HESSI

High Energy Spectroscopic Imager (HESSI) Spacecraft to Instrument Data Processing Unit (IDPU) Interface Control Document (ICD)

HSI_SYS_001H.doc

Version H – 1999-Jun-22

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Document Revision Record

Rev.	Date	Description of Change	Approved By
A	1998-May-15	Preliminary Draft	-
B	1998-Aug-25	Resolve several TBD/TBRs, change in the Command Segment format.	-
C	1998-Sep-14	Remove RAS segment from Telemetry Block. Addition of stable clock characteristics table. Minor editorial details.	-
D	1998-Oct-15	Add Spectrum Astro thermal commets, modify command block format, add 3 new spacecraft-monitored temp. Sensors	DC, PH, JP, JJ
E	1998-Dec-21	• Change in definition of instrument Safe mode (Section 1.1.1) • Change CPC and Spectrometer heaters to Instrument Heater bus (was IDPU Heater bus) (Section 3.2.1). • Define time code byte ordering (Section 4.4.1.1.1) • Change SAS sample rate to 8Hz (Section 4.4.2)	-
F	1999-Mar-5	• Update ICD Hardware Drawings, Mass & Power spreadsheets • Add separate Particle Detector (remove from IDPU VME) • Add RAS heater, remove CPC & Spectrometer heaters from Switched Service loads • Update SSR interface timing (per Matranga's e-mail of 99-1-19).	
G	1999-Mar-11	• Change SSR clock, CLK1MHZ, and CLK1Hz termination • Replace harness drawing (HSI_SYS_005) reference to harness specification reference (HSI_SYS_022)	
H	1999-Jun-22	• Update document references • Change SAFE mode definition • Change IDPU operating temp. range • Change Spectrometer Heater power • Change series termination resistance	

		• Replace series termination on HRECCLK • Add SSR Power/Record status bits to the Power status byte sent to the IDPU	

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Table of Contents

1. Introduction

This document shall describe the interface between the HESSI spacecraft bus and the Instrument Data Processing Unit (IDPU).

1.1. *IDPU Description*

The IDPU provides the electronic interface between the spacecraft bus and the instrument sensors and detectors. The IDPU collects and formats instrument data, and controls instrument operations. The IDPU consists of a 12-slot VME chassis, an Instrument Power Converter (IPC), and a Cryocooler Power Converter (CPC). Reference 4 is a block diagram of the IDPU.

The VME Chassis includes nine Detector Interface Boards, an Aspect Data Processor (ADP) board, a Data Controller Board, and a Power Controller Board. The Detector Interface Boards condition and digitize signals from the Germanium detectors in the Spectrometer. The ADP collects and formats data from Solar Aspect Sensors (SAS) and Roll Aspect Sensor (RAS). The Data Controller Board collects, formats, and passes from the Detector Interface Boards and ADP to the spacecraft. It also accepts commands from the spacecraft, controls instrument operations, and collects, formats, and transmits to the spacecraft instrument State Of Health (SOH) data. The Power Controller Board monitors and switches instrument power services, and conditions instrument temperature sensors.

The IPC includes the instrument Low Voltage Power Supply (LVPS), which conditions spacecraft power for the instrument electronics, and nine detector High Voltage Power Supplies (HVPS). The CPC conditions and modulates spacecraft power to the Spectrometer Cryocooler.

1.1.1. Operating Modes

The IDPU has a large number of independent configurations, which effect data rates, power consumption, and dissipation. For simplicity, four basic modes are defined in this document, which cover the most likely and extreme cases.

- **Cool-Down –** Cryostat cool-down mode. Extra power to the cooler is compensated by less power to the electronics. Cool down will take days, and the power profile will vary somewhat over that time. No science data will be collected.
- **Normal –** Normal operating mode (after cryostat cool-down): full science data collection.
- **Standby –** a low power mode that can be used late in the mission to save power (no science data collected). The instrument would be in Normal mode in sunlight, Standby mode in the dark.

Safe – response to a spacecraft power-shedding signal. No science data collected. The cryocooler shall be powered-off. If the system was in Normal mode, with the detectors cold, on entry to Safe mode, then power must be restored to the cooler within 24 hours to prevent an unstructured warm-up of the detectors.

1.2. *Document Conventions*

In this document, TBD (To Be Determined) means that no data currently exists. A value followed by TBR (To Be Resolved) means that this value is preliminary. In either case, the value is typically followed by UCB (University of California at Berkeley) and / or SA (Spectrum Astro) indicating who is responsible for providing the data, and a unique reference number.

1.3. *Applicable Documents*

The following documents include drawings and HESSI Project policies, and are part of the Interface Requirements. In the event of a conflict between this ICD and the following documents, this ICD takes precedence. All ICD documents and drawings can be found on the Berkeley HESSI FTP site:

ftp://apollo.ssl.berkeley.edu/pub/hessi/released/icd

Pre-released versions of these documents may be found at:

ftp://apollo.ssl.berkeley.edu/pub/hessi/icd

1. IDPU VME Chassis ICD Drawing, File HSI_SYS_011E
2. IDPU IPC ICD Drawing, File HSI_SYS_012F
3. IDPU CPC ICD Drawing, File HSI_SYS_013E
4. HESSI IDPU Block Diagram, File HSI_IDPU_001E
5. HESSI Grounding Schematic, File HSI_SYS_004D
6. HESSI Instrument Harness Specification, File HSI_SYS_022J
7. HESSI Telemetry Format, File HSI_SYS_007D
8. HESSI Telecommand Format Specification, File HSI_SYS_008B
9. HESSI Instrument Power Spreadsheet, File HSI_SYS_006K
10. HESSI Instrument Mass Spreadsheet, File HSI_SYS_010G
11. Spectrum Astro HESSI Product Assurance Plan, Rev-, December 17 1997, File EPQ09929, HSI_PA_002A.
12. HESSI Spectrometer to Spacecraft ICD, File HSI_SYS_015G.
13. Particle Detector Drawings, File HSI_SYS_034B

The indicated version number (letter code at the end of the file name) is the official version. Later versions may appear in the Web site but are not considered official until they appear in this list.

