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Global Ultraviolet Imager
Critical Design Review



TM Processor, Spacecraft Interface, & I/O Boards (ECU Subsystem)

CDR

January 28, 1998

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Introduction

- Overview
- Board Designs
 - Functional requirements
 - Block diagram
 - Critical circuits and interfaces
 - PCB layouts
 - Power & Weight
 - Thermal issues



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Changes since PDR / Action Item Status

- Divided the spacecraft interface function and the I/O interface function into two circuit cards
- Board dimensions changed
 - ECU box design changed
 - No impact on electrical designs
- Action Item Status
 - No action items from PDR
 - TIM4-4 Action Item In Progress - Instantaneous current measurement on 1553 interface



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Board Descriptions

- **TM Processor**
 - Software platform that performs telemetry formatting, ground command decoding, and instrument control
- **Spacecraft Interface**
 - Translator between TM Processor and MIL-STD-1553B messages
- **I/O Board**
 - Electrical interfaces for both control and monitoring of SIS and FPE and Detector Processor interfaces



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Parts Issues

- **PEPL Status**
 - Component Reliability Section completed reviews of board parts lists.
 - SOR-3-97037 on 10/13/97 had clarification issues - closed
 - SOR-3-98002 on 1/15/98 approved all parts
 - Exception - more info. needed on Ferrite bead and wire for choke assy. used to isolate digital noise on boards. This is a non-critical item. Information will be provided.
- **TIMED Common Buy**
 - Request early April delivery



TM Processor PEPL

Item No.	Acron (A/C/D)	Part Type (e.g. diode)	Value (e.g. 4 u0)	Order Part Number	Package Type	DRAW YYY	QTY Unit	Manufacturer	Screening Level	QAD Number / MTL Spec
001	C	Capacitor		AL32M-CQ172B	QF1		2	Avco	HR	SSJB
002		Connector		RM4-2-ZD-1924900-01B	SM		1	Airborn		
003		ICED-Sub Connector		2ED2EM5000C	TH		1	Locktonix		
004		Bidirectional Buffer		HCS348M2R	P1		8	Harri	SM D	SPCR000001000C
005		HexShm to Trigger Buffer		CD40108EM2R	P1		1	Harri	SM D	SPCR000001000C
006		160M	8K8	HE1-0054RH-Q	DD		6	Harri	SM D	SPCR000001000C
007		SRAM	10K8	H005600R0C	P1		10	Honeywell	HR	SSJB
008		Differential Driver		HE92000RH-Q	P1		1	Harri	SM D	SPCR000001000C
009		Differential Receiver		HE92000RH-Q	P1		1	Harri	SM D	SPCR000001000C
010		Oscillator	SM R	MCM 3773-PM 2000	P1		1	QTech	HR	SSJB
011		Intel 80186 processor		80C186TQB	QF1		1	SHI	HR	SSJB
012		80186 ROM	128K8	280107R1FB	P1		2	SHI	HR	SSJB
013		Discrete Resistor	TED	RLR05C 10000 5 (X=toler)	TH		1	Dale		
014		Discrete Resistor	10K	M954200B100H	SM		40	Space of the Art	HR	M9542
015		Discrete Resistor	100	M954200B1000	SM		40	Space of the Art	HR	M9542
016		Diode		JANTXV154-50-1	TH		1	Microtech	II	JTCV
017		Single In-line Resistor Network	10K	M95401001000C	TH		5	Dale	HR	M9540100
018	C	Capacitor	01 uF	C120210405KAC	SM		24	Kemet	HR	M10123
019	C	Tantalum Capacitor	22 uF	M1300010-0-001	TH		1	Kemet	HR	M13000
020		Wire Wound Resistor	250 ohms	25-0000071	TH		1	Fair-Rite		



S/C Interface PEPL

Item No.	Altitude (A/C/D)	Part Type (e.g. diode)	Value (e.g. 4 uF)	Original Part Number	Package Type	DAVID WY	QTY Units	Manufacturer	Sealing Level	SAID Number / MIL Spec
001	C	Gate array		AL3204-CQ17B	QFP		1	Amel	HR	SSCB
002		Connector		RM-42-23D-1926900-918	SM		1	Aircom		
003		Summit 1553 Chip		VTM1553-UCXX	QFP		1	VIMCO	SMD	SPC6921130QVXX
004		Dual 1553 Transceiver Chip		VTM1553-UCXX	FP		1	VIMCO	SMD	SPC692230QVXX
005		10B D-Sub Connector		81107 50002	TH		2	Isokinetics		
006		180M	SE-S	ES1-00546H-Q	FP		2	Harri	SMD	SPC6923001VXX
007		Bidirectional Buffer		HCS2462M3R	FP		6	Harri	SMD	SPC6927701VXX
008		Tri-state Buffer		HCS2462M3R	FP		3	Harri	SMD	SPC6957011VXX
009		SRAM	NE-S	ES025-NEBC	FP		2	Honeywell	HR	SSCB
010		Oscillator	32MHz	MCME2741M 24000 475925	FP		1	QTech	HR	SSCB
011		1553 Transceiver	1:170	GL1553-46	FP		2	Technrol		
012		Diode		JANTXV1N4150-1	TH		1	Microb	II	JANTXV
013		Single In-line Resistor Network	10K	MES-41-0210007-C	TH		5	Dak	HR	MES-41-07
014		194 Distance Resistor	10K	MES-42-00201010	SM		11	Seas of the Arc	HR	MES-42
015	C	Capacitor	0.1uF	C130E1045XAC	SM		24	Kemet	HR	MC123
016	C	Tantalum Capacitor	2.2uF	MCP00300-30R	TH		1	Kemet	HR	MCP003
017		Wire Wound Resistor	250 ohms	24000001	TH		1	FairRite		



I/O Board PEPL

Item No	Access (A,C,D)	Part Type (e.g. diode)	Value (e.g. 4.0)	Original Part Number	Package Type	Display Y/N	QTY Unit	Manufacturer	Sourcing Level	QAD Number / MTL Spec
001	C	Resistor		AL30M-CQ17E	QF1		1	Analog	HR	SS3E
002		Connector		RM43-23D-1936800-01E	2M		1	Airborn		
003		8-Bit DAC		AD68HV22E	II1		2	Analog Device	HR	SS3E
004		10-Bit ADC		AD68HV22E	II1		1	Analog Device	HR	SS3E
005		108 D-Sub Connector		2MD90M9000	TH		1	Isokronix		
006		8-Bit Inverter (Buffer)		HCS2462M3R	F1		8	Harrit	2MD	SP026577901000
007		Tri-state Buffer		HCS2442M3R	F1		1	Harrit	2MD	SP026578001000
008		Hex-Shield Tri-state Buffer		CD401062M3R	F1		2	Harrit	2MD	SP026566001000
009		Hex Buffer		CD401062M3R	F1		4	Harrit	2MD	SP026566001000
010		Op-Amp		OP1A02EM	TH		2	Burr Brown	II	
011		Analog Mux		HD180	F1		1	Harrit	2MD	SP026566001000
012		Zener Diode		JTCV018750A	TH		27	Macrob	II	JTCV
013		Discrete Resistor	1K	M953462061800	2M		51	State of the Art	HR	M95346
014		Discrete Resistor	100	M953462061000E	2M		35	State of the Art	HR	M95346
015		Discrete Resistor	TED	ELR08CXXXX2(X=value)	TH		10	Dak		
016		Transistor		JTCV2F2222A	TH		2	Macrob	II	JTCV
017		Single In-Line Resistor Network	10K	M953462061000C	TH		5	Dak	HR	M95346
018	C	Capacitor	0.1uF	C1210E1045XAC	2M		24	Kemet	HR	MC123
019	C	Tantalum Capacitor	2.2uF	MLP001M0-202	TH		3	Kemet	HR	MLP003
020		Wire Wound Resistor	250m	24001001	TH		3	FairRite		
021	A	Voltage Reference		AD684HV22E	TH		1	Analog Device	HR	SS3E
022	A	Tantalum Capacitor	2.2uF	MLP001M0-204	TH		2	Kemet	HR	MLP003



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Actel Design Philosophy

- **Actel 1280 gatearrays used in board designs**
- **SOR-5-97064 SEU test data and design recommendations have been reviewed** (*Very low SEU rates but as a precaution: # S modules are used - implement voting*)
- **5 mils Ta spot shielding to provide better total dose protection**
- **TM Processor Board Actels**
 - **S and C modules**
 - **Triple redundant logic implemented on all latches and flip/flops (voting)**
- **S/C Interface Board Actels**
 - **C modules only (no S modules)**
 - **No voting implemented to aid in meeting circuit timing requirements**
- **I/O Board Actels**
 - **C modules only**
 - **Voting implemented**



