MARS EXPRESS

PLANETARY FOURIER SPECTROMETER

INSTRUMENT DESCRIPTION

MEX-CNR-FUM 1

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FUM 1 - INSTRUMENT DESCRIPTION

1-INTRODUCTION

PFS is a Fourier Spectrometer working on 2 channels . The Martian radiation is devided in two parts by the entrance optics and then analised by two interferometers placed in two planes one on top of the other. Being the interferometers extremely sensitive to optomechanical distortions, the Interferometer box must be very rigid and thermally stable. Mechanical vibrations may affect the measurements. Each interferogram (each channel) is sampled every 150 nm displacement of the corner cubes retro reflectors. Therefore the motion itself must be extremely stable and accurate . The signal measured with 16 bits ADC , is filtered through 2 band pass filters, whose definition depend on the speed of the double pendulum motion. For the above reasons PFS is a very difficult experiment in space conditions.

2– INSTRUMENT HARDWARE DESCRIPTION

2.1- INTRODUCTION.

PFS is a double pendulum interferometer working in two wavelength ranges (1.2- 5 , and 5-45 µm). Mars radiation is divided in 2 beams by a dichroic mirror, and then filtered , so that the two ranges also correspond to 2 planes one on top of the other , in which the two interferometers are placed, so that the same motor can simultaneously move the 2 pendulum , and the two channels are sampled simultaneously and independently. The pendulum motion is accurately controlled by means of a laser diode reference channel making use of the same optics as for Martian radiation. The same laser diode also generates the sampling signal for the A/D converter, measuring in this way displacements of the double pendulum mirror of 600/4 nm. The measurements obtained are double sided interferograms, so that FFT on board can be computed without caring much about the zero optical path difference location.

TABLE 1 - DETAILED PFS PARAMETERS

	SW	LW
Spectral range, µm	1.2 - 5.0	5.5 - 45
cm^{-1}	2000 - 8200	230 - 1750
Spectral resolution, cm^{-1}	1.5	1.5
(by triangular apodization)		
FOW, deg FWHM	1.6	2.7
NEB, W cm-2 sr-1	$5\ 10^{-9}$	$4\ 10^{-8}$ (1)
Measurement cycle duration, s	5.0 (10)	5.0 (10)
Detector Type	Photoconductor	Pyroelectric
Material	PbSe	$LiTaO_3$
Shape/size(mm)	square,0.7x0.7	round 1.4
NEP, W/Hz^.5	$1*10^{-12}$ (2)	$4*10^{-10}$ (3)
Sensitivity, kV/W	90 (2)	30 (3)
Temperature,K	220 (4)	290
Interferometer Type	Double pendulum	
Reflecting elements	Cubic corner reflectors	
Beamsplitter	CaF_2	CsI
Refl. elements motion, mm	+/- 1.5	+/- 1.5 (5)
Max.optic. path differ., mm	5	5

Time for motion, s	5	5
Time for measurements, s	4.5	4.5
Reference source	Laser diode	
Ref. source' wavelelength, nm	1216	
Collector optics	Parabolic mirror	
Diameter, mm	49	38
Focal length, mm	20	20
Coating	Gold	
SW/LW separation	KRS-5 with a multilayer coating reflecting SW radiation	
Optics transmission	0.64	0.78 (6)
Modulation factor	0.87	0.98 (7)
Interferogram	Two-sided	
Samplings number	16384	4096 (16384)
Sampling step,nm	608	2432
Dynamical range	$+/-2^{15}$	
Spectra (from on-board FFT)		
Quantity of points	8192	2048
Dynamical range	6000	6000
Electronics		
Modulation frequency range, Hz	423 - 1600	50 - 400
On-board FFT module computation time, s	3.35	0.83
Buffer memory volume, Mbites	32	
Full PFS mass, kg	31.2	
Mass of blocks, kg		
O (optics and part of electron.)	19.9	
E (main electronics)	3.5	
P (dc/dc converter)	2.3	
S (pointing/scanning system)	4.0	
Harness	1.1	
PFS power consumption, W		
In flight to Mars	5	
Peak during observations	45	
On the orbit in "sleeping mode"	10	

(1) Values are given for wavelengths 2.5 and 15 µm. Results of measurements for PFS 07 in SW.

(2) In peak of the spectral responsivity curve (near 4.8 µm and for the modulation frequency 1000 Hz.

(3) By the modulation frequency 200 Hz. NEB and sensitivity are given for the output of the preamplifier.

(4) Radiative cooling.

(5) Linearized deviation from the position, corresponding to zero path difference.

(6) From measurements of reflection and transmission of optical elements. Values are given for wavelengths 2.5 and 15 µm

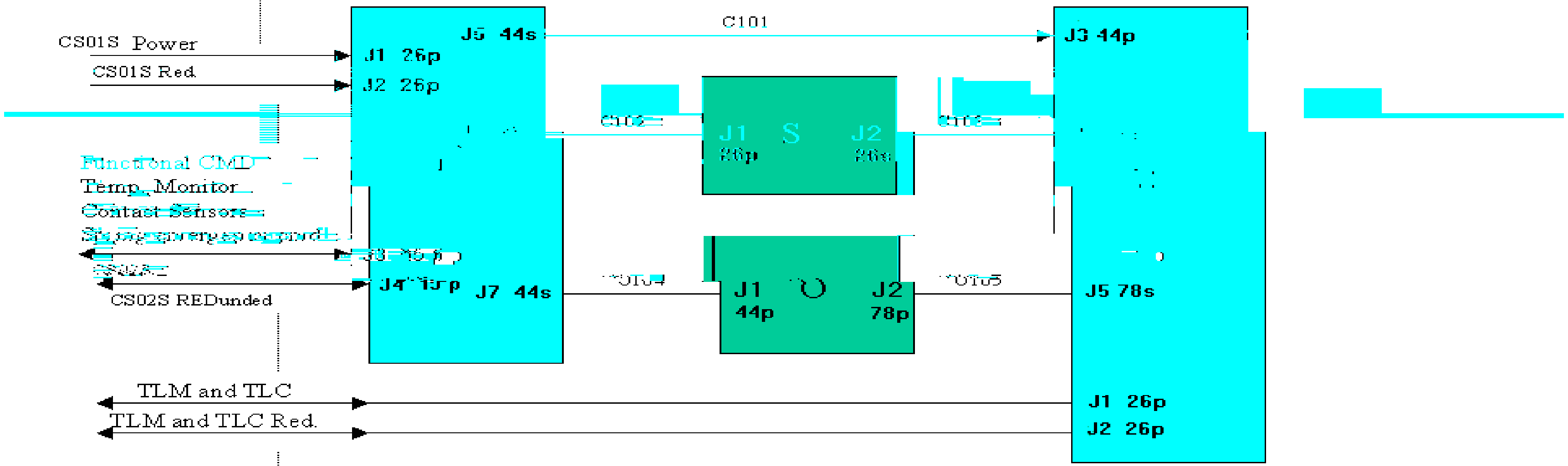
(7) From estimates of tolerances . Values are given for wavelengths 2.5 and 15 microns.

2.2- INSTRUMENT ORGANISATION.

PFS is a Fourier spectrometer resulting from the effort of several groups from different countries : Italy, Russia, Poland, Germany, France and Spain. The flight hardware is produced in Italy (main digital electronics controlling the experiment , and the Interferometer block with its controlling electronics), in Russia (the breadboard of the pointing device and its electronics, the two detectors) and in Poland (the Power supply , the flight unit of the Scanner and the GSE with the spacecraft simulator), while in Germany some special flight parts or subassembly are produced. Groups in France and Spain helped in the design of the experiment in the preliminary phase, and will be interested in the scientific Data

Analysis , as well for the USA Co.I.s. Integration , qualification and calibration was done in CNR using, when appropriate , Alenia Spazio facilities. Special calibration black bodies , produced by russian Co.I.s are used in a Thermovacuum Chamber in a Clean Room facility. Fig.1 – PFS general organisation

PFS for MARS EXPRESS harness **updated 11/99**



PFS for MARS EXPRESS Cabling

Connectors Items ending P are pins, S are sockets

C101 Power to E module , temp housekeeping E module, commands to S module and P module
C102 Power to S module , temp housekeeping of S module, Emergency Mirror Position
C103 Scanner commanding & housekeeping, Black Body temp mon. and lamp monitor.
C104 Power to O module & temp housekeeping
C105 O module commanding & data, calibration control and status

2.3- TECHNICAL DESCRIPTION.

The flight hardware of the experiment is divided in four parts which we call modules, plus the connecting cables . The four parts are : the Interferometer , with its optics and proximity electronics , which is the core of the experiment, and is called Module O. The pointing device , which allows to receive radiation from Mars or from the in flight calibration sources , which is called Module S. The Digital electronics , including a 32 Mbit mass memory, and a real time FFT , called Module E. The Power Supply , Module P, with the DC/DC converter , the redundancies, and the galvanic separated power for the 16 bits A/D converters.

