e-CALLISTO

Frequency agile radio spectrometer

Operating Manual

Document Distribution:

Name	Place to find
Everybody	http://www.astro.phys.ethz.ch/instrument/callisto/ecallisto/eCallistoManual.pdf

Reviews/Updates:

Author	Date	Issue	Comment
Chr. Monstein	23.10.2006	1.00	Op-Manual V1.00
Chr. Monstein	03.11.2006	1.01	Command list updated, I/O included
Chr. Monstein	07.11.2006	1.02	Minor updates
Chr. Monstein	08.04.2008	1.03	Minor updates in keywords of FIT-file
Chr. Monstein	18.05.2009	1.04	New pictures, some minor edits
Chr. Monstein	12.06.2009	1.05	Some minor edits
Chr. Monstein	24.06.2009	1.06	Some minor edits
Chr. Monstein	07.09.2009	1.07	Configuration file: new legend
Chr. Monstein	01.01.2010	1.08	Some minor updates
Chr. Monstein	05.03.2010	1.09	XY-plot in dB

Content

1 Packing list

quantity	component to be delivered by ETH
1	Alubox e-CALLISTO complete, including tuner and internal cables
1	RS232-cable m/f max. 3m shielded, wiring 1:1
1	Cable Callisto/Power supply 12V DIN 3-pol with banana jack or open ends

2 Additional required components

quantity	component to be delivered by the customer
1	Standard PC or Laptop with: ≥512MByte RAM, ≥1GByte HD, ≥1GHz clock, 1 serial port, network and standard I/O devices (mouse, keyboard etc.)
1	Operating system Windows 2000, XP or Windows 7 with firewall and actual virus-scanner. All SP must be installed
1	USB-RS232 Adapter (if standard RS232 is not available)
1	Cable Callisto/external clock 1MHz BNC + 50Ω termination (if needed)
1	Antenna system with one polarization (Linear, LHCP, RHCP,…)
1	Focal plane unit with calibration possibilities (if needed)
1	Power supply for Callisto 12V, min. 0.5A
1	Fixed IP-address open to servers of ETH Zurich
1	CFITSIO.DLL, CW3230.DLL, WSC32.DLL
1	callisto.cfg, callisto.exe, frq00201.cfg, scheduler.cfg

3 Installation

Make a serial connection from e-CALLISTO to RS232-port of the PC. Use a 3-wire cable 1:1, not longer than 3m. If longer lines have to be used, then insert an optical fiber or an RS485-connectio to enhance the distance. If no serial port should be available use a USB/RS232-converter module. Connection parameters are 115KiloBit/sec, 8data, 1stop, no parity and no handshake. Remark: simple commands can be sent using ASCII-terminal software like Hyperterm (Windows).

Connect antenna cable to e-Callisto. Each polarization needs a separate e-Callisto. Appropriate adapters may be used since the receiver has a female N-connector. RF-power should not exceed 95 dBµV at 75 Ω, which is -13 dBm at the receivers input. Standard operating rf-power should be kept below -60dBm using fixed broadband attenuators to prevent saturation.

Connect all power supplies to the FPU, to Callisto and to the PC.

If all components are connected together, power may be switched on. Whenever possible, use high quality power supplies with linear regulators. Try to avoid switched power supplies due to their high rfi level.

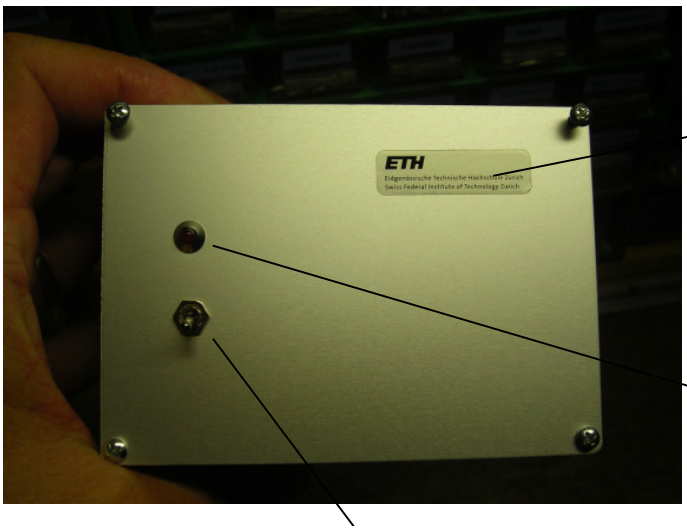
Try to keep e-Callisto in a controlled environment with temperature of 22 °C ± 2 °C and humidity 60 % ± 10 %. All qualification tests are related to these conditions.

4 Configuration

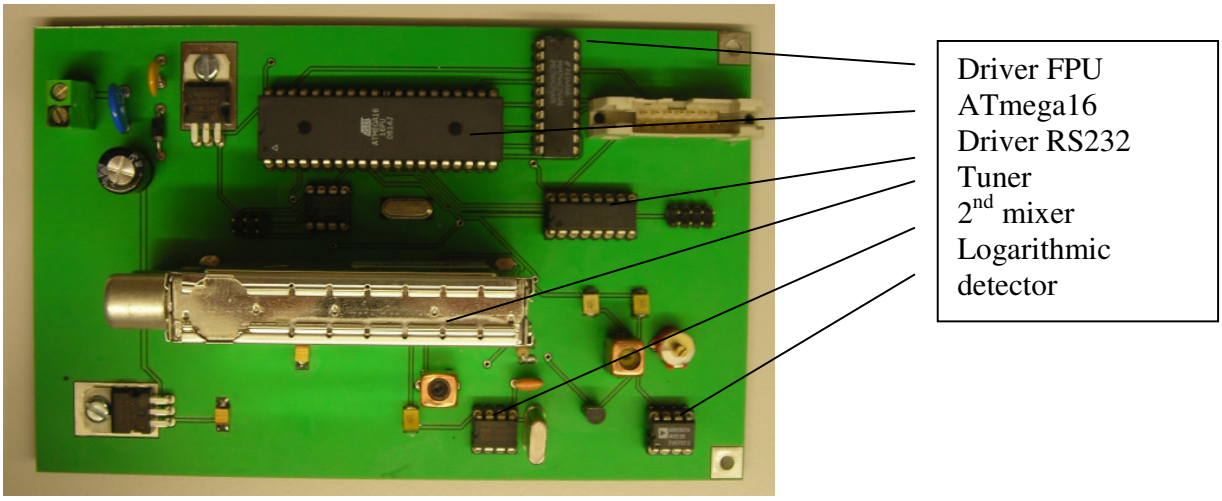
Create a separate account as ‘power user’ (no administrator) using control→userpasswords. Install AutoLogon using Tweak-UI. Set time to GMT (no daylight saving time). Install Acrobat reader. Set screen save to ‘no password on reactive’. Create a directory named ‘Callisto’ on your main hard disc to keep all binary-, frequency- and configuration files. Rename callisto.cfg_ to callisto.cfg and scheduler.cfg_ to scheduler.cfg. Create a separate directory ‘log’ for all log files and another ‘data’ for all data files (fit-files). Any other directory names can be chosen but they have to be edited within ‘callisto.cfg’ appropriately. Several frequency files will be delivered together with the source program. They may be changed with any ASCII-editor or you may create new files using an EXCEL-sheet like “FrequenzGenerator.xls” or any other means to create such a listing. You may also use the special application called Fgeni.zip which can be downloaded from here: http://www.astro.phys.ethz.ch/instrument/callisto/ecallisto/applidocs.htm

