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## **RasMux (v2)**

**The on chamber multiplexer for the  
RasNik alignment system.**

**The RasMux (version 2) is one of the multiplexers within the RasNik alignment system. It switches a maximum of 8 RasCams and 16 RasLeds. Together with the MasterMux and the USA15Mux it forms the multiplexing system for the alignment system within the barrel muon detector and the associated alignment systems in ATLAS.**

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## Introduction

The basic idea is to create an image of a coded mask on an optical sensor by means of a lens. The mask is lit by infrared LEDs. In this set up the relative position in X and Y direction is measured along the line mask, optical center of the lens and the sensor. Also the (relative) rotation of the mask or the sensor can be measured. By calculating the actual image spot size and comparing this with the mask spot size, the position of the lens along the Z-axis is calculated. Also the relative rotation around the X and Y-axis of the mask in respect to the CCD sensor can be calculated.

The system can be split into three major components

1. The optical system:

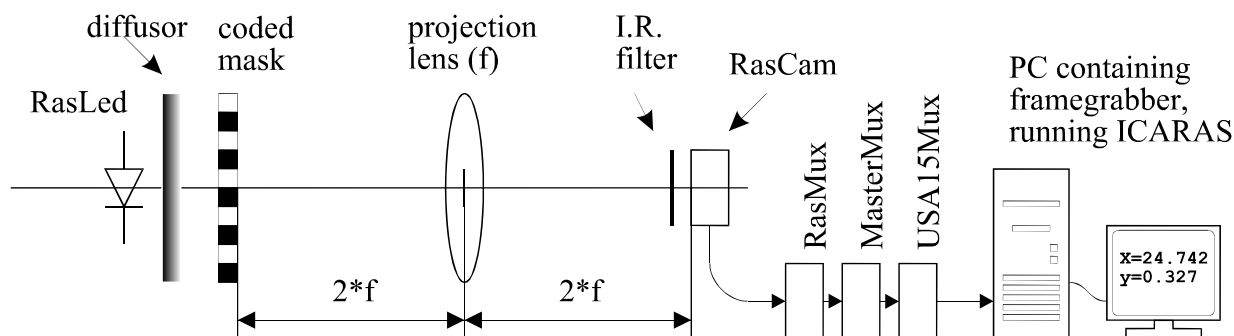
- a coded mask
- a lens
- an optical sensor

2. The sensor and framegrabber combination (video):

The optical sensor is a commercially available B&W observation camera, without a lens. This can be a CCD type or CMOS.

The framegrabber is a commercially available 8 bit grayvalue type E.G. Data Translation DT3152. Three levels of multiplexers connect one of the sensors (more than 6000 in total) to the framegrabber.