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Telemetry Processor Board

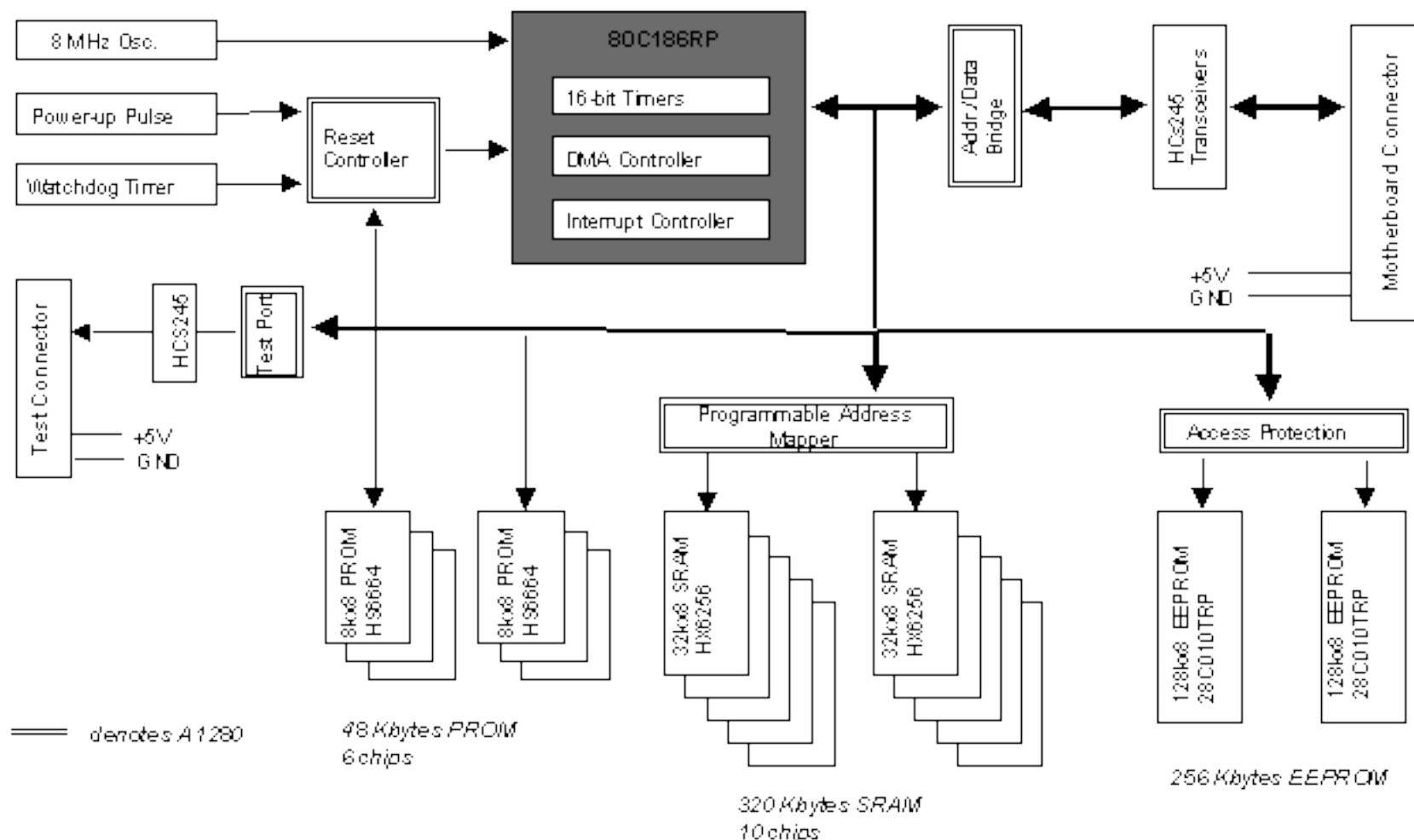


TM Processor Requirements

- **Software platform that performs telemetry formatting, ground command decoding, and instrument control**
- **Reference CDR section “Telemetry Processor Software” for detailed performance requirements**
- **Microprocessor - SEI 80C186RP**
 - Interrupt capability - generate processor interrupt every 1msec
 - 16-bit data transfers to interface with Det. Processor & 1553 data processor
 - Programmable timers with 16-bit resolution
- **Memory requirements**
 - RAM 138.8 Kbytes required ; 320 Kbytes available - Honeywell HX6256
 - PROM 16 Kbytes required ; 48 Kbytes available - Harris 6664
 - EEPROM 80 Kbytes required ; 256 Kbytes available - SEI / Hitachi 28C010
- **Make use of heritage**
 - LENA & CPT Data Processing Units recently delivered and launched use the same design.



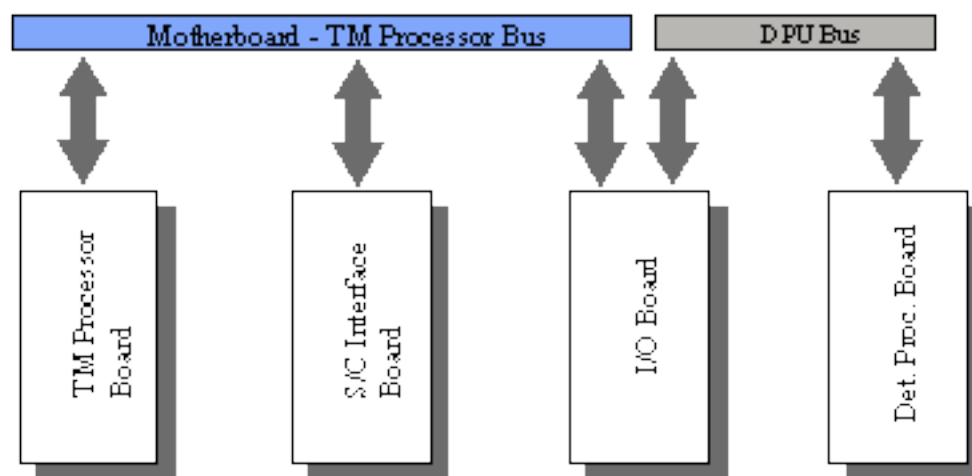
TM Processor Block Diagram





Motherboard Interface

- **TM Processor communicates with S/C interface board and I/O board over a common bus on the motherboard as shown below**
- **TM Processor controls data flow over the backplane**
 - Data transfers between boards are controlled by TMP software
 - Said another way - TMP is the sole bus master
- **Communication with Detector Processor is made through I/O board.**





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TM Processor - Fault Tolerance

- Watchdog timer safes the instrument when anomolous software operation is detected
- Ram fault tolerance
 - Address mapper allows for mapping around failed RAM locations
 - Bad RAM can be replaced by good RAM in address space
- EEPROM contents are secured using write protection
- Sufficient PROM space on board to store entire TMP program
 - Allows execution of Maintenance Mode entirely from PROM
 - Low power PROMs used to minimize power in this mode



GUVI Reset

- Telemetry Processor generates a reset signal for S/C Int. Board, I/O Board, and Det. Processor Board.
- Reset is activated under the following conditions
 - Power-up detection circuit holds reset signal low during voltage transient
 - Watchdog timer expires and generates reset pulse
 - Ground command intentionally expires watchdog timer to generate reset pulse
 - Detector processor reset signal generated by TMP software



Watchdog Timer Circuit

- External RC timing circuit generates 10ms clock as input to counter inside Actel
- Counter is disabled by power-on reset pulse
- Remains disabled in maintenance mode
- Counter enabled by software upon exiting maintenance mode
 - 16-bit key written as I/O instruction
 - Key: I/O Addr. = 0008 Hex Data = C3AA Hex
 - *Disable by writing same I/O address but with different data*
- Reset pulse to 80C186 is generated if watchdog is not refreshed within 6 seconds
- Refresh requires software write to I/O address with 16-bit key
 - Key: I/O Addr. = 0002 Hex Data = C3A5 Hex
 - Repeat < 6 seconds



EEPROM Access Circuit

- EEPROM protection circuit disallows access to stored data unless enabled by software
- Disabled at power-on or watchdog reset
- Requires a software I/O write with a 16-bit key to enable the EEPROM for subsequent memory accesses
 - Key: I/O Addr. = 0004 Hex Data = C3AF Hex
Disable by writing same I/O address but with different data
- Software usage
 - All accesses to EEPROM will be bounded by an enable and a disable operation



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Test Connector Definition

- **Test connector aids in software / hardware development**
 - **Programmable output port**
 - **Intended to help monitor CPU activity during code development**
- **25 pin female D-sub. 90° PCB connector**
- **Test connector to be capped for instrument delivery to TIMED**