2.4- MODULE O

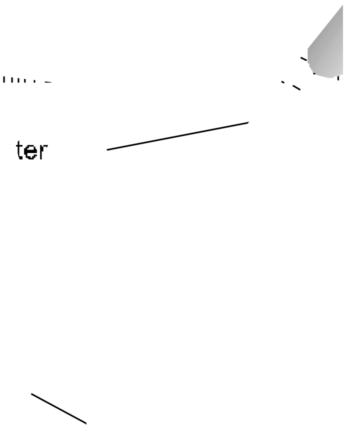
The Module O is the core of PFS. Module O, hereafter PFS-O, stands for Optical Module and it includes inside the interferometer with its proximity electronics. PFS-O is divided into two blocks: IB (Interferometer Block) and EB (Electronics Block). The two blocks are mechanically separated but electrically connected through six cables as interface. Furthermore IB is a gas tight box filled with dry nitrogen in order to preserve the optical parts that are hygroscopic. The IB is very compact and in practice it contains inside two interferometers working at the same time covering the full range of PFS between 1.2µm and 45µm. The two ranges are named "SW" as Short Wavelength and "LW" as Long Wavelength. The range of the SW channel is within (1.2:5)µm while the LW is within (5:45)µm.

2.4.1-OPTICAL SCHEME OF PFS-O

a- Martian radiation.

The main optical design of the PFS is shown in Figure 1. The incident IR beam falls onto the entrance filter that separates the radiation of SW channel from the LW channel and directs each into the appropriate interferometer channel. The scanner in front of the interferometer allows the FOV to be pointed along and laterally to the projection of the flight path onto the Martian surface. It also directs the FOV at internal black body sources, diffusers and to the open space for in-flight calibration. Each PFS channel is equipped with a pair of retroreflectors attached by brackets to an axle angularly moved by a torque motor. The axle and the drive mechanism are both used for both channels that are positioned on top of each other. The optical path difference is generated by the angular movement of the retroreflectors (Hirsch and Arnold 1993). The controller of the torque motor uses the outputs of two reference channels, which are equipped with laser diodes . This interferometer design is very robust against slight misalignment in harsh environment compared with the classical Michelson-type interferometer (Hirsch 1997). This favours the design for applications in space.

The detectors are placed in the center of the parabolic mirrors "C1" and "C2". The optical path is changed rotating the shaft of the double pendulum along its axis. In this way the optical path will be 4 times greater than a single cube corner displacement since two mirrors move at the same time. This is different for a Michelson interferometer where just one mirror moves to cover the optical path. This configuration helps in having a more compact instrument.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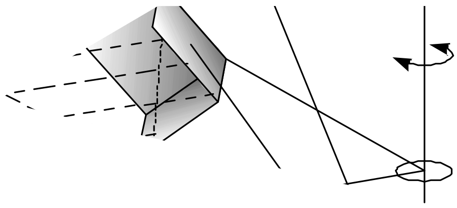


If we place the zero optical path difference in the center of the mirror displacement, we can acquire double sided interferogram. A double sided interferogram has several advantages, among which a relatively insensitivity to phase errors that otherwise should be corrected. A bilateral operation is adopted in order to reduce the time cycle of each measure but a separated calibration for each direction is recommended in order to maintain the prefixed radiometric accuracy.

b- The reference channel .

In the fig. 1 is not shown the optical part regarding the reference beam acting as spectral reference. Indeed every interferometer owns a reference channel where a beam of very well known wavelength interferes in order to produce a sine wave to be used as spectral reference. In our case the source of such beam is a laser diode (InGaAsP at 1.2μm) and its detector is an infrared photodiode having the maximum responsivity at about 1.2μm. The beam of the reference channel is processed like the input signal so that the optical path of the reference is almost exactly coincident with the optical path of the signal to be studied. In each channel the reference beam is inserted parallel to the main optical axis , just after the entrance window ,but it is travelling outside of the main beam .As each channel has its own reference beam the different length of the double pendulum arms is fully allowed and compensated. Because the beam splitter of the long wavelength channel "B2" is not transparent at the wavelength of the corresponding laser diode used as reference, a special small window was done during the manufacturing of it in order to keep negligible the attenuation of the laser beams through the beam splitter itself. At the corner cubes the laser beam moves from one side to the other of the main beam, so that the part of the beam directed backward toward the source is displaced with respect to the inward part. This part terminates into an optical trap (one per each channel).

c – The zero optical path difference signal (zopd) .

Being PFS an instrument taking double sided interferograms, it is not needed to know with large precision the position of the pendulum for which there is a zero optical path difference between the arms of the interferometers. However a rough information is still needed because the motion of the pendulum it is digitally controlled so that it goes 8192 steps on one side of the zopd, then the motion is reversed and it goes backward until it reaches the zopd and another 8192 are counted. The interferogram acquisition stops when 16 384 points are taken. The zopd signal is generated by using IR radiation from a TRW …. Device , which , if a thin mirror is placed at the correct distance, will give a pulse when the mirror is in front of the device, while no signal is obtained for any other position. The linear mirror, for PFS , is placed on the edge of an arrow fixed to the shaft of the double pendulum. During assembly it is adjusted so that its signal is within 100 pulses from the optical zopd, then is fixed. During the double pendulum motion the arrows moves in front of the TRW detector , so that a pulse is generated at the zopd position.

2.4.2-MECHANICAL DESCRIPTION OF PFS-O.

Module «O» contains the interferometer that is constituted by three main parts, the optical bench the pendulum system and the gas tight box.

2.4.2.1-THE OPTICAL BENCH .

The optical bench is a an Al7075 structure, obtained by machining and electro-erosion from a single aluminum alloy billet. All the optical elements of the interferometer are directly mounted or have a reference to the optical bench. The beam splitters are flange mounted on the reference plane of the optical bench while the supports of the axle on which the cubic corners are mounted are machined with a strict tolerance of planarity with the reference plane. The sensors are mounted on a surface of the optical bench with a 2 DOF regulation system that allows to align the detector group axes with the instrument one.

2.4.2.2-THE PENDULUM SYSTEM

Pendulum shaft is mounted on two angular contact ball bearings, axially pre-loaded with an elastic system allowing the differential thermal expansion without inducing sensible stress. The movement of the axle is a rotation of about ± 1.5° for the useful part and is up to 2.5° considering the extra-travels. The rotation is made by an electrical brushless torque motor that, for safety, is totally redundant. For the stability of the control loop a friction torque is applied to the axle. A locking device keep the pendulum in a position outside the useful travel during the launch phase and in case of orbit correction/maneuvering. The locking/unlocking procedures takes about 10 minutes, the actuator being a paraffin one, the movement is therefore slow and no vibration or relevant electromagnetic fields are induced. Provided that the pendulum mass is mainly due to the cubic corner mirrors its center is far from the rotation axes. In order to reduce the sensitivity of the instrument to acceleration transversal to the axle a balancing mass has been added. On Mars 96 for mass saving only 50% of the static momentum has been compensated. The balancing mass is kinetically mounted on the pendulum axle to avoid thermal stresses to be induced because of the different CTE of the materials. Regulation devices are mounted in place of the balancing mass during the alignment of the interferometer and afterwards removed.

2.4.2.3-THE GAS-TIGHT BOX.

The optical bench is included in a gas-tight box that during ground operation has to be filled with dry nitrogen. The gas tight box is required to avoid the degradation of the CsI beam splitter for moisture absorption. A bellow valve automatically opens and stay open when the environment pressure goes below 90 kPa allowing the inner gas to leave the instrument; when the external pressure increases above that value the valve closes again. The failure position of such valve is open to avoid an excessive overpressure in the instrument would damage of the entrance optics.

The interferometer is attached on three fixation points to the main interface plate, to which also the proximity electronics is fixed. The mounting on the spacecraft is achieved by four attachment points that are realized with dampers based on silicon rubber elements. The mounting so performed has a first eigenfrequency at about 80 Hz. The gas tight box is also mechanically supporting the thermal interface to the radiator, where a thermal flexible strap will be fixed . Structural elements fulfill the general requirement of having natural frequencies higher than 100 Hz, exception made for the modes involving the damping system. There are no pyro devices in the module.

2.4.2.4-THERMAL DESCRIPTION OF PFS-O.

PFS-O has four main thermal requirements: the temperature of the Short Wavelength detector , the Temperature/stability of the Long Wavelength detector , the temperature/stability of the two diode lasers and the temperature/stability of the optical bench.

Short Wavelength Detector. The requirement for the SWS is to have a working temperature lower than 220 K . This goal is achieved by means of a passive radiator, connected to the sensor by means of an aluminum cold finger. The sensor is mounted on a three legs pure aluminum structure, connected to the cold finger by a copper braid strap and mechanically fixed to the optical bench by a thermally insulating structure made in Vespel®, having a thermal resistance higher tan 500 K/W. The aluminum cold finger and the mounting thermal resistance were devised so that the Mars radiative peak power on the radiator expected at perihelion was delayed on the sensor of about 30 minutes to allow a complete one hour session to be performed before the transient. The cold finger is MLI insulated and all the fixation structures are made in Vespel. An electrical heater is implanted behind the sensor for temperature stabilization during the measurement session. The radiative flux on the sensor holding structure is minimized by polishing the metallic surfaces.