5 Front panel description

5.1 Front panel description



5.2 Board description



5.3 Backside panel description

Detector output (dc)

RS232 connection to PC

FPU control

Supply Callisto +12V/250mA

External
clock input
1MHz TTL
May be terminated with 50Ω

Antenna input 50Ω
max -10dBm
45MHz … 870MHz

6 Operation

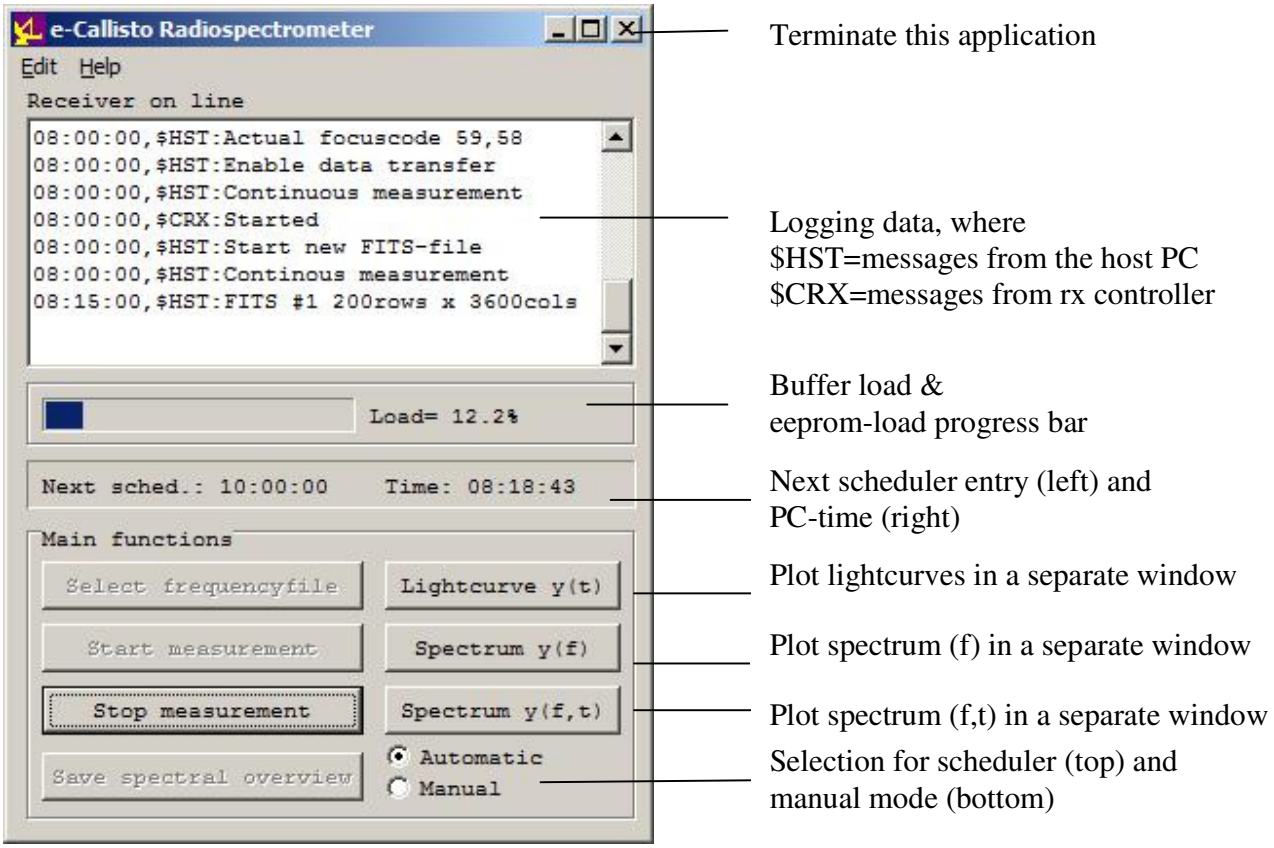
After switching on all hardware components of the instrument, the application software 'callisto.exe' can be loaded and executed either by double-clicking on to the Callisto-icon on the screen or by putting its link into the auto-start respective registry of windows. Per default, measurements are done using a scheduler file 'scheduler.cfg' in the '\Callisto' directory. This scheduler file can be modified using any ASCII-editor like Notepad. Save it always in TEXT-format. Don't change the format of the file; e-Callisto needs its fixed structure. Up to 150 entry times may be defined. All entries are repeated automatically every day, related to PC-clock. If you don't want to work with the stored scheduler, then press the radio-button labeled 'manual'. In manual mode you may do everything without any influence of the scheduler. Time entries have to be consecutive.

The system may run with its internal clock only. But we recommend to automatically synchronizing PC-clock via network to a standard UT-atomic-timing system. It is also possible to synchronize PC-clock via a separate GPS-timing system which may be plugged onto a serial port or a USB-port. One has also to decide whether measuring clock shall be triggered internally (quartz-controlled) or externally via GPS or atomic clock. The way of triggering has to be defined in the file callisto.cfg. The numbers of measurement points that can be measured are not identical for the two trigger sources.

To start a measurement press radio button 'Manual' and press button 'Start measurement'.
To stop a measurement press radio button 'Manual' and press button 'Stop measurement'.
To change frequency file, first press radio button 'Manual' then press button 'Stop measurement and then press 'Select frequency file' to select another or just the same frequency file.

To open a light curve plot just press button 'Lightcurves y(t)'.
To open a one-dimensional plot just press button 'Spectrum y(f)'
To open a two-dimensional plot just press button 'Spectrum y(f,t)'
It may be important to know that each open plot windows takes some resources of the PC. If the resources are too low you should try to open only the windows needed and therefore close the other ones. Memory resources for the plot windows can be set in the configuration file 'callisto.cfg'.

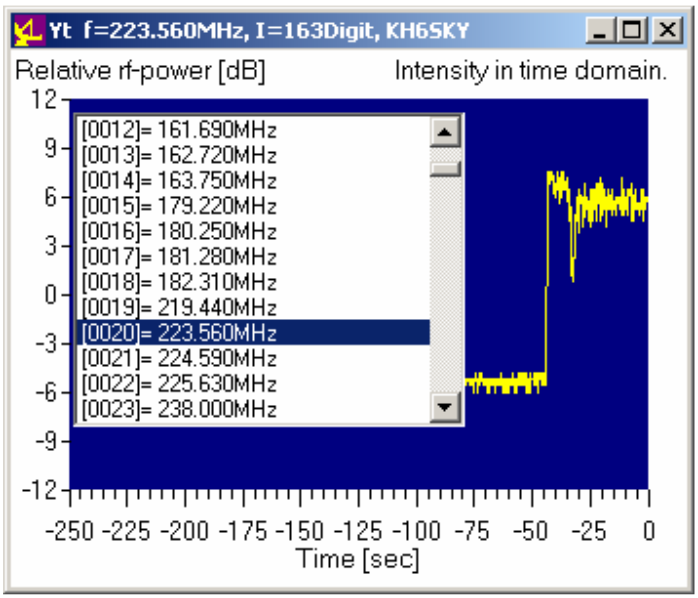
7 Application main window description



Appearance of this main window may slightly be changed during progress of the project e-Callisto radio spectrometer and it depends also on kind of Windows (XP, 2000, 7 or Win95 like).

