XMM Optical Monitor

MULLARD SPACE SCIENCE LABORATORY
UNIVERSITY COLLEGE LONDON
Author: Nigel R Bray

MSSL *XMM*OM Electrical Interfaces Specification

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Table of Contents

Part 1. Introduction

1.1. Scope

This document defines and describes the internal electrical interfaces of the XMM Spacecraft Optical Monitor (OM).

It is divided into to the following sections:

- Part1 - Introduction
- Part2 - Instrument Interconnection topology
- Part3 - Interface Types and Definitions

1.2. Naming Conventions

The following naming convention is given to unambiguously identify each cable, interface, signal, line, wire, connector and connector pin by a set of mnemonics. The mnemonics will cross reference to the interface specification, connector pinout and harness wiring detail.

This definition implements the following requirements:
each box connector pin name shall be unique for that box; and
each harness wire name shall be unique for that harness.

A description of how the naming convention works is given below.

- Each box has a name according to its type and position on the spacecraft.

E.g. DEM1 is a DEM box (there are two of them) and is in position number 1 on the spacecraft.

Note: The Box ITSELF is NOT labeled or referenced by its position. There is only one flight spare of a box which may be put in either position.

- Each fixed connector on a box is numbered with a J prefix to identify its position on the box.

E.g. J01 on a DEM box before it is put on the spacecraft. DEM1-J01 references connector J01 on the DEM box in position 1 on the spacecraft.

- Each harness connector is numbered with a P prefix according to which connector on which box it is to be attatched.

E.g. DEM1-P01 is a connector on a harness that must be connected to J01 on the DEM box in position 1 on the spacecraft.

- The pins of a connector are grouped into interfaces. Each interface is identified by a general type, which has a unique specification.

E.g. DEM-J01 contains one interface of type: DEMPWR it is defined in a section of this document.

- If there is more than one such interface within the connector an extra category label is added to distinguish them.

E.g. DEM-J02 contains three interfaces of type DC. They are DC-Blue1, DC-Blue2, DC-Red from the three detector systems.

- Pins of a connector on a box are uniquely named according to their interface, signal and line definition in this specification.

E.g. DEMPWR_Sync_Pos - is the name of the pin being the positive connection of the differential Sync signal on a connector containing the DEMPWR interface. This name is unique to a particular pin on the DEM box.

- Pins of a connector on a harness carry the unique name of the wire to which they are attatched. I.e. there will always be two harness pins with the same name.

E.g. DEMPWR-1_Sync_Pos - is the name of the wire and its two pins from the DEM1-P01 connector to the TM-J01 connector (defined in this document). It is the positive connection of the differential Sync signal on the power interface to DEM1.

1.3. Glossary

Terminology used within this document is given as precise a meaning as possible in order to avoid ambiguity in specification. Terms in italics within the document are intended to carry the associated definition in the table below.

Term	Definition
Cable	A group or bunch of *lines* routed together in the same harness.
Category	For an *interface* of which there are more than one, identifies each uniquely.
Driver	A *signal* output.
Harness	One or more cables in the same logical unit.
Interface	A group of *signals* used for communication between separate units.
Line	One wire of a set of connections between separate units.
Master	A *terminal* which controls the protocol and/or the synchronisation *signals* on an *interface*.
Receiver	A *signal* receiver.
Route	The path of a cable between two subsytems.
Signal	A representation of a variable by electrical means on a given set of *lines*.
Sink	A *terminal* which has the inputs of the *signals* on the *interface*.
Slave	A *terminal* which accepts control from a *Master*.
Source	The *terminal* which has the outputs of the *signals* on the *interface*.
Terminal	An equipment node on an *interface*.
Wire	A single connection between two connector pins.

1.4. References

[1] XMM-OM/MSSL/SP/0012
Bray N.R., "Power Budget Breakdown"

[2] XMM-OM/MSSL/SP/0045
Chaudery R.A., "External Harness"

[3] XMM-OM/MSSL/SP/0044
Self D.G., "Internal Harness"

[4] EID-A: RS-PX-0016
"Experiment Interface Document Part A"

[5] XMM-OM/MSSL/SP/0060
Bray N.R., "Instrument EMC Test Plan"

Part 2. Instrument Interconnection Topology

2.1. General

This Part establishes the relationships between the interfaces, the sub-systems and the harnesses.

All the internal instrument interconnections between the funcional blocks and the external interfaces are shown in figure 2.1.

Part 3 of this document provides the currently agreed definition of each internal interface and within each definition a standard name for each signal and connection is given.

2.2. Organisation of Interfaces between Functional Units

Figure 2.1 illustrates the interfaces employed within the XMM-OM. The major interfaces are those between the digital module and the telescope module, which are the Power Bus, the Instrument Control Bus, and the Data Capture links. The Data Capture interface is so described because the detectors which act as the source use this interface to pass image information to the digital module where the data is ’captured’ in mass memory.

The instrument control bus is a digital communications highway on which all command and control information is passed between the ICU in the digital module and the various sub-systems within the telescope module. It is based on an open collector serial bus designed for use by ESA AOCS systems called the MACS bus. The relatively large separation of the digital module and the telescope module (≈3m) in such an environment led to the choice of a digital differential interface based on RS-422 driver/receiver circuitry. The timing of this interface is derived from the serial interface port provided on the 56001 CPU used in the Digital Processing Unit (DPU).

Power for the instrument sub-systems is conditioned from primary power in separate power supplies. Inside the telescope module, the dual redundant Telescope Module Power Supply Unit (TMPSU) generates conditioned power for the detector systems and drives the heaters and motors. Inside each redundant Digital Electronics Module (DEM) there is a power supply that provides conditioned power for the DPU and Instrument Control Unit (ICU).

It can be seen that, the digital module is entirely dual redundant by the provision of two identical Digital Electronics Modules (DEM1 & DEM2); while the Telescope Module (TM) contains redundant Telescope Module Power Supply Units (TMPSU)s, and Blue detectors.

The diagram includes all interfaces which are connected inside boxes, and those that are connected via an external loom.

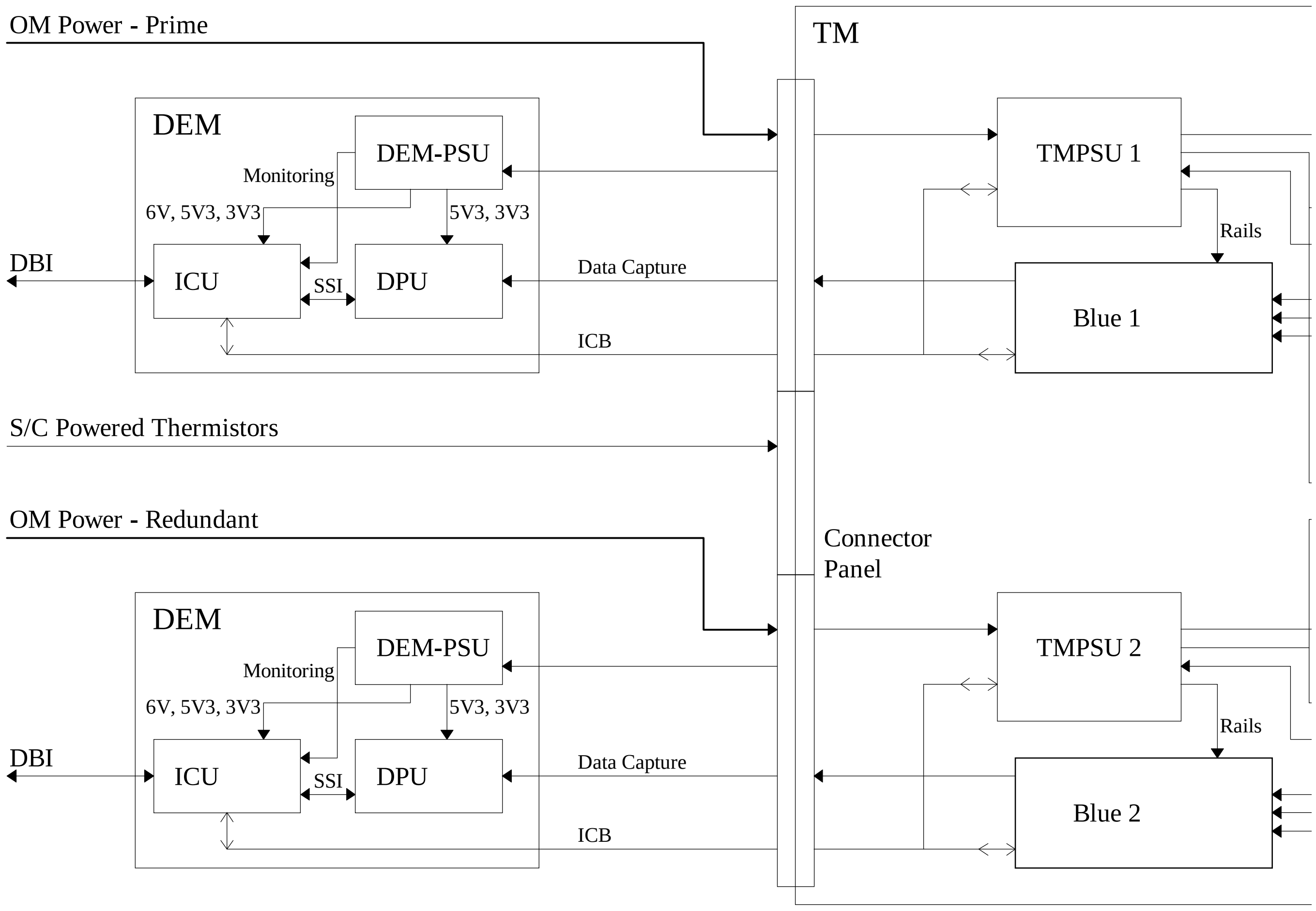

Figure 2.1: The OM Instrument Connections between Functional Units

2.3. The OM External Harness - OM3 as per EID-B [2]

The External harness routes signals between DEM1/2 and the TM.

