist anderweitig spezifiziert.

Parameter	Symbol	Min.	Typ.*	Max.	Units	Test Conditions	Fig.	Note
Input Current Threshold High to Low	$I_{THL}$		1.5	3.0	mA	$V_{CC} = 5.5\text{ V}$ , $V_O = 0.6\text{ V}$ , $I_O > 13\text{ mA}$ (Sinking)	7, 10	18
Propagation Delay Time to High Level	$t_{PLH}$		52	100	ns	$I_F = 3.5\text{ mA}$ Output $V_{CC} = 5.0\text{ V}$ , $V_E = \text{Open}$ , $C_L = 15\text{ pF}$ , $R_L = 350\Omega$	9, 11, 12	4, 9, 18
Propagation Delay Time to Low Output Level	$t_{PHL}$		53	100	ns		9, 11, 12	4, 10, 18
Pulse Width Distortion	$PWD$ $ t_{PHL} - t_{PLH} $		11	45	ns		9, 13	17, 18
Propagation Delay Skew	$t_{PSK}$			60	ns		24	11, 18
Output Rise Time	$t_R$		42		ns		9, 14	4, 18
Output Fall Time	$t_F$		12		ns		9, 14	4, 18
Propagation Delay Time of Enable from $V_{EH}$ to $V_{EL}$	$t_{EHL}$		19		ns	$I_F = 3.5\text{ mA}$ $V_{CC} = 5.0\text{ V}$ , $V_{EL} = 0\text{ V}$ , $V_{EH} = 3\text{ V}$ , $C_L = 15\text{ pF}$ , $R_L = 350\Omega$	15, 16	12
Propagation Delay Time of Enable from $V_{EL}$ to $V_{EH}$	$t_{ELH}$		30		ns		15, 16	12

\*Alle Werte bei  $T_A = 25^\circ\text{C}$ ,  $V_{CC} = 5\text{ V}$ .

### Allgemeine Gleichspannungsunterdrückungs-Spezifikation,

Alle Werte bei  $T_A = 25^\circ\text{C}$

Parameter	Symbol	Min.	Typ.	Units	Test Conditions	Fig.	Note
Output High Level Common Mode Transient Immunity	$ CM_H $	1	5	kV/ $\mu\text{s}$	$V_{CM} = 50\text{ V}$ , $V_{CC} = 5.0\text{ V}$ , $R_L = 350\Omega$ , $I_F = 0\text{ mA}$ , $T_A = 25^\circ\text{C}$ $V_{O(MIN)} = 2\text{ V}$	17	4, 13, 15, 18
Output Low Level Common Mode Transient Immunity	$ CM_L $	1	5	kV/ $\mu\text{s}$	$V_{CM} = 50\text{ V}$ , $V_{CC} = 5.0\text{ V}$ , $R_L = 350\Omega$ , $I_F = 3.5\text{ mA}$ , $V_{O(MAX)} = 0.8\text{ V}$ , $T_A = 25^\circ\text{C}$	17	4, 14, 15, 18

(In the following excerpt from the data sheet "OPA2132U High Speed FET-INPUT OPERATIONAL AMPLIFIERS" von Courtesy Texas Instruments.)

**SPECIFICATIONS**

At  $T_A = +25^\circ\text{C}$ ,  $V_S = \pm 15\text{V}$ , unless otherwise noted.