Long Wavelength Detector .The requirement for the long wavelength sensor are less stringent for the working temperature, about 25 °C, but challenging for the stability, <0.01°C/h. The sensor is mounted on an insulating Stainless Steel structure and the temperature is controlled by an electrical heater placed at its back, fed by an electronic circuit.

Lasers Diode. A wrong operative temperature of the diode lasers along with its fluctuations in time may cause degradation of the spectral resolution of the interferometer. The degradation being function of power, temperature and manufacturing of the device. For this reason the choice of the best operative temperature of the diode lasers must be planned in the calibration procedure. In such sense a good thermal controller is very important. In PFS the two laser diodes are thermally controlled within 0.01K experienced as a maximum value to avoid degradation of resolution. The temperature itself can be set in a wide range between 2°C up to 42°C but the maximum allowed depends on the operative temperature of "IB". In our case a gradient of 4°C between the fixing points and the laser diode case is achieved as a maximum.

Optical bench temperature control . In the interferometer unit there is, during operation, a dissipation of about 5 W of electrical power, mainly in the motor of the pendulum and the sensors proximity electronics. The thermal requirement is mainly in uniformity of the temperature; differences of the order of 2 °C between the average temperatures of the brackets of the pendulum leads to a reduction of the SNR of 1%. The countermeasures impleme nted to avoid the critical gradients are mainly the thermal insulation from the surrounding. The Interferometer module is covered with an MLI insulator and fastened to

the interface plate with low conductivity bolts to reduce the influence of temperature fluctuation in the parts facing its sides i.e. the electronics box, and the external box. The electronics box inside module "O" has a power consumption of about 10 W while operating.

The whole module "O" is thermally insulated from the Spacecraft because of the low thermal conductance of the dampers and of the MLI covering all the external surfaces. The electrical power dissipated inside the module is removed by the radiator of the SWS because of the heat leaks through the mountings and the radiative fluxes. The total heat flux in the design configuration is about 4 W however in the "Spare" unit for Mars96 , because of an heavy shielding used for the SWS harness the flux was up to 7 W. In order to avoid this problem we are planning to use as cabling between the detector and the proximity electronics, a kapton thin strip, so that the thermal inputs to the detector can be minimised.

In case of a Martian orbit of 6.5 h period the removal of the 15 watts dissipated during the hour of operation goes on in the following 5.5 h of sleeping mode. The resulting temperature profile for the electronics module shows a peak of temperature in operation with an increasing of about 10 °C and a cooling down phase in the rest of the orbit.

The IB unit has two thermal control system, the first operates when the instrument is in sleeping mode while the other is on during operations. The Sleeping mode thermal control system, named ASTRA, is a rough four point temperature control preventing the average temperature to fall below 7 °C, it has a total power of 4 W. The temperature control active during operation is mainly devoted to the monitoring/control of some relevant items such as the detectors, the emitting diode lasers of the reference channels plus 8 spots on the optical bench.

2.4.3- ELECTRONICS OF PFS-O.

-The OBDM : Optical Bench Digital Module.

Most of the electronics inside PFS-O is analog electronics but a board based on a microprocessor has been implemented to control all the complex procedures during the acquisition of the interferogram, including communication with PFS-E which is the main electronics. Such board has been called "OBDM", acronym of "Optical Bench Digital Module". "OBDM" also includes 32kwords of eprom memory for software storage and 96k words for data. A general scheme of the PFS-O electronics is shown in figure 2.

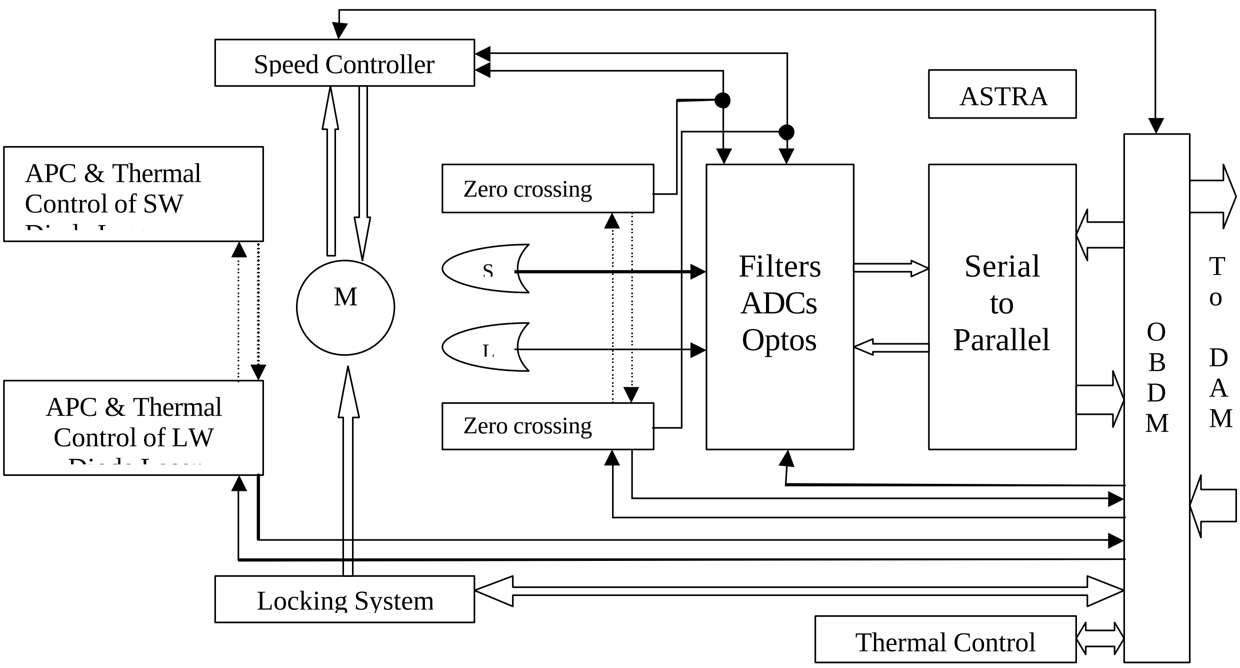


Fig.3 Module O block diagram.

-- the zero crossing .

We use a laser diode at 1200 nm as reference channel. The interferogram of a monocromatic light is a sine wave. We use this sine wave, amplified to max , in order to generate pulses , so that each time the sine wave goes through zero we get a pulse. These pulses are used in different ways : the sampling of the interferogram is triggered by these pulses , because in this way we have a sampling every 600 nm for optical path difference increments. The motion of the double pendulum is also controlled by these zero crossings , as we shall see later. The interferogram sampling is usually done by each laser diode for each channel, although for redundancy each laser can be used for both channels. Also the double pendulum motion can be controlled by either of the two laser diodes.

--The speed controller.

The most important block in the electronics of PFS-O is the speed controller. The double pendulum motion operates in a continuous mode: the speed of the mirror's motion is kept constant in the range of measure and the signal is sampled at equal intervals. In this mode the spatial interferogram is directly mapped into an electrical interferogram and some electrical filter can be used in order to integrate the signal and partially reject the noise outside the band of interest. A factor of 4 appears in our case between the mechanical speed of motion and the effective optical speed due to two mirrors moving at the same time. In any case the mirrors displacement must be very accurate to a small of fraction of a wavelength. For this purpose the zero crossing of the signal of the interferogram of a monochromatic source very stable in wavelength can be used for sampling the interferogram of the source to be studied. In the ideal case the interferogram of the monochromatic source must be a pure sine wave but it is not so just for the fact that its interferogram is limited in time. The smaller the wavelength of the reference source the better is the accuracy of the sampling. In our case a 1.2 μm was used as a reference source due to the limited variety of lasers diodes and for a simpler optical design.

-- The laser power supply.

Because the wavelength of a laser diode depends on its temperature and power, much care has to be taken in controlling them. An "Automatic Power Control" (APC) was used for the lasers diode in order to control the power within a few microwatts. The maximum power allowed for each laser is 5mW but a compromise must be chosen in order to maintain high both reliability and signal to noise ratio. In our case a power of about 3mW was chosen. An additional thermal controller provides stable temperature of the lasers within 0.01K in vacuum. Either power and temperature are set and read through "OBDM", the Module O digital electronics. As we mentioned the zero crossing signals of the reference channels are used to sample the interferogram and also as encoding signal for the speed controller. A differential amplifier provides the gain for the electrical signal coming from the photodiode and a filter is added to limit the noise band. A system of comparators generates the zero crossing signal with narrow width to be further used for speed controlling and for the analog to digital converters. The speed of the double pendulum is such that a frequency of 2kHz is generated from the SW channel laser interpherogram. Thus a train of pulses with frequency of 4kHz comes out from the electronics of the SW reference channel. There could be a difference in frequency between the two channels since the length of the arms is different and only one channel at a time is used for the speed controlling. The other channel is used only in case of failure of the former. The speed controller is of PI type (Proportional-Integral) and the zero crossing signal of one reference channel is compared with an electrical signal to obtain the wanted speed.

