xMove

Sahara Hardware Design Specifikation

Contents

1 General Information

This document gives a description of the electronic components and the functionality of the two Relay cards designed for the X-move product line.

1.1 Document history

Issue	Date	Issued by	Status	Comments
A	2007-05-09	Joakim Östberg	Approved	First issue
B	2007-05-10	Joakim Östberg	Approved	Added info about the crystal in chapter 4.2.1.

1.2 Document status

Document is complete.

1.3 References

Ref	Document ID	Issue

1.4 Terminology

Term	Explanation

2 Introduction

2.1 Purpose

Two relay cards were designed to handle different currents in a test environment in the product line xMove. These two cards can be used to simulate loads and collect data from ECU boxes and other electronic equipment.

2.2 Scope

The scope for this part of the Andree project was to design two relay cards is with a maximum current throughput of 2 and 15 Ampere. The 2A card is named Sahara 2-16 and the 15A card is named Sahara 15-8. These cards will be used to sniff on the signals from the ECU box, as well as manipulate the signal. The relay cards have four relays which can short cut the signal to ground or battery voltage as well as brake the communication and chose between two different loads. The Sahara 2-16 can handle 16 channels simultaneously while the more robust Sahara 15-8 can handle 8 channels simultaneously.

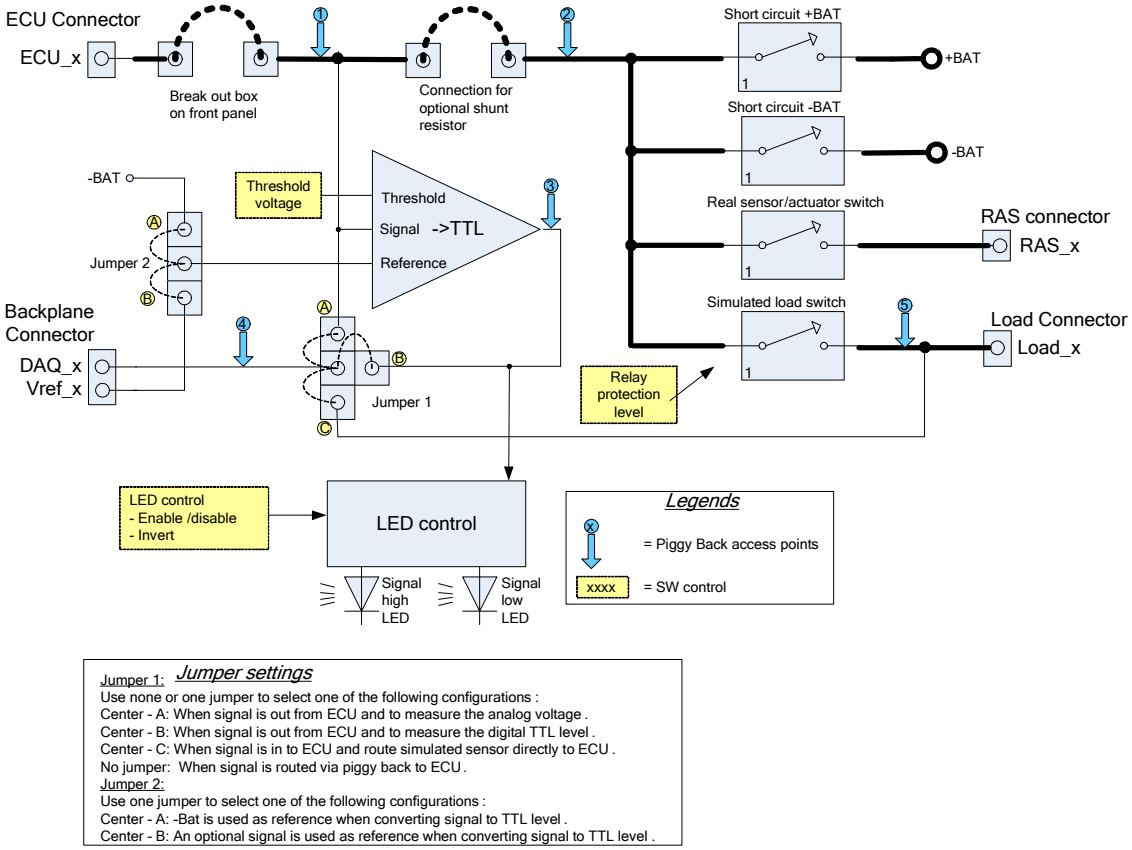

Figure 1 Function available for each Channel on the Sahara card

3 Hardware overview

Figure 2 The Sahara 2-16 relay card

The two designs are built by seven blocks, see Figure 3 Blocks in the Sahara Design. The fist block (the control block) contains the microcontroller and some close logic to communicate with a computer. The second block (the channel reference block) creates a galvanic isolation of the reference signal for each channel in the third block (the channels block). The third block contains the eight or sixteen galvanic separated channels to be measured and feedback data for each channel to the first block. The third block also contains the relays that are controlled by the fourth block (the ralay control block). The fourth block contains the drivers for the relays and is controlled by the first block (the control block). The fifth block (the power block) will manage the different types of supply voltages on the card and the sixth block contains all the connectors for the design. Block seven will process the LEDs and is controlled by the first block (the control block). In addition to the seven blocks it will be possible to connect a Piggy back card to add some special features to the design.

