ARTIQ
Sinara

2238 MCX-TTL

Features

- 16 MCX-TTL channels
- Input and output capable
- No galvanic isolation
- High speed and low jitter
- MCX connectors

Applications

- Photon counting
- External equipment trigger
- Optical shutter control

General Description

The 2238 MCX-TTL card is a 4hp EEM module. It adds general-purpose digital I/O capabilities to carrier cards such as 1124 Kasli and 1125 Kasli-SoC.

Each card provides four banks of four digital channels each for a total of sixteen digital channels, with MCX connectors in the front panel, controlled through two EEM connectors. Each individual EEM connector controls two banks independently. Single EEM operation is possible. The direction (input or output) of each bank can be selected using DIP switches, and applies to all four channels of the bank.

Each channel supports 50Ω terminations individually controllable using DIP switches. This card can achieve higher speed and lower jitter than the isolated 2118/2128 BNC/SMA-TTL cards.

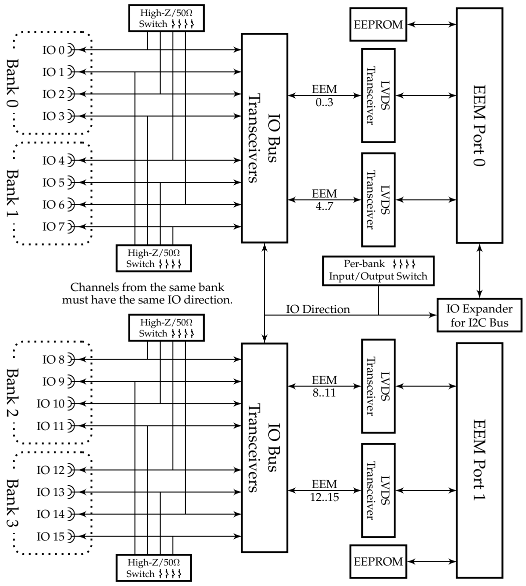

Figure 1: Simplified Block Diagram

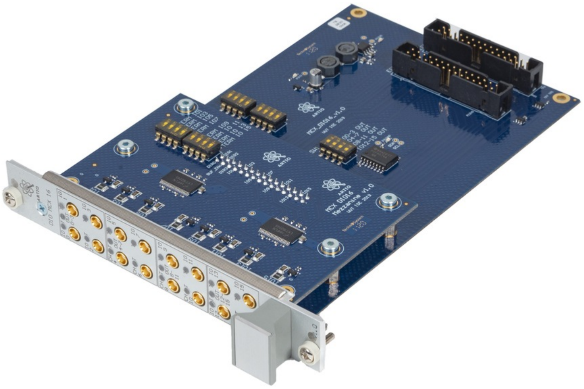

Figure 2: MCX-TTL card

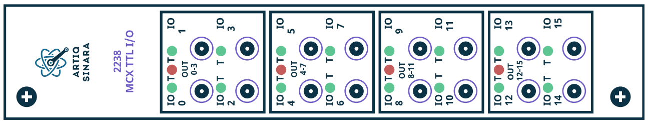

Figure 3: MCX-TTL front panel

Source

2238 MCX-TTL, like all the Sinara hardware family, is open-source hardware, and design files (schematics, PCB layouts, BOMs) can be found in detail at the repository https://github.com/sinara-hw/DIO_MCX/wiki.

Electrical Specifications

All specifications are in $-40°C \leq T_A \leq 85°C$ unless otherwise noted. Information in this section is based on the datasheet of the bus transceiver IC (74LVT162245MTD[1]).

Table 1: Recommended Operating Conditions

Parameter	Min.	Typ.	Max.	Unit	Conditions
Input voltage	0		5.5*	V	
High-level output current			-24	mA	
Low-level output current			24	mA	
Input edge rate			10	ns/V	$0.8V \leq V_I \leq 2.0V$

*With the 50Ω termination enabled, the input voltage should not exceed 5V.