In our case the frequency of the electrical signal is of course 2Khz. In the Proportional-Integral controlling the error signal is generated from the sum of two voltages: the first one proportional to the difference between the speed of the double pendulum and the frequency of the external signal, the second one proportional to the integral of the same difference. In this way the speed of the double pendulum is forced to be equal to that superimposed by the external reference. At that condition the error signal is of course zero. The settling time of the speed is maintained as low as possible thorough some parameters set by experience. In any case it must be lower than 0.5s for having a stable speed during the measure. The standard deviation of the speed controlling is less than about 0.5% depending much on the environmental condition, overall in terms of vibration level. It is hard to quantify the maximum vibration level allowed since it depends on type and direction. We can say that in general the lower vibration level the better quality of measure in terms of signal to noise ratio and radiometric accuracy. The speed of the double pendulum defines the chopping of the signal source and it is related to the integration time. In other words reducing the speed means increasing the signal to noise ratio but the filters must change the spectral width and cutoff, as they do in PFS. Reducing the speed makes it harder its control since the vibration frequencies induced by the motor become closer to the resonant frequency of the mechanics, around 200Hz. Of course reducing the speed makes the cycle time longer for a single interferogram.

- The A/D converters.

There are four analog to digital converters (Crystal CS5101A), two for each channel for redundancy, having the power supply separated from the rest and output opto-coupled to the serial converter. All of this reduces the electromagnetic interference going inside the detectors stage. Furthermore the serial output of the ADCs minimizes the cabling inside the interferometer block where the ADCs reside.

-- The thermal control.

The thermal control is also very important for an infrared interferometer and it is operated using eight points for reading the temperatures and for heating the structure. The controlling is passive so that only heating is permitted. Every point is read and set again through "OBDM". Additionally also the two detectors (SW and LW) are thermally controlled. This is important to accurately maintain the radiometric calibration without increasing very much the on flight calibration cycles. The temperature of "IB" is maintained in this way at a constant temperature of 13°C. This thermal control requires of course a minimum of external sink in order to have the equilibrium temperature a bit below the operative temperature.

-- The ASTRA system.

An additional thermal control without electrical connections with the rest is the block named "ASTRA". This stand alone electronics provides thermal control of "IB" during the cruise phase while the instrument is off. In this way also during the cruise phase the temperature inside "IB" is kept around the operative temperature and the thermal cycles are reduced at the minimum. Moreover "ASTRA" is composed by four channels and it controls four points located inside "IB" so that also thermal gradients are quite reduced. Thermal cycles and thermal gradients can be cause of misalignment of the interferometer. The total power dissipated by ASTRA is 6 W.

-- The block-unblock system.

The block named "locking system" serves to lock the double pendulum either during the launch and during maneuvering for orbital insertion and correction. The procedure of locking and unlocking takes about 10min but it can be repeated hundreds of times since it uses paraffin actuator instead of pyroelectric or similar devices. Nevertheless for the best safety the vector of launch should be along the axis of the double pendulum corresponding to the maximum robustness of the interferometer. This part of electronics activates the blocking system which is based on a paraffine pushed pin with a mechanism that activated once , puts the pin out, activated a second time puts the pin in. In any case contact sensors are present to give information about the status of the system. We shall note here that the actuators are qualified and guaranteed for 1500 + 1500 actuations. The daily reorientation of the spacecraft and the orbit correction manouvres , to be implemented every few days , do not present a problem in the sense that we do not need to block the double pendulum for those actions. Indeed it is stated that those thrusters will give 0.05 Nms2, against the 0.5 Nms2 that we can afford after having increased the balancing mass of the double pendulum.
-- The detectors : SW.

We use a photo-conductor type detector for the SW channel capable to work at a temperature down to 200K whose main characteristics are listed in the Table 4.

Table 4

Main characteristics of the SW detector	
Size [mm]	**0.7 x 0.7 square**
Spectral range [mm]	**1.2 - 4.5**
D^*(l max) [cm $Hz^{1/2}$ /W]	**0.9 10^{11} at 200 K, 1.2 kHz**
D^*(l max) [cm $Hz^{1/2}$ /W]	**0.3 10^{11} at 250 K, 1.2 kHz**

The SW detector is passively cooled through a radiator and its holder is partially insulated from the rest of «IB». The minimum conductance between holder and fixing point acts as a thermal sink to cool down the whole «IB» itself. The operative temperature of the SW detector is about 220K.

-- The detectors :LW.

For the LW channel we have used a pyroelectric detector whose characteristics are listed in the Table 5.

Table 5

Main characteristics of the LW detector	
Size [mm]	**1.4 Æ round**
Spectral cutoff [mm]	**> 50**
Threshold [W/ $Hz^{1/2}$]	**About 5 10^{-10} at 200 Hz**
Responsivity [V/W]	**About 70k**
Noise [V/Hz]	**About 5 10^{-6}**

The LW detector is able to work without performance degradation even at ambient temperature. In our case the ambient temperature is the temperature of «IB» which is about 13°C.

2.5- Module E.

Module E, hereafter PFS-E, is the main electronics and controls all the modules of PFS. PFS-E controls the communication to and from the spacecraft, memorizing and executing the command words, operating PFS and sending back the data words to the spacecraft. Moreover it synchronizes all the procedures according to the time schedule and to the time clock coming from the spacecraft.

NOTE : ALL INTERFACE COMPONENTS WILL BE HIGH REL , WHILE THE REST OF THE EXPERIMENT IS MOSTLY MIL883B LEVEL.

2.5.1-Electronics of PFS-E

The electronics of PFS-E has been divided into 8 boards having each one an own specialized function. The overall system is represented in the simplified scheme of figure 4.

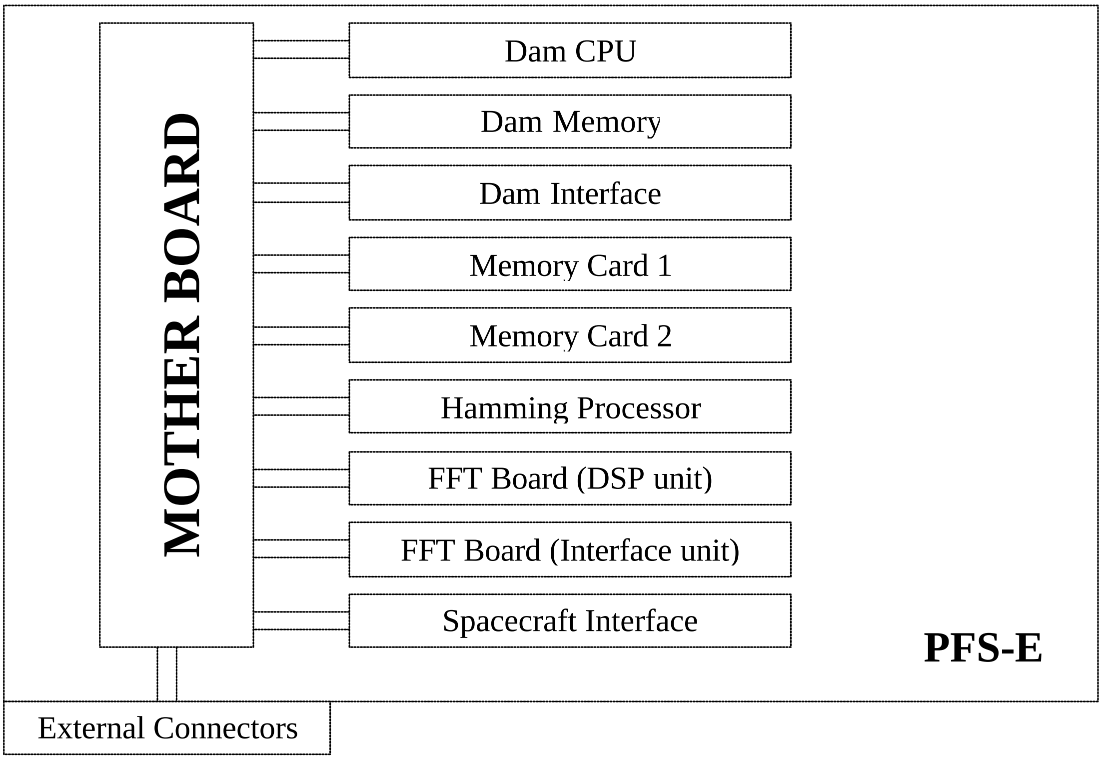


Fig.4 - Electronics of PFS-E

-The motherboard.

The «mother board», is a board without components so that it only allocates the routing to connect all the board inside PFS-E and the external connectors. Furthermore it serves as mechanical termination for the boards themselves.