2. Mechanical Interface

2.1. *Interface Drawing*

The mechanical configuration of the IDPU is shown in the IDPU ICD Drawings (Reference 1-3 and 13).

2.2. *Mass Properties*

Reference 10 shows the instrument mass properties, including current best estimate, estimate+margin, and maximum.

2.3. *Field of View and Alignment*

All three IDPU boxes have thermal radiators that should have a clear radial FOV (see Reference drawings 1-3 and 13).

3. Thermal Interface

3.1. *Thermal Design*

The thermal design shall address radiative and conductive heat transfer between the IDPU and spacecraft and the IDPU to space. Thermal dissipation shall be primarily radiative, but some dissipation shall be possible through the mechanical mount to the spacecraft deck. The design shall meet the thermal constraints of each box listed in section 3.3 based on the power dissipations shown in section 3.2.

3.1.1. Thermal Design Responsibilities

The thermal design of the IDPU, CPC, IPC, and Particle Detector is the responsibility of UCB. The components shall be thermally coupled to the spacecraft bus deck (to the strut for the Particle Detector). Since the components are thermally coupled to the spacecraft bus deck, Spectrum Astro shall provide sufficient information regarding the spacecraft bus characteristics to allow UCB to design the thermal control systems for those components. Following definitization of the thermal design, UCB shall provide sufficient information to Spectrum Astro to allow Spectrum Astro to accurately model the components as input to the spacecraft bus thermal model. Spectrum Astro shall verify that the spacecraft bus meets its thermal control system requirements using this information. Spectrum Astro shall deliver the spacecraft bus thermal model to UCB as input to the spacecraft thermal model that is integrated and verified by UCB.

3.1.2. IDPU Surface Properties

The thermal properties of the exposed surfaces of the IDPU (blanketing and radiator surface characteristics) are described in the IDPU ICD Drawings (Reference 1-3).

3.1.3. IDPU Thermal Conduction to the Spacecraft Deck

Thermal contact resistance between the IDPU and the spacecraft shall not exceed 0.13C/W.

> NOTE: This is equivalent to an effective average contact heat transfer coefficient of 20 BTU/hr-ft2-R over the entire IDPU mounting surface area of 104.8 in2 [A=10.675"x9.817']. This will be achieved through wet mount with RTV 566 applied to the entire mounting surface area to a nominal thickness of 0.010 inches but not to exceed 0.080 inches. Compliance will be verified by analysis and possibly by test as well.)

3.2. *IDPU Power Dissipation by Mode*

Reference 9, Table 2 shows the power dissipation in the IDPU boxes by instrument mode.

3.2.1. Instrument Heaters

The Instrument Heater service power is dissipated in the IDPU, IPC, CPC, and Spectrometer (see section 4.1.2.4 and reference 12). Instrument Heaters are thermostatically controlled, with a separate thermostat in each unit. These heaters are used as replacement heaters to get the instrument into its start-up temperature range prior to turn-on, and/or to avoid dropping below the non-op temperature limit when instrument power is off. The thermostat and heater characteristics are shown in Table 3.2.1-1. Heater power is based on a bus voltage of 24V. Heater power levels are TBR-UCB/SA-027.

Table 3.2.1-1 Instrument Heater Service Properties

Item	IDPU	IPC	CPC	Spectrometer
Thermostat Set Point	-30C	-30C	-30C	-30C
Heater Power	20W	10W	10W	40W

3.3. *IDPU Temperature Requirements*

The Non-Op temperature limits apply when the instrument power is off. The instrument should not be turned on unless it is in the Start-up temperature limits. The instrument will not be in calibration unless in the Operational Limits. Temperature limits are as measured at the instrument mounting foot indicated in the ICD drawing (reference 1-3, 13).

Table 3.2-1 Thermal Limits

	Temperatures, °C			
Range	Part. Det.	IDPU	IPC	CPC
Non-Op Limits	-40 - +70	-40 - +70	-40 - +70	-40 - +70
Start-up Limits	-40 - +40	-30 - +40	-30 - +50	-30 - +50
Operational Limits	-40 - +15	-10 - +30	-30 - +50	-30 - +50

4. Electrical Interface

The IDPU will be the single-point electrical interface between the spacecraft and the instruments.

4.1. *Power*

The IDPU receives electrical power on four separately switched services. Each service provides spacecraft unregulated 28 volts.

4.1.1. Spacecraft 28 Volt Service Characteristics

Each spacecraft 28 volt service shall have the following characteristics at the connector on the instrument box.

4.1.1.1 Regulation

The spacecraft 28 volt services shall be 28 volts +6/-4 Volts.

4.1.1.2 Voltage Ripple

Voltage ripple on the supply as a function of frequency is shown in Figure 4-1 (Figure 4.1-1 is representative; the exact levels are TBR-SA/UCB-004).