There will be two electrcally identical redundant cable sets for OM3.

The spacecraft is expected to provide interfaces for power to the TM and OBDH bus to the DBU1/2. Figure 2.2 shows the external harness functions.

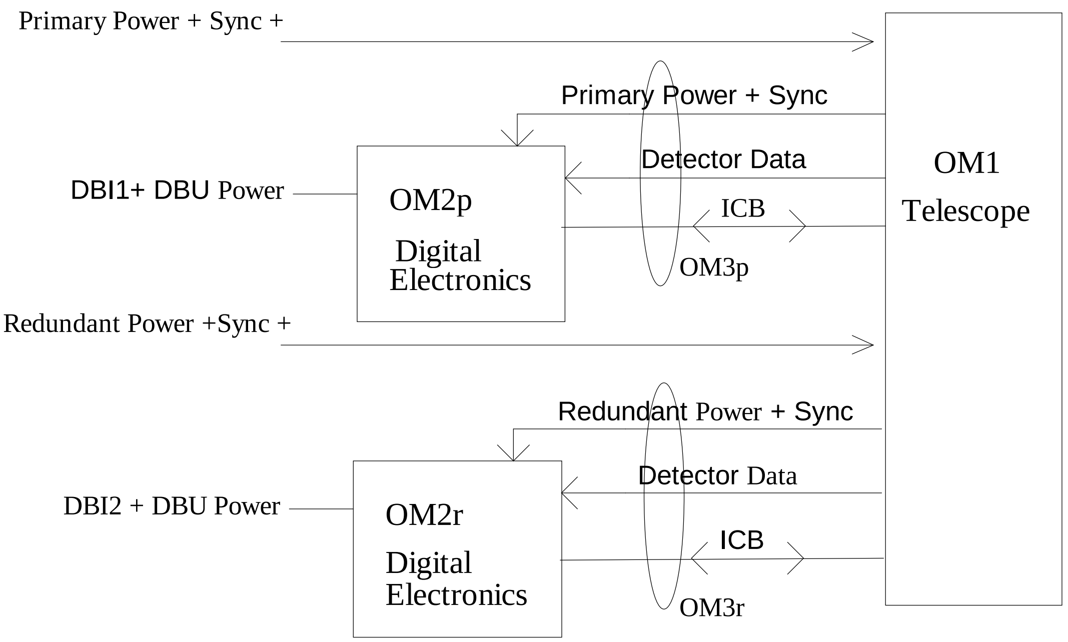

Figure 2.2: Arrangement of the External Harness Connections

2.4. The DEM Backplane

The DEM (OM2) is a single box which contains the three functions: power supply, digital data processing and instrument control. Figure 2.3 below illustrates these separate units.

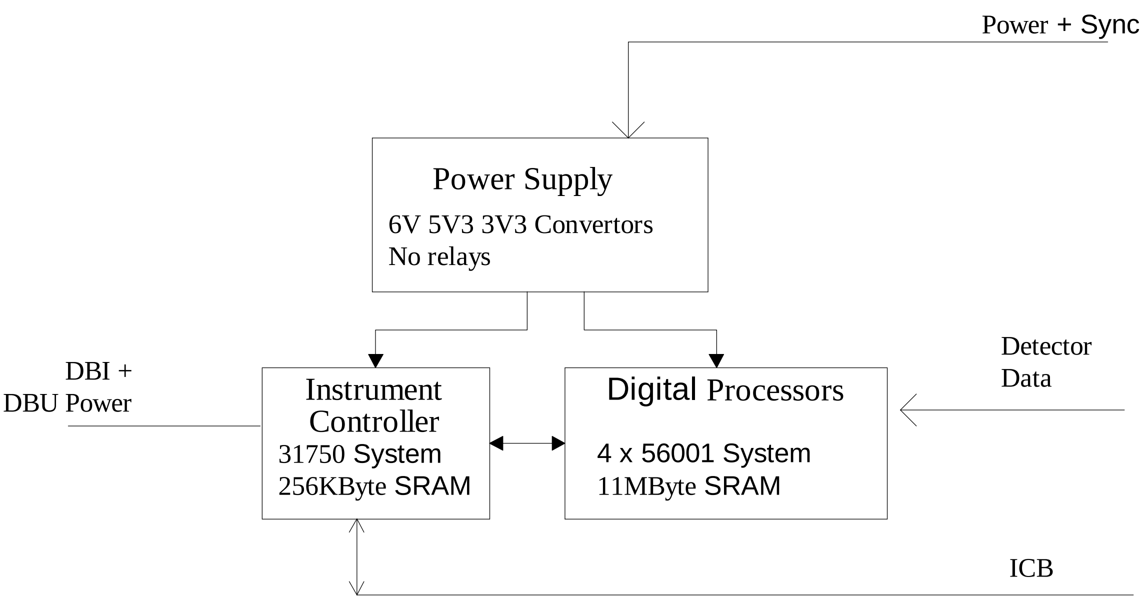

Figure 2.3: The Internal Units of the DEM

All connections inside the DEM between the ICU, PSU and DPU are carried by the DEM backplane. All external connections to the DEM will be carried by connectors mounted and wired directly to the modules' PCBs. Figure 2.4 below shows the DEM backplane general arrangement.

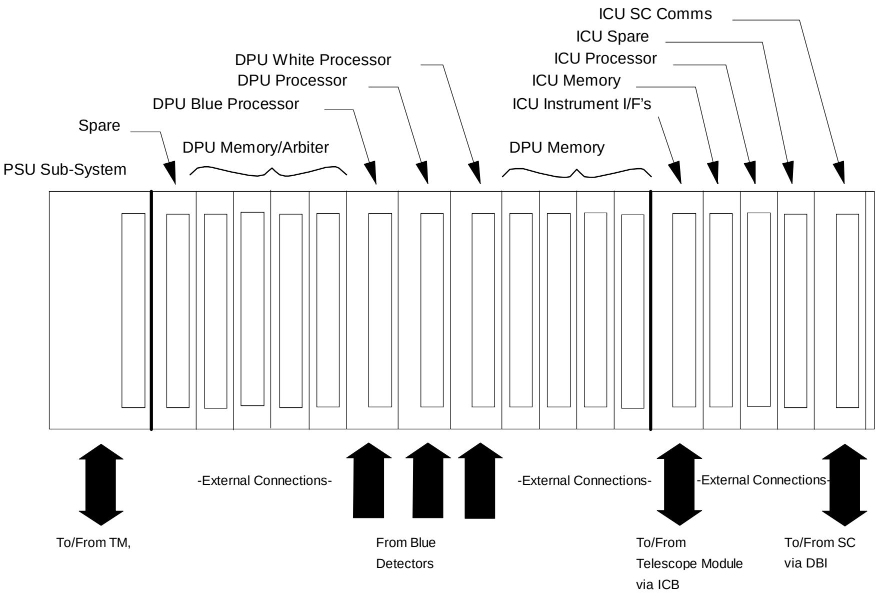

Figure 2.4: The DEM Backplane Layout

2.5. The Telescope Module Internal Connections [3]

The telescope module is a highly integrated unit and therefore the interconnections are carried by a combination of backplane, permanent loom, flying leads, captive cables and separate harness. Figure 2.5 shows the TM internal connection arrangements.