3. The reconstruction software ICARAS.



**Figure 1: Alignment system**

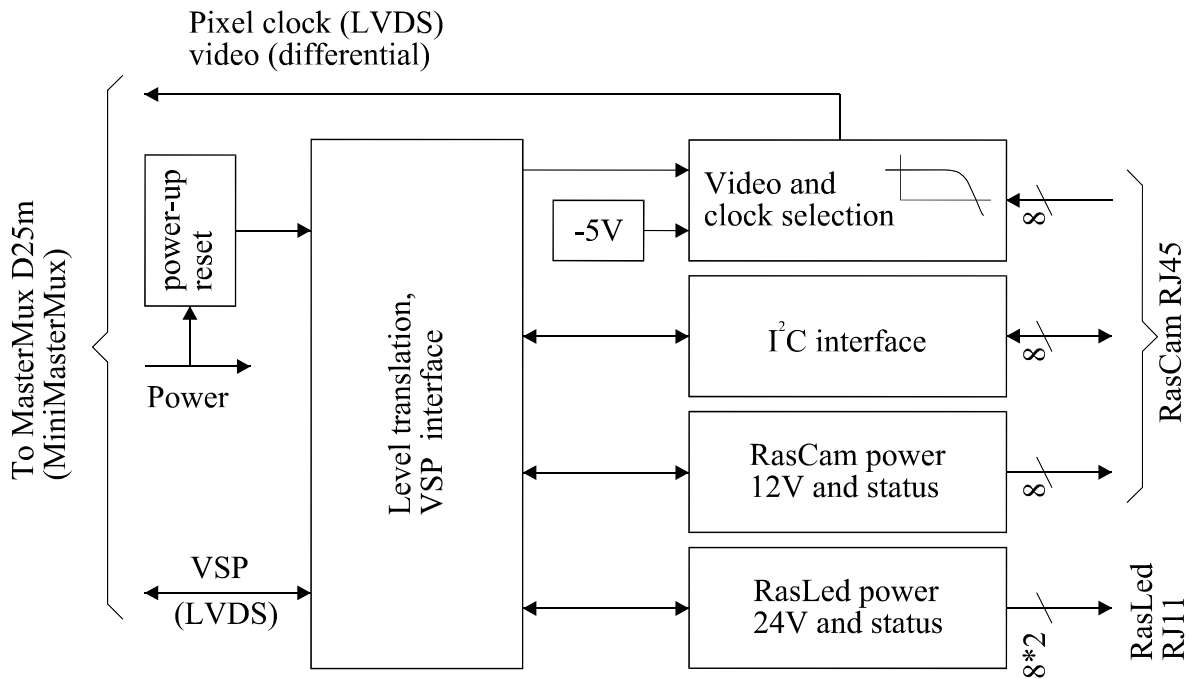
This paper describes the RasMux (RasNik multiplexer), which connects a number of RasCams and RasLeds to the framegrabber. Here the 8 cm wide version is described, not the older 16 cm version. Please note that these are **not** compatible. Two more stages of multiplexing are needed for the full system; the MasterMux and the USA15Mux. In the prototyping stage the MiniMasterMux will be used, which connects up to 4 RasMuxes to a framegrabber. The framegrabber digitizes the picture and the IcaRas software cycles through the total system and analyses the pictures.

The RasMuxes are mounted on the longbeam of the barrel muon chamber and a few other convenient places for non-chamber alignment systems.

A maximum of 16 RasLeds can be connected, always two are switched on at the same time. A maximum of 8 RasCams can be connected of which just one can be switched on. The video and pixel clock signal from the active RasCam are transmitted to the output. It is also possible that only a RasCam or a RasLed is switched on for a particular RasMux.

Commands are given using a differential JTAG-like interface port. Status can be read via the same interface.

**Specifications:**



**Figure 2: Block diagram**

Only one RasCam can be switched on at the time. One RasLed driver powers two connectors. The transient output filters are separate, so the effect of connecting a second RasLed to an output is small.

The video standard used is CCIR. The video signals from the sensors are semi differential. The signals are filtered individually on the input of the RasMux. One of the video signals is selected together with the clock signal. The output to the MasterMux is fully differential.

The clock from the RasCams uses LVDS (Low Voltage Differential Signaling) levels. The same levels are used for the communication between the RasMux and MasterMux (or MiniMasterMux).

The RasMux converts the signals from the MasterMux into I<sup>2</sup>C signals to control or read settings of the RasCam (see also page 9). These signals are similar to open collector TTL signals and, by I<sup>2</sup>C definition, not symmetrical.

Length of the cable between RasMux and RasCam is limited to 20 m.