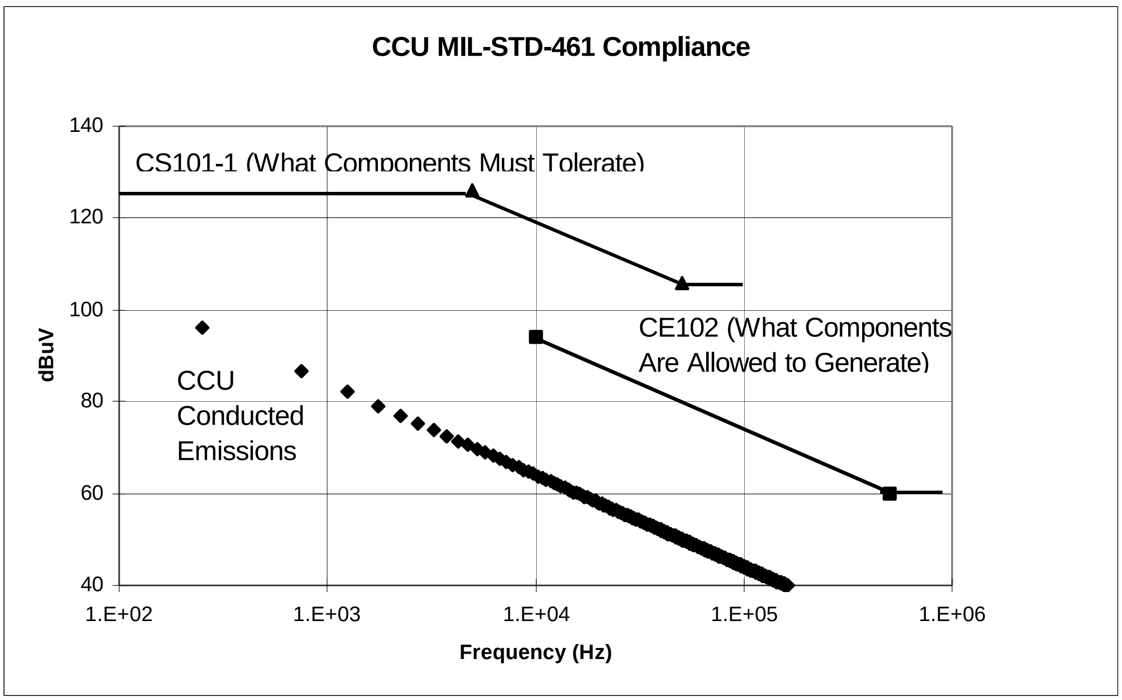


Figure 4.1-1 Conducted Emissions / Susceptibility Requirements

4.1.1.3 Voltage Transients

Voltage transients on the supply lines shall not exceed +/- 2 volts for 1 msec (TBR-SA-005).

4.1.1.4 Current Limiters

Each service shall be current limited at the source to levels indicated in Reference 9, Table 4. Limiters will act like circuit-breakers, requiring a ground-commanded reset and including an override capability. A typical 5 Amp limiter shall be designed to trip in accordance with Figure 4.1.1.4-1. The circuit breakers shall be designed not to be tripped by the in-rush current specified in 4.1.2.1.1, 4.1.2.2.1, and 4.1.2.3.1.

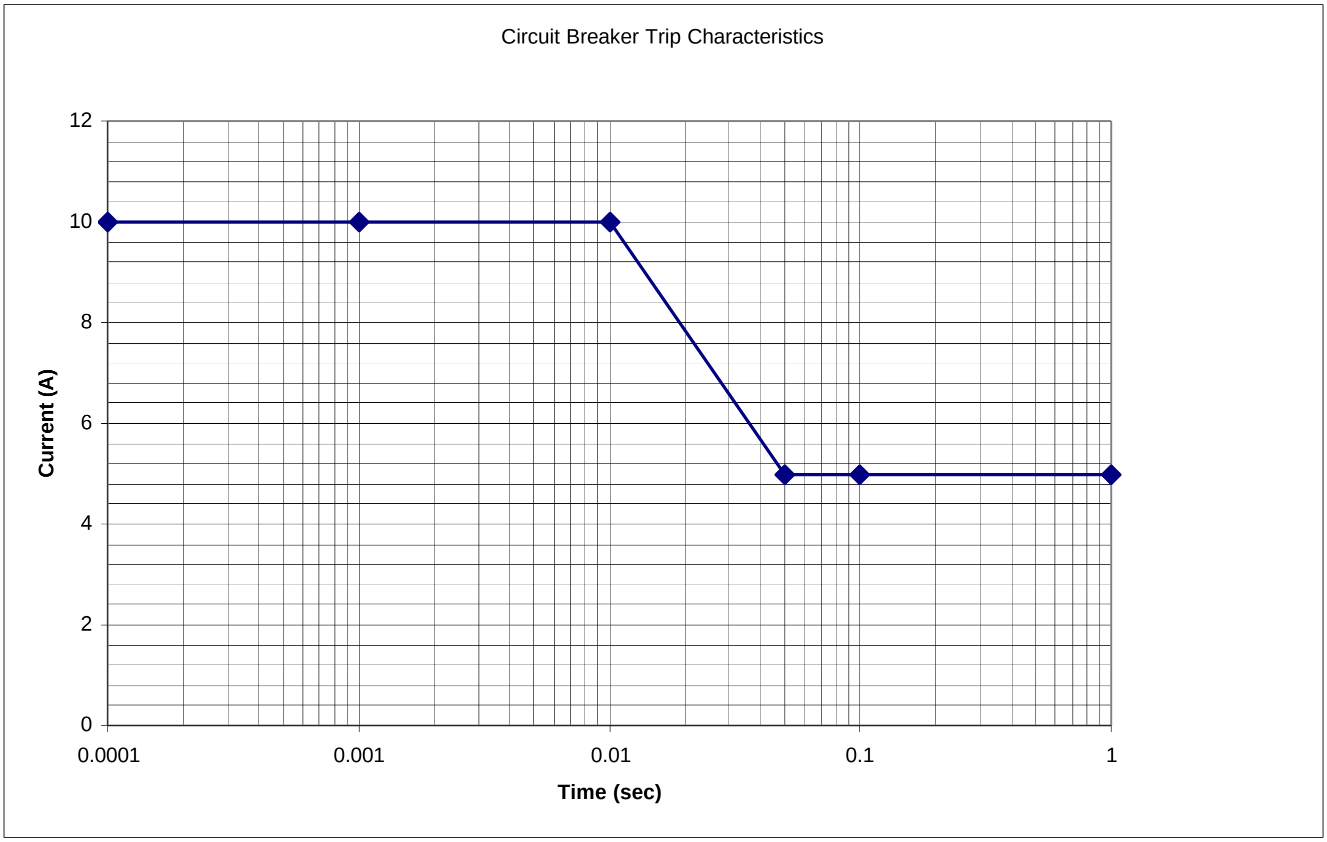


Figure 4.1.1.4-1 Instrument Power Circuit Breaker Characteristics

4.1.1.5 Current Monitors

The spacecraft shall have current monitors on each instrument power service (included in the spacecraft State of Health telemetry).