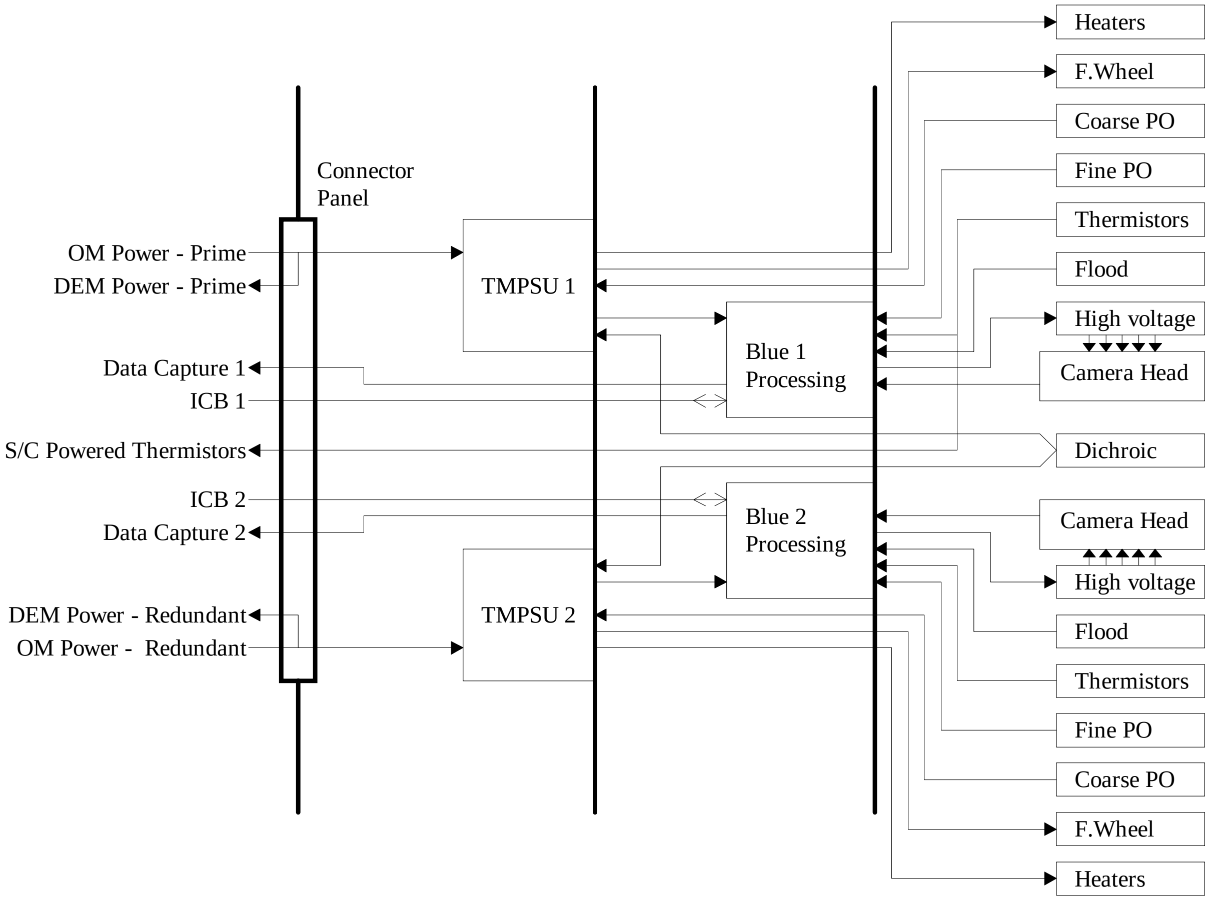

Figure 2.5: The Telescope Module Internal Connection Configuration.

2.6. Instrument EMC Philosophy

Tests levels for the instrument are defined in [4].

The instrument test plan is in document [5].

Part 3. Interface Definitions by Type

3.1. Power

3.1.1. Connector Panel ⇒ TMPSU & DEM= Main Power (MNPWR)

a) Scope

This interface definition applies to the power input to the TMPSUs and DEMs.

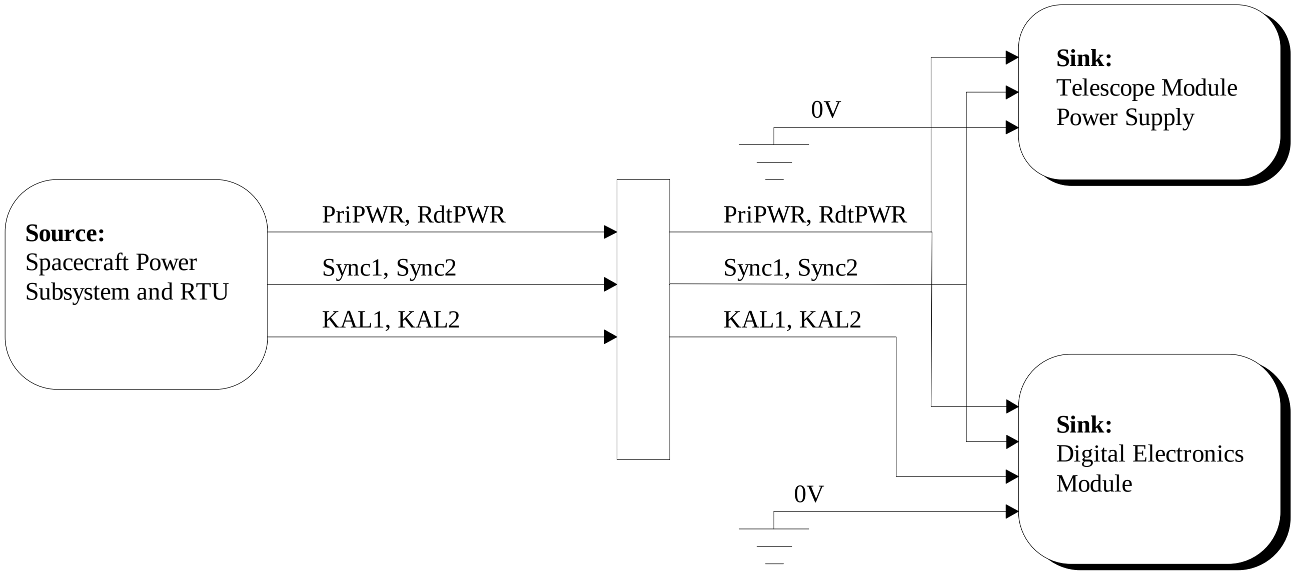

Figure 3.1: Signal Level Schematic of the Main Power Interfaces

The spacecraft supplies two sets of power signals which each supply one DEM and one TMPSU.

Note: See next section for further details of the Sync interface.

For this interface the source is the spacecraft power output to the OM; and the sinks are the OM instrument's Telescope Module Power Supply Units and Digital Electronics Modules. Figure 3.1 gives the schematic at the signal level.

b) Function

All power to the OM instrument normally will be provided by one of the two interfaces. During normal operation one interface will be switched ON and the other OFF although the KAL lines will always be powered. The instrument may be in one of four powered states:

PriPWR	RdtPWR	Instrument State
OFF	OFF	OFF
ON	OFF	ON - DEM1, TMPSU1, Blue1
OFF	ON	ON - DEM2, TMPSU2, Blue2
ON	ON	ON - All

The instrument shall cater for the final state "ON - All" above, but the spacecraft may not allow such a configuration to be selected as it is not a declared operating mode.

The power available to the OM instrument is allocated to individual units according to the instrument power budget. The overall power budget is given in the EID part B.

The Sync1/2 signals are provided to synchronise the converter frequencies.

c) EMC

The OM Instrument must conform to the power-line-conducted radiated and susceptibility limits as set down in EID Part A Issue 1.

The grounding and screening policy is as follows.

- All instrument electronics except heaters will be DC isolated from the spacecraft power bus via the instrument converters in the TMPSUs and DEM-PSUs.
- There will be a single instrument 0V structure for all electronics except some detector analogue electronics
- All cables will be externally screened and terminated to the enclosure via the connector shells.
- The instrument 0V structure will be connected to the spacecraft structure via a low impedance link inside the Telescope Module.

d) Interface

The MNPWR *interface* contains the *signals*:

- Power PriPWR, RdtPWR
- Keep Alive Power KAL1, KAL2
- Convertor Sync. Sync1, Sync2
- Instrument 0V. 0V1, 0V2

e) Signals

Signals: PriPWR, RdtPWR are derived from the *lines*:
PriPWR_goA, PriPWR_goB, PriPWR_retA, PriPWR_retA.
RdtPWR_goA, RdtPWR_goB, RdtPWR_retA, RdtPWR_retA.

Signals: KAL1, KAL2 are derived from the *lines*:
KAL1_go, KAL1_ret,
KAL2_go, KAL2_ret.

Signals: Sync1, Sync2 are derived from the *lines*:
Sync1_pos, Sync1_neg,
Sync2_pos, Sync2_neg.

0V is not really a signal as such but distributes the single point ground using the *lines*:
TM_0V1a/b, DEM_0V1a/b, TM_0V2a/b, DEM_0V2a/b

f) Characteristics

All of the source characteristics are defined by EID-A.

g) Connectivity

Signals to TMPSU1: PriPWR, Sync1, OV

Signals to TMPSU2: RdtPWR, Sync2, OV

Signals to DEM1: PriPWR, Sync1, OV, KAL1

Signals to DEM2: RdtPWR, Sync2, OV, KAL2

3.1.2. Synchronisation inputs at the DEM, and TMPSU

a) Scope

This interface definition applies to the sync inputs at the TMPSUs and DEMs.

The EID-A defines the characteristics required of the interface as seen by the spacecraft. Since it is to be shared between two instrument units, this definition is to ensure compatibility between them and the spacecraft.