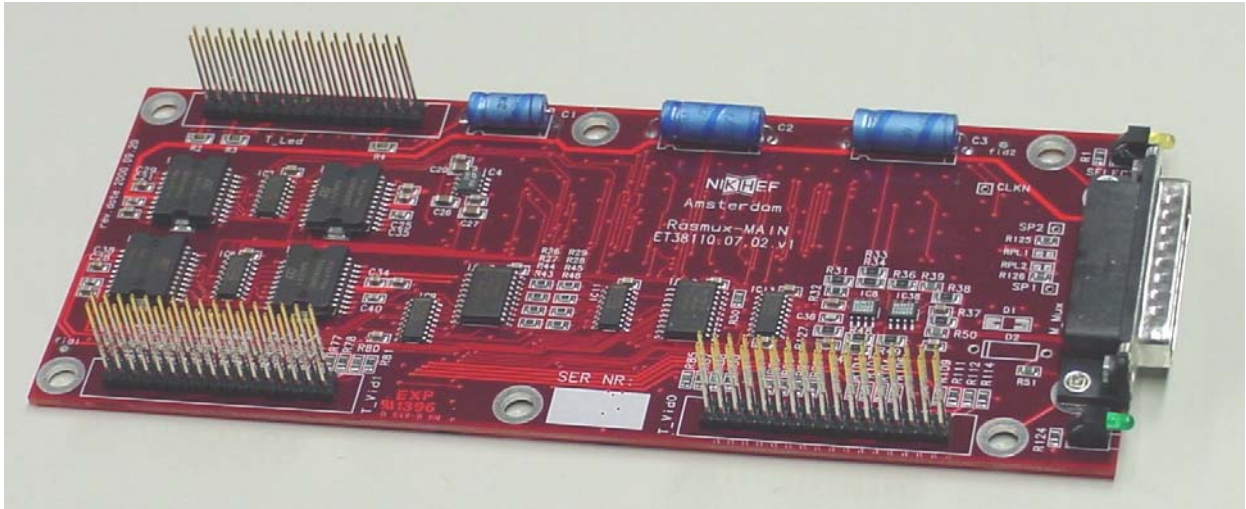
<b>RasCam connections (RJ45 connector)</b>	
<b>Pin</b>	<b>Function</b>
1	SDA: The data signal of the I <sup>2</sup> C bus.
2	+12 V power supply (switched).
3	+Video input.
4	+Pixel clock input.
5	-Pixel clock input.
6	-Video input.
7	Ground, 0 V
8	SCL: The clock signal of the I <sup>2</sup> C bus.
Case	The shield of the cable is connected to RasMux housing and ground. In the RasCam V2 (production) shield is connected to ground (in V1: via 10 k $\Omega$ .) The mounting holes of the RasMux are isolated from ground.

<b>RasLed connections (RJ11 connector)</b>	
<b>Pin</b>	<b>Function</b>
1	Ground, 0 V.
2	+24 V (switched).
3	Ground, 0 V.
4	Ground, 0 V.

<b>MasterMux connections (D25 male connector)</b>		
<b>Pin</b>	<b>Function</b>	
1	Shield.	
16	+24 V.	
21	+12 V.	
11, 23	+5 V.	
4, 9, 13, 25	Ground, 0 V.	
<b>Pos.</b>	<b>Neg.</b>	Note: All active signals are differential.
14	2	Video out, differential 1V.
15	3	TCK.
17	5	TMS.
18	6	TDI (serial data to the RasMux).
19	7	TDO (serial data from the RasMux).
20	8	V2: Spare pair to the RasMux, LVDS. Normally ground. V3: ground.
22	10	Pixel clock, LVDS.
24	12	Loop for detection of RasMux by MasterMux.

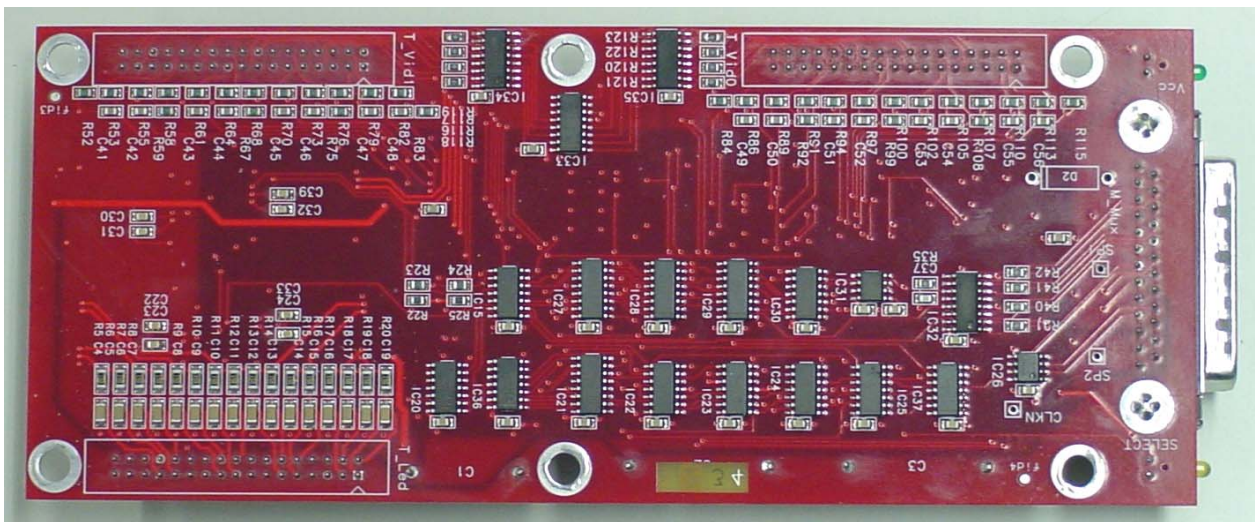
The module requires three supply voltages, which are supplied by the MasterMux. If the RasMux is not needed for the RasLed and/ or RasCam selected in the total system, it is completely switched off. When it is disconnected from the MasterMux while in operation, power is removed too. For details see page 9.

