

CoolEx User Manual

© 2008 XDIMAX LTD

Revision 1.0

Table of Contents

Foreword	0
Part I Overview	3
Part II Configuration and Setup	4
1 Terminals Layout.....	4
2 Modbus Address Switch.....	4
Part III Functional Description	5
1 Supported Modbus Functions.....	6
2 Address Map.....	7
3 Digital Outputs D0..D5.....	8
4 PWM Outputs D0..D5.....	9
5 Analog Outputs A0..A5.....	10
6 Digital I/O A0..A5.....	10
Part IV Specification	11
1 Electrical Characteristics.....	11

1 Overview

CoolEx is a MODBUS I/O extender with analog, digital and PWM inputs and outputs. CoolEx can be used in conjunction with Programmable Logic Controller (PLC) or any other MODBUS master that requires some extra I/O or special I/O functionality. CoolEx is controlled by master by means of standard MODBUS requests and provides following features:

- Analog outputs 0V..10V
- PWM outputs with configurable frequency and duty cycle.
- Digital outputs with 5V or 12V logic one level
- Digital inputs

CoolEx is fully compliant with following MODBUS specifications:

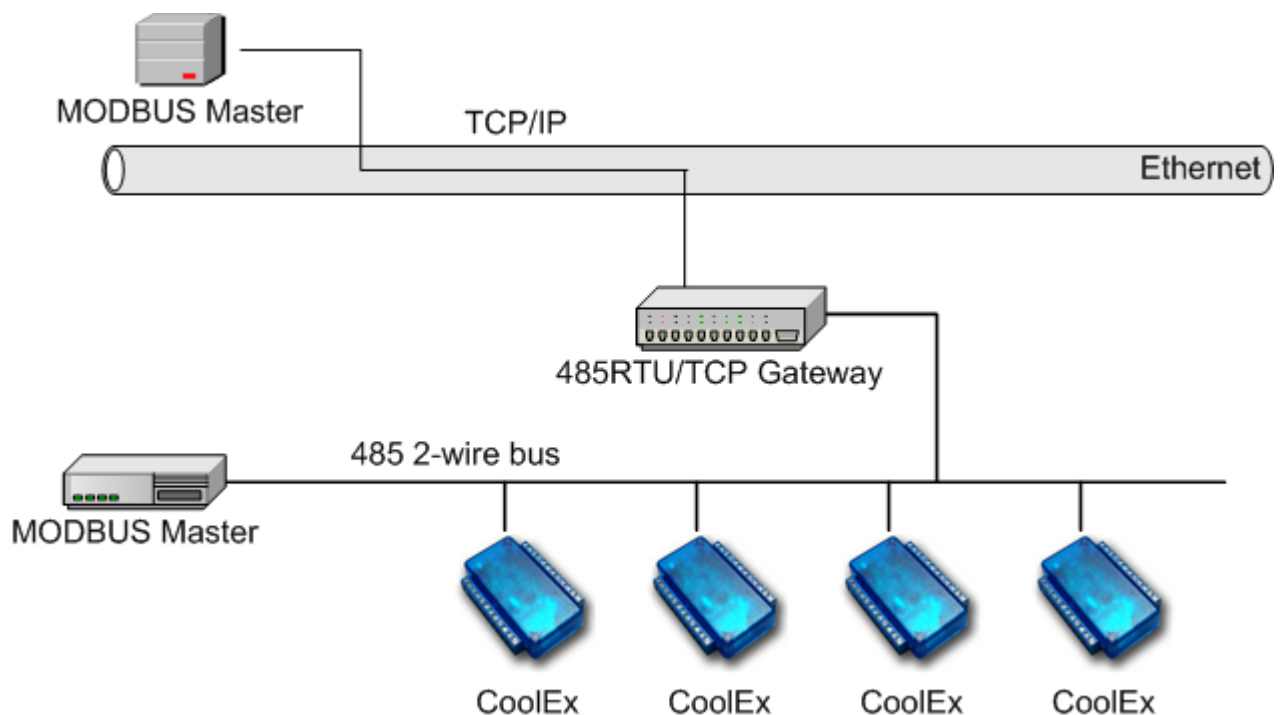
- [MODBUS over Serial Line Specification and Implementation Guide V1.02](#)
- [MODBUS application protocol specification V1.1b](#)

CoolEx physical connection to MODBUS is Two-Wire EIA/TIA-485 standard interface recommended by MODBUS specification. On such 2W-bus, at any time only one driver has the right for transmitting thus a MODBUS communication is always initiated by the master. CoolEx will never transmit without receiving a request from master. A number of CoolEx devices can be connected to single 2W-bus. Each CoolEx in this case must have unique MODBUS slave address (see [Modbus Address Switch](#) for details).