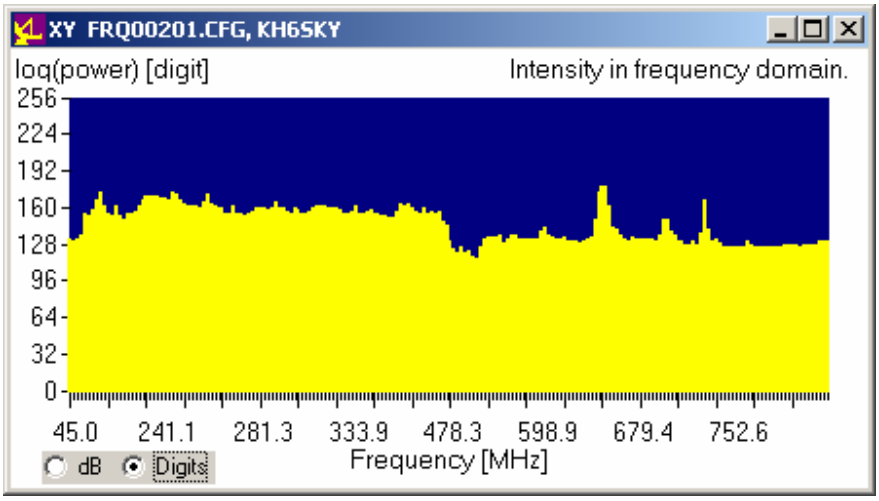
8 Windows description

8.1 Lightcurve windows description

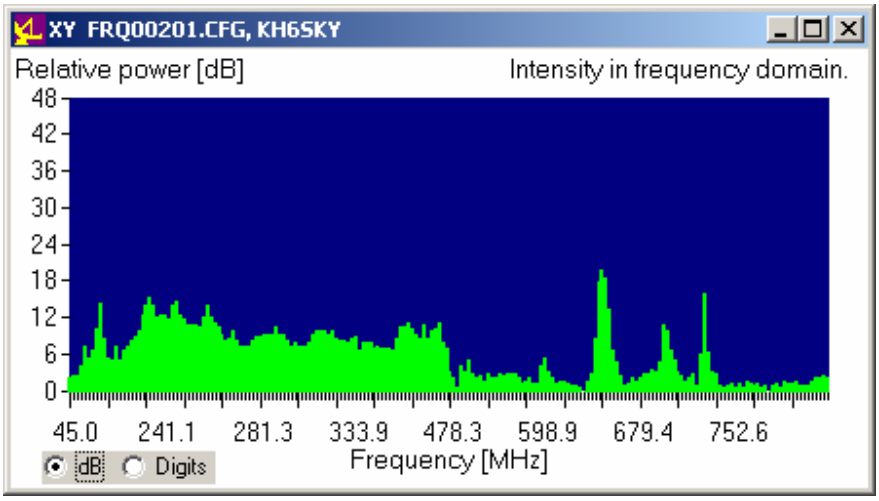


This light curve shows a single frequency channel from the receiver. This test channel is pre defined in each frequency program. The user may select any of the frequencies in the list. Right mouse click allows the user to select any other frequency of the frequency program on line. The values displayed are expressed in dB. The range is automatically adapted to the actual range of the rf power.
Physical time on the x-axis depends on parameters in the frequency file (number of measurement points per sweep, number of sweeps per second and number of pixels per second.
The x-axis range can be changed in callisto.cfg, keyword [ytbuflen]. The physical range is only limited by PC-resources (memory and processor speed).

8.2 Spectrum (f) window description

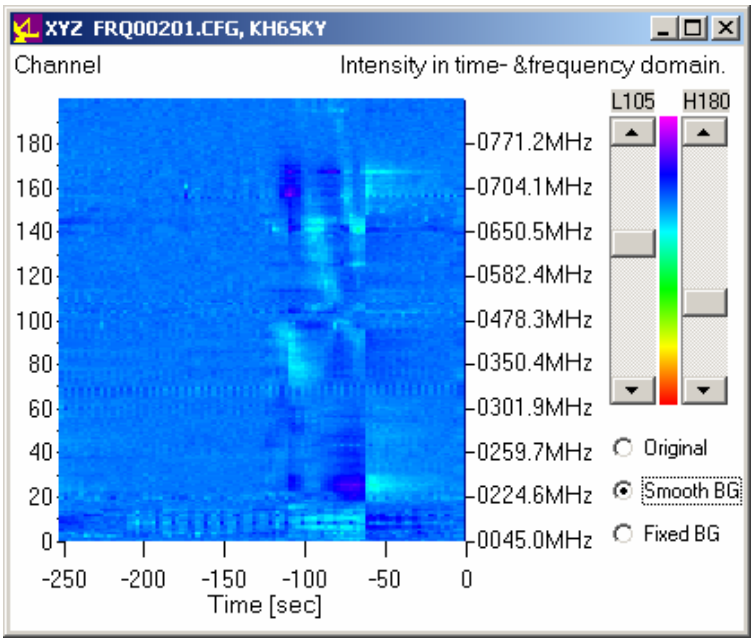


This spectrum plot shows the actual results of the receiver, the intensity versus frequency channel. The channel shown here was fed with 'Zurich' signals from a so called 'suspender'-antenna in the RFI-polluted office.
If you need to know the frequency, please look up the appropriate frequency file shown in the logging window. The value displayed is expressed in digits of the ADC, where the digits are proportional to the logarithm of IF power (default). The buffer which holds the actual data is located in callisto.cfg using keyword [xybuflen] and shall be larger than the longest frequency file. The longer the buffer is the longer it takes to display the updated values.



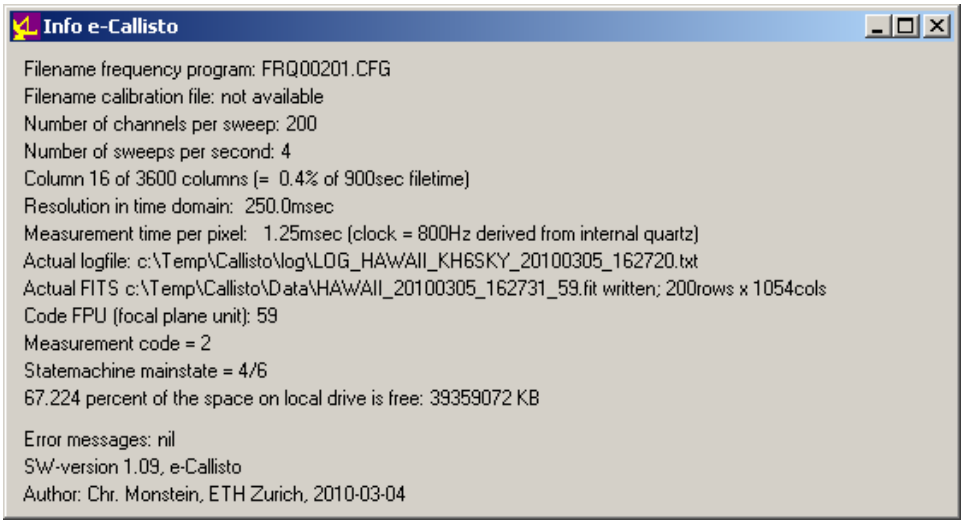
Optionally the values can be plotted in dB. Start measurement and attach a reference signal to the input. Then press radio button 'dB'. Now the reference signal is subtracted and expressed in dB. Now you can take away the reference signal and switch in an antenna signal to see the dB's. The calibration factor is stored in callisto.cfg, keyword [detector_sens]=25.4 // The value must be evaluated during a calibration process. The value is expressed in mV per dB. Also the scaling factor is stored in callisto.cfg, keyword [db_scale]=6

8.3 Spectrum (f, t) window description



This plot shows the radio frequency spectrum evolving in time where time is expressed in seconds. The radio buttons on the right side offer the possibility to subtract a fixed or a smoothed background. The scrollbars have influence to the color table. The color table is a linear interpolation between Low-value (left scrollbar 0…255) and High-value (right scrollbar 0…255).