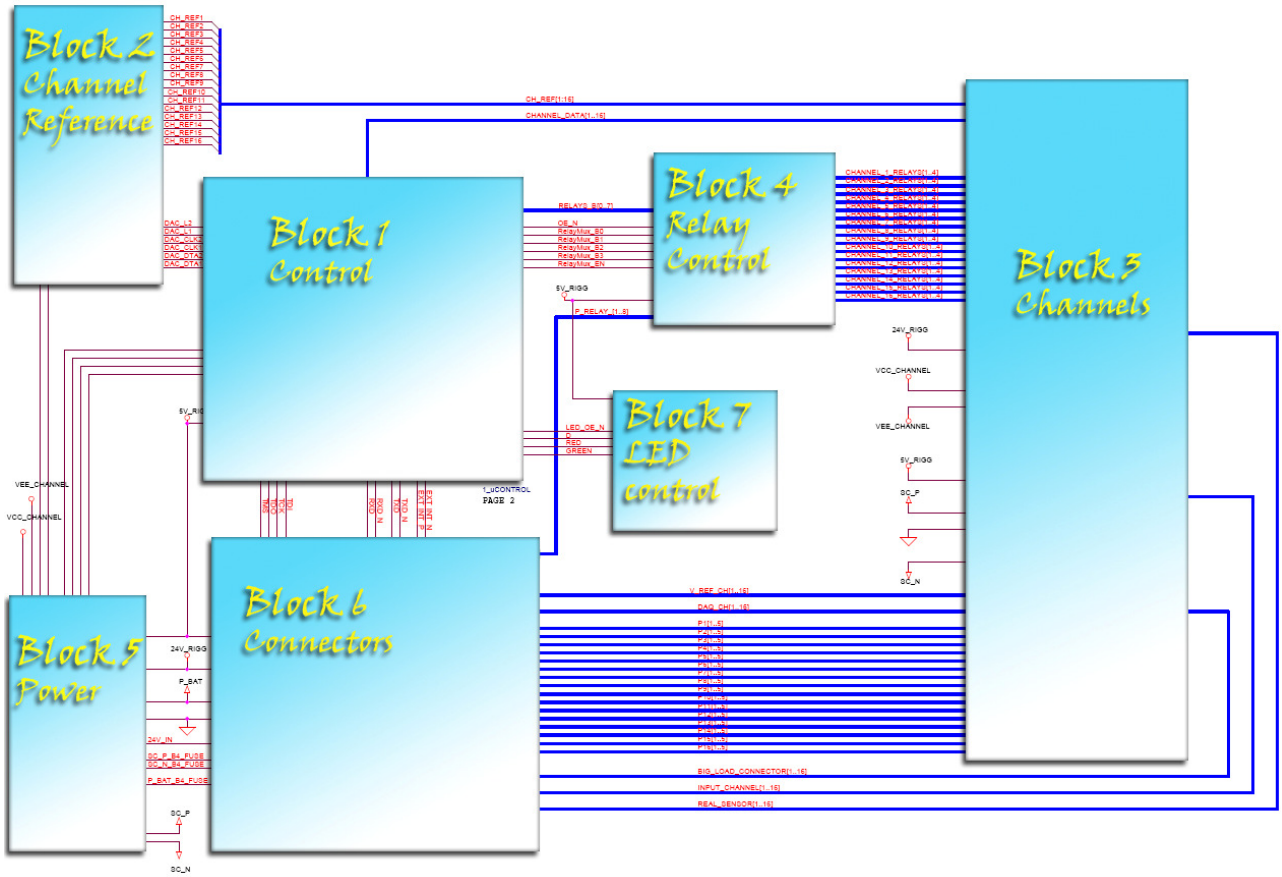

Figure 3 Blocks in the Sahara Design

4 Hardware design

4.1 Major functional blocks

4.1.1 Block 1: The Control block

The microcontroller in the first block is connected to eight or sixteen inputs from the channel block (block 3). These inputs are galvanically separated from the ground plane that the signals in channels are referred to. A RS485 driver and two RS485 receivers are also included in the control block. The first of these chips is for UART communication and the second for receiving interrupt signals from the main computer.

4.1.1.1 Outputs:

- 2 wires of Tx-data for the RS485 communication link.
- 8 bits to control the Relays in the Relay Control block
- 3 or 4 data bits to set which Relay source driver to program with the 8 bits for Relay control.
- 1 enable bit to enable the multiplexer that handles the address bits for the relays.
- One output enable (OE) signal to secure relay position at start-up.
- 4 serial lines for serial programming of the LED drivers in the LED Control block.
- 3 or 6 serial lines to the optocouplers in the Channel Reference block.
- 1 TDO bit for the JTAG intefrface.

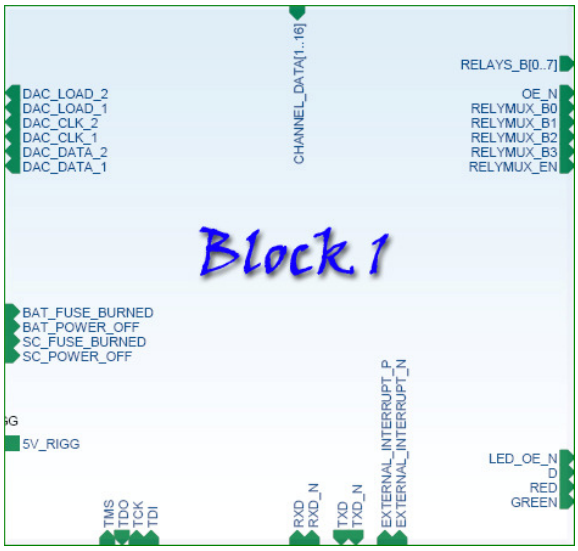

Figure 4 Block 1

4.1.1.2 Inputs:

- 2 wires of Rx-data for the RS485 communication link.
- 2 wires for the interrupt signal that is transferred in a RS485 communication link.
- 2 wires for the interrupt signal set by a burned fuse.
- Collected data from the Channels block will be received by the 8 or 16 channel data inputs.
- 3 bits for JTAG interface: TMS, TCK and TDI.