Data Link Layer supported by CoolEx is MODBUS RTU Mode. The default byte format is

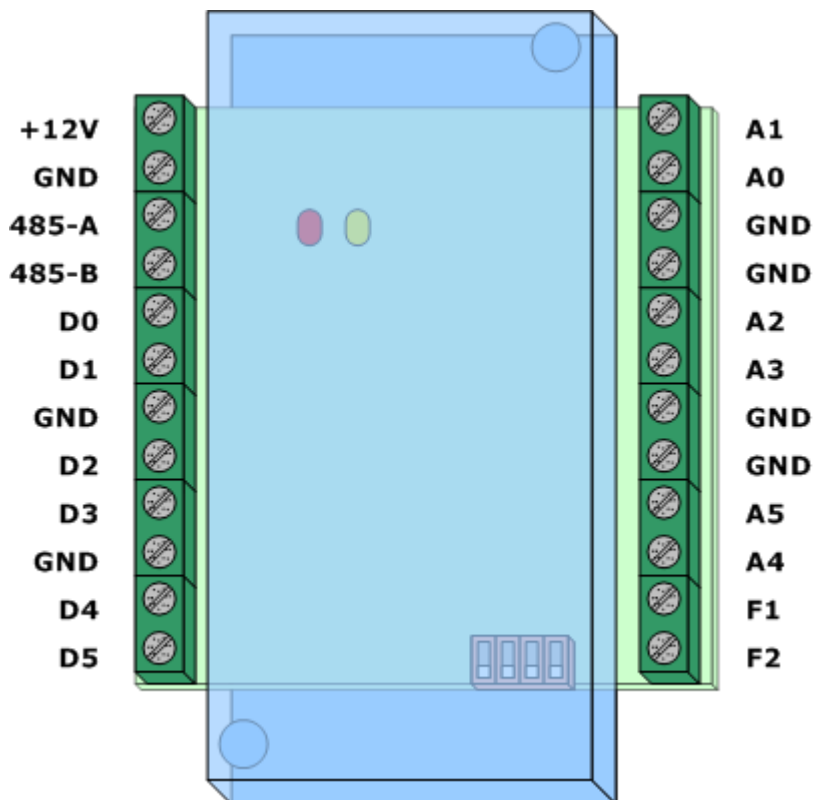
Start Bits 1
Data Bits 8
Parity None
Stop Bits 1

To utilize CoolEx with TCP/IP MODBUS master over Ethernet network MODBUS 485RTU/TCP Gateway can be used.



2 Configuration and Setup

2.1 Terminals Layout

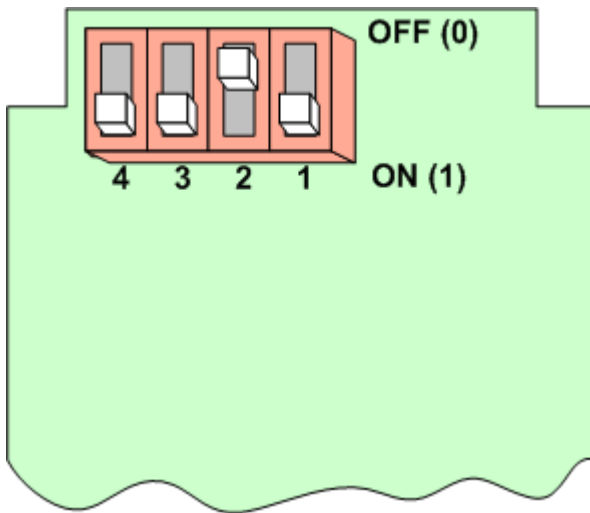


Terminal	Function				
	CoolEx-A45	CoolEx-A412	CoolEx-D45	CoolEx-D412	
+12V	12V Power Supply Input				7.5V to 25V
GND	Ground				
485-A	485 2-wire bus				Polarity is important in connection to bus
485-B					
D0..D5	5V Output	12V Output	5V Output	12V Output	Digital or PWM
A0..A5	Analog Output		5V Digital Input/Output		
F1	Connection to Air Conditioning System Communication Line				No polarity
F2					

CoolEx MODBUS is supplied in different modifications: CoolEx-A45, CoolEx-A412, CoolEx-D45, CoolEx-D412.