8.4 Info window



The window above presents the most important parameters of e-Callisto. They may help to optimize configuration parameters. In addition a few statistical parameters are shown.

9 Acronyms

Acronym	Translation
ADC	Analog to digital converter
BB	Bread board model
CALLISTO	Compound Astronomical Low-cost Low-frequency Instrument for Spectroscopy and Transportable Observatory (1st model)
e-CALLISTO	Extended-Compound Astronomical Low-cost Low-frequency Instrument for Spectroscopy and Transportable Observatory in view of IHY2007 and ISWI
DM	Development model
dBm	DeciBel with respect to 1 milli Watt
eeprom	Electrically erasable programmable memory
ETH	Eidgenössisch Technische Hochschule
FM	Flight model
FPU	Focal plane unit, see also FOPA
FOPA	Focus pack, see also FPU
GPS	Global Positioning System
I2C	I squared C bus (Philips serial data bus with 2 wires)
IF, if	Intermediate Frequency
IRASEB	Predecessor of CALLISTO, formerly known as PMS (poor man spectrometer)
PC	Personal computer
PHOENIX-2	Frequency agile spectrometer (obsolete since March 2009)
PHOENIX-3	FFT spectrometer (main instrument 1 GHz – 5 GHz)
PHOENIX-4	Successor of Phoenix-2 composed of two Callisto
PSU	Power Supply Unit
PWM	Pulse Width Modulation. Use to control tuner gain (analog voltage)
QM	Qualification Model
RCU	Receiver Control Unit
rfi, RFI	Radio frequency interference
RX, rx	Receiver unit
SCL	I2C clock
SDA	I2C data
SOW	Statement of work
TBD	To be determined or to be defined, depending on context

10 Measurement mode

(Stored in scheduler program for each entry)

Code	Measurement mode
0	Stop actual mode, go to idle. No data will be stored. Scheduler waits for another entry to be applied to Callisto
1	Spare code
2	Calibration mode. Save measured data to local disc, calibrated in SFU. Storage is compressed as 45*log(S+10). Calibration parameter file needed!
3	Continuous recording or steady mode. Sampled data are stored without calibration on local disc in raw format (digits) 8 bit resolution. This, according to configuration - and frequency - file.
4	Spare code
5	Spare code
6	Spare code
7	Terminate application program, go back to operating system (dangerous, therefore disabled within e-Callisto)
8	Automatic spectral overview OV for periodic radio monitoring (CRAF)
9	Spare code

The yellow marked modes are the most used ones.

11 Description of FITS-file header

The following header information is stored in every FITS-file. The FITS-file is composed of four parts. First the header as printed below, the binary spectrum and two BIN tables. One BIN table is for the time – axis the other for the frequency - axis.

```
SIMPLE  =                    T / file does conform to FITS standard
BITPIX  =                   16 / number of bits per data pixel
NAXIS   =                    2 / number of data axes
NAXIS1  =                  631 / length of data axis 1
NAXIS2  =                  200 / length of data axis 2
EXTEND  =                    T / FITS dataset may contain extensions
COMMENT = 'Warning: the value of CDELT1 may be rounded!'
COMMENT = 'Warning: the frequency axis may not be regular!'
COMMENT = 'Warning: the value of CDELT2 may be rounded!'
COMMENT = '         '           / empty comment
DATE    = '2004-12-06'          / Time of observation
CONTENT = '2004/12/06 Radio flux density (BLEN5M)' / Title of image
ORIGIN  = 'ETH Zurich Switzerland' / Organization name
TELESCOP = 'Radio Spectrometer' / Type of instrument
INSTRUME = 'LAB     '           / Name of the spectrometer
OBJECT  = 'Sun'                     / object description
DATE-OBS = '2004/12/06'         / Date observation starts
TIME-OBS = '12:45:23.382'       / Time observation starts
DATE-END = '2004/12/06'         / date observation ends
```

```
TIME-END = '12:50:38'            / time observation ends
BZERO  =                    0. / scaling offset
BSCALE  =                   1. / scaling factor
BUNIT   = 'digits  '           / z-axis title
DATAMIN =                     0 / minimum element in image
DATAMAX =                   255 / maximum element in image
CRVAL1  =                45923. / value on axis 1 at reference pixel [sec]
CRPIX1  =                     0 / reference pixel of axis 1
CTYPE1  = 'Time [UT]'  / title of axis 1
CDELT1  =                   0.5 / step between first and second element in
x-axis
CRVAL2  =                  200. / value on axis 2 at the reference pixel
CRPIX2  =                     0 / reference pixel of axis 2
CTYPE2  = 'Frequency [MHz]' / title of axis 2
CDELT2  =                  -1. / step between first and second element in
axis
HISTORY = '        '
OBS_LAT =     47.3412284851074 / observatory latitude in degree
OBS_LAC = 'N       '           / observatory latitude code {N,S}
OBS_LON =     8.11221504211426 / observatory longitude in degree
OBS_LOC = 'E       '           / observatory longitude code {E,W}
OBS_ALT =                416.5 / observatory altitude in meter asl
FRQFILE = FRG0021.CFG / name of the frequency file
PWM_VAL = 120 / pwm-value to control tuner gain voltage
END
```

12 Input file descriptions

12.1 Frequency program

```
/*-------------------------------------------------------------*/
/* (C) Copyright Institute of Astronomy ETHZ 8092 Zurich       */
/*-------------------------------------------------------------*/
/* Programname: FRQ08731.cfg                                   */
/*                                                             */
/* Revision: V1.1  Date: 06.12.04  Autor: Chr. Monstein        */
/*                                                             */
/* Purpose: Frequencyprogram for CALLISTO Radiospectrometer    */
/*                                                             */
/*-------------------------------------------------------------*/

/* Created by Chr. Monstein, 21.10.2002                          */
/* Updated by Chr. Monstein, 08.09.2003  minor text changes      */
/* Updated by Chr. Monstein, 06.12.2004  minor changes           */
/* Updated by Chr. Monstein, 01.01.2009  3ed column=light curve  */

[target]=CALLISTO

[on_line_testpoint_number]=56

[number_of_measurements_per_sweep]=200
[number_of_sweeps_per_second]=4

[external_lo]=0.0

/* 1. column: channel counter, use always 4 digits       */
/* 2. column: frequency/MHz                              */
/* 3. column: number of integrated sweeps in light curve */
/* up to 5 light curves possible                         */

[0001]=00180.050,0
[0002]=00180.300,0
[0003]=00180.650,0
[0004]=00180.900,0
[0005]=00181.250,0
[0006]=00181.550,160
[0029]=00188.425,0
[0030]=00188.727,0
[0031]=00189.021,0
...
..
.
[0200]=00850.003,0
{eof}

Remark: The keyword [0xxx] has to be exactly 4 digits within brackets.
Frequency has to be inserted expressed in MHz. Leading zeroes in
frequency are not necessary.
```

