IRAM Plateau de Bure Observatory

POLAR SWITCH
User manual

Philippe CHAVATTE, IRAM - Backend
Revision A, November 18th, 2009

Table of contents

1. List of illustrations

Figures:

2. Tables

3. Introduction

The aim of the POLAR SWITCH[1] module is to select, for each antenna, what horizontal or vertical polarisation data is to be sent to the correlators. The module can process 12 antenna and is fully compatible with NOEMA[12].

The digital board receives commands through the CAN[3] bus, a micro-controller (MCU[12]) translates them and drives the switches through two connectors. The switching is synchronised by the 1pps[12] pulse issued from the observatory master clock.

Last switching position, power supply voltages, temperature and IDentification information can be monitored with few CAN[12] commands.

4. General Specifications

4.1   Background

The digital board carries the 1pps[12] receiver and 4 drivers, the 5MHz clock receiver and 4 drivers, connectors and voltage regulators on the motherboard, and a C164[6] micro-controller (MCU) located on a daughter board.

The interface between the CAN bus and the switches is a commercial daughter board with a C164 micro-controller (MCU). It is a derivative of the famous Infineon C167[8] family. It receives commands through the CAN bus, computes data and translates them in switching commands. Interruption routines process CAN receive and the timing management. Switching update is synchronised by the 1pps[12] timing signal. The MCU can be reset by a local pushbutton located on the mother printed circuit board.

On the front panel are located the CAN connectors, indicators and switch connectors.

On the rear panel are located the 230VAC connector and main switch, the 5MHz and the 1pps connectors used to feed WIDEX.
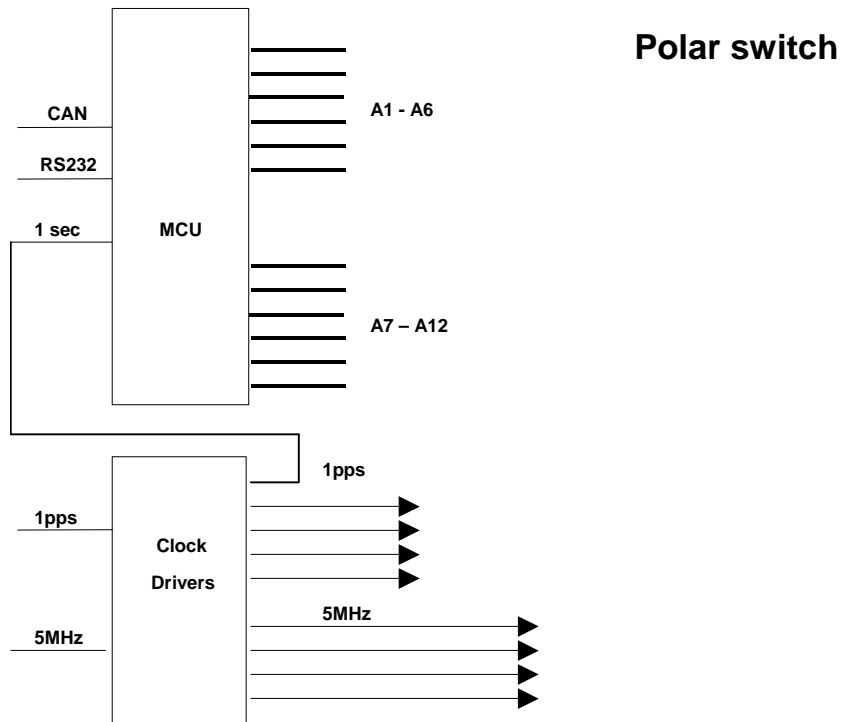
Figure 1: Block diagram

4.2   Power

The module requires a +6.5VDC/1.3A unregulated power supply, supplied through J4 connector on the module digital-side.

Total power requirement: +6.0V to 7.5V / 1.3A

Note: The 2A fuse is located inside the module.

4.3   Operating Temperature Range

All components currently used have standard temperature range specifications of 0 – 70°C.