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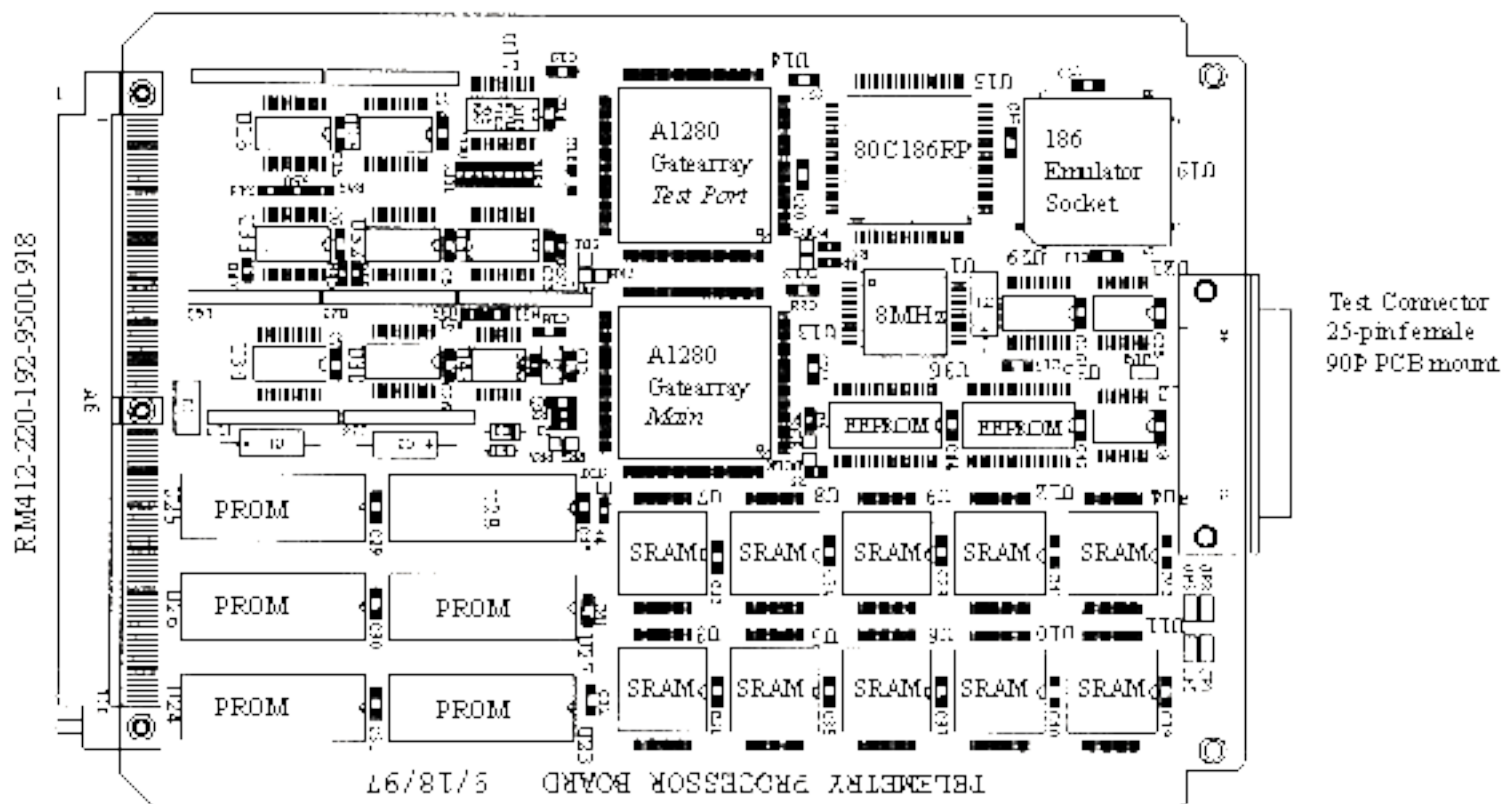
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TM Processor PCB Layout

Motherboard
Connector



No active components on back side



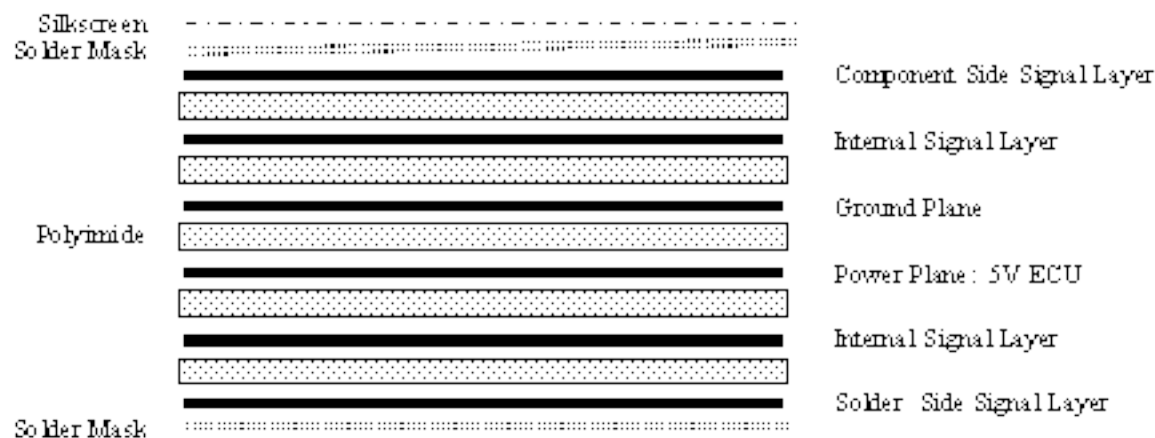
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TM Processor PCB Layout



- 6 layers
- 0.062 in. total thickness
- Polyimide material
- 1 oz. copper thickness
- Manufactured per MIL-P-55110 w/ test coupons



TM Processor - Power & Weight

- **Measured Average Power (+/- 20%)**
 - **+5V ECU @ 118.0 mA**
 - **+15V ECU @ 0 mA**
 - **-15V ECU @ 0 mA**
 - **Total average power => 0.590 W**
- **Estimated Maintenance Mode Power (+/- 20%)**
 - **+5V ECU @ 0.670 W**
- **Measured Weight (+/- 10%)**
 - **0.520 lbs**
- **No Thermal Issues**
 - **All parts operate within -55°C to 125°C**



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Spacecraft Interface Board



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S/C Interface Requirements

- Translator between TM Processor and MIL-STD-1553B messages
- Implement dual bus redundancy
- No hardware reset function on TIMED interface required
- Programmable remote terminal (RT) 1553 protocol architecture
- Local memory to buffer TM Processor telemetry data and incoming command data



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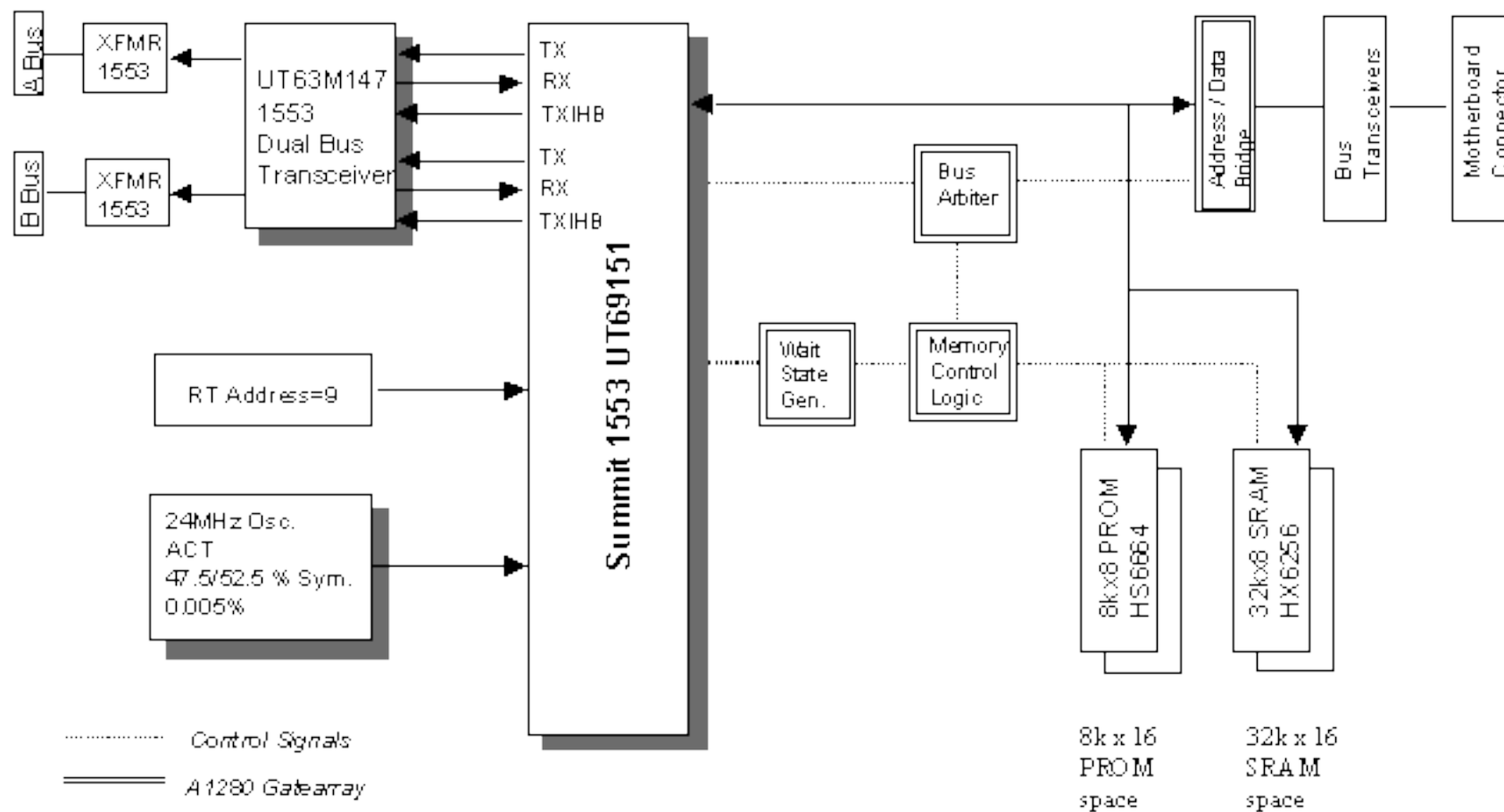