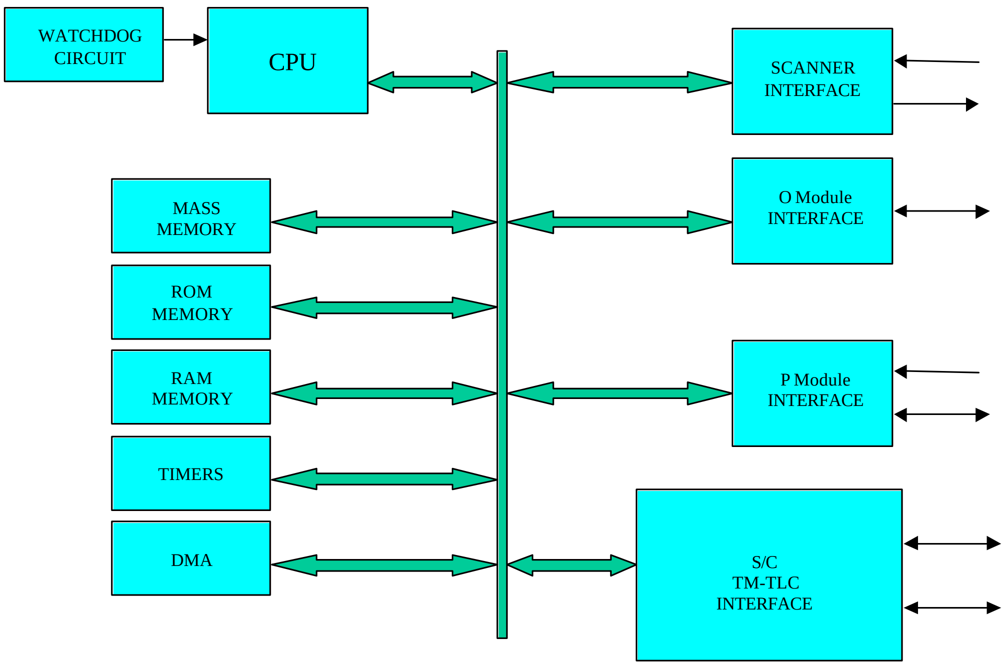
-The DAM CPU.

The board «DAM CPU» contains the cpu «80C86» and all the chips and timers necessary for it. It is the real controller of the entire experiment.

-The memories.

The board «DAM Memory» includes either «RAM» type memory and «EPROM» type memory. The latter contains the software written in assembler «8086» with its operational parameters necessary for all the controls. The former contains the data and housekeeping information acquired by PFS. During the «bootstrap» procedure, «DAM» copies software and data from the EPROM to the ram for better safety and reduced power consumption. The total amount of CPU ram memory is 256kbytes while the EPROM is 64kbytes. This memory has not to be confused with the mass memory, which resides in other boards.

E Module BLOCK DIAGRAM



Block diagram of module E.

-DAM Interface.

The board «DAM Interface» integrates all the chips needed for interfacing between PFS-E and PFS-O, PFS-S and PFS-P. The interface between PFS-E and PFS-O is a parallel type having data and commands separated. Such interface presents the highest data interchange inside PFS. Interferograms and housekeeping information acquired by PFS-O are sent through this channel. In addition special signals are introduced here for example to reset «OBDM» inside PFS-O. The communication between PFS-E and PFS-S (the scanner) is very simple due to the limited requirements to the scanner .This channel is relatively slow but the amount of data does not require a fast communication. The other interfacing included inside this board is that between PFS-E and PFS-P, the power supply. The modules are switched on or off by means of a parallel interface used as Input/Output pins that generate level signal to the PFS-P. Of course PFS-E is switched on at the beginning by a functional command from the spacecraft and PFS-E cannot switch off itself.

-Mass Memory.

The board «Memory Card » include the mass memory. The total mass memory capacity is 6 Mbytes and inside this memory are stored all the interferograms (or spectra) and housekeeping information of the current session of measure. Normally data are provided in real time to the spacecraft by means of a FIFO , in the packetized format requested by the spacecraft. Our mass memory acts as a buffer , in case some other operations is requested on the data (originally data compression was done by means of FFT only, but recently we have added for the mode 1 datatrasmission at least another compression scheme : 2000 measurements around the ZOPD are transmitted as words , while the other measurements are transmitted as bytes) . If the spacecraft do not request data from PFS , PFS will go on acquiring and storing data. Once the mass memory is completely filled, «DAM» put PFS in a stand by mode until the spacecraft uploads partially or totally the data. Moreover the mass memory can be switched off or on in several sectors.

The included «Hamming Processor» serves to identify and correct the wrong bits inside the mass memory. It increases the reliability of the data store inside the mass memory.

-ICM.

The board «ICM Board (DSP unit)» performs the calculation of the FFT on board. It can calculate the spectrum or sine-cosine components of an interferogram for one or both channels of PFS-O. The same board can include upon request also an apodization function of the weak type. In addition it can calculate the medium value of the interferogram for «DC» signal correction. The FFT on board can be useful for data reduction when we wish to observe particular scientific data, like absorption bands of particular gases or simply the radiance of a part or full band. The board allocates an Analog Devices «2101» DSP plus its static memory for data and program for a total of 48kwords.

The board «ICM Board (Interface Unit)» provides the interface between the FFT board and the CPU board. The data between the two are interchanged through a «DMA» channel («Direct Memory Access») for a fast execution.

-- Spacecraft Interface.

The board «Spacecraft Interface» includes all the chips for communication with the spacecraft. Most of the components on this board are optocouplers and buffers. The board also owns two «FIFO» memory («First In First Out») having a total capacity of 8kbytes in order to dump the interchange of the data between «DAM» and spacecraft. The interface is based on a hardware of majority logic of two over three for reliability of communication. The same logic is also foreseen for the sincro signal from the spacecraft clock.

-- Software interface.

The DAM has all required interfaces to the DMS:
- Memory Load Command (MLC)
- Serial Digital Telemetry (SDT) sampling
- Serial Digital Telemetry line

The DMS interfaces are compatible with the following ESA standards:
- Packet Telemetry Standard (ESA PSS-04-106)
- Packet Telecommand Standard (ESA PSS-04-107)
- Telecommand Decoder Specification (ESA PSS-04-151)

At the physical level the information is transferred as 16 bit serial digital telemetry acording to the ESA Data Handling Interface Standard (ESA PSS-47/ TTC-B-01).

The telemetry information is prepared according to ESA and MARS-EXPRESS mission standards. The main telemetry data unit, Source Packet, contains following fields:

- Source Packet Header
- Data Field Header
- Source

Data The Source Packet Header and the Data Field Header have predefined structure. Only the Source Data can contain private PFS information. There is no use to store headers together with the Source Data.

The Telemetry subsystem prepares only Source Data and stores them in the Mass Memory. The Source Data will be extracted from the Mass Memory, included into the Source Packet and sent to the spacecraft by the TM interface task.

Since the maximal length of the Source Data field is 4096 bytes, when the full size of the Data Pack can be as big as 40 Kbytes, the data segmentation should be used. The Telemetry subsystem cuts the Data Pack by pieces and adds a header to each piece. The header contains:

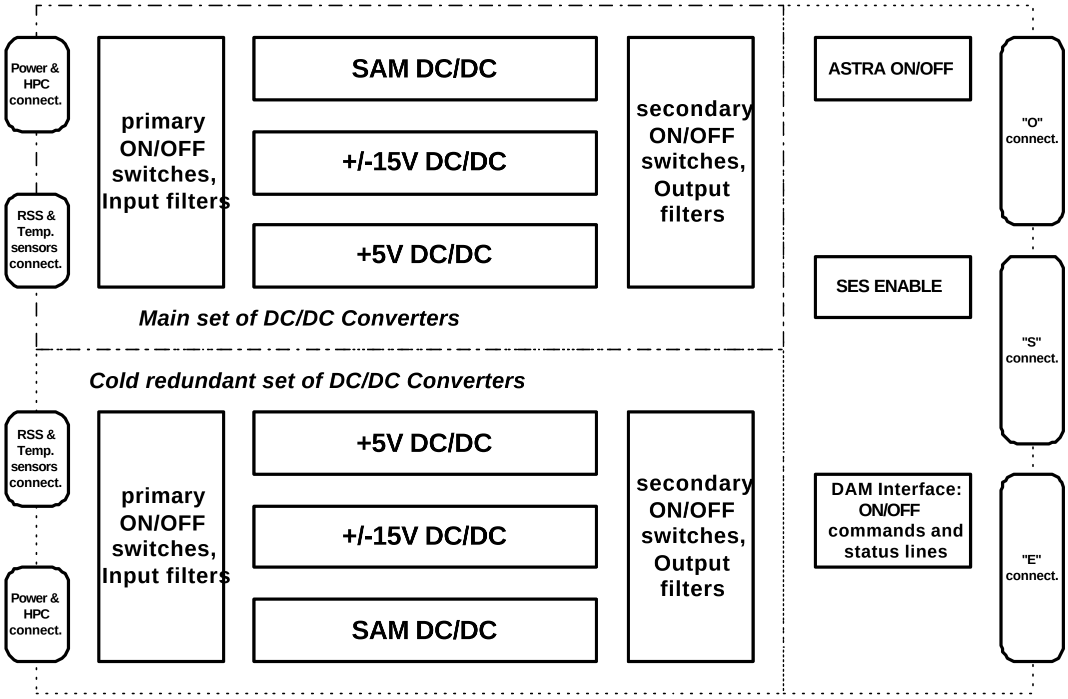
- acquisition number within the Session
- segment number within the acquisition

This allows to distinguish all segments obtained during the Session rather than during one acquisition.