4.1.1.3 Power:

- 5V DC in

4.1.2 Block 2: The Channel Reference block

The Channel reference signal is a compare signal for each of the channels. This reference signal is used to set the threshold level for the analog-to-digital conversion circuit for each channel, see Figure 1. The channel reference block (Block 2) contains three or six optocouplers to transfer three or six serial signals to one or two latched DACs. The outputs from the channel references block are galvanically isolated from the rig ground and is used as threshold signals in the Channels block (block 3).

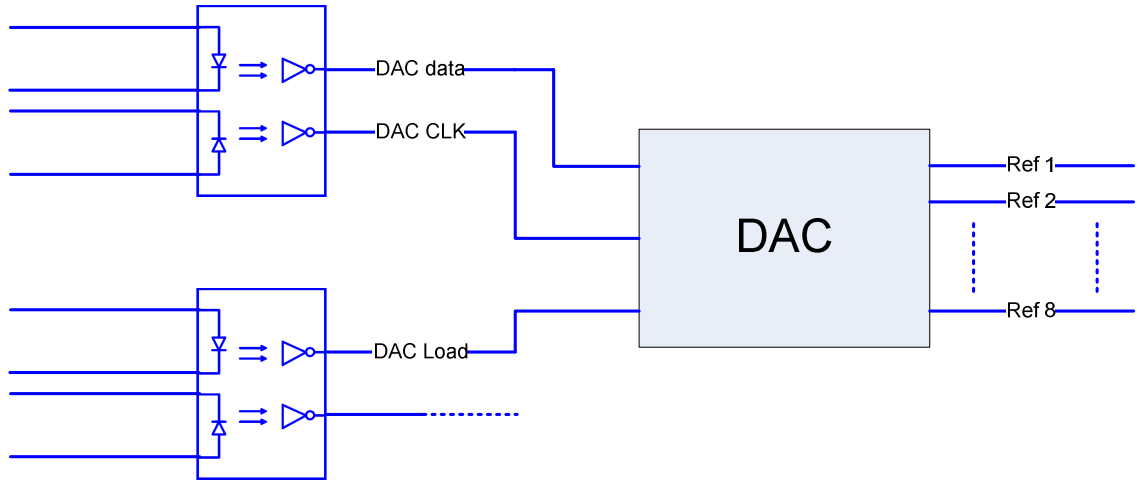

Figure 5

4.1.2.1 Outputs:

- 8 or 16 Reference signals to the Channels block to set threshold of digital conversion.

4.1.2.2 Inputs:

- 3 or 6 serial lines from the microcontroller in the Controller block.

4.1.2.3 Power:

- One 2.5V DC referred to -Bat
- One 5V DC referred to -Bat

Figure 6 Block 2

4.1.3 Block 3: The Channels block

The Channels block contains eight or sixteen channels, depending on how big the currents trough each channel is. The 15A version of the channel block will contain 8 channels. The channels are galvanically isolated from the ground of the rig and the rest of the relay card. This allows the channels to have the same ground plane as the ECU box to be tested.
Each channel contains four relays to simulate shortcuts, broken connections and to choose output of the signal to be tested. The voltage level of the signal is measured by a simple circuit that converts it to a digital signal with a 1-bit resolution. The measured signal is transformed to the rig power plane with some optocouplers before entering the first block. The Channels block also has between 40 or 80 connections to the Piggy back card and an output to the DAQ equipment in the test-rig.