12.2 Observation scheduler

```
/*-------------------------------------------------------------------*/
/* (C) Copyright Institute of Astronomy ETHZ 8092 Zuerich Switzerland
/*-------------------------------------------------------------------*/
/* File: SCHEDULER.CFG     Revision: 03, 29.09.2003  Chr. Monstein
/*-------------------------------------------------------------------*/
/* Time-scheduler describes what has when to be done on CALLISTO
/*-------------------------------------------------------------------*/

/* Created by: Chr. Monstein    29.10.2002  initial experients
/* Updated by: Chr. Monstein    07.11.2002  reviewd version
/* Updated by: Chr. Monstein    29.09.2003  switchcode killed

/* Each schedule-entry is composed of:
/* - Starttime hh:mm:ss (UT) + delimiter
/* - focuscodes decimal (63...00)
/* - Planned measurement-mode (0…9) + delimiter
/* - additional comment
/* each entry will be repeated automatically every day
/* empty lines are allowed to separate diffent task

03:00:00,59,8, // save spectral overview (Radio monitoring)

08:00:00,59,3, // antenna watching cold sky

12:00:00,59,3, // antenna pointing to horizon
12:00:30,53,2, // Tnull
12:01:00,37,2, // Texcess
12:02:00,53,2, // Tnull

14:10:00,59,3, // antenna pointing to the sun
14:12:30,53,2, // Tnull
14:15:00,37,2, // Texcess
14:17:00,59,3, // antenna pointing to the sun again

15:00:00,59,3, // restart for security reason (after power fail)

17:10:00,59,0, // stop measuring periodically

23:00:00,59,8, // save spectral overview (Radio monitoring)
```

Remark: it is possible to measure through midnight without interruption.

12.3 Logfile (example)

23.01.2004,15:11:09,$HST:Configurationfile callisto.cfg read
23.01.2004,15:11:09,$HST:Switched to automatic
23.01.2004,15:11:09,$HST:Frequencyfile frq00100.cfg
23.01.2004,15:11:10,$HST:Measurement idle
23.01.2004,15:11:10,$HST:File scheduler.cfg successful read
23.01.2004,15:11:10,$HST:Measurement enable
23.01.2004,15:11:10,$CRX:U2(+12V)=10.13V
23.01.2004,15:11:11,$HST:Frequencyfile c:\TEMP\callisto\frequency\frq00100.cfg read
23.01.2004,15:11:11,$HST:Plot buffer erased...
23.01.2004,15:11:11,$HST:Parametrisation RCU due to new frequencyfile
23.01.2004,15:11:12,$HST:Yt plot selected
23.01.2004,15:11:13,$HST:Switched to manual
23.01.2004,15:11:18,$HST:manual frequencyfile selection
23.01.2004,15:11:19,$HST:Frequencyfile c:\temp\callisto\frequency\frq00020.cfg read
23.01.2004,15:11:19,$HST:Plot buffer erased...
23.01.2004,15:11:19,$HST:Parametrisation RCU due to new frequencyfile
23.01.2004,15:11:20,$HST:Parametrisation RCU due to START
23.01.2004,15:11:20,$HST:Actual focuscode 59,58
23.01.2004,15:11:20,$HST:Enable data transfer
….
23.01.2004,15:11:48,$HST:Create new RAW-file
23.01.2004,15:11:48,$HST:Continous measurement
23.01.2004,15:11:56,$HST:Measurement stop
23.01.2004,15:11:56,$HST:Measurement wait...
23.01.2004,15:11:56,$HST:EOT detected, end of HEX-data
23.01.2004,15:11:56,$HST:Measurement halted
23.01.2004,15:11:56,$HST:Measurement idle
23.01.2004,15:11:56,$CRX:Stopped
23.01.2004,15:11:56,$HST:Measurement enable
23.01.2004,15:11:56,$CRX:U2(+12V)=10.13V
23.01.2004,15:11:57,$HST:All threads terminated
23.01.2004,15:11:57,$HST:This application closed
| | | | → Comment
| | | → Signal source
| | → Time of event
| → Date of event

12.4 Configuration file

```
/*-------------------------------------------------------------------------*/
/*  (C) Copyright Institute of Astronomy ETHZ 8092 Zuerich Switzerland     */
/*-------------------------------------------------------------------------*/
/*  Programmname: callisto.cfg                                             */
/*                                                                         */
/*  Revision: V1.5     Date: 20.10.2006    Autor: Chr. Monstein            */
/*                                                                         */
/*  Purpose: Configuration file Radiospectrometer CALLISTO                 */
/*                                                                         */
/*  Editor: Notepad or any other ASCII-Editor                              */
/*-------------------------------------------------------------------------*/

// Created by: Chr. Monstein 05.05.2003
// Updated by: Chr. Monstein 20.10.2006 e-Callisto


// RCU, receiver control unit
[rxcomport]=COM3              // COM1 .... COM18, office Monstein=COM3/7, Laptop=COM1
[rxbaudrate]=115200           // fixed, do not change
[observatory]=12              // CALLISTO=12, fixed
[instrument]= HAWAII          // instrument code -> filename_
[titlecomment]=LHCP           // additional comment on application title
[origin]=KH6SKY               // Place of instrument ETH_Zurich_Switzerland….
[longitude]=E,8.1122155       // default geographical longitude in degree
[latitude]=N,47.3412278       // default geographical latitude in degree
[height]=416.5                // default meter above sealevel
[clocksource]=1               // RISC-level: 1=internal, 2=external, default=1
[filetime]=900                // time periode for one single raw-file (in seconds)
[frqfile]=frq00201.cfg        // default frequency program
[focuscode]=59                // default focuscode (00 … 63)
[mmode]=3                     // default continuous recording
[ytbuflen]=1000               // buffer length of light curve plot, fixed
[xybuflen]=2000               // buffer length of frequency domain plot, fixed
[xyzbuflen]=20000             // buffer length of frequency-time domain plot, fixed
[timerinterval]=30            // global timing interval [msec] , fixed
[timerpreread]=2              // timer to prepare stop-process via scheduler, fixed
[timeouthexdata]=1000         // timer to empty all buffers after stop, fixed
[fitsenable]=1                // 0=no FITSfile, 1=FITS write On
[datapath]=c:\test\           // default datafile path
[logpath]=c:\test\            // default logfile path
[low_band]=171.0              // VHF band III barrier (MHz), fixed
[mid_band]=450.0              // UHF band IV barrier (MHz), fixed
[chargepump]=1                // charge pump: 0=false=off, 1=true=on=default
[agclevel]=150                // PWM level for tuner AGC 50...255, default 120
[detector_sens]=25.4          // detector sensitivity mV/dB, default 25.4
[db_scale]=6                  // dB per division in XY-plot, default 6


Legend:
You are not allowed to change entries which are marked red
You may change entries which are marked orange
You have to edit entries which are marked green according to local configuration
```

13 Commands

Important note: Always use ENTER – key from num-keyboard but not standard ENTER from main – keyboard! Otherwise Callisto will not understand commands (CR instead of CR/LF)