S/C Interface Board Implementation

- **Remote Terminal - UTMCM Summit 1553 Protocol chip**
 - Compliant to MIL-STD-1553B, Notice II
 - Descriptor Table configures each subaddress and mode code for unique processing
 - Subaddress double buffering of data
 - Internal illegalization RAM determines validity of command
- **Auto-initialization PROM stores initial Descriptor Table and chip register contents**
 - At boot up local PROM contents are transferred to SRAM automatically
 - 544 bytes required
- **Local SRAM stores PROM image and transmit/receive data buffers**
 - 12 Kbytes required
- **Actel 1280 gatearray controls interface to TM Processor**



S/C Interface Block Diagram





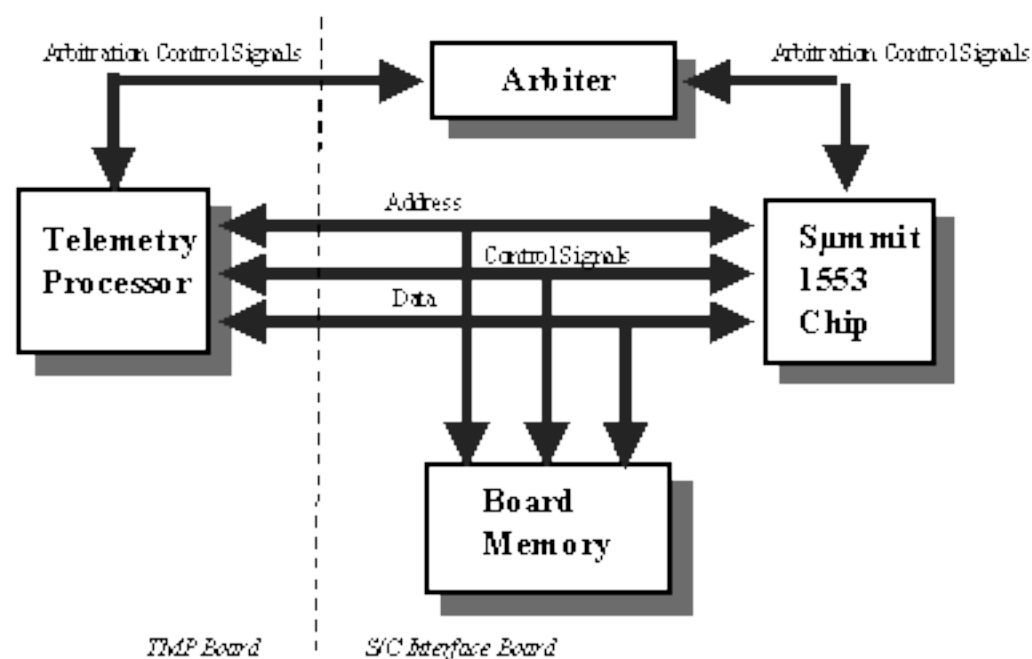
TM Processor / Summit 1553 Data Interface

• Local board memory

- Shared with TM processor
- Stores Summit configuration
- Stores transmit/receive data

• Arbiter

- Controls the sharing of board memory
- Grants access using first come first serve logic
- Summit chip allowed multiple word accesses (maximum 32 words) in one arbitration cycle
- TMP allowed only single word accesses to minimize the time Summit waits for access to board memory





Summit 1553 Data Access Timing

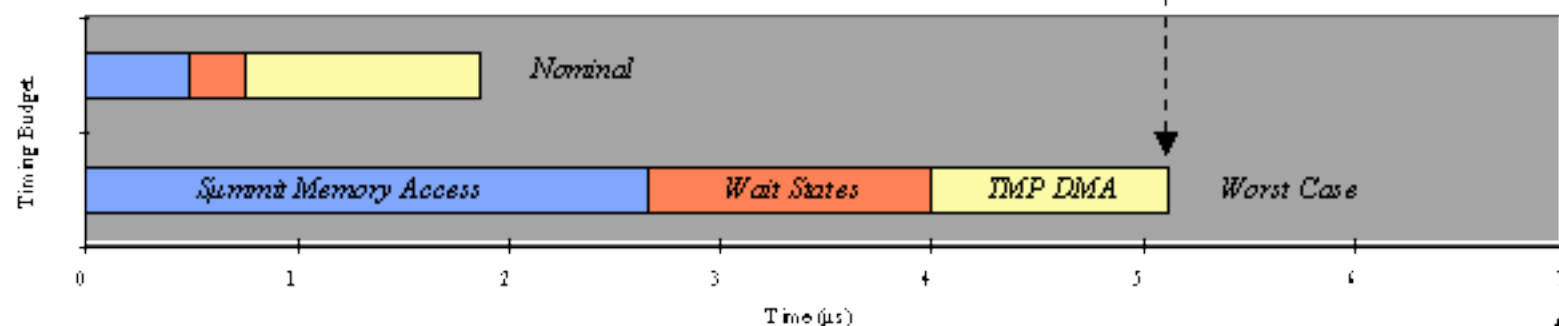
Simulation Results

Summit chip completes all board memory accesses within the specified 7 μ s thus keeping up with the transmission of data on the 1553 bus.

Results

Worst case time
to complete Summit memory
transfer = 5.2 μ s

Nominal & Worst Case Timing



Summit Memory Access - max. time it takes for Summit chip to finish transfer of data to/from memory.



Wait States - total time of all extra clock cycles added to each Summit memory transfer to meet memory chip timing margins.



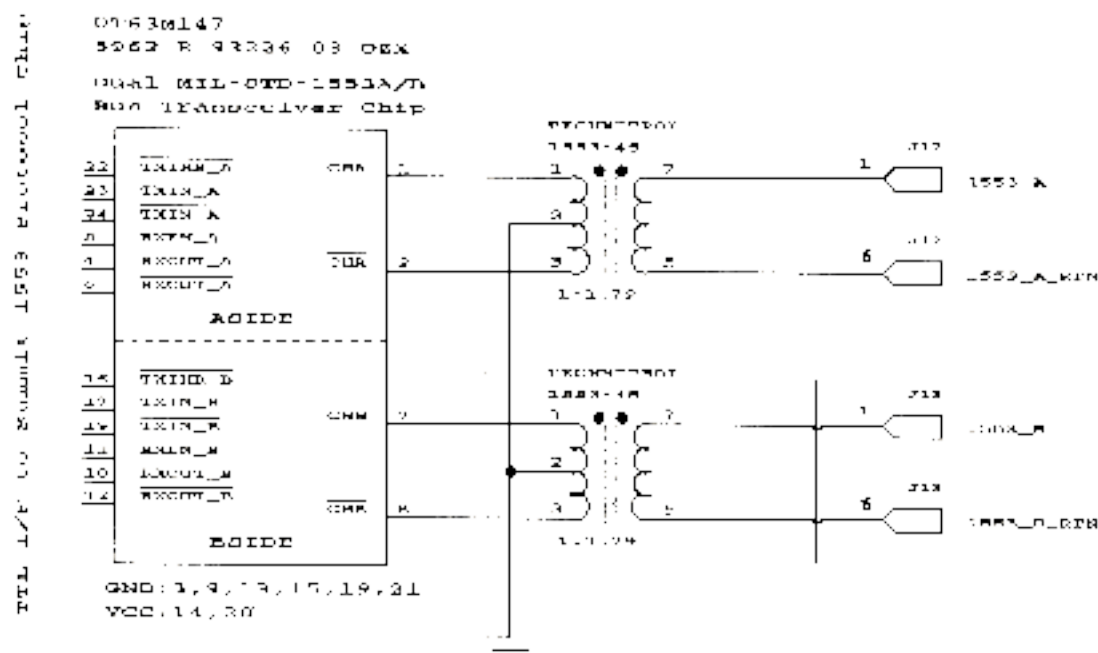
TMP DMA - max. time that Summit chip must wait for Telemetry Processor to finish board memory access so it can gain ownership of the data buffers.