4.4 Printed circuit boards details

The digital board is a two-layer surface-mount printed circuit board and measures 205mm x 242mm.
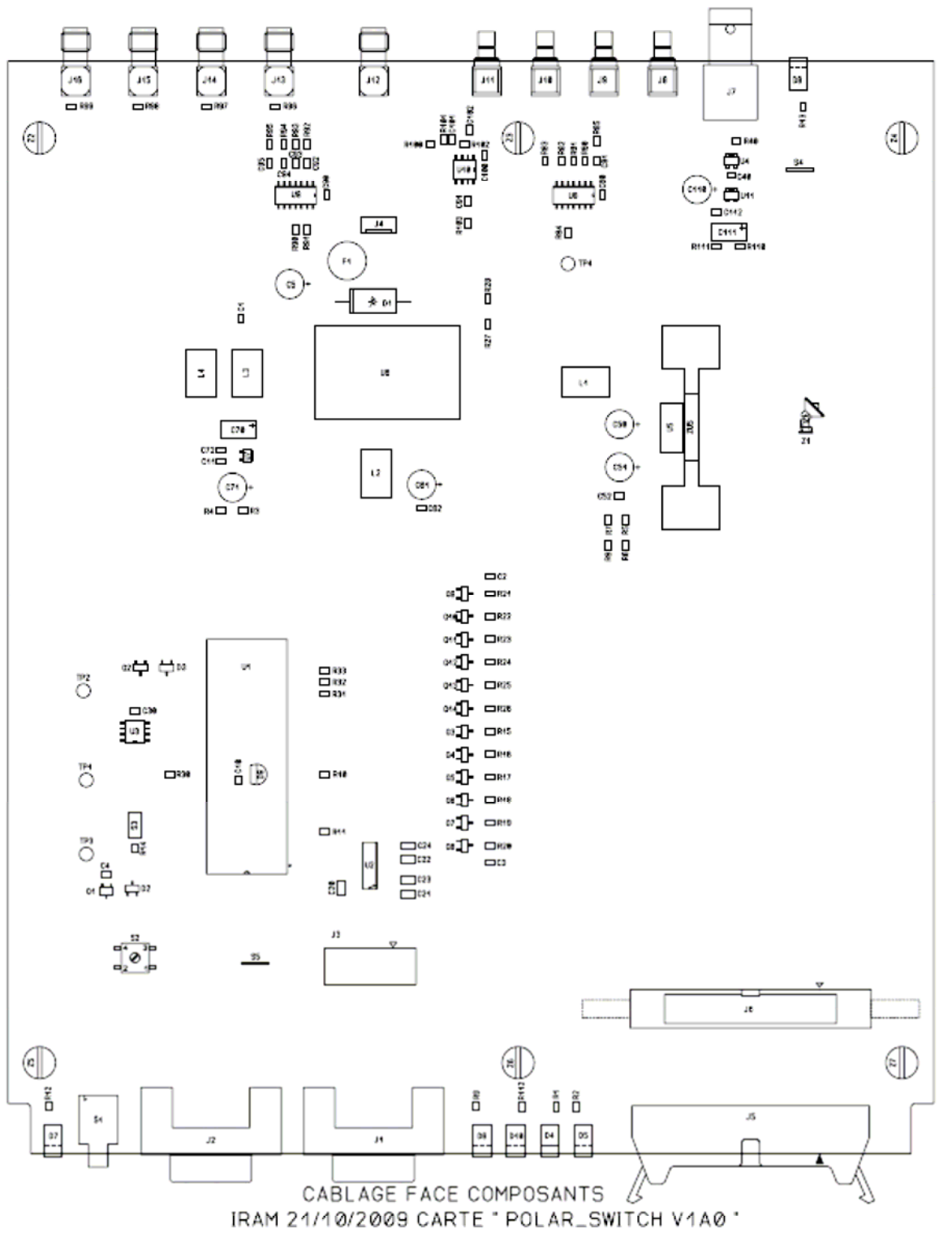
Figure 2: Digital PCB & components layout (real size)

5. Device connections

5.1   Mechanical Details

The module is a metal box that measures 250mm x 260mm. Its height is 120mm.
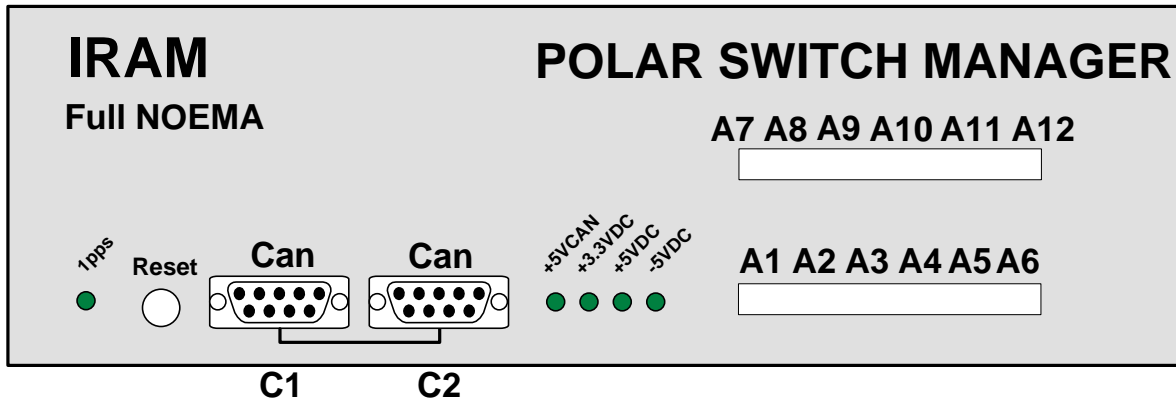
Figure 3: Module front view

5.2   Connectors

The module has several connectors located on the top of the module. Connectors are classified by function as it follows:

- C1 & C2: SubDB9 Connection to CAN bus
- C3: TTL outputs to HV switch Antenna 1-6
- C4: TTL outputs to HV switch Antenna 7-12

- C5: 230VAC/50Hz input (CEE22)
- C6: 1pps input (BNC)
- C7, C8, C9, C10: 1pps output (SMB)
- C11: 5MHz reference input (SMA)
- C12, C13, C14, C15: 5MHz reference output (SMA)

- J3: HE10 Connection to terminal RS232 (Access from inside only, on digital-side)

5.3   Indicators

The module has tree external indicators located on the top of the module. Indicators are classified by function as it follows:

- L1: 1pps green indicator (flashes when a 1pps signal is received)
- L2: Module powered (flashes when a CAN frame is received or transmitted)
- L2: +5V power supply for the external switches
- L4: -5V power supply for the external switches

5.4   C1 connector pin-out

- C1 & C2: SUBD9 connection to CAN bus
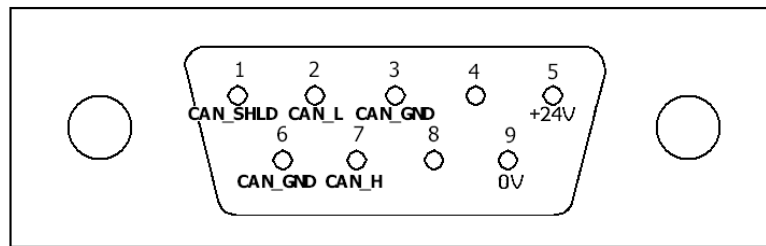
Figure 4: The DB9 male connector is shown view from the pin side

Pin	Signal	I/O	Function
1	CAN_SHLD	-	CAN Shield (Non standard!)
2	CAN_L	I/O	CAN_L Bus Line (dominant low)
3	CAN_GND	-	CAN Ground, connected to board ground
4	N/C	-	Not connected
5	POWER 24V	-	Power distribution +24V (Non standard!)
6	CAN_GND	-	CAN Ground, connected to board ground
7	CAN_H	I/O	CAN_L Bus Line (dominant high)
8	N/C	-	Not connected
9	POWER 0V	-	Power distribution return (Non standard!)