13.1 Common commands (to be sent using a Hyperterminal)

Command	Ex.	Description
Frequency-programming Receiver #0	F0x	Set main tuner (0) with frequency x, where x=frequency [MHz]
Store frequency entry in EEPROM	FEx,y,z	x=channel number, 0 ≤ x < 500, y=frequency [MHz], 045.000 < y < 870.000 [TBC], z=spare code 0 ≤ x ≤63, where z is taken from the frequency program
Read frequency number x and code	FRx	x=channel number, 0 ≤ x < 500 result frequency and FPU-Code To get a response, set debug mode on <D1>
Set low band barrier of the tuner	FLx	x=frequency of the lowest switch barrier, see tuner specification somewhere near 175MHz
Set mid band barrier of the tuner	FMx	x=frequency of the middle switch barrier, see tuner specification somewhere near 450MHz
Set high band barrier of the tuner	FHx	x=frequency of the highest switch barrier, see tuner specification somewhere near 870MHz
Measuring delay	Mx	x measuring delay in msec or number of m-points per second [TBD]
Set repeat frequency of state machine using internal clock	GSx	Set frequency in asynchronous mode x=0-5 (choose 1.0Hz; 50Hz; 200Hz, 400Hz or 800Hz) For response, press <?>
Set repeat frequency of state machine using external clock	GAx	Set frequency in synchronous mode x=0-2 (choose 20Hz; 200Hz or 400Hz /stored in the internal EEPROM) For response, press <?>
Sweep length or number of channels	Lx	Number of channels to be measured in one sweep, 1<= x <=13‘120

13.2 Measurement commands (to be sent using a Hyperterminal)

Command	Ex.	Description
Stop data transfer of state machine	GD	Disable the data transfer between host and client of the state machine
Start data transfer of state machine	GE	Enable the data transfer between host and client of the state machine
Tuner gain	Oxxx	PWM voltage to tuner expressed in digits 0….255 For PWM-value, see sensitivity plot To check tuner AGC-voltage, press <U2>
Process stop	P0	Stop continuous recording to the end of actual sweep
Process continuous	P1	Start continuous recording with beginning of next sweep

Process single sweep real data	P2	Start one single sweep from F1 to F2
Process single step+	+	Next step in actual frequency program +62.5kHz
Process single step-	-	One step back in actual frequency program -62.5kHz
Trigger via software	T0	Host controller starts a single measurement
Trigger via timer	T1	Local timer start measurements controlled by quartz crystal 11.0592MHz
Trigger extern	T2	Measurement is controlled by an external event such as a GPS, atomic clock or DCF77 (1 MHz, TTL source)
Start measuring process	S1	Start the parallel or the alternating measuring mode (state machine)
Stop measuring process	S0	Stop the parallel or the alternating measuring mode (state machine)

13.3 House keeping commands (to be sent using a Hyperterminal)

Command	**Ex.**	**Description**
Charge pump off	C0	Low charge for low phase noise on both tuner but low frequency changing
Charge pump on	C1	High charge in PLL for high frequency changing
Measure AGC voltage	U2	Gain control tuner, set voltage by command <Oxxx>
spare	U3	spare
Measure emitter voltage	U4	Test voltage at emitter BF199
spare	U5	spare
Measure input voltage	U6	10/37 of input voltage after diode and fuse
spare	U7	spare

13.4 General single commands (hacker's commands) (to be sent using a Hyperterminal)

Command	**Ex.**	**Description**
Clear bit	Cxy	Set any bit to 0 (0Volt) Port x=A,B,C,D, Bit y=0,1,2,3,4,5,6,7
Debugging off	D0	Don't send any additional info to the host controller
Debugging on	D1	Send all relevant info to the host controller
Get status	?	Dump all relevant system information back to host controller
Read Port x	Rx	Read any Port (A, B, C, D), answer 0...255
Read ADC channel x	Ax	Read any ADC, answer 10 bit reduced to 8 bit expressed in HEX 0 <= x <= 7
Set bit at Port x, Bit y	Sxy	Set any bit to1 (5Volt), x=A,B,C,D; y=0,1,2,3,4,5,6,7
Set focus code according to: focodes.xls	fsx	Switch rf-path (antenna, calibration unit and hybrids). Code x, y=00…63 decimal [use small letters here!!!]
Set data format	%0	Decimal 10 bit
Set data format	%1	Decimal 8 bit
Set data format	%2	Decimal milli Volt
Set data format	%3	HEX 8 bit including carriage return between data elements
Set data format	%4	HEX 8 bit without carriage return in between (default binary format no header)
Set data format	%5	Send frequency and decimal 8bit

Measuring a full channel overview using the hyper terminal

< Choose caption file on hyper terminal menu and save it as filename.txt >
D1 (enable debug)
O120 (default gain)
T0 (software trigger)
M1 (select delay to 1msec or any other >= 1msec)
F0045.0 (set start frequency and select F0 for RX1, or F1 for RX2)
L13200 (measure 13200 points, 62.5 kHz step size, from 45 MHz to 870 MHz)
%5 (send frequency and voltage in spreadsheet format)
? (get status to get all relevant parameters)
P2 (start a single sweep)
… (now incoming data are stored on disk, just wait a few seconds...)
< Close actual capture file >
< Start EXCEL or any other spreadsheet, load file.txt and make a XY-plot >

14 Focuscode, switchcode, rf-path

This list is 100% PHOENIX-2 compatible, e-Callisto may be used with a subset only (<1GHz)

Switch code dec	Hybrid Select	Fokuscode path	Fokuscode dec	rf-path description	measurement process on integrator card 1. ~110µs Sum. & Min.	2. ~110µs Sum. & Sub.	3. ~110µs Sum. & Sub.	4. ~110µs Sum. & Min.
0	0	A1	63	Left circular polarization until 1GHz	left circular polarization			
0	1	A3	61	Left circular polarization above 1GHz	left circular polarization			
1	0	A2	62	Right circular Polarization until 1GHz	right circular polarization			
1	1	A4	60	Right circular Polarization above 1GHz	right circular polarization			
2	-	A5	59	Linear feed nr. 1	linear feed nr. 1			
3	-	A6	58	Linear feed nr. 2	linear feed nr. 2			
4	0	B1	57	50 ohm termination until 1GHz (left)	50 ohm			
4	1	B3	55	50 ohm termination above 1GHz (left)	50 ohm			
5	0	B2	56	50 ohm termination until 1GHz (right)	50 ohm			
5	1	B4	54	50 ohm termination above 1GHz (right)	50 ohm			
6	-	B5	53	50 ohm termination linearpath 1	50 ohm			
7	-	B6	52	50 ohm termination linearpath 2	50 ohm			
8	0	C1	51	Noise -10dB left circular until 1GHz (isol)	noise -10dB left circular polarization			
8	1	C3	49	Noise -10dB left circular above 1GHz (isol)	noise -10dB left circular polarization			
9	0	C2	50	Noise -10dB right circular until 1GHz (isol)	noise -10dB right circular polarization			
9	1	C4	48	Noise -10dB right circular above 1GHz (isol)	noise -10dB right circular polarization			
10	0	E1	46	Noise -10dB left circular until 1GHz (inp)	noise -10dB left circular polarization			
10	1	E3	44	Noise -10dB left circular above 1GHz (inp)	noise -10dB left circular polarization			