Table 2: Electrical Characteristics

Parameter	Min.	Typ.	Max.	Unit	Conditions
Input clamp diode voltage			-1.2	V	$I_I = -36mA$
Input high voltage	2.0			V	
Input low voltage			0.8	V	
Output high voltage	2.0			V	$I_{OH} = -24mA$
	3.1			V	$I_{OH} = -200\mu A$
Output low voltage			0.8	V	$I_{OL} = -24mA$
			0.2	V	$I_{OL} = -200\mu A$
Input current			20	µA	$V_I = 5.5V$
			2	µA	$V_I = 3.3V$
			-10	µA	$V_I = 0V$

[1] https://www.onsemi.com/pdf/datasheet/74lvt162245-d.pdf

Configuring IO Direction & Termination

IO direction and termination must be configured by switches. The termination switches are found at the top and the IO direction switches at the middle of the card respectively.

Termination switches between high impedence (OFF) and 50Ω (ON). Note that termination switches are by-channel but IO direction switches are by-bank.

- IO direction switch closed (`ON`)
  Fixes the corresponding bank to output. The IO direction cannot be changed by I^{2}C.
- IO direction switch open (OFF)
  The corresponding bank is set to input by default. IO direction *can* be changed by I^{2}C.

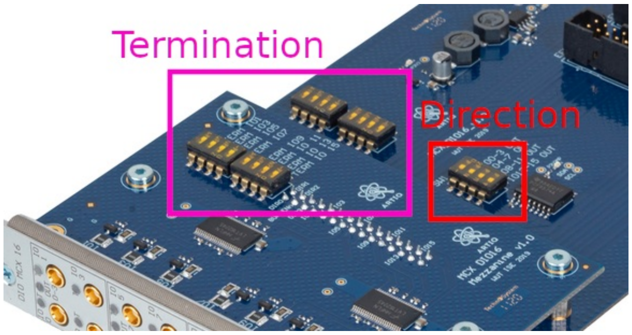

Figure 4: Position of switches

Example ARTIQ Code

The sections below demonstrate simple usage scenarios of extensions on the ARTIQ control system. These extensions make use of the resources of the 2238 MCX-TTL card. They do not exhaustively demonstrate all the features of the ARTIQ system.

The full documentation for ARTIQ software and gateware, including guides for their use, is available at https://m-labs.hk/artiq/manual/. Please consult the manual for details and reference material of the functions and structures used here.

Timing accuracy in these examples is well under 1 nanosecond thanks to ARTIQ RTIO infrastructure.

One pulse per second

The channel should be configured as output in both the gateware and hardware.

```
@kernel
def run(self):
    self.core.reset()
    while True:
        self.ttl0.pulse(500*ms)
        delay(500*ms)
```

Morse code

This example demonstrates some basic algorithmic features of the ARTIQ-Python language.

```
def prepare(self):
    # As of ARTIQ-6, the ARTIQ compiler has limited string handling
    # capabilities, so we pass a list of integers instead.
    message = ".- .-. - .. --.-"
    self.commands = [{".": 1, "-": 2, " ": 3}[c] for c in message]

@kernel
def run(self):
    self.core.reset()
    for cmd in self.commands:
        if cmd == 1:
            self.led.pulse(100*ms)
            delay(100*ms)
        if cmd == 2:
            self.led.pulse(300*ms)
            delay(100*ms)
        if cmd == 3:
            delay(700*ms)
```

Edge counting in an 1ms window

The channel should be configured as input in both gateware and hardware.

```
@kernel
def run(self):
    self.core.reset()
    gate_end_mu = self.ttl0.gate_rising(1*ms)
    counts = self.ttl0.count(gate_end_mu)
    print(counts)
```

This example code uses the software counter, which has a maximum count rate of approximately 1 million events per second. If the gateware counter is enabled on the TTL channel, it can typically count up to 125 million events per second:

```
@kernel
def run(self):
    self.core.reset()
    delay(6*ns)             # Coarse RTIO period: 0 - 7  ns
    self.ttl0.pulse(3*ns)   # Coarse RTIO period: 8 - 15 ns
```

Responding to an external trigger

One channel needs to be configured as input, and the other as output.

```
    self.core.reset()
    self.ttl0.set(62.5*MHz)
```

Ordering Information

To order, please visit https://m-labs.hk and choose 2238 MCX-TTL in the ARTIQ/Sinara hardware selection tool. Cards can be ordered as part of a fully-featured ARTIQ/Sinara crate or standalone through the 'Spare cards' option. Otherwise, orders can also be made by writing directly to mailto:sales@m-labs.hk.

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