4.1.1.6 Returns

Each service shall be provided with a separate return line.

4.1.1.7 Harness

Service and return lines shall be routed as twisted pairs of # 22 AWG wire. The cryocooler service shall have two pairs (with separate connector pins) due to the higher current requirement. The power harness to the IDPU shall utilize twisted shielded pairs, with the shield connected to spacecraft chassis ground at the signal source end (spacecraft – see Reference 5).

4.1.1.8 Impedance

Effective line impedance in the service at the instrument connector is < 500 milliohms DC-10KHz (TBR-SA-008).

4.1.2. Spacecraft 28 Volt Instrument Loads Characteristics

Each spacecraft 28V service load shall return its current through the provided return line (see Reference 5). The 28V return shall be isolated from signal and chassis ground by at least 1Mohm and no more than 1μF within the instrument.

4.1.2.1 IDPU Power Load Characteristics

The IDPU power service runs the instrument electronics.

4.1.2.1.1 Inrush and Transients

In-rush current and other power transients shall not exceed 10 Amps for longer than 1 msec, and shall not exceed the peak power consumption level indicated in Reference 9 after 10ms.

4.1.2.1.2 Current Ripple

Current ripple shall not exceed the CE curve shown in figure 4.1-1.

4.1.2.1.3 Power Consumption

Power consumption shall be a function of instrument operating modes as shown in Reference 9, Table 3.

4.1.2.2 Cryocooler Power Load Characteristics

The cryocooler power service provides power to the cryocooler power controller, which conditions that power for the cryocooler. The cryocooler is basically a motor that consumes AC power at about 60Hz. The cryocooler controller will generate a programmable amplitude AC waveform from the Cryocooler power service.

4.1.2.2.1 Inrush and Transients

In-rush current and other power transients shall not exceed 10 Amps for longer than 1 msec, and shall not exceed the peak power consumption level indicated in Reference 9 after 10ms.

4.1.2.2.2 Current Ripple

The current load shall have significant 120Hz ripple. The power levels given in Table 4.1.2-1 are RMS values, averaging over this ripple. Current ripple shall not exceed the CE curve shown in figure 4.1-1.

4.1.2.2.3 Power Consumption

The cryocooler load shall vary with the cooling requirements. Estimated and Maximum power consumption shall be a function of instrument operating modes as shown in Reference 9, Table 3.

4.1.2.3 Switched Power Load Characteristics

There are a number of transient loads whose power is switched by the IDPU off this service. This includes:

- Imager Upper Grid Tray Heater

- Imager Lower Grid Tray Heater
- RAS Heater
- RAS Shutter
- Cryostat Vacuum Valve
- Shutter Actuators

4.1.2.3.1 Inrush

In-rush current and other power transients shall not exceed 10 Amps for longer than 1 msec, and shall not exceed the peak power consumption level indicated in Reference 9 after 10ms.

4.1.2.3.2 Current Ripple

Current ripple shall not exceed the CE curve shown in figure 4.1-1.

4.1.2.3.3 Power Consumption

Power consumption shall be a function of instrument operating modes as shown in Reference 9, Table 3. Some of the power is transient loads lasting about 1 second, as shown in the Peak Power requirements. The rest goes into heaters that are powered as required, with best estimates included in the Table.

4.1.2.4 Instrument Heater Power Load Characteristics

The Instrument Heater Power service is used to power replacement heaters when the Instrument is powered off or in a low power mode. It shall be thermostatically controlled to keep the IDPU, IPC, CPC, and Spectrometer above their lower start-up temperature limits. The heater power and thermostat settings are shown in Table 3.2.1-1. A best estimate of the actual average heater power usage will be derived from the spacecraft thermal model. No significant in-rush current is expected, and there is no ripple current (resistive load).

4.2. *Signals*

Electrical signals are carried between the IDPU and spacecraft over one or more harasses. Harnesses shall be twisted shielded pairs, with the shield connected to chassis ground at the signal source end.

Single-ended logic signals shall be represented by 0-5volts CMOS logic levels. The standard interface circuit is shown in figure 4.2-1. Logic levels described in this document are as measured on the harness (these may be inverted by the receiver). Differential interface signals shall use RS-422 levels terminated as shown in Figure 4.2-2. All resistances are +/-10%.