11	0	E2	45	Noise -10dB right circular until 1GHz (inp)	noise -10dB right circular polarization			
11	1	E4	43	Noise -10dB right circular above 1GHz (inp)	noise -10dB right circular polarization			
12	-	C5	47	Noise -10dB linear nr. 1	noise -10dB linear nr. 1			
13	-	E6	42	Noise -10dB linear nr. 2	noise -10dB linear nr. 2			
14	0	D1	41	Noise left circular until 1GHz (isol)	noise left circular polarization			
14	1	D3	39	Noise left circular above 1GHz (isol)	noise left circular polarization			
15	0	D2	40	Noise right circular until 1GHz (isol)	noise right circular polarization			
15	1	D4	38	Noise right circular above 1GHz (isol)	noise right circular polarization			
16	0	F1	36	Noise left circular until 1GHz (inp)	noise left circular polarization			
16	1	F3	34	Noise left circular above 1GHz (inp)	noise left circular polarization			
17	0	F2	35	Noise right circular until 1GHz (inp)	noise right circular polarization			
17	1	F4	33	Noise right circular above 1GHz (inp)	noise right circular polarization			
18	-	D5	37	Noise linear nr. 1	noise linear nr. 1			
19	-	F6	32	Noise linear nr. 2	noise linear nr. 2			
20	0	A1	63	Normal mode SUM=L+R, DIF=L-R	left circ. pol.			left circ. pol.
20	0	A2	62	Normal mode SUM=L+R, DIF=L-R		right circ. pol.	right circ. pol.	
20	1	A3	61	Normal mode SUM=L+R, DIF=L-R	left circ. pol.			left circ. pol.
20	1	A4	60	Normal mode SUM=L+R, DIF=L-R		right circ. pol.	right circ. pol.	
21	0	A1	63	Left circular polarization DICKE	left circ. pol.			left circ. pol.
21	0	B1	57	Left circular polarization DICKE		50 ohm	50 ohm	
21	1	A3	61	Left circular polarization DICKE	left circ. pol.			left circ. pol.
21	1	B1	57	Left circular polarization DICKE		50 ohm	50 ohm	
22	0	A2	62	Right circular polarization DICKE	right circ. pol.			right circ. pol.
22	0	B1	57	Right circular polarization DICKE		50 ohm	50 ohm	
22	1	A4	60	Right circular polarization DICKE	right circ. pol.			right circ. pol.
22	1	B1	57	Right circular polarization DICKE		50 ohm	50 ohm	
23	-	A5	59	Linear feed nr. 1 DICKE	linear 1			linear 1
23	-	B5	53	Linear feed nr. 1 DICKE		50 ohm	50 ohm	
24	-	A6	58	Linear feed nr. 2 DICKE	linear 2			linear 2
24	-	B6	52	Linear feed nr. 2 DICKE		50 ohm	50 ohm	
25	-	C5	47	Difference calibration linear nr. 1	N-10dB lin. 1			N-10dB lin. 1
25	-	cB5	31	Difference calibration linear nr. 1		50 ohm	50 ohm	
26	-	cB5	31	Difference zero calibration linear nr. 1	50 ohm termination			
27	-	E6	42	Difference calibration linear nr. 2	N-10dB lin. 2			N-10dB lin. 2
27	-	eB6	30	Difference calibration linear nr. 2		50 ohm	50 ohm	
28	-	eB6	30	Difference zero calibration linear nr. 2	50 ohm termination			

What we really apply to the FPU is the so called ‘Fokuscode’ in decimal format from 30…63.

15 Cartridge Connectors

15.1 Power Callisto (3pol) male

1 = +12Volt supply Callisto 0,5A
2 = shield
3 = GND

15.2 External Clock (BNC) female

1 = timer/counter #1 (TTL) [1MHz, TTL/5V, 50Ω]
2 = GND

15.3 Audio output (Mini jack)

1 = Audio out (to Audio in of PC or Notebook)
2 = GND

15.4 Serial port RS232 SUB-D9

2 = TX
3 = RX
5 = GND

15.5 FPU interface connector SUB-D25 female

Terminal	Callisto	FPU	Comment
1	Data+	Data+	RS485 connection FPU⇔FPU-controller
2	Nil	Nil	Spare
3	Vcc	FC0+	FPU control bit 0 high potential
4	Vcc	FC1+	FPU control bit 1 high potential
5	Vcc	FC2+	FPU control bit 2 high potential
6	Vcc	FC3+	FPU control bit 3 high potential
7	Vcc	FC4+	FPU control bit 4 high potential
8	Vcc	FC5+	FPU control bit 5 high potential
9	V_fpu	U_input	Power supply FPU 32V...48V dc (high potential)
10	V_fpu	U_input	Power supply FPU 32V...48V dc (high potential)
11	V_fpu	U_input	Power supply FPU 32V...48V dc (high potential)
12	V_fpu	U_input	Power supply FPU 32V...48V dc (high potential)
13	GND_fpu	Shield	Shield for all wires
14	Data-	Data-	RS485 connection FPU⇔FPU-controller
15	Nil	Nil	Spare
16	FPU0	FC0-	FPU control bit 0 low potential
17	FPU1	FC1-	FPU control bit 1 low potential
18	FPU2	FC2-	FPU control bit 2 low potential
19	FPU3	FC3-	FPU control bit 3 low potential
20	FPU4	FC4-	FPU control bit 4 low potential
21	FPU5	FC5-	FPU control bit 5 low potential
22	GND_fpu	GND	Power supply FPU 32V...48V dc (low potential)
23	GND_fpu	GND	Power supply FPU 32V...48V dc (low potential)
24	GND_fpu	GND	Power supply FPU 32V...48V dc (low potential)
25	GND_fpu	GND	Power supply FPU 32V...48V dc (low potential)

Remarks:
Each FCx– should be twisted with its partner FCx+, where 0<x<=5
Each U_input should be twisted with its partner GND
Data+ and Data- should also be twisted together
The orange shaded pins are not used within e-Callisto, they are used in Phoenix-2 and Phoenix-3 only!

16 Board connectors

16.1 KL1 (screw-terminal 2pol, power supply)

K1.01 = Power supply input +10Vdc …. +15Vdc / 500mA
K1.02 = Power supply input 0V = GND

16.2 KL2 (ICSP6 programming plug)

KL2.1 = PB6 = MISO
KL2.2 = +5V
KL2.3 = PB7 = SCK
KL2.4 = PB5 = MOSI
KL2.5 = RESET = RST (pull up 47 kohm to +5V)
KL2.6 = GND = 0V

16.3 K3 (header 14pol, digital output to FPU)

K3.01 = FOPA_0
K3.02 = +5Volt processor
K3.03 = FOPA_1
K3.04 = +5Volt processor
K3.05 = FOPA_2
K3.06 = +5Volt processor
K3.07 = FOPA_3
K3.08 = +5Volt processor
K3.09 = FOPA_4
K3.10 = +5Volt processor
K3.11 = FOPA_5
K3.12 = +5Volt processor
K3.13 = GND
K3.14 = GND

16.4 K4 (header 6pol, RS232 in/out)

K4.01 = Video (from detector/integrator)
K4.02 = GND
K4.03 = Clock input 1MHz, TTL
K4.04 = GND
K4.05 = TX, RS232
K4.06 = GND
K4.07 = RX, RS232
K4.06 = GND

17 Specifications

Parameter	Range	Unit
Frequency range	45.0 – 870.0 (in 3 separate rf-band, see tuner spec.)	MHz
Frequency resolution	62.5	KHz
Observation bandwidth	300 / 378	KHz @ -3dB / -10dB
Antenna input impedance	~50	Ω
Dynamic range	-120 … -10 2)	dBm
SFDR	> 40	dB
Gradient	25.4 ± 1	mV / dB
Noise figure max	10	dB
ALLAN time @ To	>100	Sec
Warm up time	15	Minutes
Sampling time internal clock	≤ 800 1)	Samples/sec
Sampling time external clock	≤ 1000 1)	Samples/sec
Max. Gradient dF/dT	~30.0	MHz/msec
Number of channels	1, 2, 4, 5 ,8 ,10, 20, …500	entries
Timing uncertainty	≤ 0.3	sec
Voltage power supply	12.0 ± 2	Volt
Current power supply	~ 225 ± 5	mA
COM-parameters	115200N81 (no handshake)	Baudrate
Input configuration file Input scheduler file Input frequency program	callisto.cfg scheduler.cfg frq99999.cfg	ASCII ASCII ASCII
Output data file Output log file Output overview file Output light curve	XXXX_yyyymmdd_hhmmss_ff.fit 3) LOGyyyymmddhhmmss.TXT OV_XXXX_yyyymmddhhmmss.PRN LCyyyymmdd_uuu_nnnnnn.txt	FITS ASCII ASCII ASCII
Weight (without cables)	850	grams
Dimensions	W = 110, H = 82, D = 200	mm