Requirement

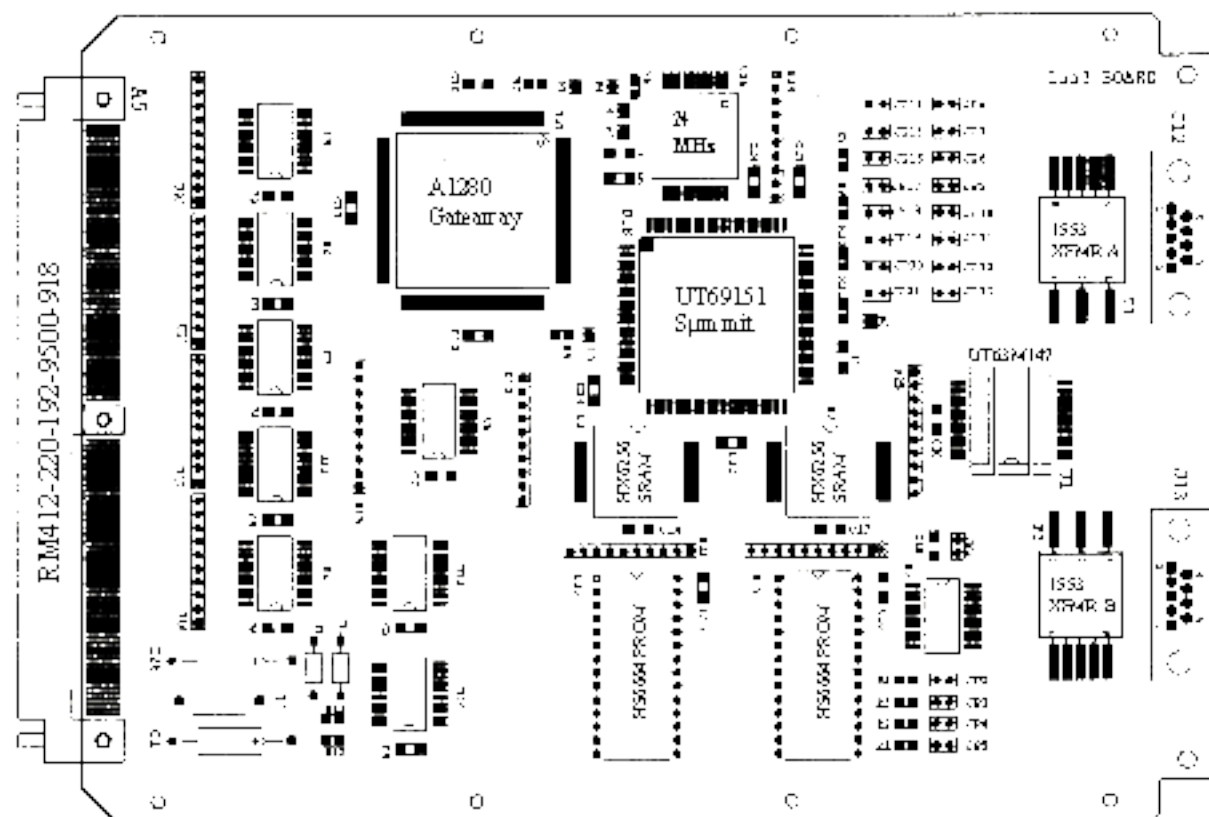
Memory acquisition time
limit for Summit chip to
meet 1553 transmission
timing
(DMA timeout limit)



1553 Bus Interface Circuit



- J12, J13 Interface Connectors
 - DEMM 9SD NMB K52
 - 9-pin D-sub. 90p PCB mount
- Long-stub transformer coupling configuration
 - Isolation transformer has 1:1.79 turns ratio
- Idle low - state of interface during quiet times

Motherboard
Connector

1553 Bus
Connectors
9-pin Female
90P PCB Mount

CTFwdoe CDR #29



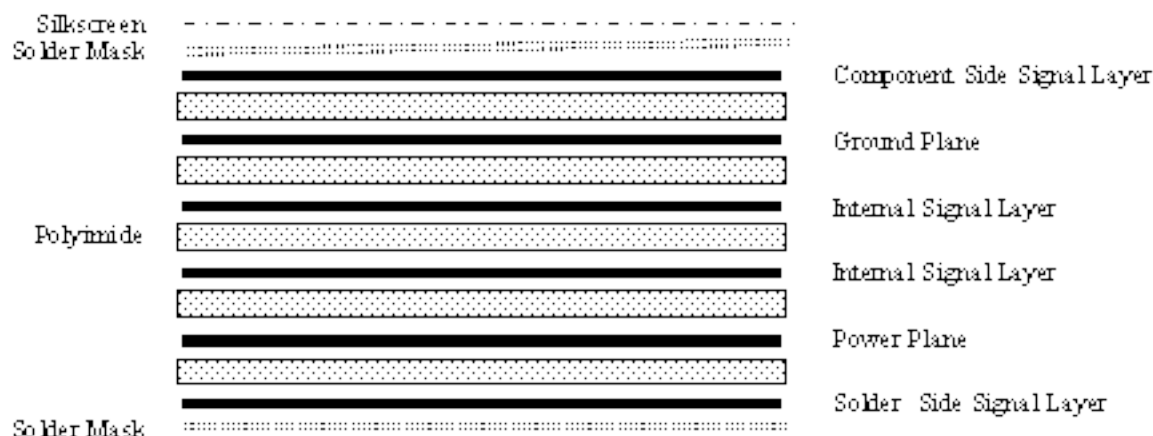
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S/C Interface PCB Layout



- 6 layers
- 0.062 in. total thickness
- Polyimide material
- 2 oz copper ground plane
- Manufactured per MIL-P-55110 w/ test coupons



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S/C Interface - Power & Weight

- Estimated Average Power (+/- 10%)
 - +5V ECU @ 207.3 mA
 - +15V ECU @ 0 mA
 - -15V ECU @ 0 mA
 - Total average power => 1.037 W
 - Estimated for 10% avg. duty cycle on 1553 bus.
- Measured Weight (+/- 10%)
 - 0.460 lbs



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Thermal Issues

- All electronic parts operate within -55°C to +125 °C
- Thermal analysis results
 - Hottest board temperature is UT63M147 transceiver chip running @ ~ +65°C
- UT63M147 thermal relief design
 - Thermal vias beneath component conduct heat to one 2oz. copper ground plane
 - Thermal conductive material (Delta Bond) to insure heat transfer between component and copper plane