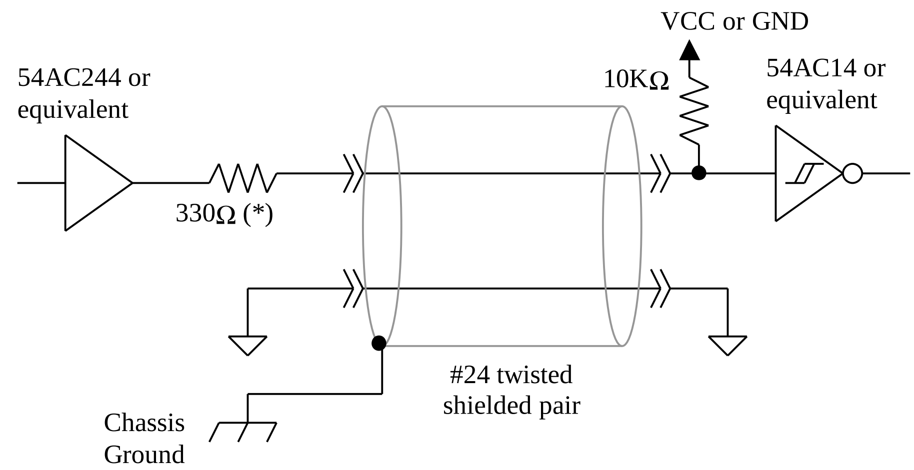


Figure 4.2-1 Single-ended Logic Interface Schematic

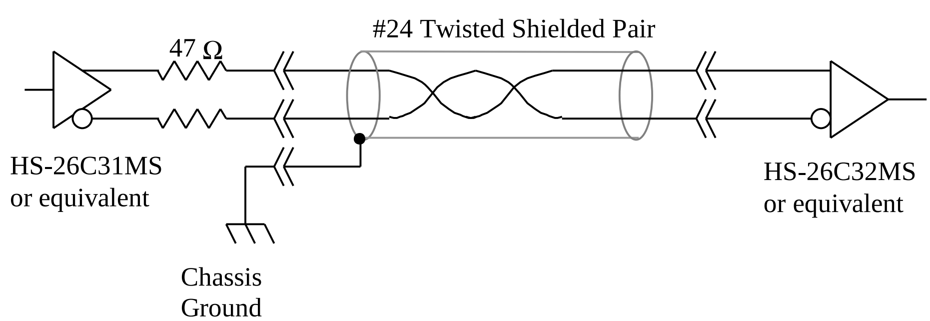


Figure 4.2-2 Differential Interface Schematic

4.2.1. Timing Interface

The IDPU receives spacecraft time in the form of two clock signals (1Hz and 1MHz) plus a periodic synchronizing command. The command is described is section 4.4.1. The timing clock signals are described here. The clocks shall have single-ended interfaces, as shown in figure 4.2-1, except that the series drive resistor shall be 47 ohms rather than 330 ohms.

The 1Hz clock shall consist of a pulse occurring once a second, based on the stable spacecraft clock as described in Table 4.2.1-1. The 1MHz clock shall be a square wave at F_{1MHZ}=1,048,576 Hz, also based on the stable spacecraft clock. There shall always be exactly F_{1MHZ} 1MHz clocks per 1Hz clock tic. The signal timing is shown in figure 4.2.1-1. 1Hz shall be logic high for T_{HI} = 50% ±10% of ($1/F_{1MHZ}$), and the edges of 1Hz shall be synchronous with the falling edge of 1MHz ±10% of ($1/F_{1MHZ}$). The included rising edge of 1MHz corresponds to the actual 1-second time mark.

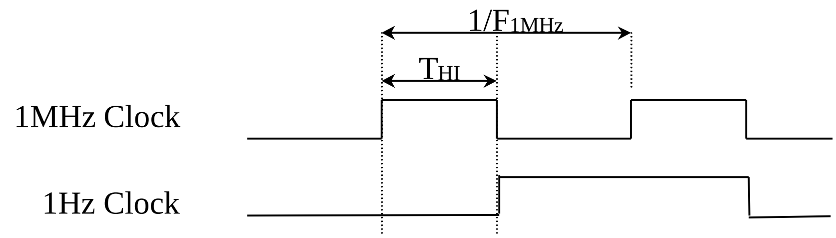


Figure 4.2.1-1 Clock Signal Timing

Table 4.2.1-1 Stable Spacecraft Clock Characteristics

Item	Value (Typical)
Frequency Accuracy	±0.25ppm
Frequency Stability	±20ppb

4.2.2. Reset Signal Interface

The spacecraft shall provide a Reset signal to reset the IDPU to a known state. The signal shall be normally low, and shall pulse high for 100ms on ground command. The Reset line shall have a single-ended interface.

4.2.3. Safe Mode Interface

The spacecraft shall provide a ‘Safe Mode’ signal to request that the IDPU go into safe mode in response to an under-voltage situation. This signal shall be a single-ended signal, active high, and should remain high at least 2 seconds. When this signal is removed, the instrument shall stay in safe mode until commanded otherwise from the ground.

4.2.4. Command Interface

The Command interface is a serial interface used to send data from the spacecraft to the IDPU. The information sent over this interface is described in section 4.4.1. The data is transmitted on a single serial line using UART encoding, and a differential interface. Data shall be transmitted at 38.4Kbaud, with 1 start bit, 8 data bits, 1 parity bit (Even), and one stop bit per 8-bit byte transmitted, as shown in Figure 4.2.4-1.

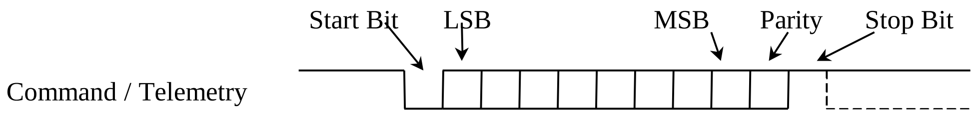


Figure 4.2.4-1.