2.2 Modbus Address Switch

According to MODBUS specification, individual slave device must be assigned unique (within entire bus) slave address in the range of 1 - 247. CoolEx slave address is configured with 4 DIP switches component. Below you can see it's layout.



The resulting slave address address can be determined as $0x50 + \text{DIP switch value}$. Following table illustrates all possible combinations.

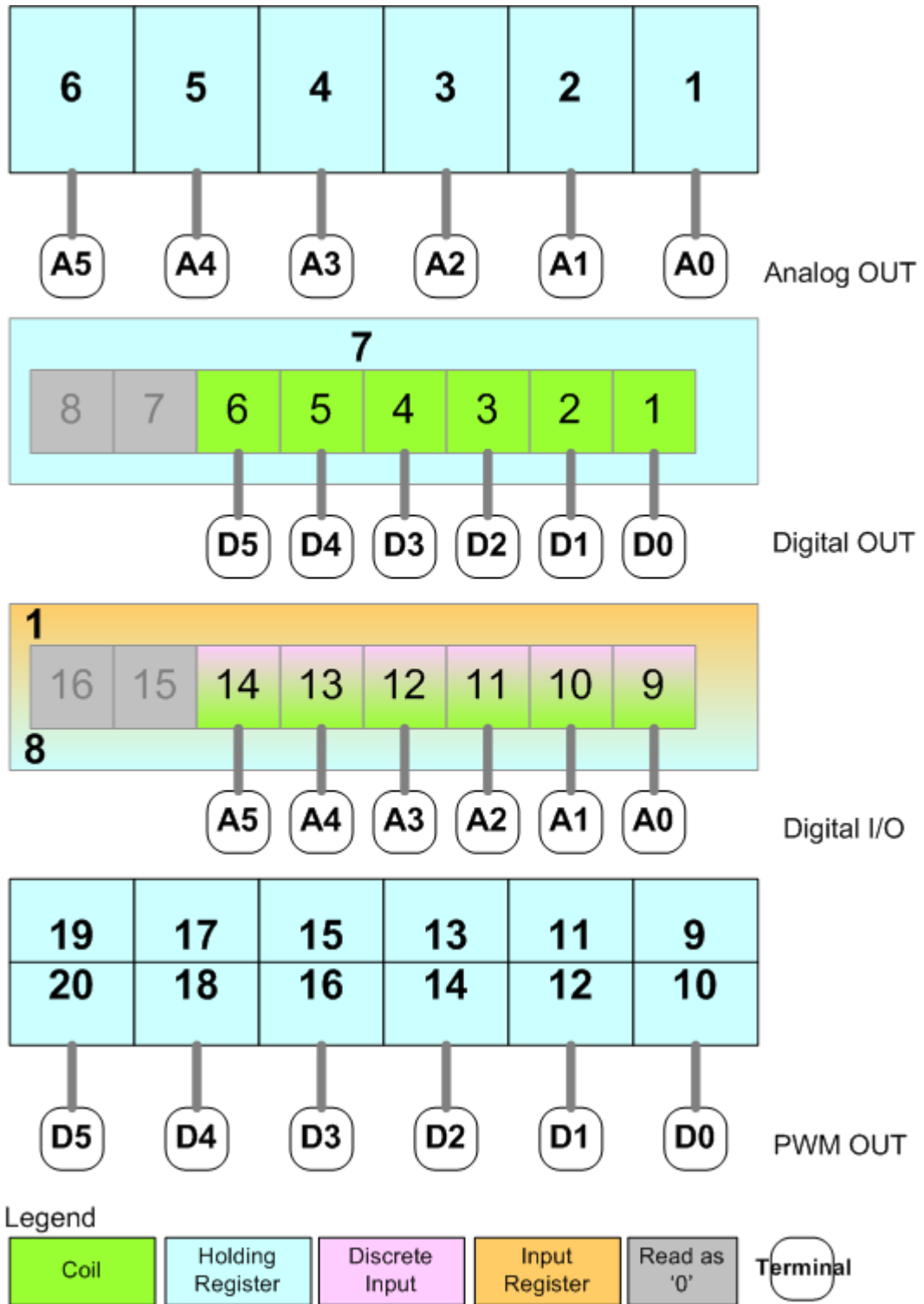
SW 4	SW 3	SW 2	SW 1	Address Hex	Address Decimal
0	0	0	0	0x50	80
0	0	0	1	0x51	81
0	0	1	0	0x52	82
0	0	1	1	0x53	83
0	1	0	0	0x54	84
0	1	0	1	0x55	85
0	1	1	0	0x56	86
0	1	1	1	0x57	87
1	0	0	0	0x58	88
1	0	0	1	0x59	89
1	0	1	0	0x5A	90
1	0	1	1	0x5B	91
1	1	0	0	0x5C	92
1	1	0	1	0x5D	93
1	1	1	0	0x5E	94
1	1	1	1	0x5F	95