PARAMETER	CONDITION	OPA132P, U OPA2132P, U			UNITS
		MIN	TYP	MAX	
<b>OFFSET VOLTAGE</b> Input Offset Voltage vs Temperature <sup>(1)</sup> vs Power Supply Channel Separation (dual and quad)	Operating Temperature Range $V_S = \pm 2.5\text{V to } \pm 18\text{V}$ $R_L = 2\text{k}\Omega$		$\pm 0.25$ $\pm 2$ 5 0.2	$\pm 0.5$ $\pm 10$ 15	mV $\mu\text{V}/^\circ\text{C}$ $\mu\text{V/V}$ $\mu\text{V/V}$
<b>INPUT BIAS CURRENT</b> Input Bias Current <sup>(2)</sup> vs Temperature Input Offset Current <sup>(2)</sup>	$V_{CM} = 0\text{V}$  $V_{CM} = 0\text{V}$		+5 See Typical Curve $\pm 2$	$\pm 50$  $\pm 50$	pA  pA
<b>NOISE</b> Input Voltage Noise Noise Density, $f = 10\text{Hz}$ $f = 100\text{Hz}$ $f = 1\text{kHz}$ $f = 10\text{kHz}$ Current Noise Density, $f = 1\text{kHz}$			23 10 8 8 3		nV/ $\sqrt{\text{Hz}}$ nV/ $\sqrt{\text{Hz}}$ nV/ $\sqrt{\text{Hz}}$ nV/ $\sqrt{\text{Hz}}$ fA/ $\sqrt{\text{Hz}}$
<b>INPUT VOLTAGE RANGE</b> Common-Mode Voltage Range Common-Mode Rejection	$V_{CM} = -12.5\text{V to } +12.5\text{V}$	(V-)+2.5 96	$\pm 13$ 100	(V+)-2.5	V dB
<b>INPUT IMPEDANCE</b> Differential Common-Mode	$V_{CM} = -12.5\text{V to } +12.5\text{V}$		$10^{13} \parallel 2$ $10^{13} \parallel 6$		$\Omega \parallel \text{pF}$ $\Omega \parallel \text{pF}$
<b>OPEN-LOOP GAIN</b> Open-Loop Voltage Gain	$R_L = 10\text{k}\Omega$ , $V_O = -14.5\text{V to } +13.8\text{V}$ $R_L = 2\text{k}\Omega$ , $V_O = -13.8\text{V to } +13.5\text{V}$ $R_L = 600\Omega$ , $V_O = -12.8\text{V to } +12.5\text{V}$	110 110 110	120 126 130		dB dB dB
<b>FREQUENCY RESPONSE</b> Gain-Bandwidth Product $8 * \text{MHz}$ Slew Rate Settling Time: 0.1% 0.01% Overload Recovery Time Total Harmonic Distortion + Noise	$G = -1$ , 10V Step, $C_L = 100\text{pF}$ 0.7 $G = -1$ , 10V Step, $C_L = 100\text{pF}$ 1 $G = \pm 1$ 1kHz, $G = 1$ , $V_O = 3.5\text{Vrms}$ $R_L = 2\text{k}\Omega$ $R_L = 600\Omega$		8 $\pm 20$ 0.7 1 0.5  0.00008 0.00009		MHz V/ $\mu\text{s}$ $\mu\text{s}$ $\mu\text{s}$ $\mu\text{s}$ % %
<b>OUTPUT</b> Voltage Output, Positive Negative Positive Negative Positive Negative Short-Circuit Current Capacitive Load Drive (Stable Operation)	$R_L = 10\Omega$  $R_L = 2\text{k}\Omega$  $R_L = 600\Omega$	(V+)-1.2 (V-)+0.5 (V+)-1.5 (V-)+1.2 (V+)-2.5 (V-)+2.2	(V+)-0.9 (V-)+0.3 (V+)-1.2 (V-)+0.9 (V+)-2.0 (V-)+1.9 $\pm 40$ See Typical Curve		V V V V V V mA
<b>POWER SUPPLY</b> Specified Operating Voltage Operating Voltage Range Quiescent Current (per amplifier)	$I_O = 0$	$\pm 2.5$	$\pm 15$ $\pm 4$	$\pm 18$ $\pm 4.8$	V V mA
<b>TEMPERATURE RANGE</b> Operating Range Storage Thermal Resistance, $\theta_{JA}$ 8-Pin DIP SO-8 Surface-Mount 14-Pin DIP SO-14 Surface-Mount		-40 -40		+85 +125	$^\circ\text{C}$ $^\circ\text{C}$ $^\circ\text{C/W}$ $^\circ\text{C/W}$ $^\circ\text{C/W}$ $^\circ\text{C/W}$



NOTES: (1) Guaranteed by wafer test. (2) High-speed test at  $T_J = 25^{\circ}\text{C}$ .

**ABSOLUTE MAXIMUM RATINGS**

Supply Voltage, $V_+$ to $V_-$	36V
Input Voltage	( $V_-$ ) $-0.7\text{V}$ to ( $V_+$ ) $+0.7\text{V}$
Output Short-Circuit (1)	Continuous
Operating Temperature	$-40^{\circ}\text{C}$ to $+125^{\circ}\text{C}$
Storage Temperature	$-40^{\circ}\text{C}$ to $+125^{\circ}\text{C}$
Junction Temperature	$150^{\circ}\text{C}$
Lead Temperature (soldering, 10s)	$300^{\circ}\text{C}$

NOTE: (1) Short-circuit to ground, one amplifier per package.