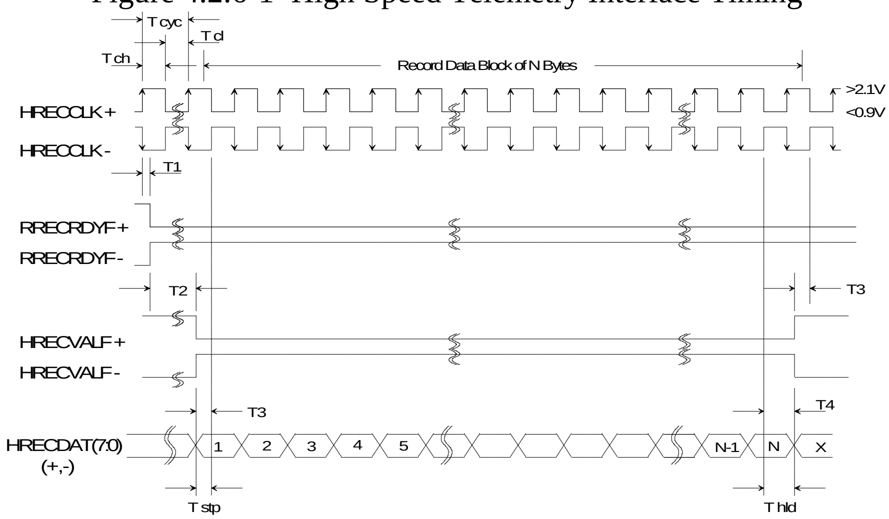
4.2.5. Low Speed Telemetry Interface

The Low Speed Telemetry interface is a serial interface used to send status and housekeeping data from the IDPU to the spacecraft. The data is transmitted on a single serial line using UART encoding, and a differential interface. Data shall be transmitted at 38.4Kbaud, with 1 start bit, 8 data bits, 1 parity bit, and one stop bit per 8-bit byte transmitted, as shown in Figure 4.2.4-1.

4.2.6. High Speed Telemetry Interface

The High Speed Telemetry interface is an 8-bit parallel interface used to send science telemetry packets from the IDPU to the spacecraft Solid State Recorder (SSR). The information sent over this interface is described in section 4.4.3. This consists of 8 data bits (HRECDAT(7:0), a continuous clock (HRECCLK) and an data gate (HRECVALF) to transfer the data, plus a data enable line from the SSR to the IDPU (RRECRDYF) indicating that it is ready to accept data. All 11 signals shall be differential (there will be no signal ground interface between the SSR and the IDPU) as shown in figure 4.2-2, except for the HRECCLK signal, which shall use the circuit shown in figure 4.2-3. The timing characteristics of this interface are shown in Figure 4.2.6-1. The record data block size is arbitrary.

Figure 4.2.6-1 High Speed Telemetry Interface Timing



	Characteristic	Min	Max	Comments
T cyc	Clock Period	200 ns	-	5.0 Mhz +/- 0.005% Maximum
T ch	Clock Pulse Width (High)	90 ns	-	Clock Duty Cycle of 50 +/- 5%
T cl	Clock Pulse Width (Low)	90 ns	-	Clock Duty Cycle of 50 +/- 5%
T1	HRECCLK+ High to RRECRDYF Valid	-	110 ns	-
T2	RRECRDYF Valid to HRECVALF Valid	0 ns	-	Considerred asynchronous
T3	HRECVALF to HRECCLK+ Low (Setup Time)	50 ns	-	-
T4	HRECCLK+ Low to HRECVALF Transition (Hold Time)	12 ns	-	-
T stp	HRECDAT Valid to HRECCLK+ Low (Setup Time)	50 ns	-	-
T hld	HRECCLK+ Low to HRECDAT Transition (Hold Time)	12 ns	-	-

- Record Data and Data Valid are transitioned by the host based on the rising edge of HRECCLK+
- The SSR latches record data on the falling edge of HRECCLK+
- All transitions measured at 50%
- Data is positive true
- Data transfers MSByte first, MSBit is bit 7, LSBit is bit 0
- The SSR shall assert RRECRDYF unless in BIT or executing a commanded reset.
- Min/Max at SSR/SEM interface
- Data Value of 1 for HRECDAT is defined as (HRECDAT +) - (HRECDAT -) > 0.2V
- Data Value of 0 for HRECDAT is defined as (HRECDAT +) - (HRECDAT -) < - 0.2V

4.2.7. Temperature Sensor Interfaces

The IDPU shall provide five passive temperature sensor interfaces to be conditioned, converted, and telemetered by the spacecraft. One temperature sensor will be in the IDPU VME chassis and one in the IPC, one in the CPC, one in the RAS, and one in the Spectrometer. The IDPU provides additional monitors the temperatures of the instrument systems when it is powered on. The spacecraft-monitored temperature sensors shall be type AD590, and shall be provided by Spectrum Astro to Berkeley.

4.3. *Connectors & Harnessing*

The spacecraft to Instrument electrical interface shall be made on three connectors as described below. Each connector shall include a backshell to provide strain relief to the harness.

4.3.1. Instrument Power Interface Connector, IPC-J1

The instrument power interface between the IDPU and the spacecraft shall be on connector IPC-J1 on the IPC. The connector on the box shall be a 9 pin normal density male D connector, GSFC type S-311-P-4 or equivalent. The pinout and harnessing of this connector shall be as shown in Table 4.3.1-1.

Table 4.3.1-1 Connector IPC-J1 Pinout

Pin	Signal	Harness
1	Heater 28V	#22 TSPN w/ 6
2	IDPU 28V	#22 TSPN w/ 7
3	Switched 28V	#22 TSPN w/ 8
4	Unused	
5	IPC Temp. Sensor	#24 TSPN w/ 9
6	Heater 28V Return	#22 TSPN w/ 1
7	IDPU 28V Return	#22 TSPN w/ 2
8	Switched 28V Return	#22 TSPN w/ 3
9	IPC Temp. Sensor Return	#24 TSPN w/ 5

TSPN is a twisted-shielded pair with shield not connected (at this end).
TSPS is a twisted shielded pair with shield terminated on the connector backshell.

4.3.2. Cryocooler Power Interface Connector, CPC-J1

The Cryocooler power interface to the spacecraft shall be on connector CPC-J1 on the CPC. The connector on the box shall be a 9-pin normal-density male D connector, GSFC type S-311-P-4 or equivalent. The pinout and harnessing of this connector shall be as shown in Table 4.3.2-1.