3 Functional Description

3.1 Supported Modbus Functions

Function Name	Function Code	Description
I/O Controls		
Read Coils	0x01	Read status of contiguous coils
Read Discrete Inputs	0x02	Read status of contiguous discrete inputs
Read Holding Registers	0x03	Read contents of a contiguous block of holding registers
Read Input Registers	0x04	Read contiguous input registers
Write Single Coil	0x05	Write a single coil to ON or OFF
Write Single Register	0x06	Write single holding register
Write Multiple Coils	0x0F	Force each coils in the sequence of coils to either ON or OFF
Write Multiple Registers	0x10	Write a block of contiguous registers
Diagnostics and Service		
Read Device Identification	0x2B 0x0E	Read identification information relative to the physical and functional description of the device (Vendor Name, Product Name, Model Name, Revision, e.t.c.)

3.2 Address Map



	Address	Terminal	Function
Coil (RW)	1	D0	Digital Output
	2	D1	
	3	D2	
	4	D3	
	5	D4	
	6	D5	
Coil (RW)	9	A0	Digital Input/Output
	10	A1	
	11	A2	
	12	A3	
	13	A4	
	14	A5	
Discrete Input (Read)	9	A0	Digital Input
	10	A1	
	11	A2	
	12	A3	
	13	A4	
	14	A5	
Holding Register (RW)	1	A0	Analog Outputs
	2	A1	
	3	A2	
	4	A3	
	5	A4	
	6	A5	
Holding Register (RW)	7	D0..D5	Digital Outputs
Holding Register (RW)	8	A0..A5	Digital Input/Outputs
Holding Register (R/W)	9,10	D0	PWM Outputs
	11,12	D1	
	13,14	D2	
	15,16	D3	
	17,18	D4	
	19,20	D5	
Input Register (Read)	1	A0..A5	Digital Inputs

3.3 Digital Outputs D0..D5

Digital Outputs D0..D5 can be controlled via corresponding coils or bits of Holding Register (see [Address Map](#)). Writing coil to "ON" or Holding register bit to "1" will set output to 5V or 12V depending on CoolEx type (CoolEx-xx5 or CoolEx-xx12). Writing coil to "OFF" or Holding Register to "0" will set output to zero.