## Inside the RasMux



**Figure 3: Main board**

Top of the board contains the power-switches and associated circuitry, the negative supply generator (analog switches and Op-Amps) and the differential video amplifier.



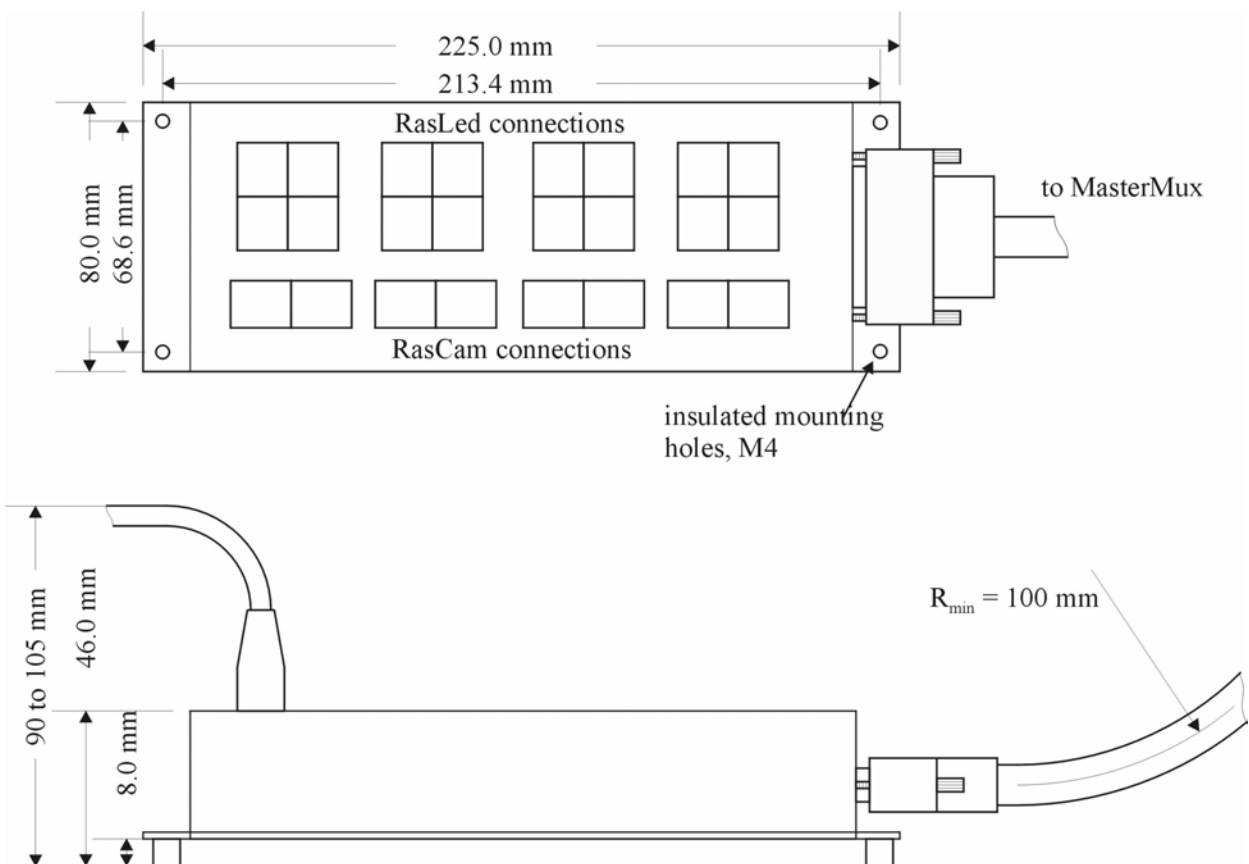
**Figure 4: Main board, bottom**

On top of the picture one sees the video and clock multiplexers. The two rows of chips contain the VSP interface, level converters, voltage supervisor and clock-driver.



**Figure 5: Prototype RasMux**

The total height of the RasMux is determined by the fact that there are three printed circuits stacked in the box. One contains the active electronics and sits in the middle. On top of that there is the connector board, which contains passive components only. Beneath the active board is a shielding board, which is also used to mount the complete assembly insulated from the environment.



**Figure 6: Dimensions**

## VSP

For the serial protocol to communicate with the MasterMux a simple standard has been defined (Very Simple Protocol). The electrical implementation is fully differential (LVDS). All lines are uni-directional and terminated at the receiving end. The interface is used to control the power supplies of the sensors (RasCam) and LEDs (RasLed) and to send commands or read settings of the sensors. RasMux translates the MasterMux commands to the I<sup>2</sup>C protocol understood by the sensors and translates the sensors' response back to LVDS.

A more detailed description of the protocol can be found in the (Mini)MasterMux description. The RasMux recognizes address 0001 and has one eight bit command register. When this is written to, a ten bit status is returned. The address points to a level in the multiplexing scheme, RasMux selection is done by the MasterMux (data send to the MasterMux).

VSP input register		
Bits	Name	Bits
0	LDE	Enable LED power
1	LD2	LED selection
2	LD1	
3	LD0	
4	CAE	Enable camera power
5	CA2	Camera selection
6	CA1	
7	CA0	

VSP output register		