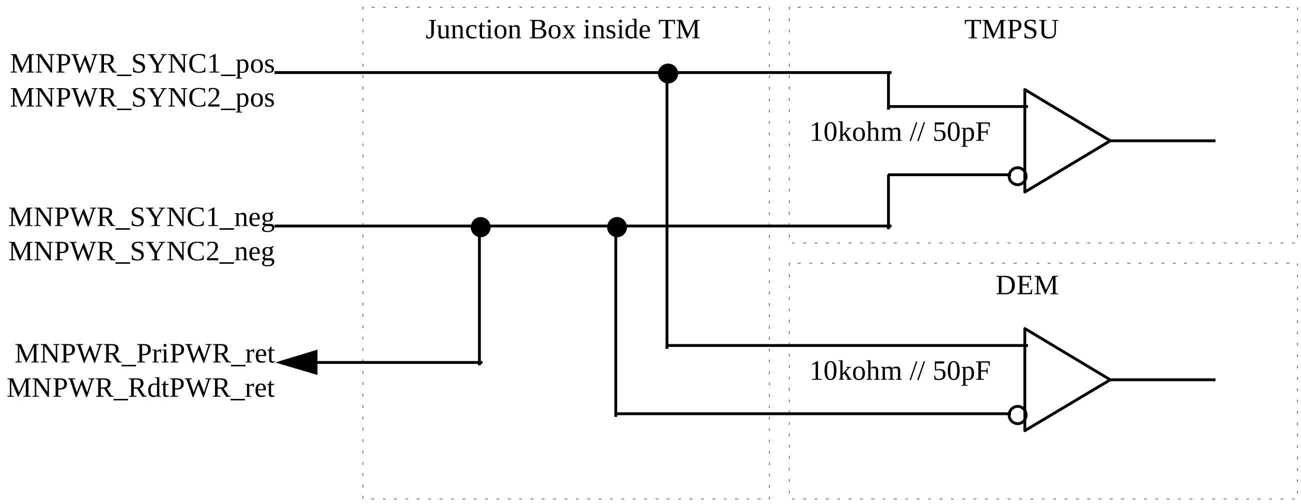

Figure 3.2: Signal Level Schematic of the Main Power Sync Interfaces

b) Function

Following discussions from ESA, it has been determined that high impedance differential receivers are recommended. To be compliant with the EID-A, the input impedace should be achieved with discrete components as defined below.

c) EMC

The Sync1_neg signal is connected to the MNPWR_PriPWR_ret at the junction box inside the TM. The Sync interface must be isolated from the secondary circuitry.

d) Interface

The MNPWR *interface* contains the *signals*:

- Convertor Sync. Sync1, Sync2

e) Signals

Signals: Sync1, Sync2 are derived from the *lines*:
Sync1_pos, Sync1_neg,
Sync2_pos, Sync2_neg.

f) Characteristics

Circuit type: differential receiver, dc coupled

Input impedance: 10kΩ ± 10% in parallel with 50pF ± 10%, non-inductive.

3.1.3. DEM-PSU ⇔ ICU/DPU = DEM Secondary Power DEMSP

a) Scope

This interface applies to the DEM-PSU output, the ICU and DPU power inputs and the DEM backplane power line connections.

The PSU is the source of conditioned power for the ICU/DPU in the DEM. It is the requirements of the ICU and DPU that determines the nature of this interface, but it is required to keep to a single supply sufficient for the digital circuitry. In order to provide latchup protection, the supplied voltage will be higher than would otherwise be required by the digital circuitry without protection.

There are two DEMS, within each DEM this interface definition applies.

For each interface there is a source: the PSU output, and multiple sinks, consisting of the individual PCB's on the DEM backplane. The PCB's are in two groups: those belonging to the ICU sub-system, and those belonging to the DPU sub-system. Figure 3.3 illustrates the signal connections.

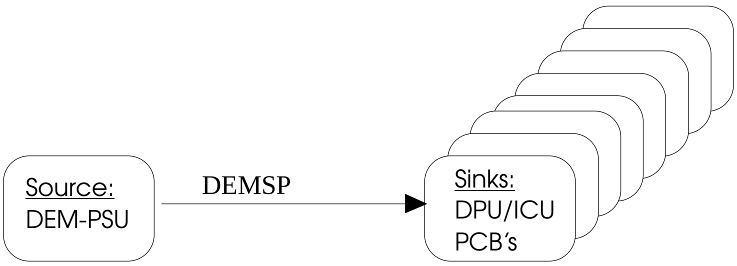

Figure 3.3: Signal Level Schematic of DEM-PSU ⇒ ICU/DPU

b) Function

The PSU generates conditioned power for the other sub-systems within the DEM. There is no direct switching control of the power inside the DEM. When power is applied to the PSU from the spacecraft, both the DPU and ICU are supplied, but subject to overcurrent protection on the PSU output. Additionally the PSU receives as an input a signal from each of the DPU sub-system PCB's latchup protection circuit which causes the PSU to switch off the VDPU when a latchup is detected. VDR-DPU will be maintained unless the DPUs program RAM card has latched up in which case both VDPU and VDR-DPU will switch off.

Cycling of the power supply by the spacecraft will reset the latchup protection circuits. A digital control to reset the DEM-PSU latchup circuits will come from the ICU.

The supplies to the ICU (VDR-ICU), VICU, and VDBU are never interrupted.

c) EMC

Raw Power inputs from the spacecraft should be screened from the rest of the electronics inside the DEM. The internal 0V structure will be tied to the instrument 0V structure and therefore must be isolated from the structure.

d) Interface

There are five output power signals from the PSU, an input latchup signal from all the cards in the DEM, and a latchup reset signal from ICU to the DEM-PSU. They are:

VDBU, VDPU, VICU, VDR_DPU, VDR_ICU, Latchup, ResLatch

e) Signals

Power signals are transmitted on the lines named as per their respective signals, and measured with respect to a further line: GND.

f) Characteristics

The inrush characteristics, peak, average and transient currents drawn mwst be consistent with the specification on the whole instrument and as given below.

The source characteristics of signal PSU_DEM_Pwr is specified according to the table below:

Parameter	Min.	Typ	Max	Units
VDBU - GND	5.7	6.0	6.3	V
VDEM or VICU - GND	5.3		5.4	V
VDR_(DPU or ICU) - GND	3.2	3.5	3.7	V
Output Impedance to 1kHz	0	-	100	mΩ
Voltage Ripple	-	-	100	mV

The sink characteristics of the ResLatch signal are defined in XMM-OM/PENN/SP/0008.01 § 2.2.2 Note 2.

The source characteristics of signal PSU_DEM_Latchup are:

- A PNP open collector driver followed by a silicon signal diode.
- The output is normally not driven.
- When latchup is detected the output will pull high, within 0.8V of VDEM with a maximum current sourced of 10mA.

The sink characteristics are

- A maximum pull down resistor of 1kΩ between Latchup and GND.
- A maximum capacitive load of 10nF.

3.1.4. TMPSU1/2 ⇒ Blue1/2 = TM Secondary Power

a) Scope

Power for the detector systems is provided on a number of voltage rails by this interface.

Figure 3.4: Signal Level Schematic of the TMPSU ⇒ Blue1/2, Red Interface

b) Function

The TMPSU will convert power from the spacecraft 28V power bus to give regulated voltage rails.

All power will be switched to a detector simultaneously on command from the ICB.

c) Interface

Each detector power interface is identical with the following signals:

Nominal Value[1]	Output Current /mA (max)	Efficiency	Regulation[2]	Voltage Ripple	Spikes[3]
pos25V	100	>72% @ 36mA	±4%	<50mVpp	<100mVpp
pos15V	100	>72% @ 25mA	±1%	<20mVpp	<100mVpp
pos11V	290	>72% @ 237mA	±1%	<50mVpp	<100mVpp
pos5.3V	1800	>72% @1457mA	±1%	<50mVpp	<100mVpp
neg15V	100	>72% @ 9mA	±1%	<20mVpp	<100mVpp
neg5.3V	600	>72% @ 490mA	±1%	<50mVpp	<100mVpp

The total power that will be drawn from the combined outputs of these TMPSU rails in any case is 16W.

For thermal design considerations the power drawn from the converters should be taken from the latest version of the Power Budget Breakdown, XMM-OM/MSSL/SP/0012.

d) Signals

The signals above are derived from the lines:
pos25V_go, pos25V_ret
pos15V_go, pos15V_ret
pos11V_go, pos11V_ret
pos5.3V_go, pos5.3V_ret
neg5.3V_go, neg5.3V_ret
neg15V_go, neg15V_ret

3.2. Data

3.2.1. DBU ⇔ ICU = *DBI*

This is a spacecraft interface which will be fully defined by the XMM Project.

Current assumptions are:

The pinout is that adopted from the SAAB DBU ref: 1986-08-07 MRM/TREP/1003/SAAB.

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[1]This is also to be used as the proper name for the output.

[2]Of nominal value under all combinations of input, output and environmental conditions.

[3]Bandwidth of 50MHz into 50Ω.

The electrical definition is that given by TTC-B-O1, and THB/APo/KZ/1386/av Issue 2.

The Interrogation and Response data formats are those implemented by the MC1031 Standard RBI Chip for OBDH Interface. (Awaiting further data.)

3.2.2. ICU ⇔ DPU = *SSI*

a) Scope

Bi-directional communications between the DPU and ICU are handled by this interface which is carried on the DEM backplane.

There are two DEMs, this interface applies identically to each DEM.

Both DPU and ICU are sources and sinks of signals but the ICU is designated the Master Terminal, while the DPU will be referred to as the Slave Terminal as the figure below illustrates.

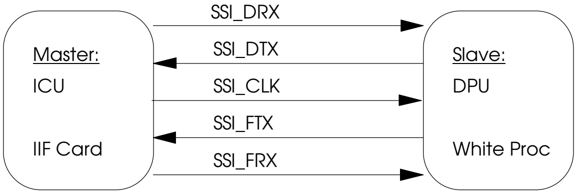


Figure 3.5: Signal Level Schematic of the ICU ⇔ DPU = SSI Interface.

Note that the naming of the signals refers to the function of the SSI interface with respect to the DPU.

b) Function

Processed science data will be buffered and passed from the DPU to the ICU on demand by the ICU. The 'demand' will be by an instruction within the protocol and does not refer to one of the hardware signals.