## Appendix

## > ILD223

(In the following excerpt from the data sheet "ILD223 DUAL PHOTODARLINGTON SMALL OUTLINE SURFACE MOUNT OPTOCOUPLER" von Siemens)

### Characteristics (T = 25°C)

	Symbol	Min.	Typ.	Max.	Unit	Condition
<b>Emitter</b>						
Forward Voltage	$V_F$			1.3	V	$I_F = 1 \text{ mA}$
Reverse Current	$I_R$		0.1	100	$\mu\text{A}$	$V_R = 6.0 \text{ V}$
Capacitance	$C_O$		25		pF	$V_F = 0 \text{ V}$ , $F = 1 \text{ MHz}$
<b>Detector</b>						
Breakdown Voltage	$BV_{CEO}$	30			V	$I_C = 10 \text{ mA}$
Collector-Emitter	$BV_{ECO}$	5			V	$I_E = 10 \text{ mA}$
Emitter-Collector						
Current, Collector-Emitter	$I_{CEO}$			50	nA	$V_{CE} = 5 \text{ V}$ , $I_F = 0$
Capacitance, Collector-Emitter	$C_{CE}$		3.4	pF	V	$C_E = 5 \text{ V}$
<b>Package</b>						
DC Current Transfer Ratio	$CTR_{DC}$	500			%	$I_F = 1 \text{ mA}$ , $V_{CE} = 5 \text{ V}$
Saturation Voltage, Collector-Emitter	$V_{CEsat}$			1	V	$I_F = 1 \text{ mA}$ , $I_{CE} = 0.5 \text{ mA}$
Capacitance, Input to Output	$C_{IO}$	0.5		pF		
Resistance, Input to Output	$R_{IO}$	100		G $\Omega$		
Turn-On Time	$t_{ON}$	15		$\mu\text{s}$		$V_{CC} = 10 \text{ V}$ $R_L = 100 \Omega$ $I_F = 5 \text{ mA}$
Turn-Off Time	$t_{OFF}$	30		$\mu\text{s}$		
Isolation Test Voltage	$V_{IO}$					(t=1 min.) 2500 VAC <sub>RMS</sub>

### Maximum Ratings (Each Channel)

<b>Emitter</b>	
Peak Reverse Voltage	6.0 V
Peak Pulsed Current (1 ms, 300 pps)	3 A
Continuous Forward Current per Channel	30 mA
Power Dissipation at 25°C	45 mW
Derate Linearly from 25°C	0.4 mW/°C
<b>Detector</b>	
Collector-Emitter Breakdown Voltage	30 V
Emitter-Collector Breakdown Voltage	5 V
Power Dissipation per Channel	75 mW
Derate Linearly from 25°C	3.1 mW/°C
<b>Package</b>	
Total Package Dissipation at 25°C Ambient	
(2 LEDs + 2 Detectors, 2 Channels)	240 mW
Derate Linearly from 25°C	2 mW/°C
Storage Temperature	-55°C to +150°C
Operating Temperature	-55°C to +100°C
Soldering Time at 260°C	10 sec.

**74AHC541**

(In the following excerpt from the data sheet "Octal buffer/line driver; 3-state 74AHC541" von Philips Semiconductors)

**QUICK REFERENCE DATA**

GND = 0 V;  $T_{amb} = 25^{\circ}\text{C}$ ;  $t_r = t_f \leq 3.0 \text{ ns}$ .

SYMBOL	PARAMETER	CONDITIONS	TYPICAL		UNIT
			AHC	AHCT	
$t_{PHL}/t_{PLH}$	propagation delay $A_n$ to $Y_n$	$C_L = 15 \text{ pF}$ ; $V_{CC} = 5 \text{ V}$	3.5	3.5	ns
$C_I$	input capacitance	$V_I = V_{CC}$ or GND	3	3	pF
$C_O$	output capacitance		4.0	4.0	pF
$C_{PD}$	power dissipation capacitance	$C_L = 50 \text{ pF}$ ; $f = 1 \text{ MHz}$ ; notes 1 and 2	10	12	pF

**Notes**

1.  $C_{PD}$  is used to determine the dynamic power dissipation ( $P_D$  in  $\mu\text{W}$ ).