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I/O Board



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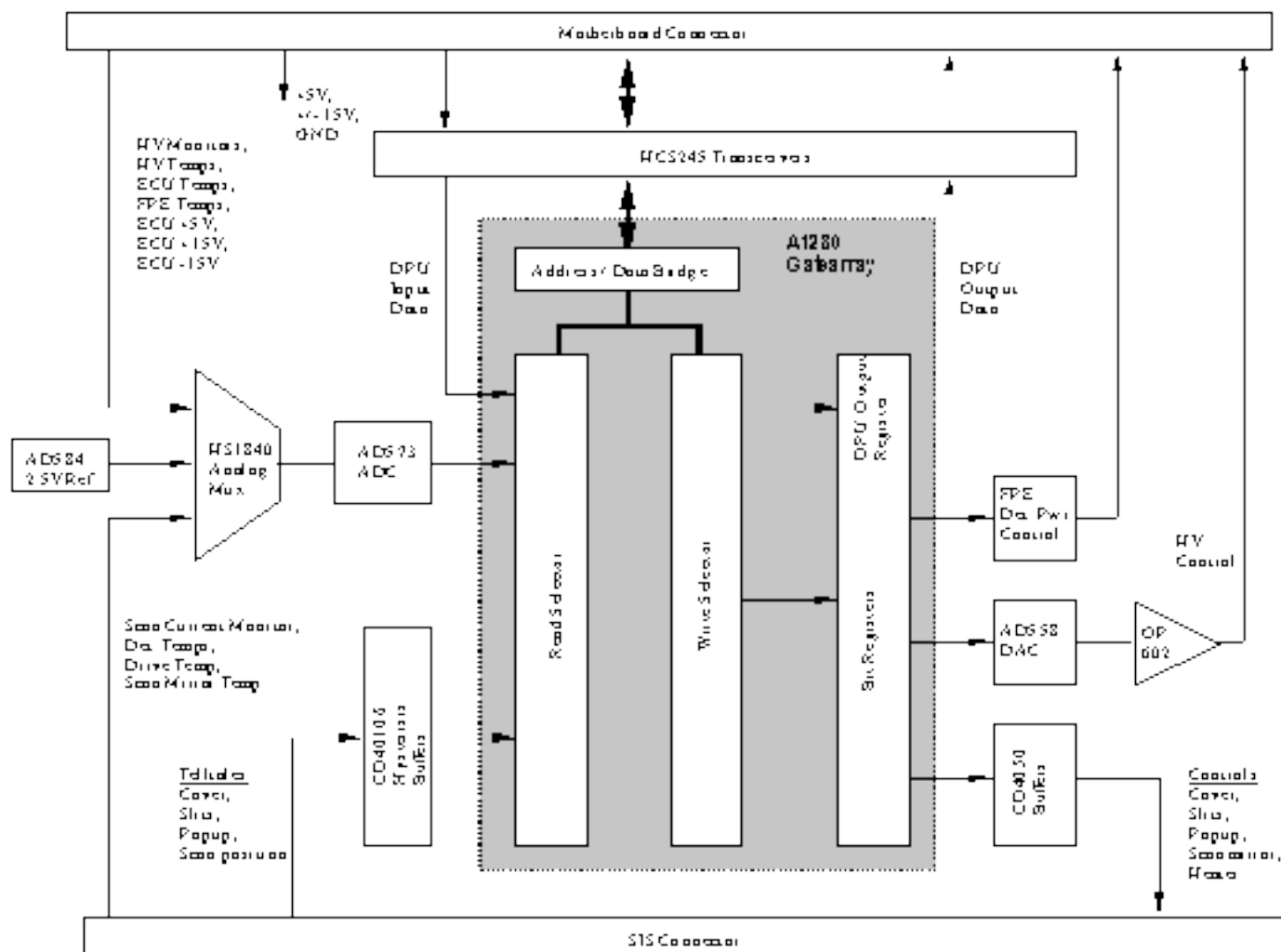


I/O Board Requirements

- Provide electrical interfaces for both control and monitoring of SIS, FPE, and interfaces to Detector Processor
- TM Processor Software controls interface functions
- Interface Functions
 - Control high voltage power supplies
 - Control cover, slits, pop-up mirror, scan motor, and heater
 - Monitors telltales for above control points
 - TM Processor to Detector Processor data interface
- Digitize analog housekeeping to 8-bits
 - Scan motor current, temperature monitors, high voltage power supply voltage and current monitors
 - ECU low voltages