Command and control instructions will be generated by the ICU and sent to the DPU. The DPU will respond with status information.

Various alerts may be raised by either DPU or ICU within the routine data traffic.

The two channels, transmit and receive are considered to be autonomous, with no direct feedback defined as part of the protocol in either direction.

c) EMC

The signals are all single ended normal CMOS outputs and inputs carried by the DEM backplane. The EMC environment of this interface is taken care of in the definition of the DEM backplane.

d) Interface

The Interface ICU ⇔ DPU = SSI consists of five *signals*:

- SSI_DRX
- SSI_DTX
- SSI_CLK
- SSI_FTX
- SSI_FRX

e) Protocol

The interface is bi-directional. Each direction is defined as an interface ICU ⇒ DPU and ICU ⇐ DPU. Both interfaces have an identical protocol.

The following defines the lower layer of protocol. Further layers of protocol may be defined with reference to the software definitions.

- The data is transmitted in blocks of consecutive words.
- A gap between consecutive words of >1word frame period defines the start of a new block.
- Words are 16 bits. The Most Significant Bit, Bit 15 is transmitted first.
- The first word of the block identifies a predefined block TYPE.
- The second word of the block is present if expected by the definition of the block TYPE. It determines the length of the subsequent stream of data words.
- A variable length block contains N+1 data words where N is the positive integer value of the second word of the block.
- An error condition occurs if the stream of N+1 data words is interrupted by an interblock gap.
- An error condition occurs if greater than N+1 data words are transmitted before the next interblock gap.

f) Signals

Each signal is derived from the line of the same name, referenced to the line DEM_GND. E.g.: Signal SSI_DTX is derived from the two lines:

DTX
DEMSP_GND

g) Characteristics

The timing of the interface is defined below:

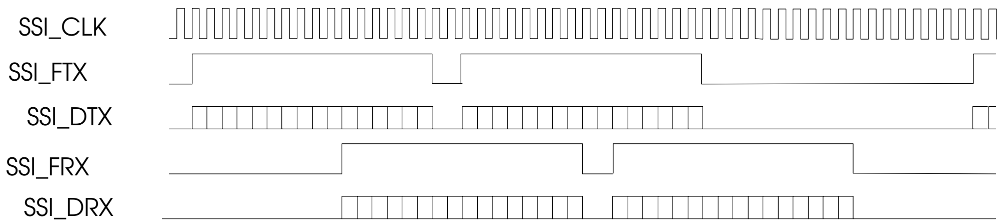


Figure 3.6: Timing Characteristics of the ICU ⇔ DPU = SSI Interface.

The driver characteristics of each signal are defined below:

Parameter	Min.	Typ	Max.	Units
Rise Time			25	ns
Fall Time			25	ns
Clock Speed	Typ-5%	125	Typ+5%	kHz
Output Low Voltage	0		0.5	V
Output High Voltage	4.5		Vdd	V
Output Current (High)	0		4	mA
Output Current (Low)	-4		0	mA

The receiver characteristics of each signal are defined below:

Parameter	Min.	Typ	Max.	Units
Input High Voltage	4.0		Vdd+0.2	V
Input Low Voltage	0		0.8	V
Input High Current	-1			mA
Input Low Current			1	mA

3.2.3. ICU ⇔ DPU = *Time*

a) Scope

Time information on the spacecraft is generated by the spacecraft and distributed to all users via the OBDH bus (see DBU ⇔ ICU). It is decoded by the RBI Chip in the ICU into a serial interface. This time interface is used for maintaining a 43 bit counter in the users equipment.

The ICU will contain the RBI Chip which contains the full 43 bit counter. The DPU will also need a counter which is driven by the spacecraft's 524,288 Hz clock but need only implement the lower bits with the remaining being maintained in software driven by an interrupt handler.

The signal level schematic is given below:

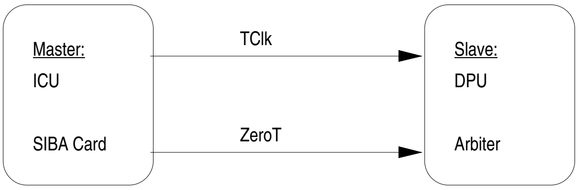


Figure 3.7: Signal Level Schematic of the ICU ⇒ DPU = *Time* Interface.

b) Function

The functional definition can be found in the MC1031 'Standard RBI Chip for OBDH Interface' data sheet.

c) EMC

The signals are all single ended normal CMOS outputs and inputs carried by the DEM backplane. The EMC environment of this interface is taken care of in the definition of the DEM backplane.

d) Interface

The Interface ICU ⇒ DPU = *Time* consists of the *signals*:

Time_TClk, Time_ZeroT.

e) Protocol

ZeroT is issued on the falling edge of TClk for one TClk period. The time counter is clocked on the RISING EDGE of TClk. When ZeroT is logic '0' the time counter shall be incremented by one, when ZeroT is logic '1' the time counter shall be set to Zero.

f) Signals

Each signal has a digital line which is referenced to DEM_GND.
Time_TClk_go, Time_ZeroT_go.

g) Timing

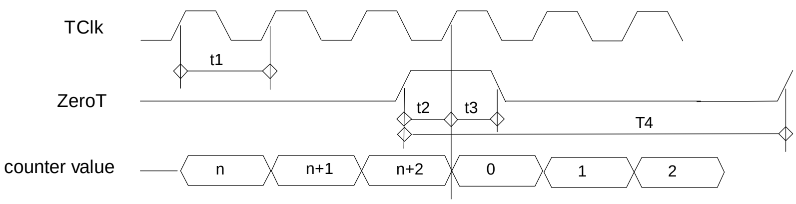


Figure 3.8: ICU ⇒ DPU = *Time* Interface Timing

Parameter	Min.	Typ	Max.	Units
1/t1	Typ-5%	524,288	Typ+5%	Hz
t2	Typ-5%	953	Typ+5%	ns
t3	Typ-5%	953	Typ+5%	ns
t4	Typ-5%	1	Typ+5%	s

g) Line Characteristics

The signals have the following characteristics:

- Output Impedance: ≤ 1 kΩ in parallel with 40pF max sufficient to drive a load of 120pF in parallel with 40kΩ with a rise/fall time less than 270ns (measured between 10% and 90%).
- Voltage thresholds:
  Logical one: ≥ 3.9V, ≤5.5V
  Logical zero: ≥ 0V, ≤0.4V

3.2.4. ICU/EGSE ⇔ TMPSU/RED/BLUE1/2 = *ICB*

a) Scope

Control and monitoring of the instrument sub-systems are performed by the ICU. The ICB is the digital data highway that the ICU uses to send and receive commands and status.

An existing standard has been adopted for the ICB called the MACS bus (Modular Attitude Control Systems bus) detailed in the "MACS Handbook", Prepared by MATRA for ESA under ESTEC contract No. 6586/86/NL/AN. Specifically developed for spacecraft attitude control systems, it has been found to be well suited to XMM-OM. It is a prioritised multi-master bus. The signal level schematic is shown below.

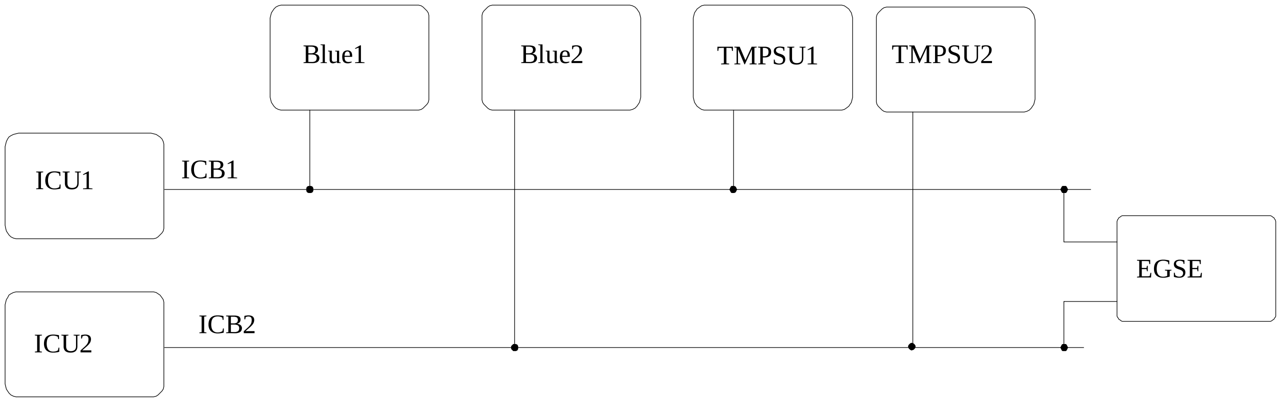


Figure 3.9: Signal Level Schematic of the ICB Interface

b) Function

Because there are a number of units on the bus the ICB has several functions. The detail of the functions performed on the bus is controlled by software in the ICU and EGSE.

The functions performed via the ICB are:

1. Loading of calibration tables into the detectors.
2. Commanding of the detectors
3. Status monitoring of detectors
4. Reading filter wheel positions and temperature sensors.
5. Controlling power switching
6. Controlling heater switching
7. Controlling motor drives
8. Monitoring voltages/currents
9. Acting as a test connector to the EGSE.

The MACS bus specification defines a redundant bus. In the OM, redundancy is provided by two separate detector chains, and therefore only one MACS interface is used per redundant half.