Table 4.3.2-1 Connector CPC-J1 Pinout

Pin	Signal	Harness
1	Cryocooler 28V A	#22 TSPN w/ 6
2	Cryocooler 28V B	#22 TSPN w/ 7
3	Unused	

4	CPC Temp. Sensor	#24 TSPN w/ 8
5	Spectrometer Temp. Sensor	#24 TSPN w/ 9
6	Cryocooler 28V Return A	#22 TSPN w/ 1
7	Cryocooler 28V Return B	#22 TSPN w/ 2
8	CPC Temp. Sensor Return	#24 TSPN w/ 4
9	Spectrometer Temp. Sensor Return	#24 TSPN w/ 5

TSPN is a twisted-shielded pair with shield not connected (at this end).
TSPS is a twisted shielded pair with shield terminated on the connector backshell.

4.3.3. Signal Interface Connector, IDPU-J1

The signal interface from the IDPU to the spacecraft shall be on connector IDPU-J1 on the IDPU VME Chassis Data Controller card. The connector on the box shall be a 37 pin normal density male D connector, GSFC type S-311-P-4 or equivalent. . The pinout and harnessing of this connector shall be as shown in Table 4.3.3-1.

Table 4.3.2-1 Connector IDPU-J1 Pinout

Pin	Signal	Harness
1	HRECDAT0+ (LSB)	#24 TSPS w/ 20
2	HRECDAT1+	#24 TSPS w/ 21
3	HRECDAT2+	#24 TSPS w/ 22
4	HRECDAT3+	#24 TSPS w/ 23
5	HRECDAT4+	#24 TSPS w/ 24
6	HRECDAT5+	#24 TSPS w/ 25
7	HRECDAT6+	#24 TSPS w/ 26
8	HRECDAT7+ (MSB)	#24 TSPS w/ 27
9	HRECCLK+	#24 TSPS w/ 28
10	HRECVALF+	#24 TSPS w/ 29
11	RRECRDYF+	#24 TSPN w/ 30
12	Command+	#24 TSPN w/ 31
13	Telemetry+	#24 TSPS w/ 32
14	CLK1HZ	#24 TSPN w/ 33
15	CLK1MHZ	#24 TSPN w/ 34
16	Reset	#24 TSPN w/ 17
17	Safe	#24 TSPN w/ 16
18	RAS Temp. Sensor	#24 TSPN w/ 36
19	IDPU Temp. Sensor	#24 TSPN w/ 37
20	HRECDAT0- (LSB)	#24 TSPS w/ 1
21	HRECDAT1-	#24 TSPS w/ 2
22	HRECDAT2-	#24 TSPS w/ 3
23	HRECDAT3-	#24 TSPS w/ 4
24	HRECDAT4-	#24 TSPS w/ 5

25	HRECDAT5-	#24 TSPS w/ 6
26	HRECDAT6-	#24 TSPS w/ 7
27	HRECDAT7- (MSB)	#24 TSPS w/ 8
28	HRECCLK-	#24 TSPS w/ 9
29	HRECVALF-	#24 TSPS w/ 10
30	RRECRDYF-	#24 TSPN w/ 11
31	Command-	#24 TSPN w/ 12
32	Telemetry-	#24 TSPS w/ 13
33	Signal Ground	#24 TSPN w/ 14
34	Signal Ground	#24 TSPN w/ 15
35	Unused	
36	RAS Temp. Sensor Return	#24 TSPN w/ 18
37	IDPU Temp. Sensor Ret.	#24 TSPN w/ 19

TSPN is a twisted-shielded pair with shield not connected (at this end).
TSPS is a twisted shielded pair with shield terminated on the connector backshell.

4.4. *Data Interchange Specification*

In this document, a Byte is an 8-bit quantity. Except where noted, multi-byte integers are transmitted Least Significant Byte first.

4.4.1. Command Interface

The spacecraft shall transmit to the instrument a fixed size "Command Block" of data once a second over the Command Interface. This transmission shall start between zero and 100ms after the 1Hz Clock pulse, and shall complete in no more than 500ms. The transmission shall include a spacecraft status segment, and a command segment. Figure 4.4.1-1 shows the command block format.

16 bytes	1024 bytes
Spacecraft Status Segment	Command Segment

Figure 4.4.1-1 – Command Block Format

4.4.1.1 Spacecraft Status Segment

The spacecraft status segment includes information on the status of the spacecraft bus, generated automatically on board by the spacecraft processor. The format is shown in Figure 4.4.1.1-1.

4 bytes	1 Byte	1 Byte	1 Byte	1 Byte	8 Bytes
Time	SSR	Power	TC	ACS	Spare

Figure 4.4.1.1-1 Spacecraft Status Segment Format

4.4.1.1.1 Time

The Time field is the spacecraft clock time (with 1-second resolution) at the time of the preceding 1Hz clock tick. The field is ordered least significant byte first.

4.4.1.1.2 SSR

SSR is the available capacity of the Solid State Recorder, coded as 0=empty, 255 = Full.

4.4.1.1.3 Power

Power indicates the state of the Instrument power service switches, as shown in Figure 4.4.1.1.3-1. A zero indicates the service is off, and a one indicates that it is on. SSRR is a special case: a 1 indicates the SSR Record is in progress, 0=not recording.

MSB							LSB
7	6	5	4	3	2	1	0
0	0	SSRR	SSR	Switched	Cryo	IDPU	Heater

Figure 4.4.1.1.3-1 Power Byte Format

4.4.1.1.4 TC

The TC byte indicates the status of the Telecommand system, as shown in Figure 4.4.1.1.4-1. The Xmit bit is one when the transmitter is powered on data, else zero. The SendSSR bit is one when SSR data is being transmitted, zero otherwise. The Lock bit is one if uplink is locked, else zero. The Send bit is one if the spacecraft computer is transmitting data, else zero.

MSB							LSB
7	6	5	4	3	2	1	0
0	0	0	0	Send	Lock	SendSSR	Xmit

Figure 4.4.1.1.4-1 TC Byte Format

4.4.1.1.5 ACS

The ACS byte indicates the status of the ACS system, as shown in Figure 4.4.1.1.5-1. The InSun bit is One when the spacecraft is in sunlight, else zero.