Bits	Name	Bits
-1	*ACK	Address acknowledge
0	LDS	Status LED driver
1	LD2	LED selection
2	LD1	
3	LD0	
4	CAS	Status camera driver
5	CA2	Camera selection
6	CA1	
7	CA0	
8	PUR	Power up reset
*: Address acknowledge is active low		

## Power

The internal RasMux logic consumes 80 mA from the 5 V supply. The 12 V is used for the RasCam, which consumes 100 mA, including 12 mA for the I<sup>2</sup>C pull-ups (located on the RasMux). The RasLeds are connected to the 24 V, taking 70 mA. There may be two RasLeds, channel A and B, connected to one driver. Thus reducing the amount of bits and electronics.

The power switches for the RasCam and RasLed limit the current to 800 mA in short circuit condition. If a an overload condition –more than 500 mA- persists for 2 ms, the power is switched off. This is indicated by the status bit. The first version of the RasMux only indicates the problem by a status bit, but continuously tries to power up the component again. In version 2, power is switched off until it explicitly switched on again by the external control program. In addition the power consumption is monitored in the USA15Mux (MiniMasterMux), where lower limits can be set. The speed of this process is varies however.

The power-up reset bit is set at power up and reset by the end of a VSP cycle. So in the next cycle it should be reset.

## I<sup>2</sup>C

When a sensor is switched on, its I<sup>2</sup>C bus is connected to the VSP bus. Parameters inside the RasCam can be changed or read. The RasMux does only the electrical translation. It is a minimal implementation of the I<sup>2</sup>C protocol. This means that SCL, the clock signal, can only be send by the RasMux. The RasCam is not capable of generating SCL. SDA is bi-directional. The pull-ups for both lines are located on the RasMux and activated for the RasCam that has been switched on only.

A detailed description of the various settings and status bits of the RasCam can be found in the MiniMasterMux description.