Table 1: C1, CAN & Control connector pin outs

5.5   Internal connector pin-out (digital-side)

- J3: HE10 connection to terminal RS232 (Access from inside only)

Pin	Signal	Dir	Function
1	N/C	-	Not Connected
2	N/C	-	Not Connected
3	SERIAL_TxD	O	RS232 Transmit
4	N/C	-	Not Connected
5	SERIAL_RxD	I	RS232 Receive
6	N/C	-	Not Connected
7	N/C	-	Not Connected
8	N/C	-	Not Connected
9	GND	-	Board Ground
10	GND	-	Board Ground

Table 2: J3, RS232 connector pin outs

6. Instrument Interfaces

6.1   CAN bus I/O Signals

The DB9 sockets C1&C2 connect the module to the external CAN bus[3] network. CAN_L & CAN_H feed a CAN transceiver (PCA82C251) located on the MCU daughter board. The CAN controller is embedded inside the MCU C164.

6.2   1pps Sync interface

The 1pps Timing signal is delivered in coaxial through the C6 connector described in paragraph 5. A NC7S14[14] trigger receiver feeds four drivers whose outputs go to the connectors C7 up to C10. The 1pps[12] timing signal also feeds a fast interrupt input of the MCU to synchronize the events that takes place in the module.

6.3   Reset button

The Reset button is located on the left side of the front panel. The Reset signal feeds the Master Reset of the C164 MCU. It is used to re-initialize the MCU.

6.4   RS232 Serial Port

The RS232 port is connected to a MAX2330[13], transceiver and levels translator, before feeding the asynchronous serial channel #0 of the MCU. This port is used to download the user software into the flash RAM. The HE10 socket J2, described in paragraph 5.5 table 2, is dedicated to maintenance and software upgrade. The 3M 10-pin connector J2 is only reachable when the module is open.

6.5   5MHz reference clock

The 5MHz reference clock input delivered in coaxial through the C11 connector, AC coupled in single mode with 0dBm level, feeds a LT1719[12] comparator. Its output feeds four inverters whose outputs go to the connectors C12 up to C15.

7. Local Interfaces

7.1   One Wire interface

Each motherboard has a unique serial ID number generated by a Dallas Semiconductor DS18S20[11] device, which offers a temperature sensor in addition. The serial ID number is delivered in 48-bit format (6 bytes) and temperature in 9 bits format (2 bytes). For maintenance purpose, module temperature and ID number can be requested with CAN commands.

7.2   Analog Voltages Monitoring

The MCU includes an on-chip 8-channel Analog to Digital Converter with 10-bit resolution. Four output voltages are monitored: +5V, +3.3V, M5V, P5V and an input

voltage: +6.5V. For maintenance purpose, voltages reading can be requested with few CAN commands.

ADC Channel	Signal	Dir	Function
0	+5V	I	Read VCC output voltage
1	P5V	I	Read +5.0V output voltage
2	M5V	I	Read -5.0V output voltage
3	+3.3V	I	Read +3.3V output voltage
4	+6.5V	I	Read the +6.5V input voltage
5	Unused	I	Free
6	Unused	I	Free
7	Unused	I	Free

Table 3: ADC channels assignment

8. Implementation Details

8.1 Micro Controller Unit (MCU)

The MCU is a DIPmodul-164[4] from SYSTEC used as a daughter board. It carries a C164 μicrocontroller running at 20MHz with a 10MHz quartz, 128 KB of FLASH memory, 32 KB of SRAM, 2 KB of serial EEPROM, 8 dipswitches and a CAN transceiver. A single +5V / 80mA power supply is required. According to SYSTEC, its MTBF is 1,307,950 hours or 149 years.

8.1.1 C164 Micro-Controller Unit (MCU)

The micro-controller is a C164[6], a 16-bit processor from INFINEON. It is a derivative of the C167[8] family in an 80-pin TQFP package. It combines high CPU performance (up to 10 MIPS) with high peripheral functionality: full CAN interface, 8-input ADC, asynchronous serial port, High Speed synchronous serial port, timers, RTC[12], 14 digital I/Os available to user and high speed DMA under interruption. A bootstrap loader is available to download user software into Flash memory. For more information, refer to the datasheet listed at the end the document[4].

8.1.2 CAN Controller

The micro-controller has an on-chip CAN controller (Rev. 2.0B) with 15 message objects. It is capable of 1-Mbaud operations.

8.1.3 Analog to Digital Converter

The micro-controller has an 8-channel Analog to Digital Converter with 10-bit resolution. A conversion can take place in less than 10 microseconds.
Any unused channel can be used as an extra conventional digital input.

8.1.4 Digital I/O

The micro-controller has up to 59 general purpose I/Os among which 14 are available outside of the daughter board. This is enough for our application.

8.1.5 Asynchronous Serial Controller

The micro-controller has a single serial channel dedicated to the RS232 interface. This interface is used to download user software.

8.1.6 Synchronous Serial Controller

The micro-controller has a high-speed synchronous serial channel capable of 5-Mbaud operations. It can be used for: I2C, SPI or any serial transmission. In this module, it is dedicated to communicate with an EEPROM and is not available on external pins.