Related MODBUS functions

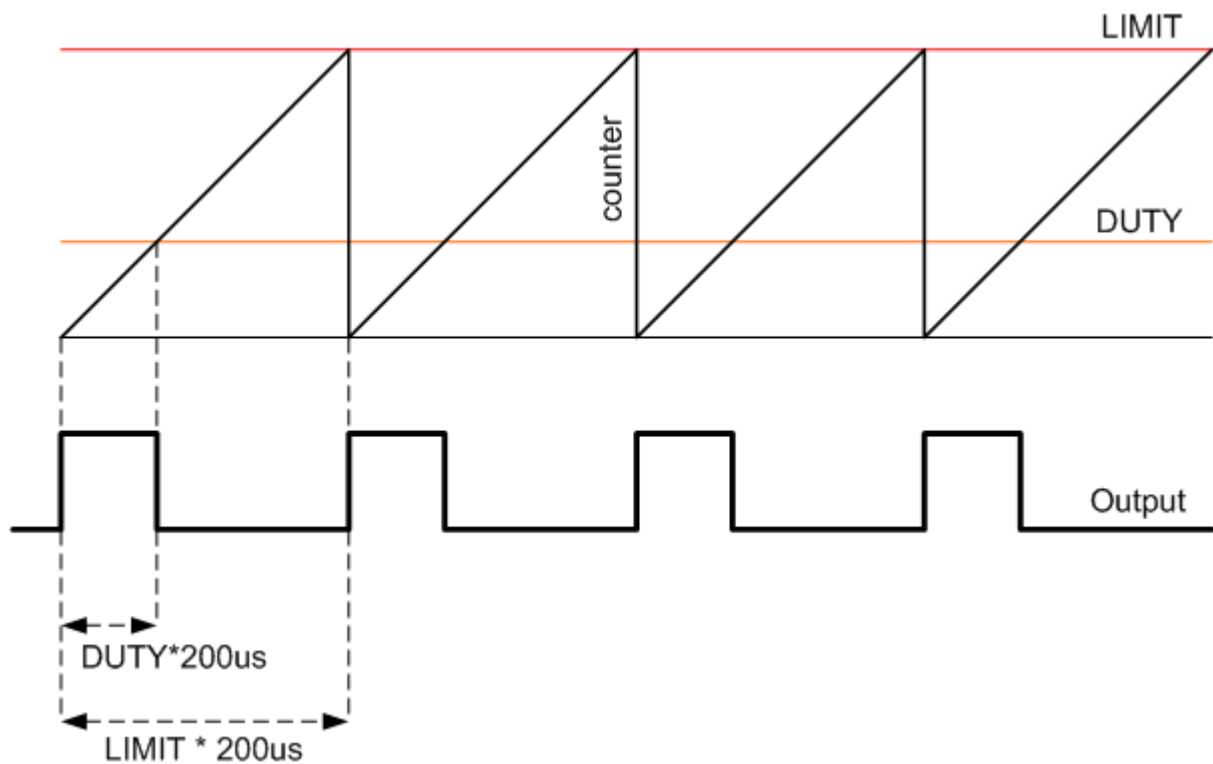
- Write Single Register
- Write Multiple Registers
- Read Holding Registers
- Read Coils

- Write Single Coil
- Write Multiple Coils

3.4 PWM Outputs D0..D5

Six independent PWM outputs are available on terminals D0..D5. Each PWM output is controlled by corresponding Holding Registers pair. First register defines counter top limit second defines PWM duty cycle. Time resolution is 200us. Counter will count from 0 to LIMIT. While counter is less then DUTY output will be high. When counter becomes above DUTY output will go low. When counter reaches LIMIT it is cleared and output goes high.

Register N	LIMIT
Register N+1	DUTY



$$\text{Output Frequency} = 1/(200\mu\text{s} * \text{LIMIT})$$

$$\text{Duty Cycle} = \text{DUTY} / \text{LIMIT} * 100\%$$

For example if LIMIT = 100 and DUTY = 20, PWM period will be $100 * 200\mu\text{s} = 20000\mu\text{s} = 20\text{ms} = 0.02\text{s}$. PWM Frequency = $1 / 0.02 = 50\text{Hz}$. Duty Cycle is $20 / 100 * 100\% = 20\%$.

PWM Output function will take over digital output. To turn off PWM limit register must be cleared (LIMIT=0). If DUTY > LIMIT, output will be constantly high. If DUTY = 0, output will be constantly low. Maximal LIMIT value is 0xFFFF = 65535, it gives maximal period of $65535 * 200\mu\text{s} = 13.107\text{s}$

Related MODBUS functions

- Write Single Register

- Write Multiple Registers
- Read Holding Registers

3.5 Analog Outputs A0..A5

Six analog outputs are available on terminals A0..A5 in CoolEx-A45 and CoolEx-A412. Each output can source up to 40mA and provide output voltage 0V to 10V depending on the value of corresponding holding register (see [Address Map](#)).