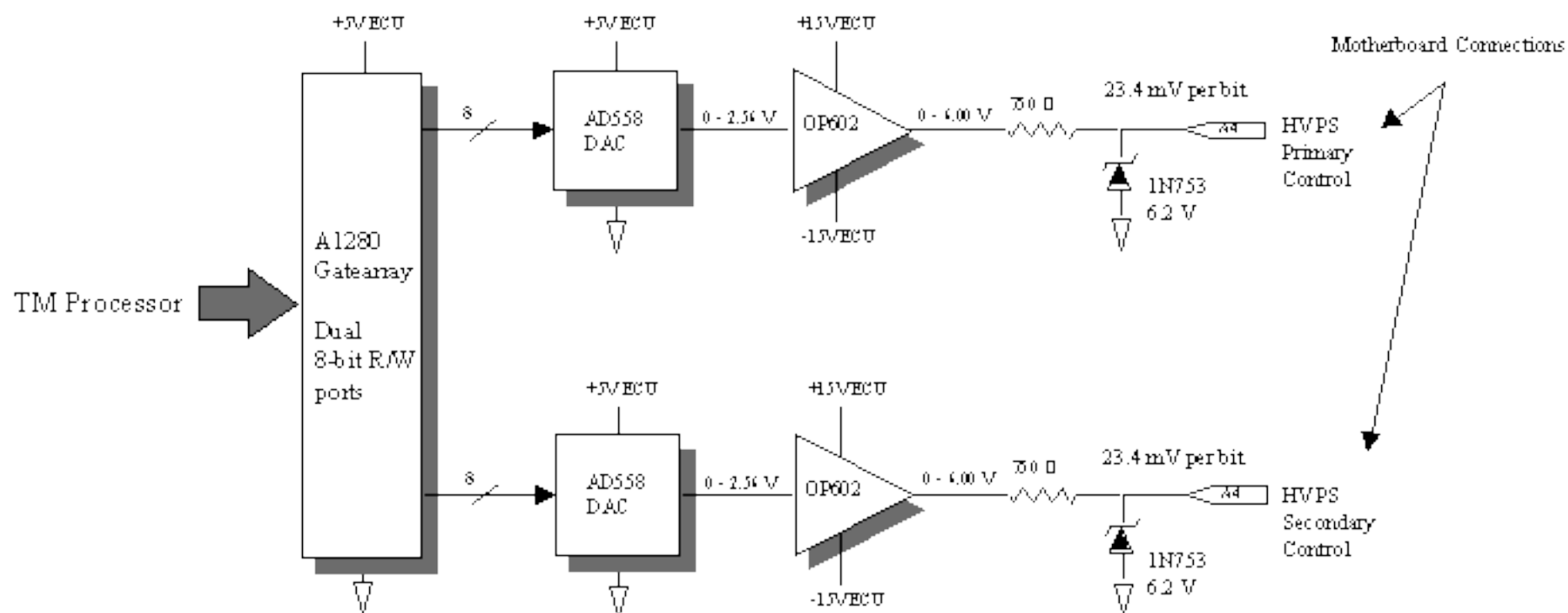


I/O Board Block Diagram



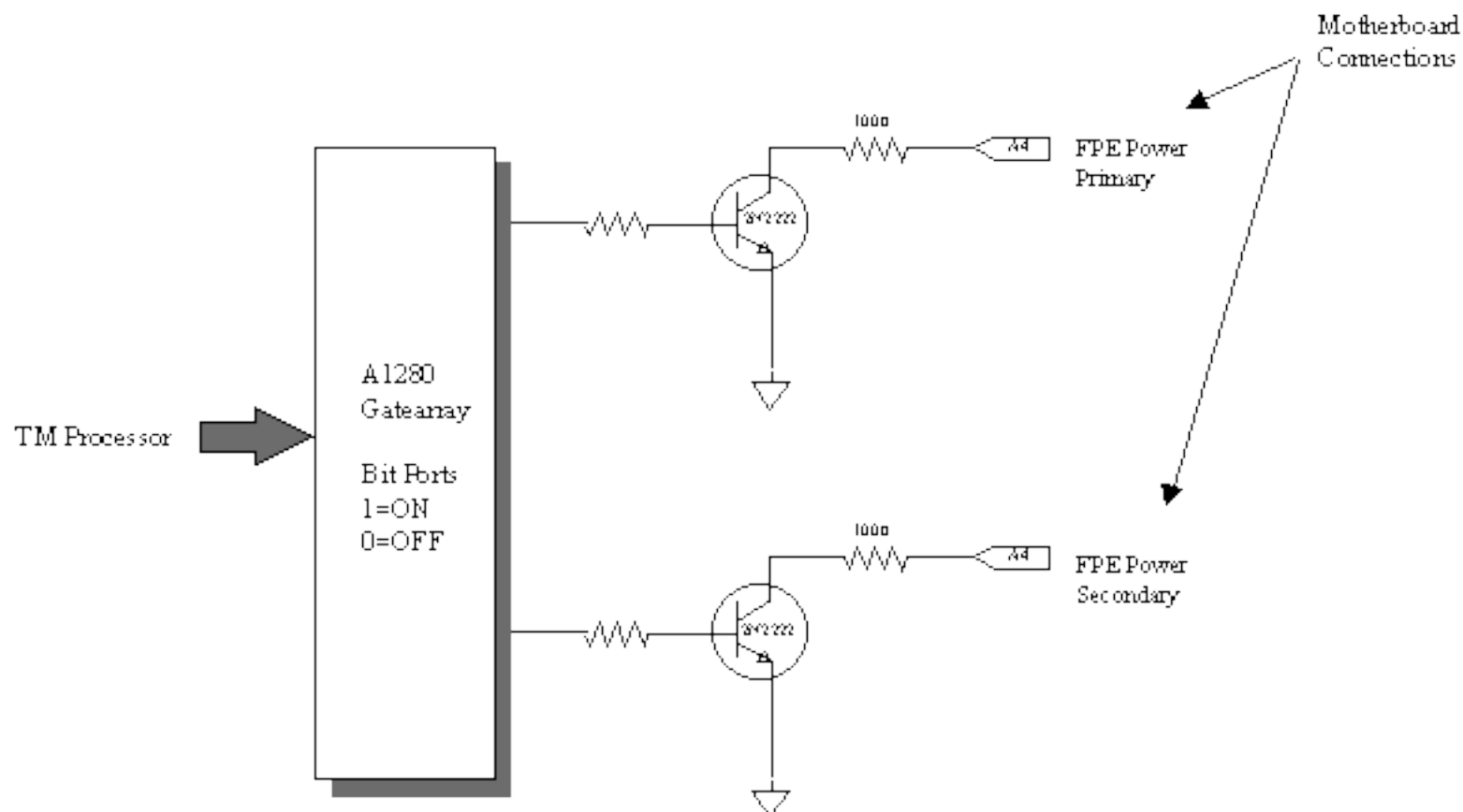


HV Control Interface



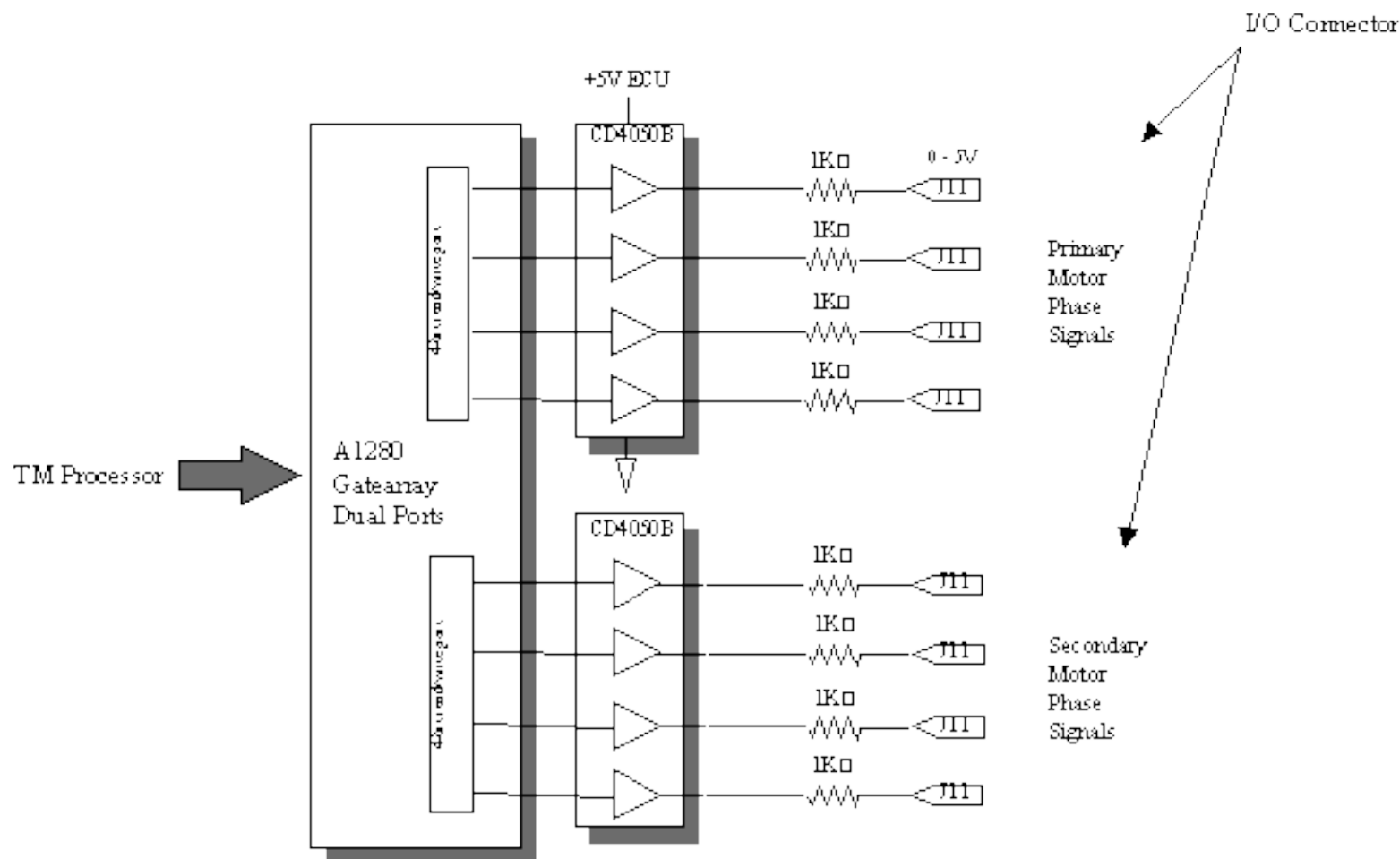


FPE Power Control Interface



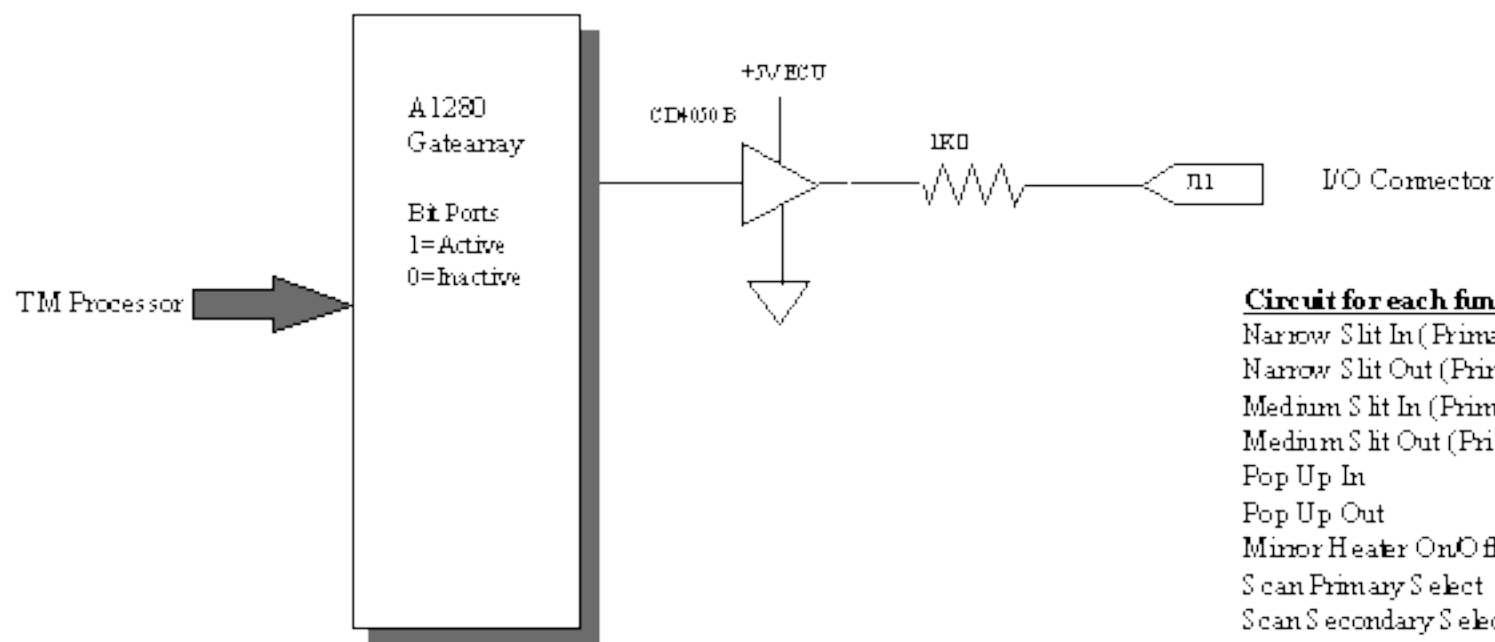


Scan Motor Phase Control Interface





SIS Control Interfaces





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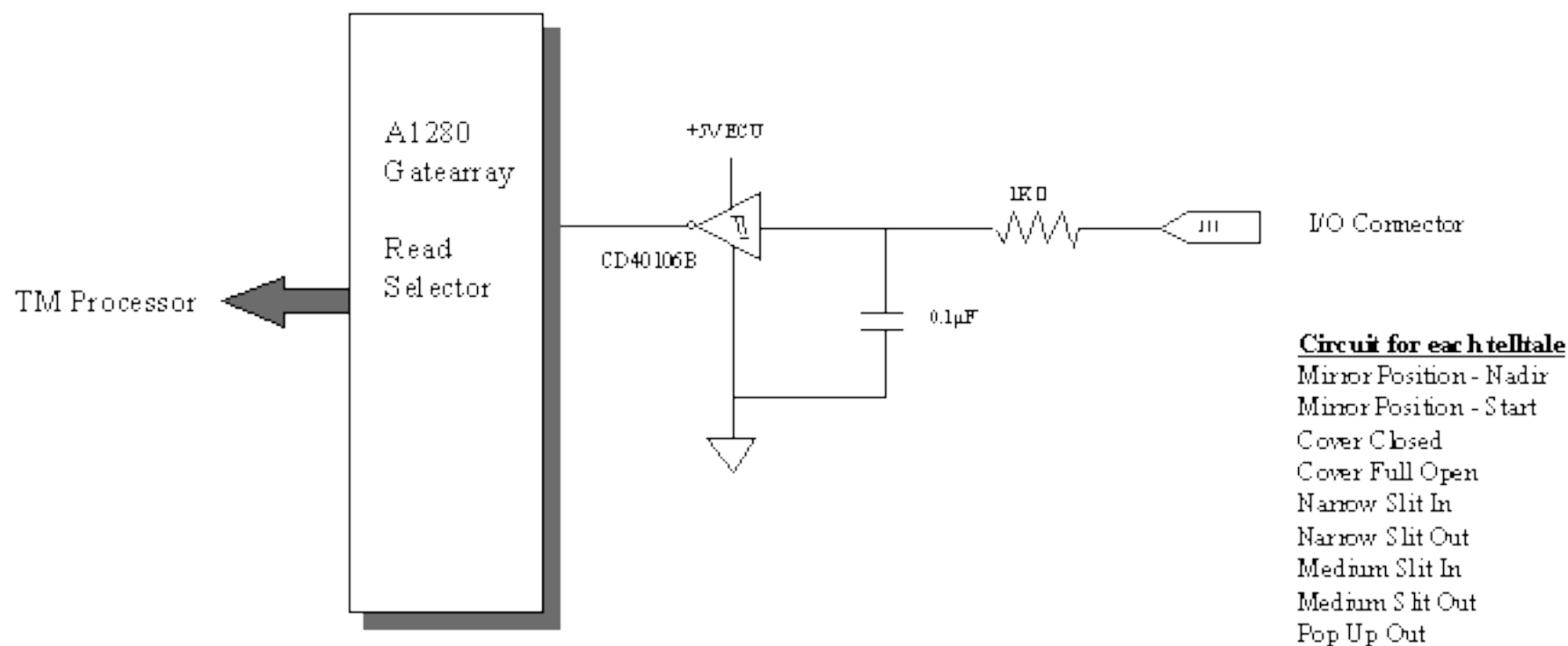
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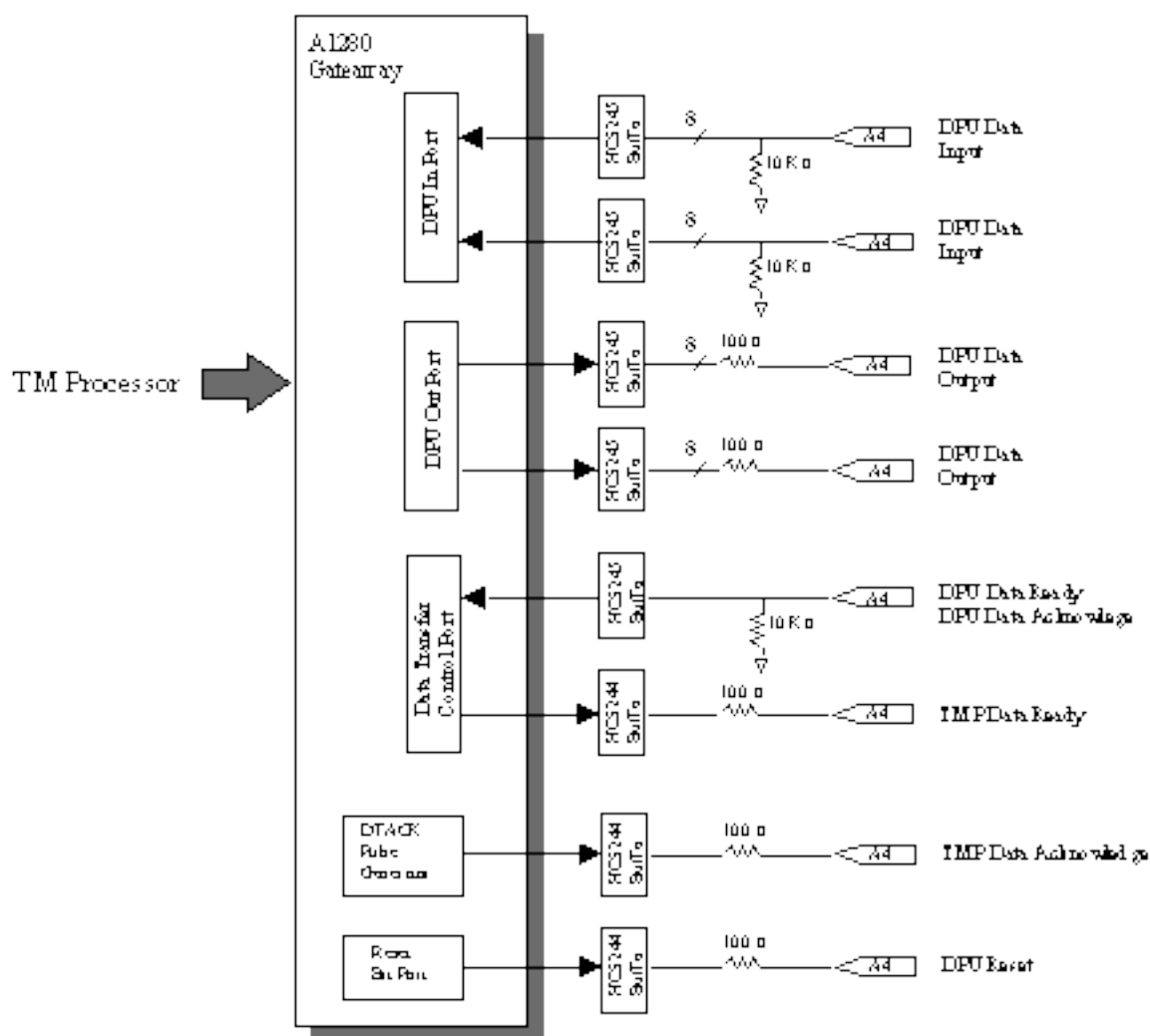