$P_D = C_{PD} \times V_{CC}^2 \times f_i + \sum (C_L \times V_{CC}^2 \times f_o)$  where:

$f_i$  = input frequency in MHz;

$f_o$  = output frequency in MHz;

$\sum (C_L \times V_{CC}^2 \times f_o)$  = sum of outputs;

$C_L$  = output load capacitance in pF;

$V_{CC}$  = supply voltage in Volts.

2. The condition is  $V_I = \text{GND to } V_{CC}$ .

**LIMITING VALUES**

In accordance with the Absolute Maximum Rating System (IEC 134); voltages are referenced to GND (ground = 0 V).

SYMBOL	PARAMETER	CONDITIONS	MIN.	MAX.	UNIT
$V_{CC}$	DC supply voltage		-0.5	+7.0	V
$V_I$	input voltage		-0.5	+7.0	V
$I_{IK}$	DC input diode current	$V_I < -0.5 \text{ V}$ ; note 1	-	-20	mA
$I_{OK}$	DC output diode current	$V_O < -0.5 \text{ V}$ or $V_O > V_{CC} + 0.5 \text{ V}$ ; note 1	-	$\pm 20$	mA
$I_O$	DC output source or sink current	$-0.5 \text{ V} < V_O < V_{CC} + 0.5 \text{ V}$	-	$\pm 25$	mA
$I_{CC}$	DC $V_{CC}$ or GND current		-	$\pm 75$	mA
$T_{stg}$	storage temperature		-65	+150	$^{\circ}\text{C}$
$P_D$	power dissipation per package	for temperature range: $-40$ to $+125^{\circ}\text{C}$ ; note 2	-	500	mW

**Notes**

1. The input and output voltage ratings may be exceeded if the input and output current ratings are observed.

2. For SO-package: above  $70^{\circ}\text{C}$  the value of  $P_D$  derates linearly with  $8 \text{ mW/K}$ .

For TSSOP-package: above  $60^{\circ}\text{C}$  the value of  $P_D$  derates linearly with  $5.5 \text{ mW/K}$ .

**DC CHARACTERISTICS****Family 74AHC**

Over recommended operating conditions; voltage are referenced to GND (ground = 0 V).

SYMBOL	PARAMETER	TEST CONDITIONS		T <sub>amb</sub> (°C)							UNIT
				25			-40 to +85		-40 to +125		
		OTHER	V <sub>CC</sub> (V)	MIN.	TYP.	MAX.	MAX.	MIN.	MIN.	MAX.	
V <sub>IH</sub>	HIGH-level input voltage		2.0	1.5	-	-	1.5	-	1.5	-	V
			3.0	2.1	-	-	2.1	-	2.1	-	
			5.5	3.85	-	-	3.85	-	3.85	-	
V <sub>IL</sub>	LOW-level input		2.0	-	-	0.5	-	0.5	-	0.5	V

	voltage		3.0	-	-	0.9	-	0.9	-	0.9	
			5.5	-	-	1.65	-	1.65	-	1.65	
$V_{OH}$	HIGH-level output voltage	$V_I = V_{IH} \text{ or } V_{IL};$ $I_O = -50 \mu A$	2.0	1.9	2.0	-	1.9	-	1.9	-	V
			3.0	2.9	3.0	-	2.9	-	2.9	-	
			4.5	4.4	4.5	-	4.4	-	4.4	-	
		$V_I = V_{IH} \text{ or } V_{IL};$ $I_O = -4.0 \text{ mA}$	3.0	2.58	-	-	2.48	-	2.40	-	V
		$V_I = V_{IH} \text{ or } V_{IL};$ $I_O = -8.0 \text{ mA}$	4.5	3.94	-	-	3.8	-	3.70	-	
$V_{OL}$	LOW-level output voltage	$V_I = V_{IH} \text{ or } V_{IL};$ $I_O = 50 \mu A$	2.0	-	0	0.1	-	0.1	-	0.1	V
			3.0	-	0	0.1	-	0.1	-	0.1	
			4.5	-	0	0.1	-	0.1	-	0.1	
		$V_I = V_{IH} \text{ or } V_{IL};$ $I_O = 4.0 \text{ mA}$	3.0	-	-	0.36	-	0.44	-	0.55	V
		$V_I = V_{IH} \text{ or } V_{IL};$ $I_O = 8.0 \text{ mA}$	4.5	-	-	0.36	-	0.44	-	0.55	
$I_I$	input leakage current	$V_I = V_{CC} \text{ or GND}$	5.5	-	-	0.1	-	1.0	-	2.0	$\mu A$
$I_{OZ}$	3-state output OFF-state current	$V_I = V_{IH} \text{ or } V_{IL};$ $V_O = V_{CC} \text{ or GND}$	5.5	-	-	$\pm 0.25$	-	$\pm 2.5$	-	$\pm 10.0$	$\mu A$
$I_{CC}$	quiescent supply current	$V_I = V_{CC} \text{ or GND};$ $I_O = 0$	5.5	-	-	4.0	-	40	-	80	$\mu A$
$C_I$	input capacitance		-	-	3	10	-	10	-	10	pF