2.5 - MODULE P.

PFS combines many kinds of electrical energy consumers: standard digital and analogue electronics, sensitive preamplifiers and A/D converters, light sources and electromechanical devices (motors and relays). All of them have different requirements for the supply (voltages, currents, ..), in fact some of them need to be galvanically separated from others and/or individually controlled by PFS's main microprocessor (DAM). This is the reason why block P is more complicated than the simple DC/DC Converter – it consists of three independent converters, six different power outputs (totally 13 independent voltages), one common input interface to satellite and one interface to DAM. All converters have cold redundancy. Switching between main/reserve +5V is controlled by satellite, others main/reserve converters are controlled by PFS itself.
PFS-P is almost fully redundant system. It consists of two independent sets of DC/DC Converters working in cold redundancy. Each set has three converters dedicated to: supply the digital +5V, supply the sensitive electronics inside SAM and to supply all others analogue electronics, heaters and motors. Switching between main/reserve +5V is controlled by satellite, others main/reserve converters are controlled by PFS itself trough the commands from DAM.

Figure below shows the block diagram of block P.



Each of independent converters works at 131 kHz with variable pulse width. Siliconix Si9110 is used as PWM controller, the feed back loop is closed magnetically. Overvoltage and overcurrent protections are built-in.

Power outputs consist of the filters and SIPMOS switches to be used for controlling (by the commands from DAM) the supply of Scanner, SAM, Block O and Calibration Lamps.

Block P generates six status signals to be used inside DAM for H/K purposes. These are the +5V Main/Reserve, +/-15V Main/Reserve, SAM Main/Reserve, +5V OK, +/-15V OK and SAM OK lines. The output drivers for these signals are not redundant.

ASTRA System, located inside block O, is connected to satellite trough interface inside block P. These are the power lines, the High Power Commands for ASTRA ON and OFF and relays to execute the commands.

Scanner Emergency Spring, located inside the Scanner, is initialised by the subsystem inside block P. This subsystem is controlled by satellite HPC and DAM commands. Only when both commands appear the SES can be supplied (initialised).

Five temperature sensors (thermistors: one in P, one in S, one in E and two inside O) are connected to satellite Analogue Conditioned Telemetry trough interface (connector) located at P box.

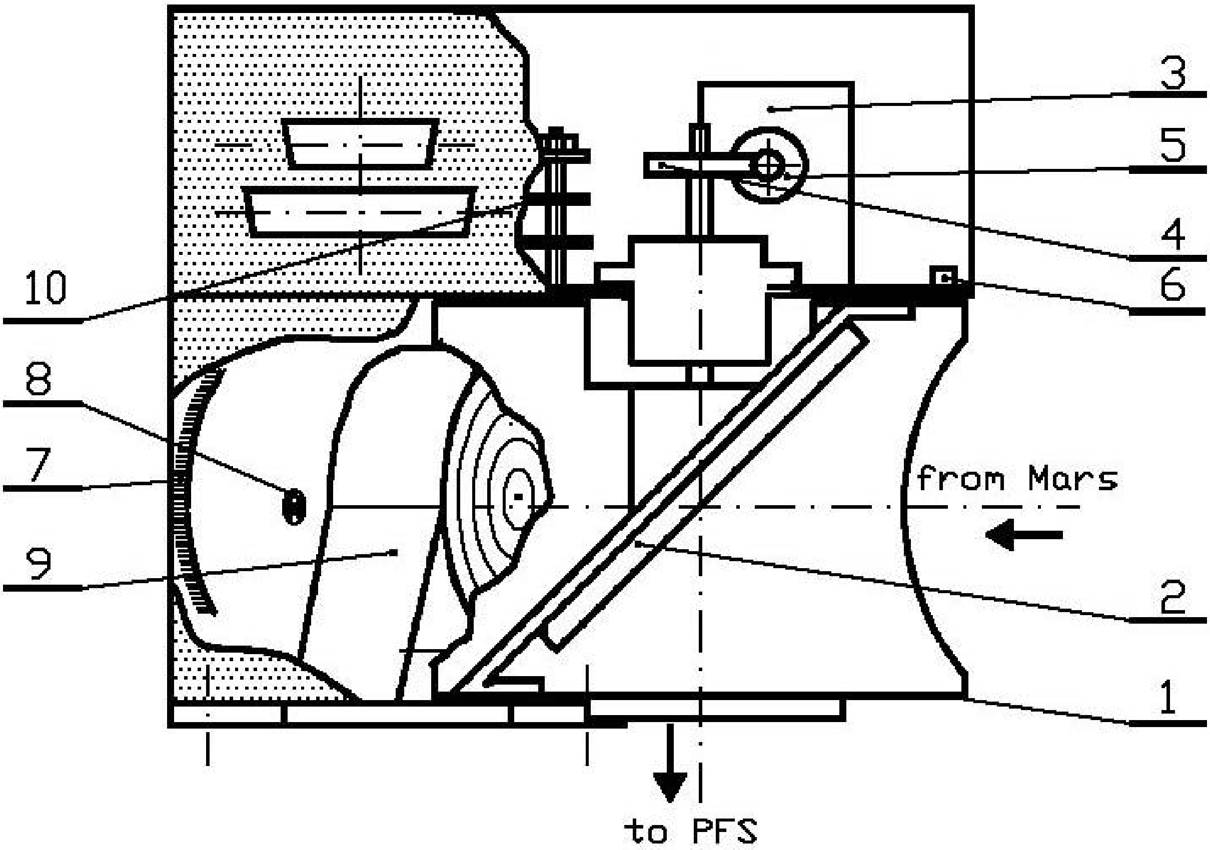
PFS-P parameters

Primary input voltage	**28V**	**+1% / -2% - 0.3W*I_{load}**
Primary input current	**0.3A**	**sleep mode**
	(0.8A – 1.3A)	**normal mode**
	(1.7A)	**max., motors on**
Average power consumption	***(35W)***	**during normal operation**
	8.1W	**sleep mode**
Secondary voltages/currents	**+5V/600mA**	**E block**
	+5V/300mA	**O and A blocks**
	(+5V/1.1A)	**C and K blocks**
	+15V/100mA	**A block**
	+15V/440mA	**O block**
	-15V/350mA	**O block**
	+5V/150mA	**SAM**
	-5V/65mA	**SAM**
	+15V/20mA	**SAM**
	-15V/13mA	**SAM**
	28V/25-360mA	**ASTRA**
	(28V/40-600mA)	**motors in C**
	28V/350mA	**blockout of O (5 min)**
Dimensions	**180mm**	**height**
	60mm	**width**
	230mm	**depth**
Mass	**2300g**	

2.7- MODULE S.

The module S (scanner) is a single-axis pointing system located in front of the optical entrance of Module O . The axis of rotation of the scanner mirror will be in coincidence to the optical axis of the module O. Space will be scanned in the plane perpendicular to the axis of rotation. The scanner consists of two parts. The first contains a cylindrical housing with a golden cover mirror and calibration units for Long Wavelength Calibration (LWC) and Short Wavelength Calibration (SWC) . The second contains a system that rotates the mirror and an electronics for the scanner .

PFS-S simplified schematic overview is shown on the figure below.



The cylindrical housing (1) has a round empty window (an entrance window with diameter Φ88mm) through which the IR radiation to be measured comes to the mirror and goes through an exit window (diameter Φ78mm) to PFS-O optical inlet. The axis of optical outlet of PFS-S must coincide with the axis of PFS-O's inlet within 0.1^0 .
The flat golden cover mirror (2) (with its cylindrical housing (1)) can be rotated by the motor (3) through the worm gear reductor (4) and freewheel clutch (5). Owing to this clutch the motor is able to rotate the mirror in one direction only (but the number of revolutions is not limited).
The mirror has 8 working angular positions. Three of them are used for calibrations (cold space, absolute black-body and the calibration lamp), the other 5 are the measuring ones: nadir, 12.5 deg to the "left" from nadir, 25 deg left, 12.5 deg "right" and 25 deg right. The precision of angular positioning is about 0.25 degree. The expected time of one full revolution without break will not exceed 10s. After switching on the scanner automatically stops at the initial position-in front of LWC .
The sequence of operations is much simplified: PFS-S gets a command from PFS-E to move the mirror to the next of 8 pre-defined positions, executes the command, measures the reached angle and informs PFS-E of the new position. To inform PFS-E that the mirror is in the right position, differential magnetoresistive sensors and a system of cooperating T-screws located on top of the cylindrical housing are used.
The T-screws are made of paramagnetic material.

Thanks to the system of T-screws each position has its own binary code, which can be read by 3 sensors. 3 sensors are sufficient to read 8 positions. An independent system of T-screws exists for validation position. For redundancy this independent system is doubled and positions are read by 2 independent sensors. After each move, the next mirror's position is validated and the code of the current position is sent to the module E. Additionally, the nadir position has an independent sensor. This sensor can also be used to check the proper functionality of the motor and the electronics. The checking procedure can be run in the module E software. In case of the negative result of checking the module E by the command to the module P can switch on the reserve part of the scanner.