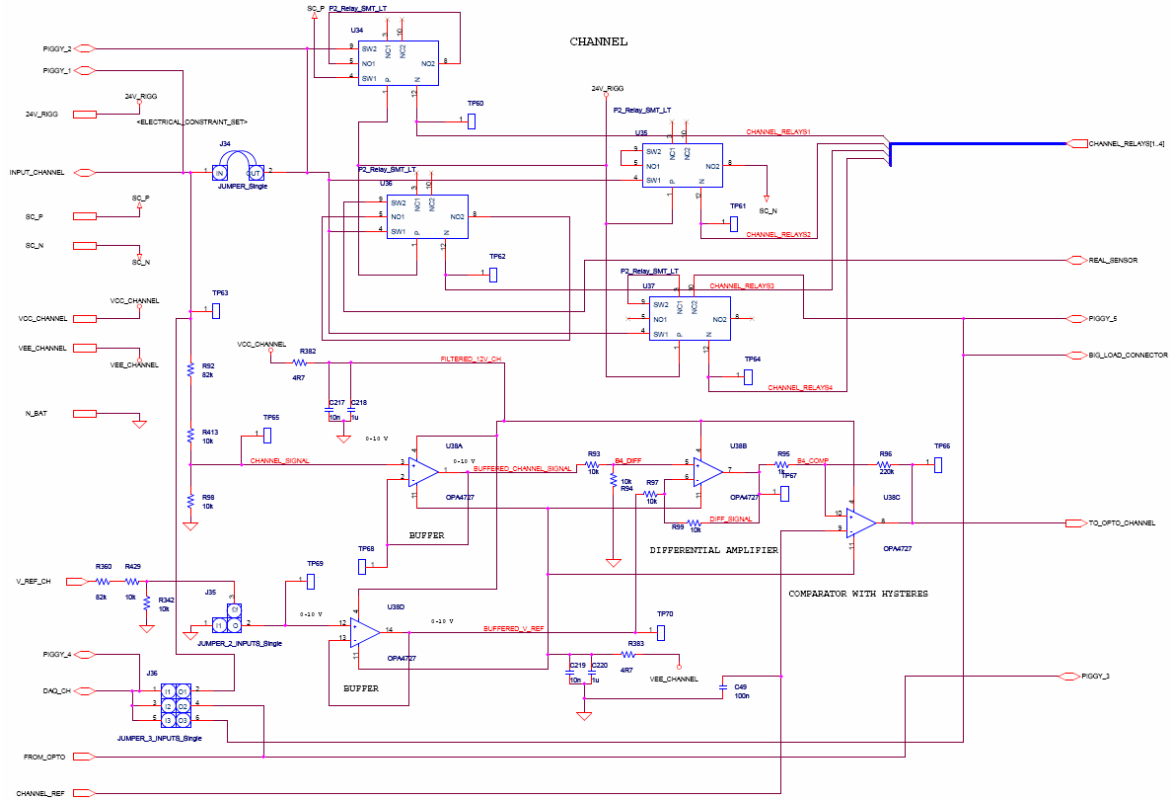

Figure 7 A channel in the Channels block

4.1.3.1 Bidirectional ports:

- 8 or 16 outputs to a Real Sensor.
- 8 or 16 outputs to a Big Load Connector.
- 40 or 80 Piggy back connections.
- 8 or 16 DAQ connections.
- 8 or 16 inputs from the ECU box.

4.1.3.2 Outputs:

- 8 or 16 digital signals representing the channel with a 1-bit resolution is transmitted to the microcontroller in the Control block

4.1.3.3 Inputs:

- 32 or 64 relay-driving signals from the Relay Control block.
- 8 or 16 Channel Reference signals are received from the Channel Reference block to determine threshold for A/D conversion.
- 8 or 16 Voltage References are received to refer signals to a certain voltage instead of negative battery voltage.

4.1.3.4 Power

- 24V DC in
- 5V DC in
- 12V DC referred to –Bat
- -Bat
- +Short Circuit (SC_P)
- -Short Circuit (SC_N)

Figure 8

4.1.4 Block 4: The Relay Control block

The Relay Control block contains five or nine latched drivers for the relays and a multiplexer to select which driver circuit to be updated by the microcontroller. The fifth or ninth driver is for external relays on the Piggy Back card.

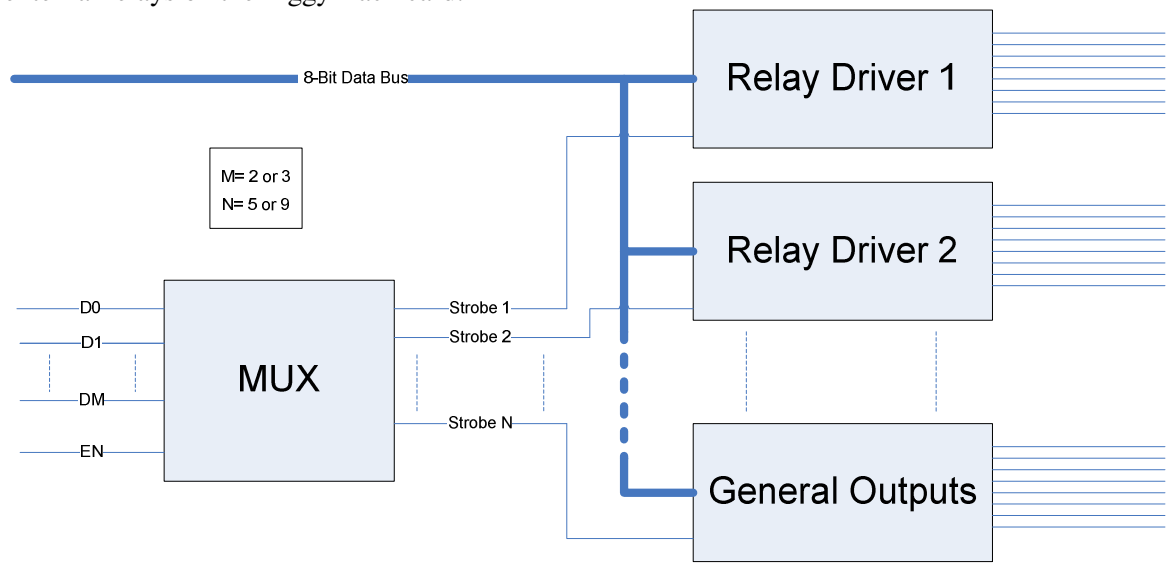

Figure 9

4.1.4.1 Outputs:

- 4 driver signals for the four relays on each channel in the Channels block.
- One output bus for driving eight external relay on the piggy back card (P_RELAY).

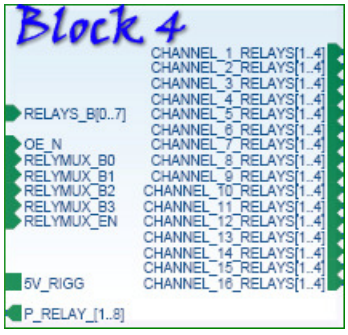

Figure 10

4.1.4.2 Inputs:

- 8 bits to control the Relays from the Control block
- 3 or 4 bits to set which relay driver to control with the 8 relay control bits.
- 1 enable signal to enable multiplexer for the address bits.
- 1 Output enable signal to enable/disable output on relay drivers.