8.1.7 One Wire controller

One-Wire interfacing has easily been developed in C for this micro-controller. This interface use one pin and is dedicated to DALLAS integrated circuits.

8.2 Voltage regulators

A DC/DC converter and three low drop voltage regulators are used in this module. Fed by +6.5V, the four regulators deliver:

- M5.0V/ 480mA   for the switches
- P5.0V / 720mA   for the switches
- +3.3V / 20mA   for the 1pps interface
- +5.0V / 100mA   for the ICs

9. Built-in Firmware

9.1 Bootstrap loader

A bootstrap loader is available to download user software. By simultaneously pressing RESET and BOOT then release first RESET, and 3 seconds later release BOOT. Now the MCU is ready to accept user software from the RS232 line. Run Flashtools16W on any PC to download the firmware into the FLASH memory. At the end of the download process, pressing RESET will initialise the program.

9.2 Power up or Reset sequence

At init, receivers with horizontal polarisation are selected to feed the correlators.

10. Device-Specific Software / CAN Functions Interface

10.1 Operating program

In normal operation, the module receives Can frames with next polarisation settings for the antennas 1 up to 12. The 1pps pulse synchronizes all changes.

10.2 CAN Overview

The POLAR SWITCH module is controlled and monitored by the PdB[2] CAN network, revision 2.0B (extended format), operating at 1Mbauds. The module is a slave CAN node operating in the address range 0x0828 0000 (hex), through 0x082C 0000 (hex). Its CAN relative address space spans from 0x0 0000 to 0x3 FFFF (hex). 8 switches located on the MCU daughter board define the module global address. Each switch being a power of 2, the result ranging from 0 up to 255 is multiplied by 0x4 0000 (hex) to generate the module global address. When a broadcast message 0 is received, the module transmits its address. CAN payload bytes are listed from 1 up to 8.

Address range	0x0828 0000	0x082B FFFF (hex)
Relative address	0x0000 0000	0x0003 FFFF (hex)

Note: L1 indicator flashes when a CAN frame is received or transmitted.

10.3 Summary of the CAN Monitor points

Name	Relative CAN Address (hex)	Data Size (Bytes)	Target	Timing Event Related?
MODULE_ID	0x0 00 00	8	Maintenance	No
SERIAL_&_TEMP	0x0 00 01	8	Maintenance	No
PSU_VOLTAGE1	0x0 00 02	8	Maintenance	No
PSU_VOLTAGE2	0x0 00 03	2	Maintenance	No
MODULE_STATUS	0x0 00 04	6	Maintenance	No
ELAPSED_TIME	0x0 00 05	5	Maintenance	No
LAST_HV_POLAR	0x0 02 20	2	Maintenance	No

Table 4: Summary of Monitor Points

10.4 Summary of the CAN Control points

Name	Relative CAN Address (hex)	Data Size (Bytes)	Target	Timing Event Related?
HV_POLAR	0x0 01 20	2	Operation	Yes
INIT	0x0 01 F0	1	Operation	No
CPU_RESET	0x0 01 FF	1	Operation	No

Table 5: Summary of Control Points

10.5   CAN payload contents

10.5.1 Monitor points in detail

a) MODULE_ID

Relative CAN Address	*0x0 00 00*
Description	*This monitor point returns the module ID and waste.*
Target	*Maintenance*
TE Related	*No*
Data	*8 bytes:* *Byte 1: Integrated circuit family code* *Byte 2, 3, 4, 5, 6 & 7: 48 bits serial number* *Byte 8: CRC*

b) SERIAL_&_TEMP

Relative CAN Address	*0x0 00 01*
Description	*This command returns the module serial number followed by its internal temperature. The answer is sent within 2 seconds.*
Target	*Maintenance (never use it during operation!)*
TE Related	*No*
Data	*8 bytes:* *Byte 1, 2, 3, 4, 5 & 6: 48 bits serial number* *Byte 7 & 8: Module temperature*
Conversion factor	*Temperature = First Byte + Second Byte/100*
Operating Range	*15°C - 55°C recommended range*

c) PSU_VOLTAGE1

Relative CAN Address	*0x0 00 02*
Description	*This monitor point indicates the measured output voltages of the power supply.*
Target	*Maintenance*
TE Related	*No*
Data	*8 bytes:* *Byte 1 & 2: M5.0V (0.00-6.00)* *Byte 3 & 4: P5.0V (0.00-6.00)* *Byte 5 & 6: 3.3V (0.00-5.00)* *Byte 7 & 8: 5.0V (0.00-6.00)*
Conversion factor	*Voltage = First Byte + Second Byte/100*
Operating Range	*M5.0V -> (4.75-5.25)* *P5.0V -> (4.75-5.25)* *3.3V -> (3.15-3.45)* *5.0V -> (4.75-5.25)*

d) PSU_VOLTAGE2

Relative CAN Address	*0x0 00 03*
Description	*This monitor point indicates the measured input voltage of the Power Supply.*
Target	*Maintenance*
TE Related	*No*
Data	*2 bytes:* *Byte 1 & 2: 6.5V (0.00-10.00)*
Conversion factor	*Voltage = First Byte + Second Byte/100*
Operating Range	*6.5V -> (6.0-8.0)*

e) MODULE_STATUS

Relative CAN Address	*0x0 00 04*
Description	*This monitor point reports the CAN bus reliability, the firmware revision date and the Timer7 value.*
Target	*Maintenance*
TE Related	*No*
Data	*6 bytes:* *Byte 1: CAN bus errors (0-255)* *Byte 2, 3, 4: Firmware revision date Day, Month, Year* *Byte 5 & 6: Timer7 content (27 473 +/-10)*