#### Family 74AHCT

Over recommended operating conditions; voltage are referenced to GND (ground = 0 V).

SYMBOL	PARAMETER	TEST CONDITIONS		T <sub>amb</sub> (°C)							UNIT
				25			-40 to +85		-40 to +125		
		OTHER	V <sub>CC</sub> (V)	MIN.	TYP.	MAX.	MAX.	MIN.	MIN.	MAX.	
V <sub>IH</sub>	HIGH-level input voltage		4.5 to 5.5	2.0	-	-	2.05	-	2.0	-	V
V <sub>IL</sub>	LOW-level input voltage		4.5 to 5.5	-	-	0.8	-	0.8	-	0.8	V
V <sub>OH</sub>	HIGH-level output voltage	V <sub>I</sub> =V <sub>IH</sub> or V <sub>IL</sub> ; I <sub>O</sub> = -50 μA	4.5	4.4	4.5	-	4.4	-	4.4	-	V
		V <sub>I</sub> =V <sub>IH</sub> or V <sub>IL</sub> ; I <sub>O</sub> = -8.0 mA	4.5	3.94	-	-	3.8	-	3.70	-	V
V <sub>OL</sub>	LOW-level output voltage	V <sub>I</sub> =V <sub>IH</sub> or V <sub>IL</sub> ; I <sub>O</sub> =50μA	4.5	-	0	0.1	-	0.1	-	0.1	V
		V <sub>I</sub> =V <sub>IH</sub> or V <sub>IL</sub> ; I <sub>O</sub> = 8.0 mA	4.5	-	-	0.36	-	0.44	-	0.55	V
I <sub>I</sub>	input leakage current	V <sub>I</sub> =V <sub>IH</sub> or V <sub>IL</sub>	5.5	-	-	0.1	-	1.0	-	2.0	μA
I <sub>OZ</sub>	3-state output OFF-state current	V <sub>I</sub> =V <sub>IH</sub> or V <sub>IL</sub> ; V <sub>O</sub> =V <sub>CC</sub> or GND per input pin; other inputs at V <sub>CC</sub> or GND; I <sub>O</sub> =0	5.5	-	-	±0.25	-	±2.5	-	±10.0	μA
I <sub>CC</sub>	quiescent supply current	V <sub>I</sub> =V <sub>CC</sub> or GND; I <sub>O</sub> =0	5.5	-	-	4.0	-	40	-	80	μA
ΔI <sub>CC</sub>	additional quiescent supply current per input pin	V <sub>I</sub> =V <sub>CC</sub> - 2.1 V other inputs at V <sub>CC</sub> or GND; I <sub>O</sub> =0	4.5 to 5.5	-	-	1.35	-	1.5	-	1.5	mA
C <sub>I</sub>	input capacitance		-	-	3	10	-	10	-	10	pF

In the following excerpt from the data sheet "DC/DC-Konverter TES 6 Serie 6 Watt" von Comptec)

<b>Eingangsspannung</b>	9 - 18 VDC
<b>Ausgangsspannung</b>	15 VDC
<b>Ausgangsstrom max.</b>	400 mA
<b>Wirkungsgrad typ.</b>	83 %