4.1.4.3 Power

- 24V DC in
- 5V DC in

4.1.5 Block 5: The Power Management block

The relay card is supplied by a 24V test-rig voltage, positive battery voltage and negative battery voltage as well as a positive and negative Short Circuit power. To supply the microprocessor and other logic on the "test-rig"-part of Relay card a downconverter is used for 5V supply voltage. A DC-DC-converter is used to create 12V relative to negative battery voltage on the galvanically separated channels on the relay card. The power management block does also contain a downconverter to convert the 12V relative to negative battery to 5V and 2.5V relative to negative battery. The Power Management block does also contain 3 fuses to protect the relay-card against over-currents due to short cuts. The Fuse supervision receives the voltage level before and after the fuse. If the voltage level is below 4 V the optocouplers on the output of the low-power LDOs will switch mode, and a Voltage failure will be detected on the micro-controller. Both the battery voltage and the Short Circuit voltage are controlled by a fuse supervision circuit. On the Short Circuit voltage it is possible to disable the fuse supervision.

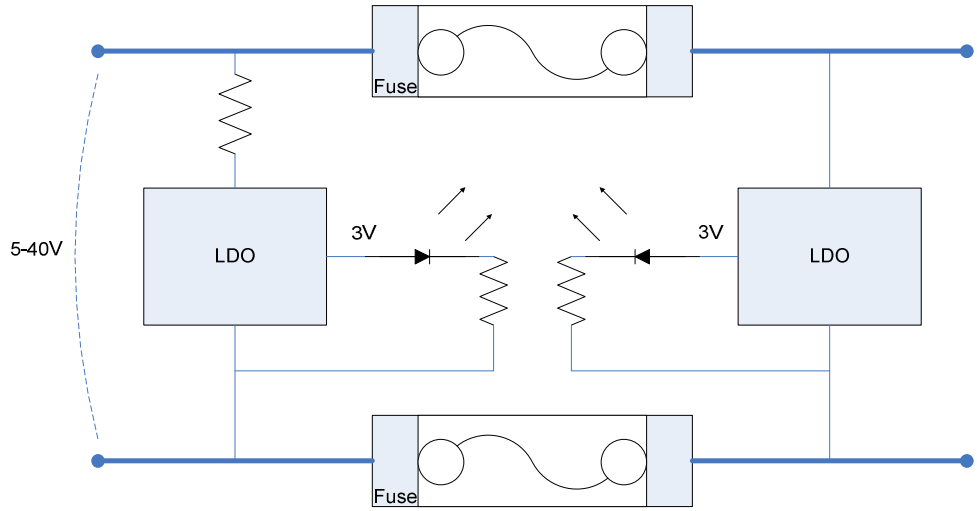

Figure 11 Fuse supervision circuit

4.1.5.1 Outputs:

- 2 fuse voltage levels for Short Circuit
- 2 fuse voltage levels for Battery

4.1.5.2 Power

- 5V DC Out
- 24V DC Out
- 2.5V DC Referred to -Bat
- 5V DC Referred to -Bat
- 12V DC Referred to -Bat
- +Short Circuit in before fuses
- -Short Circuit in before fuses
- +Short Circuit out after fuses
- -Short Circuit out after fuses
- +Bat Circuit in before fuses
- -Bat Circuit in before fuses
- +Bat
- -Bat

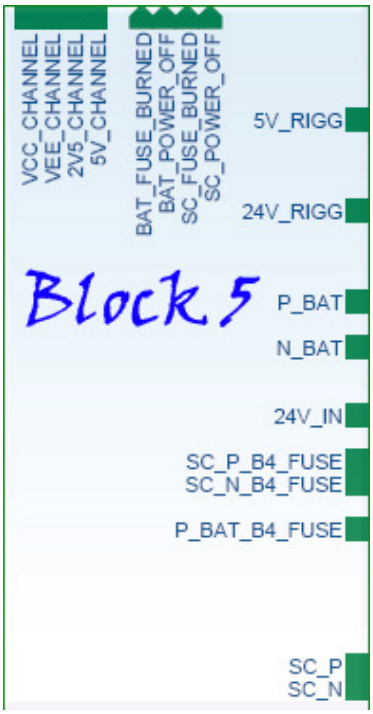

Figure 12

- 5V DC Referred to –Short Circuit
- 24V DC in

4.1.6 Block 6: The Connectors block

The connectors block contains all the connectors of the relay card. The Connectors block contains one 96-pin connector to connect the relay card in the backplane of the interface box, one JTAG connection and three wired connectors to connect to simulated loads, real loads and inputs of the ECU boxes. It also contains 120 Piggy back connections to equip the Sahara card with a special feature Piggy Back card. The input to each channel may be broken with an extra connector, the Break Out Panel (BOP) on the front of the card.

4.1.6.1 Bidirectional ports:

- 40 or 80 piggy back connections
- 8 or 16 pins for the Big load connector
- 8 or 16 pins for the Input channel
- 8 or 16 pins for the Real sensor
- 8 or 16 pins for the DAQ

4.1.6.2 Outputs:

- 2 pins for RXD
- 2 pins for External interrupts
- 8 or 16 pins for Voltage reference
- 3 JTAG pins, TMS, TCK and TDI