MSB							LSB
7	6	5	4	3	2	1	0
0	0	0	0	0	0	0	InSun

Figure 4.4.1.1.5-1 ACS Byte Format

4.4.1.2 Command Segment

This segment contains the instrument real-time command packets that were received by the spacecraft in the previous second and time-tagged commands that were scheduled for execution in the previous second. The spacecraft shall install instrument command packets into this buffer sequentially, with the unused portion at the end being zero filled. Commands shall be limited to no more than 256 bytes in length. In the unlikely event that the buffer gets full, the unsent commands are lost, and an error is reported in the spacecraft SOH. Only full commands shall be included in the Command Segment, no partial commands.

4.4.2. Low Speed Telemetry Interface

The instrument shall transmit to the spacecraft a fixed-size "Telemetry Block" of data once a second over the Low Speed Telemetry interface. This transmission shall start between zero and 100ms after the 1Hz Clock pulse, and shall complete in no more than 500ms. The transmission shall include a Sync marker, a SAS segment, an Instrument State of Health (SOH) segment, and a Diagnostic. Figure 4.4.2-1 shows the Telemetry Block format. The Sync Marker shall contain the fixed value F0A5 hexadecimal, (transferred least significant byte first).

2 bytes	16 bytes	350 bytes	1098 bytes
Sync Marker	SAS Segment	SOH Segment	Diagnostic Segment

Figure 4.4.2-1 – Telemetry Block Format

4.4.2.1 SAS Segment

The SAS shall provide the offset of the sun-center from the center-line of the Imager FOV eight times a second. The samples shall be taken each 125ms synchronous with the 1 Hz Clock tick. The time delay between the first sample in the segment and the 1Hz clock tick just before the Telemetry block is transferred to the spacecraft is 2.0 seconds. The offset shall be coded as X and Y offsets in Imager (=Spacecraft) coordinates at the time of the sample, 8 bits per value. The number shall be 2's complement (with the imager center-line at zero), with a conversion factor of 1/128 degrees per count (TBR-UCB-024). Code X=255, Y=255 indicates "No Solution" (sun out of FOV or other problem). The eight samples shall be included in the SAS segment as pairs (first X then Y), in the order they are collected.

4.4.2.2 SOH Segment

The SOH Segment data includes all instrument state of health, including temperatures, currents, voltages, instrument configuration, command verification, error reporting, and software status. The format of this data shall be described in Reference 7. SOH Segment data shall be copied into the spacecraft real-time SOH packets transmitted each second. The same SOH data shall be copied into the recorded spacecraft SOH packets as often as the spacecraft generates them.

4.4.2.3 Diagnostic Segment

Diagnostic packets (as described in Reference 7) will be generated by the IDPU in special circumstances, typically in response to a ground command. They shall be included in the

Diagnostic Segment of the Telemetry Block as a complete packet, sized to exactly fill one transfer frame. When no diagnostic packet has been requested, the Diagnostic Segment shall include a fill packet (ApID=2047), which shall be ignored by the spacecraft. Valid Diagnostic packets may be sent by the IDPU as often as once a second.

During ground contacts, valid Diagnostic Packets shall be transmitted as soon as received from the IDPU in the real-time SOH telemetry Virtual Channel, (in addition to the real time SOH), but shall not be recorded. When not in contact, valid diagnostic packets shall be recorded in the SOH recorder. The SOH recorder shall accommodate up to 1,000 Diagnostic packets. If more than that number of Diagnostic packets is sent by the IDPU between ground contacts, the extra packets will be discarded by the spacecraft.

4.4.3. High Speed Telemetry Interface

The high-speed telemetry interface shall be used to transfer CCSDS-formatted instrument telemetry packets as described in Reference 7. For synchronization purposes, each packet shall be preceded by a 4-byte Attached Synchronization Marker (ASM) containing the value:

ASM = 1ACFFC1D (Hexadecimal, transferred Most Significant Byte first)

The spacecraft shall record all transferred packets over the high-speed telemetry interface in the Solid State Recorder. Data shall be stored until transmitted to the ground in a First-In-First-Out scheme. It is the responsibility of the IDPU to avoid over-filling the memory (based on the SSR capacity information provided by the spacecraft in the Command Block). If data continues to be written to the memory by the IDPU after it is full, the oldest data will be over-written.

4.5. ***EMI/EMC Issues***

This section lists significant and unusual EMC concerns for the instrument.

4.5.1. Grounding

The instrument grounding plan is shown in Reference 5. All three box chassis (excluding the Particle Detector) are connected to spacecraft chassis ground. The Particle Detector box is electrically isolated from the bus and connected to signal ground.

4.5.2. IDPU VME Chassis

The VME chassis processes very sensitive signals, and should be kept away from noise sources. The box is fairly well sealed, but may be sensitive to high frequency magnetic coupling.

The signal harness from the VME chassis to the Spectrometer detectors carries very sensitive signals. This harness shall be well shielded, but should be kept away from noise sources and other harnesses.

4.5.3. IPC

The High Voltage Power Supplies in the IPC are moderately sensitive, and should be kept away from noise sources. The box is fairly well sealed, but may be sensitive to high-level high frequency magnetic coupling.

The high voltage harness from the IPC to the Spectrometer is also moderately sensitive, and should be routed with the VME Chassis to Spectrometer detector harness described in section 4.5.2.

4.5.4. CPC

The CPC will generate significant EMI at 60Hz due to magnetic elements. This noise is not easily shielded since it is transmitted magnetically. It needs to be kept physically far (>30cm) from any system which is processing sensitive high-impedance signals. That includes the IDPU VME chassis and IPC (due to the high voltage supplies). The RAS is expected to be less sensitive.

The power harness from the spacecraft to the CPC and from the CPC to the Spectrometer should be kept away from sensitive signals, (NOT routed with the IDPU to Spectrometer detector harness), and shall be separately shielded due to the large current modulation.