In order to increase the reliability of the scanner system, most of the parts inside are duplicated, except of the LWC and SWC units and the interface to the E block (drivers and connector). There are two independent motor mechanisms and two motor drivers/controllers working in cold redundancy. In case of failure in motor system the mirror can be rotated in the same direction by the redundant motor with its clutch.

The switching between main and redundant scanner's parts can be done through the supply lines from module P and a dedicated command to be sent from module E to module P.

The scanner is equipped with two calibration units:

- Short Wavelength Calibration (SWC) unit for the spectral range from 1 to 4 μm,
- Long Wavelength Calibration (LWC) unit for the spectral range from 5 to 45μm.

The SWC unit consists of a parabolic mirror (7) and a special lamp (8).

The LWC unit (so-called: absolute black body) is placed near the mirror housing. It consists of an IR-emitter (9) and temperature-measuring electronics (10). The emitter is a black-body model with emissivity >0.99; it has the same temperature as PFS-S' mechanical structure. Two resistive thermosensors Pt-100 are implemented inside the black-body. Its resistance is measured by electronics (10) and the resulted analogue signal is cabled to PFS-E and further to PFS-O for AD-conversion. Accuracy of temperature measurement is 0.1K .

When the mirror is rotated away from the LWC calibration unit, the external side of mirror's cylindrical housing appears in front of the black-body and serves as a kind of cover. This external side has a very low emissivity factor (e<0.04) and thus does not affect the black-body temperature.

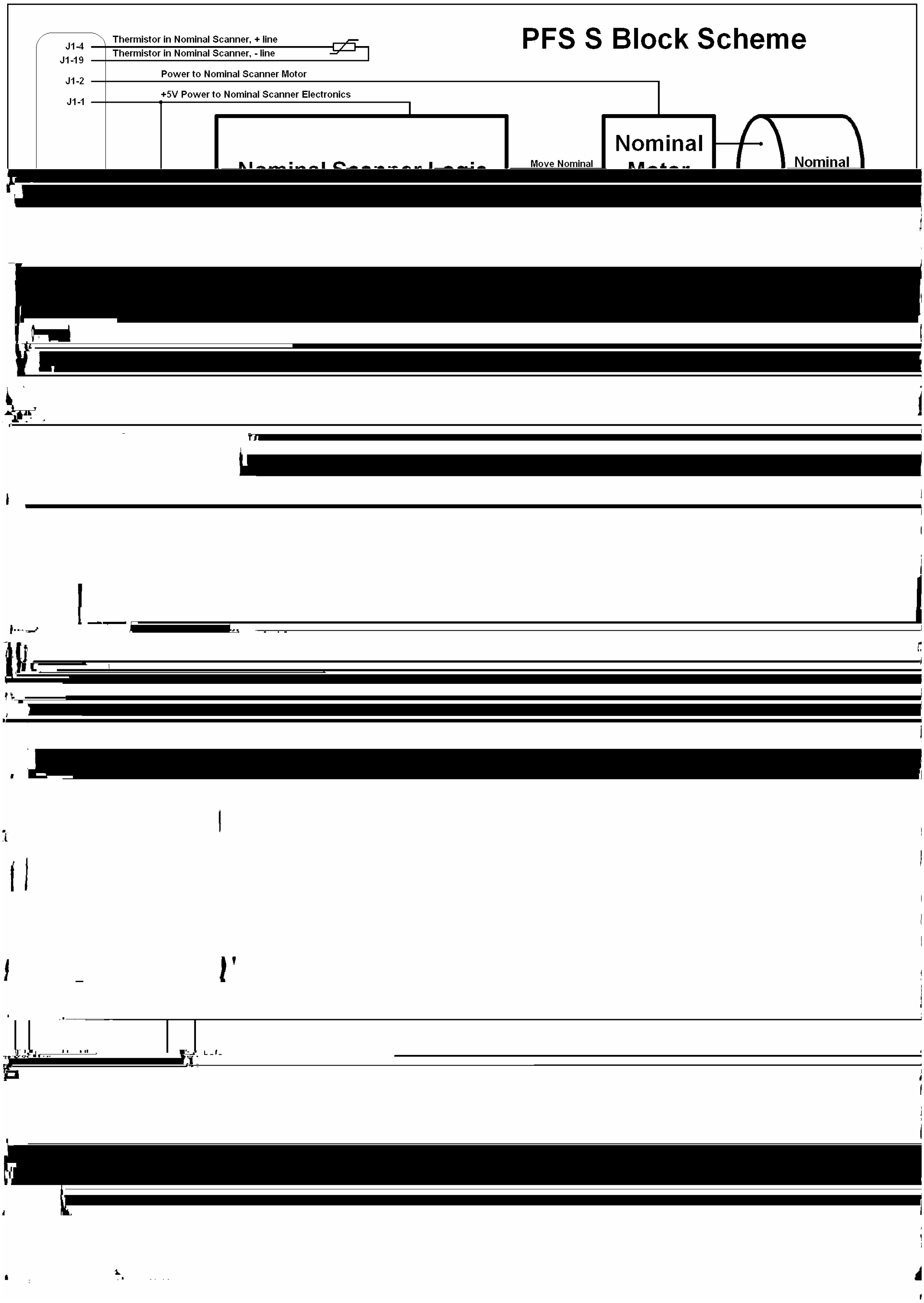
The temperature of PFS-S will be measured by termistors located inside the PFS-S mechanical structure. Their resistance will be measured directly by Spacecraft's temperature measuring system (Nominal and Redundant channels).

The overall size will be about 250x180x180 mm; mass less than - 3,5 kg; The power consumption depends on the mode of operation.

1. Normal or sleeping mode mirror fixed and electronics switched on 0.5W,
2. Calibration mode electronics and the calibration lamp switched on 4W,
3. Mirror positioning mode 5,5W.

Spacecraft walls will protect the PFS-S external surface (excluding the mirror housing (1), what give the possibility to keep the temperature within (-20...+40) centigrade.

The PFS-S block scheme is shown on the figure below.



2.8 – HARNESS.

All connectors on boxes shall be female, all connectors on cables shall be male. Cables shall be approximately 50 cm long.
PFS has 5 internal cables : we shall call them C101 , C102 , C103, C104, C105 .
PFS has from the spacecraft 6 exthernal cables : CS01S, CS02S, CS03S.

For pin functions and type of connectors , see document MEX-CNR-IPDR-09.01
C101 is a cable between module P and E. TBD pins.
C102 is a cable between module P ans S. “
C103 is a cable between module S and E. “
C104 is a cable between module P and module O. “
C105 is a cable between module O and module E. “

CS01S is the power supply interface cable to module P. TBD pins.
CS02S is the functional commands, temp.monitor., contact sensors and emergency actions to module P. TBD pins.
CS103S is the telemetry and telecommands interface with module E. TBD pins.

3.- MODES OF OPERATION

3.1 - MODES OF OPERATION .

PFS has five modes of operation, not considering the off mode. These modes are :
- astra
- sleeping
- autonomous test
- calibration
- science.

3.1.1- ASTRA MODE.

One or two days after launch, the ASTRA mode should be switched on. This mode allows the dissipation of some power inside the Interferometer block, so that the temperature shall not decrease in time , as it would be if no power is dissipated. Indeed the Interferometer block has the SW channel which works at low temperatures, therefore it is always connected to a passive radiator. During cruise phase the temperature could therefore go down very much if no heater is on. ASTRA provides 4 heating points inside IB , so that extreme low temperatures , which could permanently affect the interferometer, are avoided. In this mode PFS is off, only power is given to the ASTRA board.

3.1.2 – THE SLEEPING MODE.

In orbit around Mars, when not operating, PFS will be in the so called sleeping mode . In this mode power is give to ASTRA and to Module E : Module O and the Scanner are off. This mode is used to keep data in the mass memory, waiting for the possibility to provide data to the spacecraft. In this mode , also, DAM may try the supercompression of the spectra, before giving data to the spacecraft. In this mode PFS may receive telecommands and the time information, so that may awake-up when the correct time is reached. The correct time is prescheduled in the orbit parameter computation.

3.1.3 – THE AUTONOMOUS TEST.

This is the first activity after the awake-up command is received by DAM. The module O is switched on, and the autonomous test is started. In this mode we acquire information not only on the housekeeping of moduleO,E,P,S but also we move the double pendulum, we sample the laser diode interferogram, we control the speed control device by measuring for one full ramp the timing of the zero crossings, we test also the gains of the amplifiers, and other important quantities (see description of the autonomous test in section below).
The autotest procedure has the aim to test the status and the functioning of all the PFS parts. The autotest will also generate some data which shall be trasmitted and examined on ground. The data trasmitted will be in the same amount of a full interferogram for both LW and SW channel, but the content of the information will be different.

-AUTOTEST OF MODULE O.

The autotest will be performed in at least 60 seconds, as it will request several full motions of the pendulum in one direction and back.