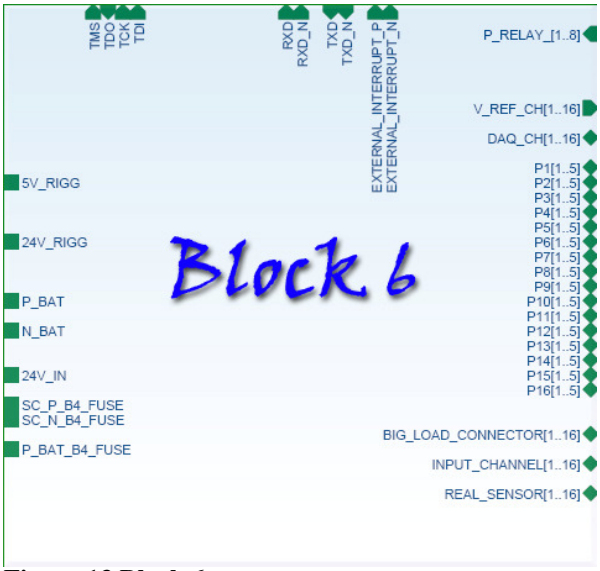

Figure 13 Block 6

4.1.6.3 Inputs:

- 2 pins for TXD
- 8 pins for external relays on piggy back
- 1 pin for TDO in JTAG connection
- 4 signals to control the LEDs (D, CP, STR and E0)

4.1.6.4 Power

- 5V DC in
- 24V DC out (24V_IN)
- 24V DC in (24V_RIGG)
- +Bat
- -Bat
- +Short Circuit in before fuses
- -Short Circuit in before fuses
- +Bat Circuit in before fuses
- -Bat Circuit in before fuses

4.1.7 Block 7: The LED Control block

The eighth block contains two LEDs for each channel on the Relay card and a status led for the whole system. These LEDs are controlled by serially controlled shift-and-store register LED drivers. These LED drivers are controlled by the Microcontroller in the first block.

4.1.7.1 Inputs:

- 4 serial lines from the Control block to control the LED drivers.

4.1.7.2 Power

- 5V DC in

Figure 14 Block 5

4.2 Key components

The key components in this Design are the microcontroller, the relays, the source drivers and latches for the relays, the DC-DC converters for galvanically separated power supply, the Step-down converter for 5V supply, the fast optocouplers for galvanic isolation, fast Operational amplifiers with a wide bandwidth, the DACs for the reference signals and the LED drivers.

4.2.1 The Microcontroller

The microcontroller for this design is an Atmel ATmega 64. The reason for this choice is because it is a cheap microcontroller with a satisfactory number of I/O, UART interface and the ability to work with a 5V power supply. It has been used in other projects in Flextronixs in Gothenburg and has been proven reliable and compilers and debugging equipment is easily accessible. The ATmega64 may be replaced with the ATmega 169 later on in the project. ATmega 169 is a cheaper microcontroller with less memory but with the same footprint and connection pins as the ATmega64. The ATmega64 is run with a 7.372800 Mhz crystal named HC49/4H with low profile from CMAC.

Table 1

Manufacturer	ATMEL
Manufacturer order number	
Part Number	ATMEGA64-16AU
Pertinent spec	http://www.atmel.com/dyn/resources/prod_documents/doc2490.pdf
Temperature grade	-40°C to 85°C
ROHS compatible	Yes
Package parameters	TQFP 64 - Pb-Free (64A surface mounted, 16 x 16 x 1.20 mm, 64 pins)

4.2.2 The Relays

The main differences between the two relay cards are the Relays. The 15A Relay card uses more robust Relays than the 2A Relay card.

4.2.2.1 15A Relay

The Relays used on the Sahara 15-8 card will stand 100 000 operations at 15A and 30V DC. The G2R relays from Omron are PCB power relays. The Sahara 15-8 is equipped with 32 of these on each card.

Table 2

Manufacturer	Omron
Manufacturer order number	G2R-1A-E-24V
Part Number	-
Pertinent spec	http://www.omroncomponents.eu/home/products/Relays/PCBPowerRelays/upto16A/G2R/default.asp
Temperature grade	-40°C to 85°C (with no icing)
ROHS compatible	Yes
Package parameters	G2R high capacity 16A/30VDC

4.2.2.2 2A Relay

The Relays used on the Sahara 2-16 card will stand 100 000 operations at 2A and 30V DC. The P2 relays from Tyco are 2 pole telecom relay relays. The Sahara 2-16 is equipped with 64 of these on each card. Since the relays are 2 pole, each relay contains two switches on each coil and these switches are connected in series to suppress arcs while switching.

Table 3

Manufacturer	Tyco electronics
Manufacturer order number	V23079-G1005-B301
Part Number	7-1393788-8
Pertinent spec	
Temperature grade	-40°C to 85°C (with no icing)
ROHS compatible	Yes
Package parameters	P2 SMT, short pins, non-latching, standard coil

4.2.3 The Source Drivers

Booth types of relays are driven by Darlington Transistor Array. The power outputs are bipolar npn Darlingtons and the maximum drive current is 500mA.

Table 4

Manufacturer	Texas Instruments
Manufacturer order number	
Part Number	ULN2803ADW
Pertinent spec	
Temperature grade	
ROHS compatible	Yes
Package parameters	SO18

4.2.4 The 8-bit Latches

The OCTAL TRANSPARENT D-TYPE latches are used together with the source drivers to buffer the source driver signal.