The ICU always drives the clock on its bus.

Each sub-system has dual redundant ICB ports to allow it to communicate on either bus. It should respond to valid commands on either half of the bus.

c) Interface

The ICB interface consists of 4 signals:

- ICB1 _Clock
- ICB1 _Data
- ICB2 _Clock
- ICB2 _Data

d) Protocol

The lower layer of protocol is defined in the Section "MACS Protocol" of the the MACS Handbook. This sub-section defines the protocol that is required by virtue of the hardware design. Further layers of protocol may be defined as necessary in software.

Each sub-system on the MACS bus has its own instruction set which is defined in terms of ICB-macros and/or individual ICB-commands - see definitions below.

ICB-macros are defined here as a command sequence necessary to perform a function in the sub-system.

ICB-commands are defined here as indivisible operations that may be performed on the MACS bus. Possible commands are:

- 16bit transfer of data from the ICU to the sub-system initiated by the ICU - ICBsend
- 16bit transfer of data from the sub-system to the ICU initiated by the ICU - ICBacquire

These ICB-commands are made up pairs[4] of ICB-words. ICB-words are 24 bits long and can be of one of two types ICBinstruction, or ICBdata:

<u>ICBinstruction</u>

0	3	8	13	18	21	22	23
ext	source	dest	subaddr	instr	par	err	ack
3	5	5	5	3	1	1	1

<u>ICBdata</u>

0	3	5	21	22	23
ext	xx	data	par	err	ack
3	2	16	1	1	1

The format of the ICB-commands are as follows:

<u>ICBsend</u>

ICBinstruction								ICBdata					
0	3	8	13	18	21	22	23	0	3	5	21	22	23
010	ICUaddr	dest	subaddr	010	par	err	ack	011	00	data	par	err	ack
3	5	5	5	3	1	1	1	3	2	16	1	1	1

Both ICB-words are generated by the ICU (or EGSE).

ICUaddr -	the ICB address of the ICU. It will have the value of one of the source address defined below.[5]
dest -	the ICB address of the sub-system which should respond to this command
subaddr -	if implemented defines one of 32 locations in the sub-system to which the data is to be assigned
par -	parity for the word
err -	error condition, if true the command should be ignored
ack -	acknowledge, generated by the sub-system

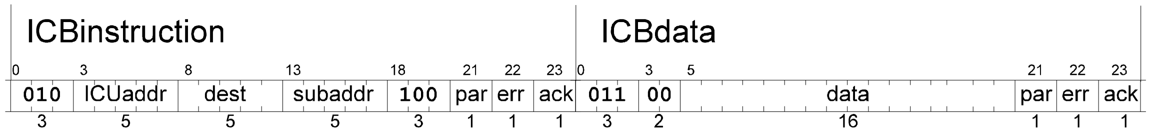
---

[4]This is the simplest case. Other commands are possible with the MACS protocol, but are currently not used. Block commands which use 1 ICBinstruction and 32 ICBdata words may be introduced later to speed up loading of the Blue detector.

[5]Normaly the ICBinstruction will be issued by an ICU, but during ground testing the EGSE may also issue commands. EGSE operations are primarily intended for establishing a link with the ICU only, but the EGSE may also command the sub-systems(emulating the ICU) for diagnostic purposes.

data - 16bit value to be used by the sub-system

ICBacquire



The ICBinstruction word is generated by the ICU (or EGSE) and the ICBdata word is generated by the sub-system that is addressed in the instruction.

ICUaddr - the ICB address of the ICU. It will have the value of one of the source address defined below.

dest - the ICB address of the sub-system which should respond to this command

subaddr - if implemented defines one of 32 locations in the sub-system from which the data is to be acquired

par - parity for the word

err - error condition, if true during the instruction the command should be ignored, if true during ICBdata the response will be ignored by the ICU

ack - acknowledge, generated by the sub-system in response to the instruction, generated by the ICU in response to the ICBdata.

data - 16bit value to be used by the sub-system

The ICB addresses are:

Source Addresses
00001 - EGSE
00010 - ICU

Destination Addresses
00001 - EGSE
00010 - ICU (for EGSE operations)
11000 - Blue Detector
00111 - TMPSU

The ICB instruction sets are defined below:

Primary/Redundant ICU

ICBsend commands

command	subaddr	data
EGSE to ICU transfer	00000	defined by software

ICBacquire commands

command	subaddr	data
ICU to EGSE transfer	00000	defined by software

Blue 1/2 Detector

Commands are currently defined in XMM-OM/MSSL/SP/0035

TMPSU-Blue1/2 module

Commands are defined in XMM-OM/IALS/SP/0002

e) Signals

Each signal is derived from the differential of a pair of lines. The lines are named with suffixes _true and _inv. E.g.:

Signal ICB1_ Clock is derived from the two lines:
ICB1_ Clock_true
ICB1_ Clock_inv

f) Timings

The timing of the interface is defined below:

Parameter	Min	Max	Units
Clock Frequency	500	512	kHz

g) Characteristics

All timings can be obtained from Section ’MACS Bus Line’ in the MACS Handbook.

3.2.5. BLUE1/2 ⇒ DPU1/2 = *Data Capture*

a) Scope

High speed data from each of the detector systems is sent to both DPUs via dedicated serial links. This custom interface is designed to exploit features found on the Motorola 56001 DSP used in the DEMs in order to minimise the circuitry required. The harness for this interface incorporates a bulkhead connection at the wall of the Telescope Module tube. The arrangement of all the interfaces to which this specification applies is given in figure 3.8. The signals which comprise each individual interface are illustrated in figure 3.9.

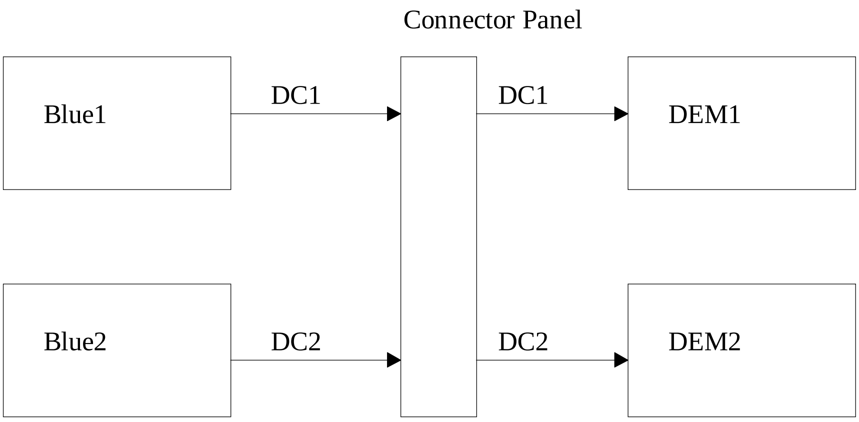


Figure 3.10: Interface Level Schematic of the Data Capture Interface.

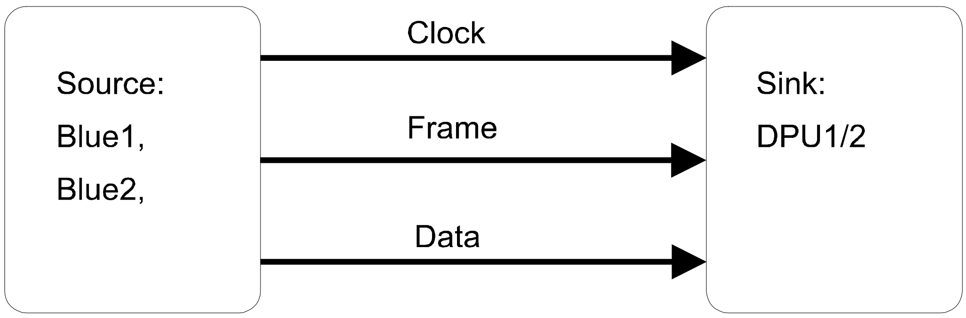


Figure 3.11: Signal Level Schematic of the Data Capture Interface.

b) Function

Raw data from the detectors are passed to the DPU as events occur with only minimal buffering at the detector. The DPU has no control of the data flow and therefore must be capable of processing the data at the maximum rate at all times.

c) EMC

There is a large separation between the DPU and detectors. Given that the interface is running at high speed, particular attention must be paid to EMC aspects.

Screened twisted pair differential lines are specified which will help reduce susceptibility to radiative interference. However the lines are unbalanced differential and therefore there will be some noise due to common mode interference.

Being a high bandwidth interface it will not be easy to remove noise by filtering. In particular most of the digital clock frequencies and sub-harmonics will fall within the bandwidth of the signal.

It is the possible for noise to be injected into the detector electronics from the DPU. This would be the most serious case since the detectors contain the sensitive analogue electronics. In the DPU therefore, careful separation of the interface electronics from potential noise sources is needed.

Another line of defence may be to reduce the power of noise injected into either unit by designing the interface series resistor as high as possible which should be placed as close as possible to the physical connector.

d) Interface

There are two separate interfaces

The interfaces are: DC1and DC2.

Each interface has three separate signals. They are refered to as:

- <interface>_Clock   Data bit-clock signal
- <interface>_Strobe   Word strobe line
- <interface>_Data   Word data line

e) Protocol

There are two defined protocols, one for the Blue detector, the other for the Red detector.