Motion 1
In the first motion the timing between successive zero crossings will be measured and stored in memory. 16384 measur.
Motion 2
In the second returning motion we will sample ten full sine wave from the reference channels (there should be 30 measurements in one cycle, therefore we take 300 measurements)
300 measur.
then we sample the sine wave taking only two periods (30 points per period) , in the following conditions :
4 gain factors for fotodiode = . 240 measur.
4 laser diode power values (out of 256 possible) = 240 measur.
4 values of the power read directely on the laser. 244 measur.
At the zero optical path difference pulse arrival read the calibration sources for both channels for 4 possible gain factors : 20 measurements each , 80 measurements per channel = 160 measurements. 160 measur.
Motion 3-4
In the third and fourth motion we change the reference frequency by 2 % above and 2 % below the nominal value. We take 210 measurements of the zero crossing timing at the zero optical path difference pulse arrival. 440 measur.,
Motion 5-6
In the fifth and sixth motion we swicht on the second motor and repete the previous measurement, collecting other 40 measurements. 40 measur.,
Motion 7-8
In the seventh and eight motion we change the power of the TRW led up and down by 10 % and take the same measurement as in motion 3,4 in the sense that going is with TRW power up and reference frequency 2% up, coming is with TRW 10% down and reference frequency 2% down
. 40 measur.

-- AUTOTEST OF MODULE E

This will consist of the procedure implemented at the switch on and no extra information will be generated than what is already given in the housekeeping.

-- AUTOTEST OF MODULE S.

This autotest should permit motion of the scanner to one or more fixed positions predetermined, the information returned should be not only the angles given for motion and those measured as result of motion, but also the time needed for the motions.

42 measur.

-- AUTOTEST OF MODULE P.

In this case we would like to check the voltages on the different lines. The resulting information is already given in the housekeeping data and in the status words.

-AUTOTEST DATA TRASMISSION.

The autotest data will be in a format similar to the usual one :

HEADER	20 bytes
HOUSEKEEPING	52 bytes
SCIENCE GENERALITIES	14bytes
MOTION DATA	32 768 bytes
SINE WAVE	600 bytes
FOTODIODE GAIN	480 bytes
LASER POWER	488 bytes
GAIN DETECTORS	320 bytes
REFERENCE FREQUENCY	180 bytes
SECOND MOTOR	180 bytes
TRW POWER	180 bytes
SCANNER	14 bytes
total	34995 bytes.

3.1.4 – THE CALIBRATION MODE.

Immediately after the autonomous test, PFS goes into the calibration mode, if the IB temperatures are OK. In this mode also the scanner moves, providing the possibility to acquire a number of measurements pointing first at the internal black body, then to deep space, then again to the black body. In each case a minimum of 10 measurements (20 measurements in the commissioning phase) are taken. These sequences must be done in time before the science section starts. But they are also repeated after the science section is finished.
As these two calibration sessions are repeated every orbit, they provide us with 60 measurements to be transmitted, to be added to the 480 martian spectra per orbit (at least).

3.1.5 – THE SCIENCE MODE.

Along each orbit we will have a science session in which the science mode will be used for PFS . The operating period will in general last 80 minutes. In this period the scanner will be in a fixed position (probably nadir pointing).
By operating 80 minutes , as the cycling acquisition time is of 10 sec max, we should get 480 measurements per orbit. If we are able to reach repetition time of 7.5 sec, then we can achieve more spectra per orbit. With an orbit of 6.5 hours we will have 1680 spectra per day. The possibility to

transmit these measurements will depend on the capability to match the allocated data rate by means of data compression (FFT , spectral cutting or other).

3.2 - DATA ACQUISITION CYCLE.

We have given above the general information on the modes of operation of the experiment. We shall give here the detailed information on the cycle that provides one full measurement.
We start with the command from E to O to start a new measurement. O moves the double pendulum which goes in the so called "starting position" . The motion of the pendulum starts and at each zero crossing of the laser diode interferogram of the SW channel the SW signal is sampled. At the same time the other laser diode gives another zero crossing for the sampling of the LW channel. While taking these measurements at a certain point the ZOPD zero optical path difference signals is received and a counter starts. When this counter reaches 8196 , then the double pendulum is stopped. The number of measurements is simmetrized so that 16384 points are available for both channels. All this should be done in less than 5 sec. Data are then transferred to module E : for the SW all 16384 points are transferred, while for the LW there are 2 possibilities (depending of the mode requested) either all points are given or 4096 data points (one out of 4) are sent to module E. Here DAM receives the data, pass the data to ICM which performs the FFT for each set and then data are put in the mass memory. If interferograms are requested, ICM is ignored and data are put into the mass memory directely. From logic point of view only at this point DAM gives order to OBDM to start a new acquisition, but in reality the order has already been given after all data have been received from module O to Module E.
After each data acquisition cycle PFS checks whether new telecommands have been received and executes them (if any). The telemetry information it is sent at any time on request from the spacecraft according to a FIFO procedure taking data from the mass memory sequence.

4 – SCIENTIFIC OBJECTIVES.

The Planetary Fourier Spectrometer (P.F.S.) proposed here for the Mars Express mission is an infrared spectrometer optimised for atmospheric studies able to cover the wavelength range from 1.2 to 45 µm divided in two channels with a boundary at 5 µm . The spectral resolution is 2 cm-1 . The instrument field of view FOV is about 2 ^{o} for the Short Wavelenght SW channel and 4 ^{o} for the Long Wavelength LWchannel which corresponds to a spatial resolution of 10 and 20 km when Mars is observed from an height of 300 km (nominal height of the pericentre). P.F.S. can give unique data necessary to improve our knowledge not only of the atmosphere properties but also about mineralogical composition of the surface and the surface-atmosphere interaction.

The scientific objectives of the P.F.S. experiment can be summarised as it follows:

1) Atmospheric studies:

a) global long time monitoring of the three-dimensional temperature field in the lower atmosphere (from the surface up to 40-60 km);

b) measurements of the minor constituents variations (water vapour and carbon monoxide);

c) search for possible other small components of the atmosphere;

d) new determination of the D/H ratio;

e) study of the optical properties of the atmospheric aerosols: dust clouds ice clouds hazes; determination of the size distribution and chemical composition;

f) investigation of radiance balance of the atmosphere and the influence of aerosols on energetics of the atmosphere.

g) study of global circulation, mesoscale dynamics and wave phoenomena.

2) Surface studies:

a)monitoring of the surface temperature;

b)determination of the thermal inertia obtained from the daily surface temperature variations;

c)determination of the restrictions on the mineralogical composition of the surface layer;

d) determination of the nature of the surface condensate and seasonal variations of its composition;

e) measurements of the scattering phase function for selected places of the surface;

f) pressure and height local determination (CO_2 altimetry) for selected regions;

g) surface-atmosphere exchange processes.

The experiment is a double pendulum interferometer that will measure Martian radiation from 1.2 to 45 microns in two channels with a resolution of 2 cm -1, i.e. 2000 spectral points in the LW and 8000 spectral points in the SW channel .

The experiment will have real time FFT on board to be able to select the spectral range of interest for data transmission to ground. Measurement of the 15 micron CO_2 band is very important .Its profile gives, by means of a complex temperature profile retrieval technique, the vertical pressure temperature relation, basis of the global atmospheric study. Essential for this study is the possibility to measure not only Martian radiation , but also space (3 K black body) , a calibration B.B. and a Lambertian screen solar illuminated, measurements allowed by the presence of a pointing device with one axis of rotation. Consequently the FOV of the experiment requires an unobstructed field view of 4 deg x 120 deg in a plane roughly perpendicular to the orbital velocity vector (+- 40 deg are accepted). In this field of view both Nadir and Space directions (at 90 deg from each other) should be contained.

PFS will be working around the pericentre of the orbit , with a foothprint that in the best case is of 10 Km or 20 Km size for the SW and LW channels respectively. Being the repetition time of the measurements 1 every 7.5 - 10 sec , and the working time being + - 0.5 hour around pericentre, a total of more than 480 measurements per orbit will be acquired corresponding to 1 680 measurements per day for a 6.5 hours orbit .Compression of data on board is achieved in several ways (for example by computing the FFT of the interferogram on board) in order to comply with the possible data to ground transmission. We produce 540 x 40 000 bytes = 176.9 Megabits including 25 % houskeeping and autotest and calibrations. In the 80 minutes of data taking , the atmospheric measurements will be made at high altitude, because atmospheric studies do not need high space resolution, while surface oriented measurements will be taken closer to pericenter, where higher space resolution can be achieved.. An important requirement of PFS is that we need to measure at all local times in order to have the atmospheric vertical temperature profiles also in the night side.

No Fourier spectrometer has ever been flown around Mars or around the Earth covering the wavelength range 1 to 5 microns.

The team has concluded that the model available (called PFS07) can be used as EM/QM model, but should not be used as flight model , as the degradation with time of the many coatings over the optical elements, and the degradation of the hygroscopic optical material

(CsI for the beam splitter) would not ensure us the achievement of the scientific objectives.