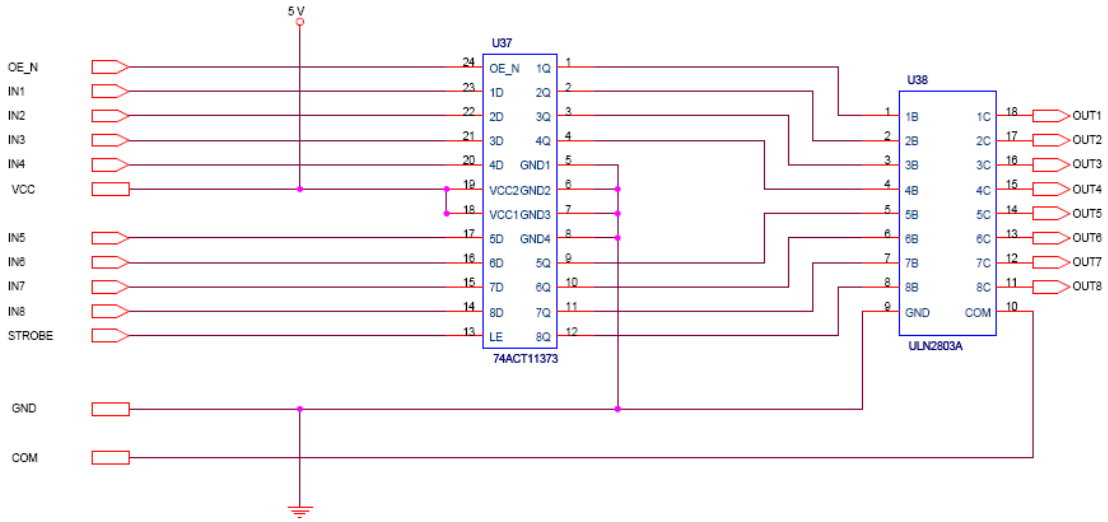

Figure 15 The 8-bit Latch working together with the 8 channel driver.

Table 5

Manufacturer	Texas Instruments
Manufacturer order number	

Part Number	74ACT11373NSR
Pertinent spec	
Temperature grade	-40 to +85°C
ROHS compatible	Yes
Package parameters	SO24

4.2.5 The DC-DC Converters for 12V galvanically isolated supply.

The DC-DC converter will supply the galvanic isolated channels with power and a common ground with the ECU unit. The supply voltage on the channels is 12V and the converter can convert 18-36V to 12V. The Sahara PCB allow two different types of DC-DC converters, either the SC001A2B91 converter or the TEL5 converter from Tracopower

Table 6

Manufacturer	Tyco electronics
Manufacturer order number	108988267
Part Number	SC001A2B91
Pertinent spec	
Temperature grade	–25°C to +75°C
ROHS compatible	Yes
Package parameters	24 V in, 12V out, galvanic isolated

Table 7

Manufacturer	Tracopower
Manufacturer order number	TEL5-2412
Part Number	DC/DC-omv TEL5-2412
Pertinent spec	
Temperature grade	–25°C to +75°C
ROHS compatible	Yes
Package parameters	24 V in, 12V out, galvanic isolated

4.2.6 The Step-down converters for 5V supply.

The LM25010 is used in two places on the Relay card. The LM25010 DC-DC converter will give a steady 5V supply voltage for the integrated circuits on the test-rig side on the relay card as well as for the fuse supervision.

Table 8

Manufacturer	Tyco electronics
Manufacturer order number	LM25010SD
Part Number	LM25010
Pertinent spec	
Temperature grade	-40°C to +85°C
ROHS compatible	Yes
Package parameters	

4.2.7 The Optocouplers

To isolate data measurements from the channels an optocoupler is used. Since the required bandwidth is 10 MHz the optocoupler have to be fast. The HCPL 0630 from Agilent Technologies can transfer data with a speed of 10 Mbit/s.

Table 9

Manufacturer	Agilent Technologies
Manufacturer order number	
Part Number	HCPL-0630
Pertinent spec	http://www.elfa.se/pdf/75/07504392.pdf
Temperature grade	–40°C to +85°C
ROHS compatible	Yes/Will be
Package parameters	SO8

4.2.8 The Operational Amplifiers

Each channel in the design will contain four operational amplifiers. The operational amplifiers has to work with a "single" sided supply of -0.5 to 11.5V and need to have a bandwidth of at least 10 Mhz and rail to rail behaviour. It does also require low input bias currents and a high slew rate. Due to the lack of free space on the Sahara card, the operational amplifier has to be small. An amplifier in a quad package and with low power consumption is therefore preferred. OPA4727 from Texas Instruments is a wide band, low power operational amplifier with rail to rail on the output and 12V single supply capability.

Table 10

Manufacturer	Texas Instruments
Manufacturer order number	OPA4727AIPWR
Part Number	OPA4727AIPWR
Pertinent spec	
Temperature grade	-40°C to +125°C
ROHS compatible	Yes
Package parameters	SO14

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4.2.9 The DACs

The main requirement on the DACs is to require few bits from the microcontroller and to keep the range of values. The output signal from the DAC is used as a reference signal in the A/D conversion for each channel and doesn't require a higher resolution than 8 bits in a 2.5V range. The TLC5628 has eight analog outputs and is programmed by three serial lines.

Table 11

Manufacturer	Texas Instruments
Manufacturer order number	
Part Number	TLC5628IDWR
Pertinent spec	http://focus.ti.com/docs/prod/folders/print/tlc5628.html<
Temperature grade	–40°C to +125°C
ROHS compatible	Yes
Package parameters	SOIC (16)

4.2.10 The LED Drivers

The LED driver to be used is the SN74LV8153. SN74LV8153 is an 8-stage shift-and-store register LED driver with configurable addresses and a capability of 8 LED drivers on one two wire bus.

Table 12

Manufacturer	Texas Instruments
Manufacturer order number	SN74LV8153PW
Part Number	HEF4894BT
Pertinent spec	-
Temperature grade	-40 to 85°C
ROHS compatible	Yes
Package parameters	TSSOP20

4.3 Reset Strategy

The system will be reset from the software or from a reset button on the Sahara card. The UART communication allows the user to reset the microcontroller by decreasing the Watch dog time and enter an eternal loop.

4.4 JTAG chain configuration

The microcontroller can be programmed and analysed trough the JTAG interface.