$$V_{out} = 10V * (Value/255)$$

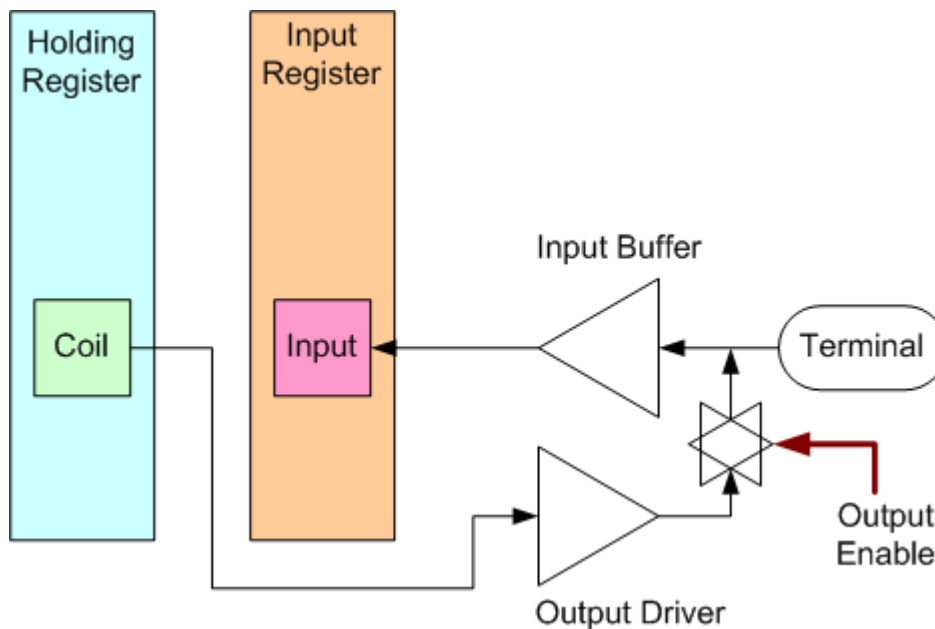
Holding register value for analog output should be in a range 0 to 255 (0x0000 to 0x00FF).

Related MODBUS functions

- Write Single Register
- Write Multiple Registers
- Read Holding Registers

3.6 Digital I/O A0..A5

Six digital Inputs/Outputs (I/O) are available on A0..A5 terminals in CoolEx-D45 and CoolEx-D412. I/O are controlled via corresponding coils, discrete inputs, holding register and input register (see [Address Map](#)). Each terminal can be set as output or input independently.



Terminal signal direction (input or output) is determined by last operation on corresponding MODBUS object.

Operation	Output Enable	Terminal Direction	Result
Write Coil to ON/OFF or Holding Register bit to 1/0	1 (Enable)	Output	Set Terminal output to high/low
Read Coil or Holding Register	No Change	No Change	Read Coil Value
Read Discrete Input or Input Register	0 (Disabled)	Input	Read input signal level

4 Specification

4.1 Electrical Characteristics

Parameter	Symbol	Conditions	Value			Units
			Min	Typ	Max	
Analog Outputs A0..A5 (CoolEx-A45, CoolEx-A412)						
Analog Output Voltage	Va		0		10	V
Precision				0.3		V
Max Analog Output Current*	Ia	Source, Vout=2V, Ta=25°C	20	40		mA
Short Circuit to Ground*		Continuous, Ta=25°C		40	60	mA
ESD Tolerance		Human body model, 1.5 k in series with 100 pF.		250		V
* The sum of all Ia on A0..A5 should not exceed 100mA						
Digital or PWM Outputs D0..D5						
Output Low Voltage			0		0.3	V
Output High Voltage		CoolEx-xx5 CoolEx-xx12		5 12		V
Output High Current (source)		CoolEx-xx5 CoolEx-xx12		5 12		mA
Output Low Current (sink)					100	mA
PWM Outputs D0..D5						
Frequency	Fpwm		0,076		5000	Hz
Duty Cycle		Fpwm < 50Hz	0		100	%
Step				200		µS
Digital Input/Outputs A0..A5 (CoolEx-D45, CoolEx-D412)						
Output Low Voltage		Iol = 20 mA			0.5	V
Output High Voltage		Ioh = 20mA	4.2			V
Output High Current (source)	Ioh				20	mA
Output Low Current (sink)	Iol				20	mA
Input Low Voltage			-0.5		1	V
Input High Voltage			3		5.5	V
Input Leakage Current					1	µA