f) ELAPSED_TIME

Relative CAN Address	*0x0 00 05*
Description	*This monitor point indicates the elapsed time since last reset.*
Target	*Maintenance*
TE Related	*No*
Data	*5 bytes:* *Byte 1 & 2: Elapsed days (0 <-> 65535 days)* *Byte 3: Elapsed hours (0 <-> 24 hours)* *Byte 4: Elapsed minutes (0 <-> 60 minutes)* *Byte 5: Elapsed seconds (0 <-> 60 seconds)*
Conversion factor	*Reading = 256*First Byte + Second Byte or single Byte only*
Operating Range	*Elapsed days -> (0 <-> 5000 days)* *Elapsed hours -> (0 <-> 24 hours)* *Elapsed minutes -> (0 <-> 60 minutes)* *Elapsed seconds -> (0 <-> 60 seconds)*

g) LAST_HV_POLAR

Relative CAN Address	0x0 02 20
Description	This monitor point reports the last polarisation command sent to the POLAR SWITCH module.
Target	Maintenance
TE Related	No
Data	2 bytes: Byte 1: A6 to A1, data=00bb bbbb Byte 2: A12 to A7, data=00bb bbbb
Conversion factor	Data = First Byte, Second Byte

10.5.2 Control points in detail

a) HV_POLAR

Relative CAN Address	0x0 01 20
Description	That command selects the H or V receiver polarisation for each input of the correlator. It should be the first command sent to this device before each sky observation.
Target	Operation
TE Related	Yes (1 sec.)
Data	2 bytes: Byte 1: A6 to A1, data=00bb bbbb Byte 2: A12 to A7, data=00bb bbbb With b=0 : H$\rightarrow$H and V$\rightarrow$V, b=1 : H$\rightarrow$V and V$\rightarrow$H

b) INIT

Relative CAN Address	0x0 01 F0
Description	This command initialises the module with its default values.
Target	Operation
TE Related	No
Data	1 byte: Byte 1: Don't care Note: the default set-up is H$\rightarrow$H and V$\rightarrow$V for each antenna.

c) CPU_RESET

Relative CAN Address	0x0 01 FF
Description	This command initialises the module MCU.
Target	Operation
TE Related	No
Data	1 byte: Byte 1: Don't care

11. Test Software

The POLAR SWITCH module can be controlled and monitored by the "Polar_switch_test.vi".
It can be run with LABVIEW from any PC hosting a CAN interface. The test equipment is
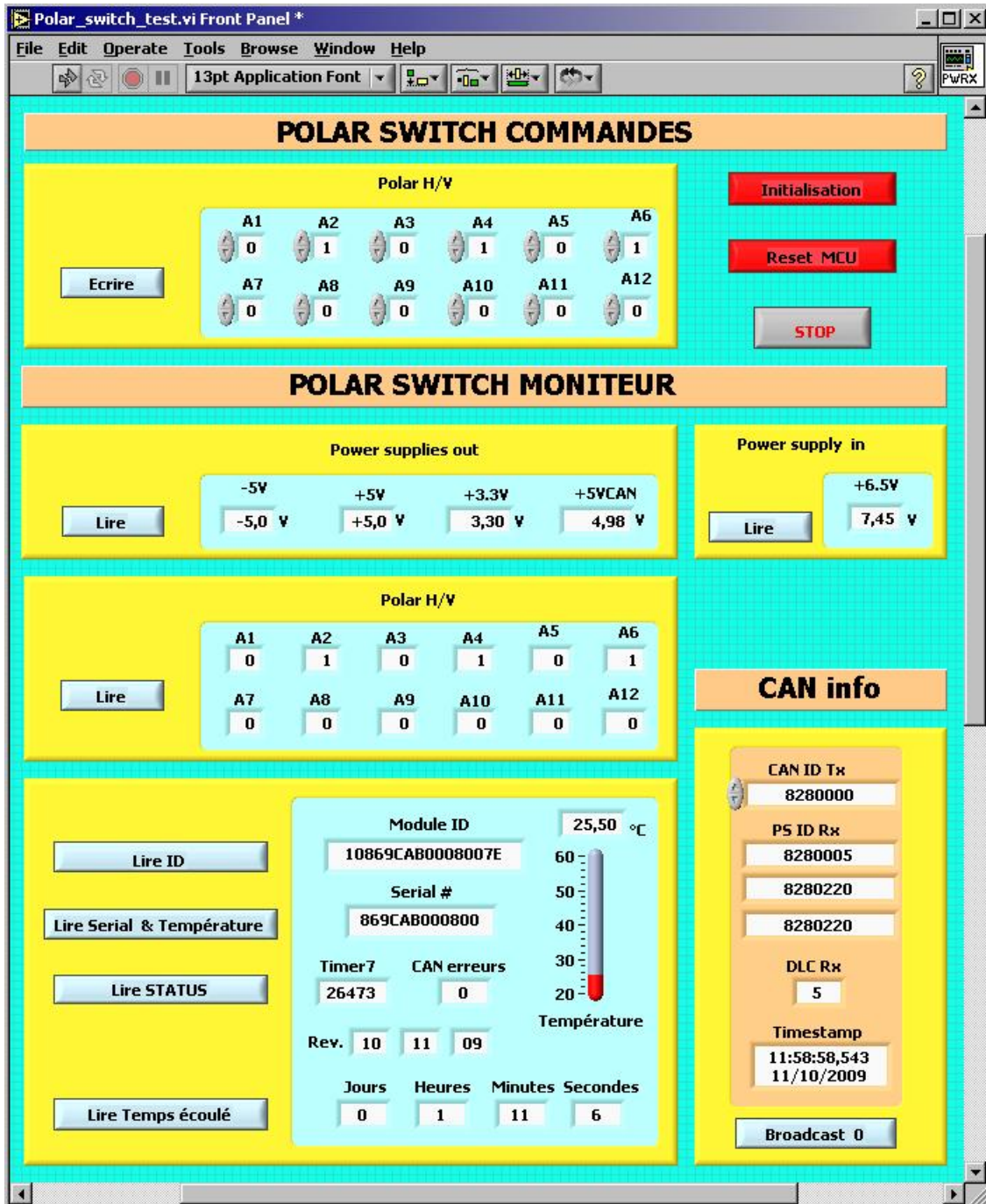self-teaching and a view of the its control screen is displayed next:

Figure 5: POLAR SWITCH test panel

12. Abbreviations and Acronyms

1 pps	1 Pulse per second, PdB reference timing with TTL signalling
ADC	Analog to Digital Converter
C164	Reduced version of the C167 (Infineon – Siemens)
C167	16-bit micro-controller of the C166 family (Infineon – Siemens)
CAN	Controller Area Network, field bus dedicated to control. (Bosch)
CPU	Central Processing Unit
DMA	Direct Memory Access
EEPROM	Electrically Erasable & Programmable Read Only Memory
FLASH	Permanent memory that can be reprogrammed
I/O	Inputs and Outputs
LSB / MSB	Least Significant Bit / Most Significant Bit
MSPS	Mega Samples per Second
MCU	Micro Controller Unit
MTBF	Mean Time Between Failures
NOEMA	NOrthern Extended Millimeter Array with 12 antennas
One-Wire	Serial bus using one wire with ground return (DALLAS)
PC	Personal Computer
PCB	Printed Circuit Board
RS232	Standard computer interface for serial communication with a terminal
RTC	Real Time Clock

13.   References

1. Polarization processing for PdB, may 2009, Scientific software group.

2. PdB CAN specification, june 2004, A Perrigouard.

3. CAN specification, version 2.0, 1991, Bosch.

4. DIPmodul 164 hardware manual, edition january 2002, Systec: a Phytec Technology Holding Company.

5. C164CI 16-Bit Single Chip Micro-controller, data sheet, 04.1997, Siemens-Infineon.

6. C164CI 16-Bit CMOS Single Chip Micro-controllers, user's manual, 11/97, version 1.0, Siemens-Infineon.

7. Programmation et utilisation du microcontrôleur SAB-C167, Remy Bellenger, sciences de l'ingénieur, MASSON, 1996, IRAM TE22.

8. 166 Family designer's guide, Hitex development tools Ltd, second edition, April 1999.

9. Software quality management 'C' compiler report KEIL C166 v3.12j, revision F, 22/06/2000, Hitex development tools Ltd.

10. An Introduction to C on the 166 Family using the KEIL C166 compiler, Hitex development tools Ltd, issue Z/V, 1998.

11. DS18S20, Serial code and Digital thermometer, data sheet, 05-01-02, Dallas Semiconductors.

12. LT1719 Comparator, data sheet, 2000, Linear Technology.

13. MAX 233, RS232 drivers/receivers, data sheet, 19-4323 rev 10, 08/01, Maxim Integrated Products.

14. NC7S14 Schmitt trigger inverter, data sheet, January 1996, Fairchild semiconductor.

15. 74AC04 Hex inverter, data sheet, National Semiconductor.

16. LP2985, Micropower 150mA low noise ultra low dropout regulator, data sheet, January 2003, National Semiconductor.

17. LP2940, Micropower 1A low dropout regulator, data sheet, January 2003, National Semiconductor.

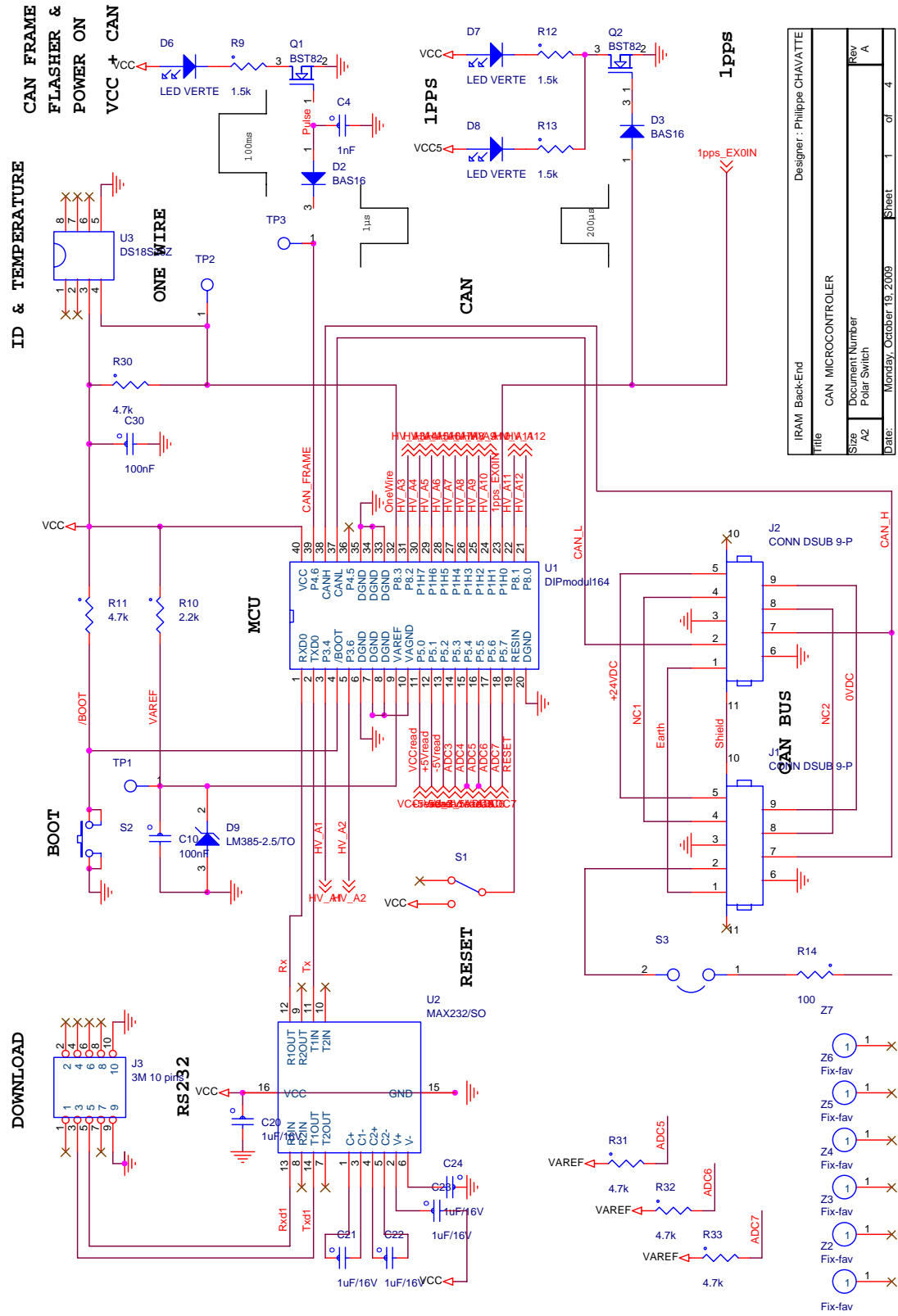18. TEN 3-0511, DC/DC converter, data sheet, 06/2000, TRACO power.