Each protocol defines only the bit pattern within the word as follows:

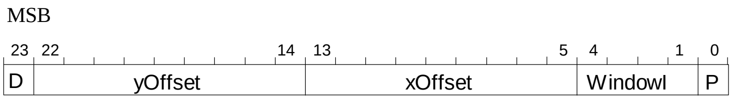


Figure 3.12: Protocol Definitions for the Data Capture Interface

The definition of the fields are:

Field	No. of Bits	Definition
D	1	Double event flag
yOffset	9	Relative position address in Yaxis
xOffset	9	Relative position address in X axis
WindowID	4	Pixel window identifier
P	1	Parity bit - ensures that there are an odd number of ones in the 24 bit word including P.

f) Signals

Each signal is derived from the differential of a pair of lines. The lines are named with suffixes _true and _inv. Eg:

Signal <interface>_Clock is derived from the two lines:
<interface>_Clock_true
<interface>_Clock_inv

g) Timings

The timing of the interface is defined below:

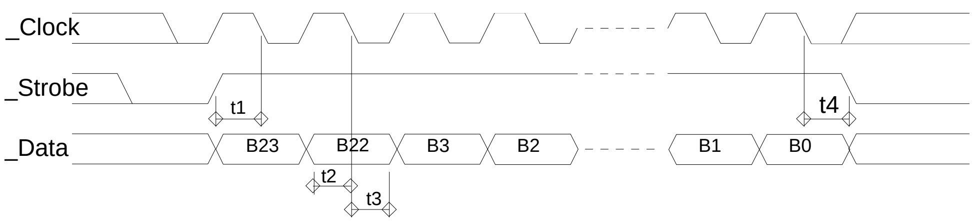


Figure 3.13: Timing Characteristics of the Data Capture Interface

Parameter	Min	Max	Units
t1	50	150	ns
t2 for each bit B23:0	50		ns
t3 for each bit B23:0	50		ns
t4	50		ns
Clock Frequency		5.1	MHz

Note that the two detector systems and their timings are entirely independant.

h) Line Characteristics

The digital interface signals are carried by differential lines.

The scheme is given by the figure below. The lines are symetrical, one identified as ’true’ the other as ’inverse’.

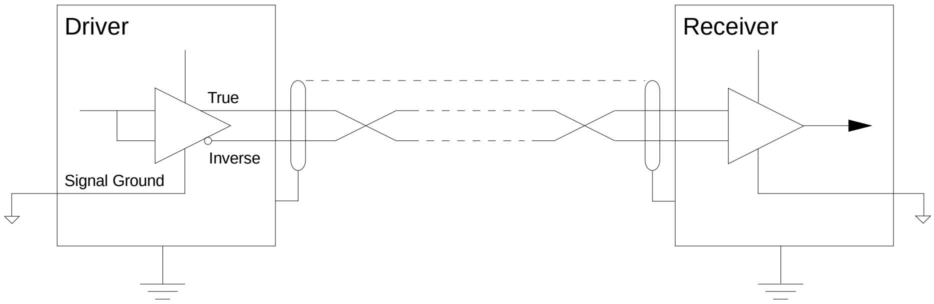


Figure 3.14: Data Capture Interface Line Driving Scheme

The signal value is determined from the levels on the lines:

’1’ corresponds to a positive differential voltage between true and inverse lines (Vtrue - Vinverse > 0 Volts)

’0’ corresponds to a negative differential voltage between true and inverse lines (Vtrue - Vinverse < 0 Volts)

The interface will be treated as a transmission line and therefore the statements above could equally be expressed in terms of current instead of voltage.

Because of the redundancy configuration either side may be powered off while the other side is on. Therefore it is required that components are not stressed beyond derated limits and that powering via interfaces does not occur in any permutation of powered and unpowered units with worst case specifications.

The tables below give the specifications of the driver and receiver circuits:

Driver Specifications

Type of Circuit	0-5V differential line driver (Use SN55ALS194 or HS26C31MS)
Transfer	DC coupled
Coding	NRZ-L
Logic ’1’ level	Drive >2mA into 100Ω
Logic ’0’ level	Drive <-2mA into 100Ω
Rise and fall times	<30ns
Current drive capability	Sufficient to comply with specified rise and fall times
Short circuit tolerance	a short circuit of the output will not damage the output neither will it affect the operation of any other output, the current will be limited to <200mA
Overvoltage tolerance	the output will not be damaged by the application of an overvoltage between -5V and 15V in series with 1.5kΩ neither will it affect the operation of any other output

Receiver Specifications

Type of Circuit	0-5V differential line receiver ‘RS-422’ (Use SN55ALS195 or HS26C32MS)
Transfer	DC coupled
Coding	NRZ-L
Logic '1' level	Drive >2mA into 100Ω
Logic '0' level	Drive <-2mA into 100Ω
Rise and fall times	<30ns
Current drive capability	Sufficient to comply with specified rise and fall times
Short circuit tolerance	a short circuit of the output will not damage the output neither will it affect the operation of any other output, the current will be limited to <200mA
Overvoltage tolerance	the output will not be damaged by the application of an overvoltage between -5V and 15V in series with 1.5kΩ neither will it affect the operation of any other output

3.3. Drives

3.3.1. TMPSU ⇒ Motor Drives

a) Scope

There are 4 motors of 2 types in the system. 3 Filter Wheels, and one Dichroic. Each will be driven from a 28V unipolar drive.

NOTE: NO MORE THAN ONE MOTOR MAY BE ENERGISED AT ONE TIME.

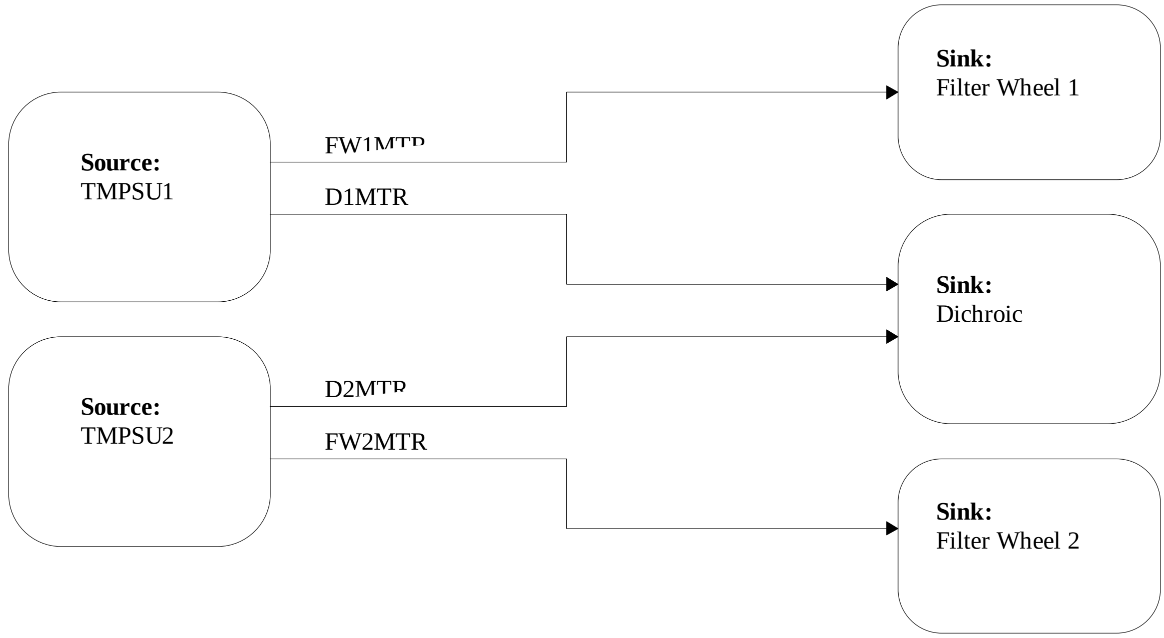


Figure 3.15: Interface Level Schematic of the Motor Drives

b) Function

Logic Modes

Mode A: Only one phase at a time is energised, i.e. one phase is switched off at the same time as the next phase is switched on. The motor will execute one basic step for each input pulse.

Mode B: Two phases are energised at any one time. This mode will produce higher holding and dynamic torque in 4 phase motors and will reduce rotor oscillations but power input to the motor will double compared with mode A. The motor will also execute one basic step for each input pulse.

Mode AB: This is a combination of modes A and B in which the motor phases are energised sequentially in mode A followed by mode B. In this mode the motor will execute half of the basic step for each input pulse consequently, a motor having a basic step angle of 90° will move in increments of 45° when operating in AB mode. This mode has the advantage of producing a smaller step angle and enables the motor to operate at approximately twice the pulse rate obtainable with modes A or B.