Remarks:

1) higher measuring speeds are possible, if one accepts a reduction in SNR, see http://www.astro.phys.ethz.ch/instrument/callisto/fm/fm.htm
   There is some additional loss of channels at the low end of the sweep due to finite speed of VCO in the internal synthesizer. One has to expect a loss in channels of about 1.25% of number of pixels per sweep. E.g. for a sweep rate of 800 pixels/sec we expect a loss of up to 10 channels.

2) Sensitivity depends on control voltage on AGC input, see sensitivity plot
3) XXXX stands for station name like BLEN, OOTY, GAURI, SSRT, KASI etc.

18 Possible data rates

18.1 Internal clock only

internal clock	pixel/s	mpps	Nsps
	40	1	40
		2	20
		4	10
		5	8
	100	10	10
		20	5
		50	2
	400	10	40
		20	20
		50	8
		100	4
		200	2
		400	1

800	20	40
	40	20
	50	16
	100	8
	200	4
	400	2

mpps = measurement points per second, 1 <= mpps <= 500, integer only
nsps = number of sweeps per second, need to be an integer > 0
if you want to have a correct filetime length the product of *mpps* and *nsps* must be equal to pixel/s.
Speeds above 800 mpps are not recommended due to finite response of synthesizer
Default value is 800 pixels/sec (200 pixels/sweep x 4 sweeps/sec)

18.2 External clock only (1MHz TTL)

external clock	Pixel/s	mpps	nsps
	40	1	40
		2	20
		4	10
		5	8
	100	10	10
		20	5
		50	2
	400	10	40
		20	20
		50	8
		100	4
		200	2
		400	1
	800	20	40
		40	20
		50	16
		100	8
		200	4
		400	2
	1000	20	50
		100	10
		200	5
		250	4
		500	2

mpps = measurement points per second, 1 <= mpps <= 500, integer only
nsps = number of sweeps per second, need to be an integer > 0
if you want to have a correct filetime length the product of *mpps* and *nsps* must be equal to pixel/s.
Speeds above 800 mpps are not recommended due to finite response of synthesizer
Default value is 800 pixels/sec (200 pixels/sweep x 4 sweeps/sec)

19 I/O-manual RISC processor ATmega16

Analog inputs from periphery			
Signal name	**Port**	**Alias**	**Remarks**
Video	PA0	ADC0	Detector voltage main receiver
0V	PA1	ADC1	
AGC	PA2	ADC2	Tuner control voltage
0V	PA3	ADC3	
Emitter BF199	PA4	ADC4	IF transistor
0V	PA5	ADC5	
Input voltage	PA6	ADC6	Via divider 10/37
0V	PA7	ADC7	

Digital input/output from/to EEPROM			
Signal name	**Port**	**Alias**	**Remarks**
	PB0	TO	Timer/Counter0 external counter input
Clock 1MHz	PB1	T1	Timer/Counter1 external counter input
	PB2	AIN0	
	PB3	AIN1	
EEPROM_~CS	PB4	~SS	SPI-EEPROM 25LC320 (32Kbyte) select
EEPROM_SI	PB5	MOSI	SPI-EEPROM 25LC320 (32Kbyte) input
EEPROM_SO	PB6	MISO	SPI-EEPROM 25LC320 (32Kbyte) output
EEPROM_SCK	PB7	SCK	SPI-EEPROM 25LC320 (32Kbyte) clock

Digital outputs to focal plane unit			
Signal name	**Port**	**Alias**	**Remarks**
FOPA_0	PC0	PC0	Focuscode to FPU which there will be decoded by either a RISC-processor or a GAL to: L, R, hot, cold, hot-10dB, DICKE, Hybrid-select, etc. etc
FOPA_1	PC1	PC1	
FOPA_2	PC2	PC2	
FOPA_3	PC3	PC3	
FOPA_4	PC4	PC4	
FOPA_5	PC5	PC5	
Do not use...	PC6	TOSC1	Timer oscillator Pin 1
Do not use...	PC7	TOSC2	Timer oscillator Pin 2

Digital input/output to periphery			
Signalname	**Port**	**Alias**	**Remarks**
RS232-TX	PD0	RXD	RS232 transmission to host PC
RS232-RX	PD1	TXD	RS232 transmission from host PC
	PD2	INT0	
	PD3	INT1	
SCL	PD4	OC1B	I2C-Clock to tuner
SDA	PD5	OC1A	I2C-Data to tunern
	PD6	ICP	
AGC	PD7	OC2	AGC-control via PWM

20 Hints & tricks

- Every COM port shall only be configured once at a certain time
- Don't forget last backslash ('\') in path-description
- Don't change format of keywords in configuration file
- Don't use 'SPACE' in configuration parameters, use underscore instead
- Keep the number of open applications on PC as low as possible
- PC should be configured for everything always ON (no sleep activities)
- Switch hibernation (Windows XP/2000/7 power management) to off
- Number format must be ddd'ddd'ddd.dd [European format due to sscanf()]
- Set time&date regional format to 24 hours (no AM/PM) in UTC or GMT to be compliant with 'scheduler.cfg'
- Switch indexing (Microsoft Office) to off
- Virus-scanner: if possible, exclude data- and log-directory of Callisto
- Don't forget to terminate external clock by 50 ohms
- Before connection of external clock is made, be sure to have TTL-clock (0V/+5V) at 1MHz duty cycle 50% (adjust FREQ, AMPL and DC-OFFSET appropriate)
- Keep RS232 cable as short as possible and take a well shielded cable
- If spectrum 'jumps', try to disable RX-&TX-FIFO in COM-port configuration
- In case of blockades due to an overloaded PC, terminate the application or kill it using TaskMan, then switch Callisto off&on and restart callisto.exe again.
- To reduce rfi, put e-Callisto into a separate metal box (19" like)
- Cables from/to e-Callisto should be fed through individual ferrite cores
- All keywords in frequency file must be in small letters.
- Frequency file keyword shall have exactly 4 digits within brackets like [nnnn]=
- Switch Windows 2000/XP/7 desktop→appearance to 'windows classic' (Windows 95-like)
- Switch desktop→appearance→fontsize to normal
- If Callisto does not start then change compatibility mode to 'Win9x'
- Put the link of callisto.exe into AutoStart-menu of Windows
- Disable automatic reboot after updating of Windows OS, Virus scanner or Firewall etc.
- If you have two Callistos running on the same computer, keep focus-code different, e.g. 59 for the 1st and 58 for 2nd polarization. Otherwise it is not possible to store fits-data on the same drive. And, prepare 2 separate log-directories, one for 1st and another for the 2nd Callisto.

Appendices

- For schematic diagrams, see http://www.astro.phys.ethz.ch/instrument/callisto/ecallisto/applidocs.htm