## Eingangsspezifikationen

<b>Eingangsstrom (Leerlauf)</b>	20 mA
<b>Eingangsstrom (Vollast)</b>	600 mA typ.
<b>Startspannung / Abschaltspannung</b>	6 VDC / 8 VDC typ.
<b>Transiente Überspannung (1 sec. max.)</b>	25 V max.
<b>Verpolungsschutz</b>	1.0 A max.
<b>Leitungsgebundene Störungen (Eingang)</b>	EN 55022 Level A, FCC Teil 15, Klasse A

## Ausgangsspezifikationen

<b>Einstellgenauigkeit</b>	± 1 %
<b>Regelabweichung</b> - Eingangsspannungsänderung - Laständerung 10 - 100 % - Singleausgang - Dualausgang (symmetrische Last) - Dualausgang (unsymmetrische Last)	0.3 % max. 1 % max. 1 % max. 2.5 % max.
<b>Restwelligkeit (20 MHz Bandbreite)</b>	75 mVpk-pk max.
<b>Temperaturkoeffizient</b>	± 0.02 % / °C
<b>Strombegrenzung</b>	> 120 % I <sub>aus</sub> max., Konstantstrom
<b>Kurzschlußschutz</b>	Foldback, autom. Neustart
<b>Kapazitive Last</b>	100 µF max.

## Allgemeine Spezifikationen

<b>Temperaturbereich</b> - Betrieb - Gehäusetemperatur - Lagerung (nicht in Betrieb)	- 40 °C ... + 71 °C (keine Leistungsreduktion) + 95 °C max. - 40 °C ... + 125 °C
<b>Leistungsreduktion</b>	4 %/K oberhalb 71 °C
<b>Luftfeuchtigkeit (nicht betauend)</b>	95 % rel H max.
<b>Zuverlässigkeit, kalkulierte MTBF (MIL-HDBK-217 E)</b>	>1 Mio. Std. bei + 25 °C
<b>Isolationsspannung Eingang/Ausgang</b>	1 '500 VDC
<b>Isolationskapazität Eingang/Ausgang</b>	380 pF typ.
<b>Isolationswiderand Eingang/Ausgang (500 VDC)</b>	> 1 '000 MOhm
<b>Schaltfrequenz</b>	300 kHz
<b>Sicherheitsstandards</b>	IEC / EN 60950, UL 60950
<b>Sicherheitszulassungen</b>	UL / cUL, CB-Scheme in Vorbereitung

Alle Spezifikationen bei Nominal-Eingangsspannung, Vollast und +25°C nach Aufwärmzeit ausg. anders spezifiziert.

## Physikalische Spezifikationen

<b>Gehäusematerial</b>	nicht leitender schwarzer Kunststoff
<b>Vergussmasse Epoxid</b>	(UL 94V-0)
<b>Gewicht</b>	14 g



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## Pin Layout Table:

Measuring range	Input	Pin		Measured value	10V value
		+	-		
-10 ... +10V	DAC1 1	34	68		
-10 ... +10V	DAC2 2	33	67		
-10 ... +10V	ADC 1	32	66		
-10 ... +10V	ADC 2	31	65		
-10 ... +10V	ADC 3	30	64		
-10 ... +10V	ADC 4	29	63		
-10 ... +10V	ADC 5	28	62		
-10 ... +10V	ADC 6	27	61		
-10 ... +10V	ADC 7	26	60		
-10 ... +10V	ADC 8	25	59		
	Output 00	24	58		
	Output 01	23	57		
	Output 02	22	56		
	Output 03	21	55		
	Output 04	20	54		
	Output 05	19	53		
	Output 06	18	52		
	Output 07	17	51		
	Output 08	16	50		
	Output 09	15	49		
15V: potenzial free current supply for external circuits	-		48		
	+		47		
	not occupy		46		
	Input 10	14	45		
	Input 11	13			
	Input 12	12			
	Input 13	11			
	Input 14	10	44		
	Input 15	09	43		
Encoder1 R	Input 16	08	42		
Encoder1 a	Input 17	07	41		
Encoder1 b	Input 18	06	40		
	Input 19	05	39		
Encoder0 R	Input 20	4	38		
Encoder0 a	Input 21	3	37		
Encoder0 b	Input 22	2	36		
	Input 23	1	35		