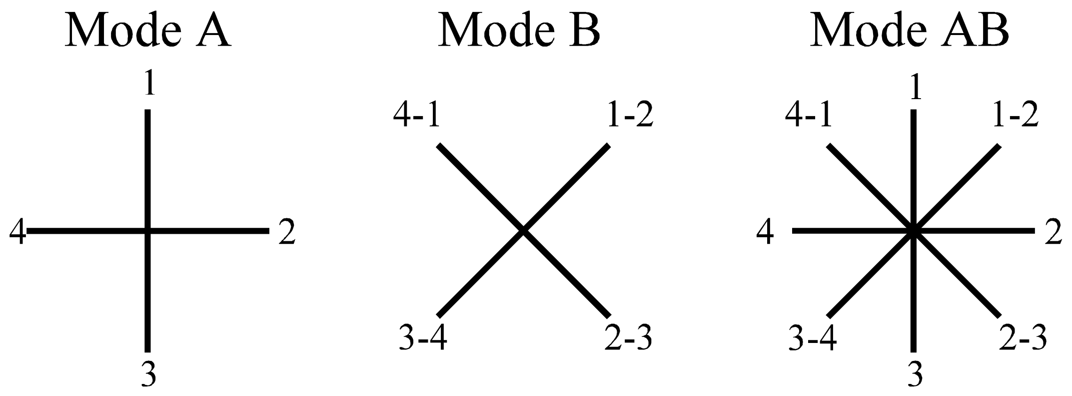


Figure 3.16: An Illustration of the Phases Energised for Each Motor Position

The mode of driving the motor is an ICU software function.

The dichroic motor will only be driven in mode A.

The filter wheel motors may be driven in mode A or mode AB.

c) EMC

The motors will only be driven when there is no data being taken from the detector so the data cannot be corrupted by noise from the motor drives.

d) Interface

There are 4 interfaces as shown in the interface level schematic above. Each interface contains a signal for each phase:

<interface>_phase1
<interface>_phase2
<interface>_phase3
<interface>_phase4

e) Signals

Each signal has a drive and return line. Two of the return lines (C/T below) are commoned at the filter wheel motor. Separate ballast resistors are to be used on each return line inside the TMPSU. All of the return lines are commoned at the dichroic motor which thus has only one ballast resistor.

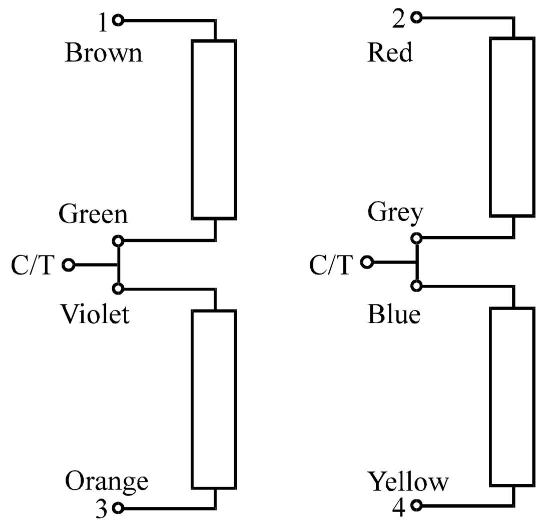


Figure 3.17:Wiring detail of the Motors

The lines are given names as follows:

<interface>_ph1	drive line for _phase1
<interface>_ph2	drive line for _phase2

<interface>_ph3	drive line for _phase3
<interface>_ph4	drive line for _phase4
<interface>_ret13	return line for _phase1 and _phase3
<interface>_ret24	return line for _phase2 and _phase4

f) Characteristics

Filter Wheel Motor

This is a size 23 motor. The manufacturers information is given below for 4 Phase Unipolar operation. The two central terminals C/T are to go separately to ground through resistors in the TMPSU with a value that matches the coil resistance.

Max. supply voltage	28V
DC resistance/phase	36-44Ω at 25°C
Inductance	50-80mH @1000Hz
Max. current/phase	0.35A
Power dissipated/phase	9.8W
Single phase holding torque	0.4Nm Nominal

Dichroic Motor

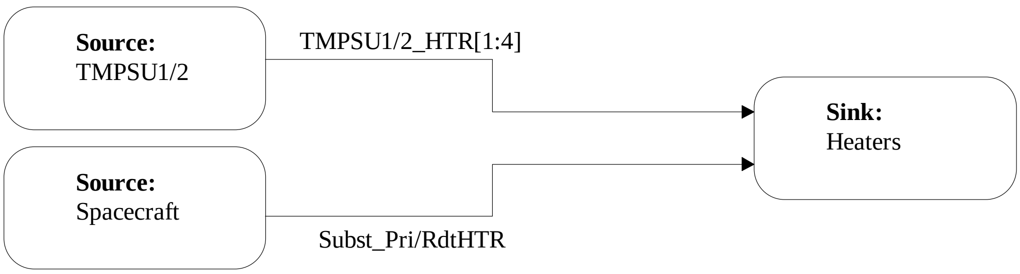
This is a size 11 motor. The manufacturers information is given below for 4 Phase Unipolar operation. The central terminals are to be connected together and are to be connected to ground through a ballast resistor in the TMPSU that matches the coil resistance.

Max. supply voltage	28V
DC resistance/phase	140-180Ω at 25°C
Inductance	45-65mH @ 1000Hz
Max. current/phase	0.175 A
Power dissipated/phase	4.9 W
Single phase holding torque	0.01Nm Nominal

3.3.2. TMPSU ⇒ Heaters

a) Scope

There is one redundant Substitution heater and there are four redundant Instrument heaters.



b) Function

The Substitution heaters are driven by the spacecraft, and routed via the OM1 connector panel to the heaters mounted on the outside of the tube.

The four Instrument heaters are used as follows:

HTR1 connects to the Main Interface heater, and HTR2 connects to the Forward Tube heater. These are used in an active control loop to maintain the interface temperature within tight limits.

HTR3 is connected to the “Focus +” heaters on the metering rods. HTR4 connects to the “Focus -” heaters on the secondary mirror. These are driven in open loop to compensate for a focus shift after launch if necessary.

c) EMC

The heaters are switched with a period of the order of 10-100 seconds. Transient requirements in the EID-A apply.

d) Interface

Interface	Resistance	Location	Source
Subst_Pri/RdtHTR	35W	Rear of Interface	Spacecraft
TMPSU1/2_HTR1	44.64Ω	Main Interface	TMPSU1/2
TMPSU1/2_HTR2	29.76Ω	Forward Tube	TMPSU1/2
TMPSU1/2_HTR3	112.33Ω	Metering Rods Focusing	TMPSU1/2
TMPSU1/2_HTR4	202Ω	Secondary Mirror Focusing	TMPSU1/2

e) Signals

The lines are given names as follows:

<interface>_go active switched +28V line
<interface>_ret separate line for un-switched common to main power return line.

3.4. Monitors

3.4.1. Filter Wheel Position Sensor ⇒ TMPSU/Blue1/2

a) Scope

For each filter wheel one position sensor is controlled by the associated detector (the fine position sensor) and the other by the TMPSU (the coarse position sensor).

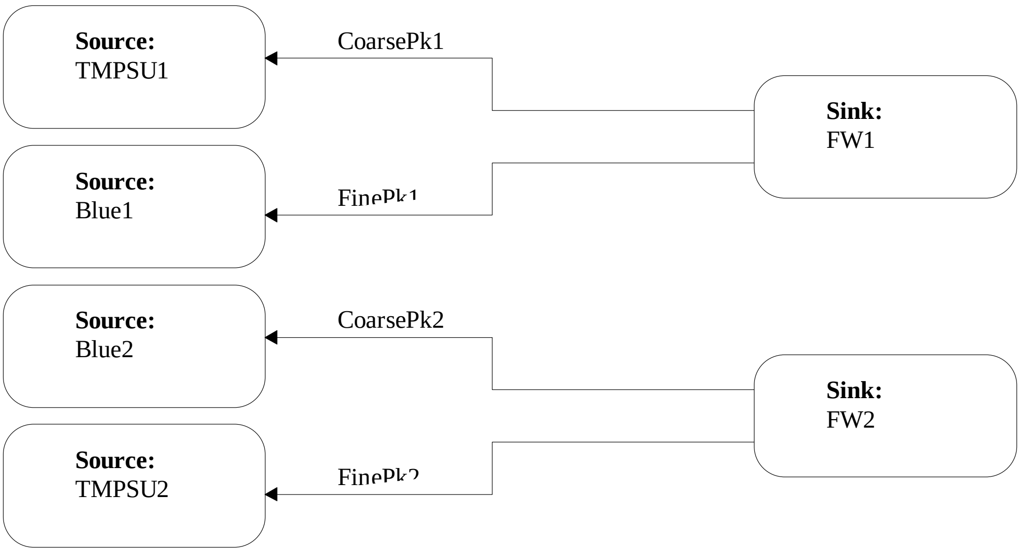


Figure 3.18: Interface Level Schematic of the Filter Wheel Pick-offs

b) Function

For each filter wheel, there are two position sensors. Each position sensor consists of an infrared emitter and receiver pair.

The emitter shall be driven with a controllable current from 0 to 100mA in at least 8 steps.

c) EMC

The position sensing is not speed critical, therefore some filtering is possible. Since the position sensing can be done with the motors stopped, noise from the motor drive is not a big concern.

d) Interface

There are 4 interfaces as shown in the interface level schematic above. Each interface conatains a signal for each phase:

<interface>_emit
<interface>_rcv

e) Signals

The lines are given names as follows:

<interface>_tx	drive line from source for the _emit signal
<interface>_rx	receive line from the sink for the _recv signal
<interface>_ret	common return for the _emit and _recv signals

f) Characteristics

The characteristics of each sensor is as follows:

Emitter

Optek/US op224 Infrared light emitting, GaAlAs, hermetic Spec: BAe SDI01-002

Receiver

Optek/US op604 Silicon NPN phototransistor Spec: BAe STR01-003

Method of transmision

Reflective 30%