4.5 Signal Integrity

To minimize noise in the ground plane it is important that the ground plane has a big area around the crystal. All signals that are connected to the channels will have to work in the same ground plane as the battery, while the control part of the relay card work in a ground plane that is connected to the RS485 interface. To separate these two ground planes optocouplers have been used to galvanically isolate the signals.

5 Power analysis

The relay cards are supplied from an external power source in the rack where the card will be placed. Since the channels is galvanically isolated from the rest of the Rely card a DC-DC converter with galvanic isolation between the ground planes is placed on each Rely card.

5.1 Power requirements

The four power sources on a Sahara relay cars is 24V and 5V referred to rig ground and 12V and 5V referred to Battery ground. The 5V supply referred to battery ground is used to drive the optocouplers and the tlc5628 circuits. A step-down conversion from the test rig supply voltage to 5V is required to drive ICs on the test-rig side of the relay card. The supply voltage ripple on the analog circuits shouldn't be more than 100mV peak to peak and no more than 200mV peak to peak for the digital devices.

5.2 Power solution

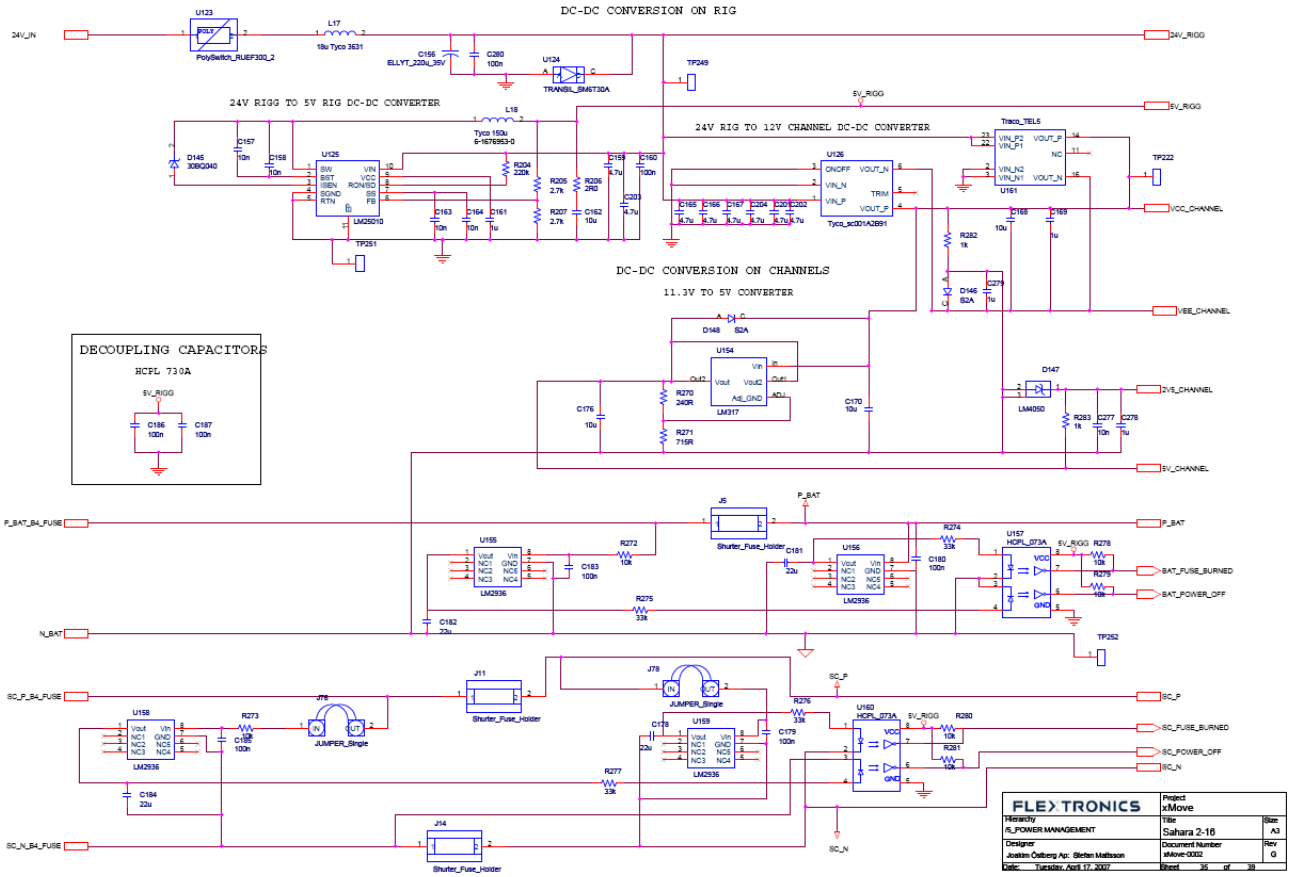

Figure 16 Power Management for the Sahara relay cards.

5.3 General Power Supply design considerations

5.3.1 Total power consumption

Sahara 2-16 and Sahara 15-8 is supplied with 24V to work correctly. When no relays are closed and no LEDs are lit, Sahara 2-16 and Sahara 15-8 consumes about 6.25W. When all the relays are drawn the Sahara 2-16 consumes 11W and Sahara 15-8 consumes 14.7W. If the relays are drawn and all the LEDs are lit the two cars will consume 11.8W and 15.4W.

5.3.2 Power up sequence

There is no special power up sequence.

5.3.3 Voltage supply supervision

The 24v rig power has a Poly switch to break currents above 3A. The Battery power connected to the card brake if the current exceeds 6A and the short circuit rails breaks the current if it raises above the specified current for the relay card.