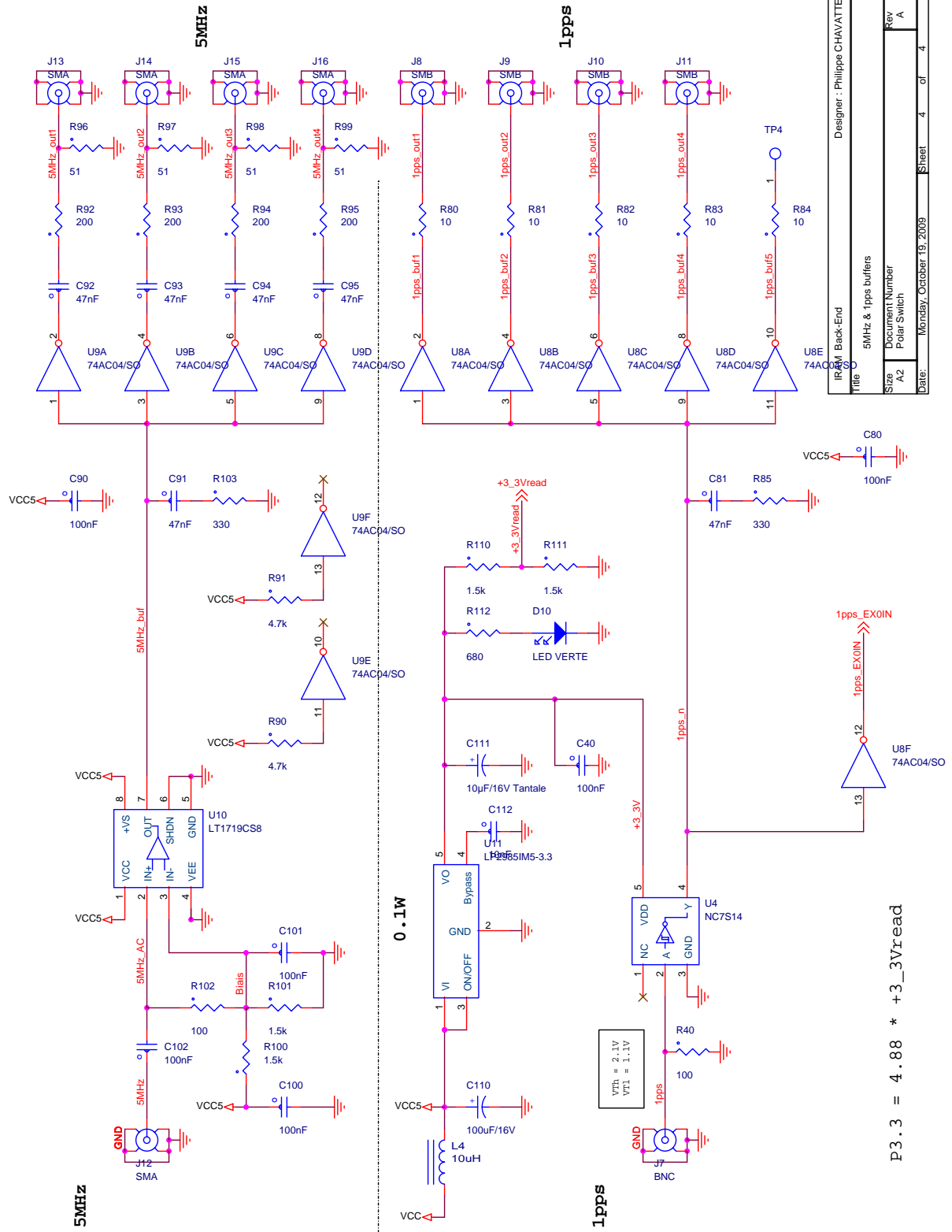## 14. POLAR SWITCH drawing list

CAN micro-controller

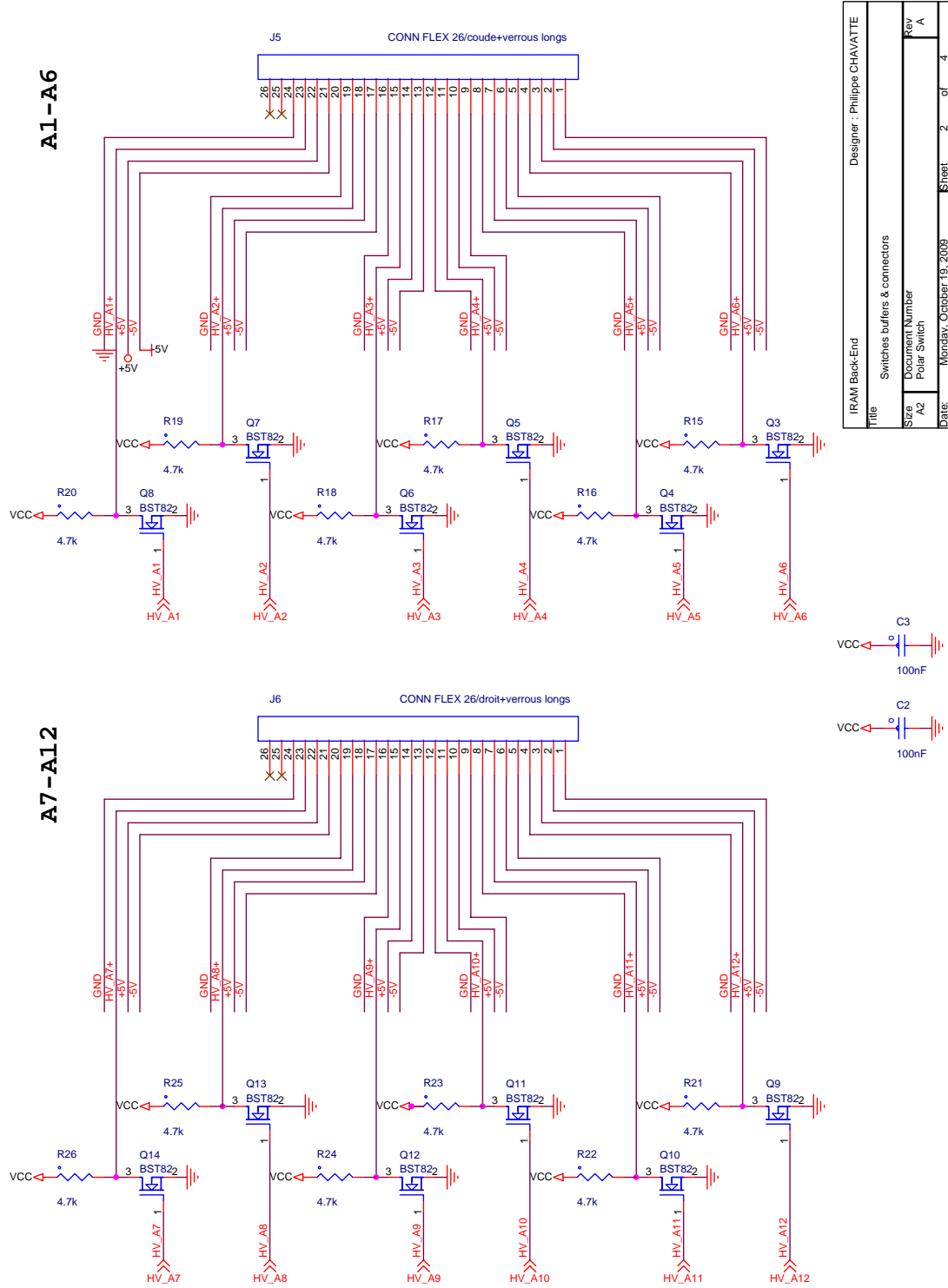Switches buffers & connectors

Power supplies

5MHz & 1pps buffers

14. POLAR SWITCH drawing list

$$P3.3 = 4.88 * +3\_3Vread$$

$P5 = 2.77 * +5Vread$

+5Vread

R5 3.9k   R6 2.2k

-5Vread

R7 3.9k   R8 6.8k

+5V   -5V

$M5 = (2.74 * -5Vread) - (1.74 * P5)$

VCCread

R3 3.9k   R4 2.2k

VCC

$VCC = 2.77 * VCCread$

C52 100nF   C62 100nF   C11 100nF

+5.0V / 720mA   -5.0V / 480mA   +5VCAN / 100mA

R1 1.5k   D4 LED VERTE   R2 1.5k   D5 LED VERTE

C71 100uF/16V

C51 100uF/16V   C61 100uF/16V

U5 LM2940CT-5
VO 3
GND 2
VI 1

sur radiateur
1.5w

C72 100nF   LP2985IM5-5.0

U6 TRACO
14 +Vout   NC 11
16 -Vout   No pin 9
22 +Vin22   -Vin3 3
23 +Vin23   -Vin2 2
TEN 3-0511

VK200 10uH L2

0.5w

0.2w

VO 5
Bypass 4
GND 2
ON/OFF
VI 1
3

C50 100uF/16V   C70 10µF/16V Tantale

+7_5VFF   +7_5VFFF

VK200 10uH L1   VK200 10uH L3

+7_5Vread

R28 6.8k   R27 2.2k   C5 100uF/16V

C1 100nF

+7_5VF

D1 1.5KE-7.5CA

$P7\_5 = 4.1 * +7\_5Vread$

ALIM DC

2A   F1 FUSEHOLDER

+7_5VDC

J4 CONN RECT 2
1   2

+7.5VDC   GND

Z1 Antenne

S4 STRAP
2
1

S5 STRAP
2
1