SIS Teletale Interfaces





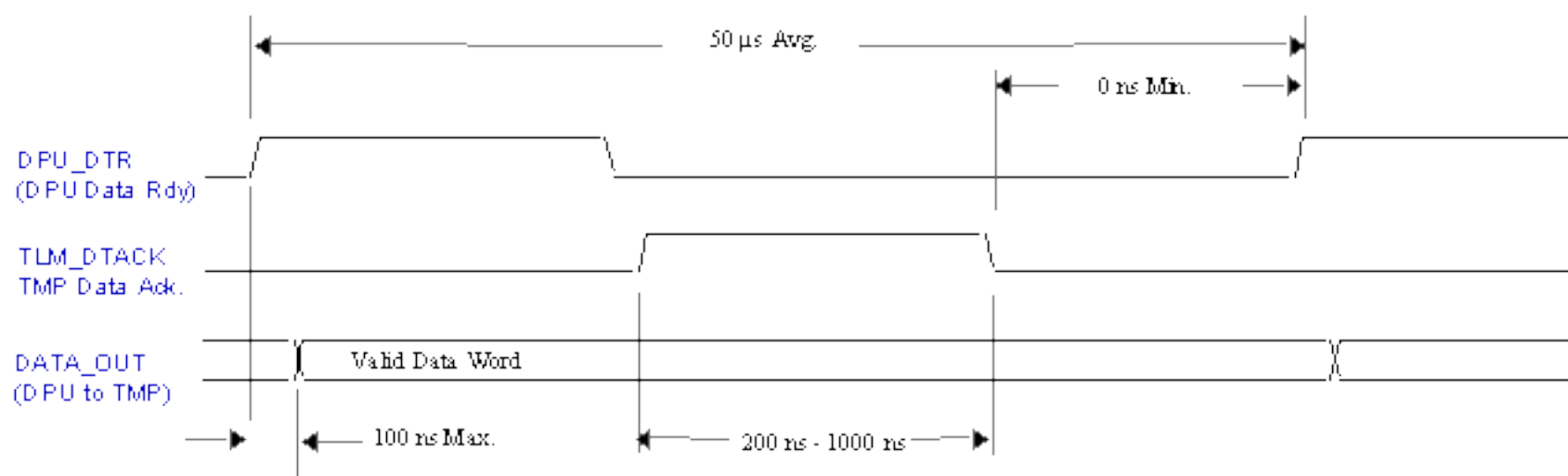
Detector Processor Interface (DPU Bus)

- Two 16-bit data ports
- Four handshaking signals
- DPU Reset signal
- TMP to DPU transfers
 - TMP Data Rdy indicates valid data present in DPU output port.
 - DPU Data Acknowledge indicates Det. Proc. has latched data.
- DPU to TMP transfers
 - DPU Data Rdy indicates valid data present on DPU data input lines.
 - TMP Data Acknowledge asserted by the A1280 when TM processor reads DPU input port. This indicates to the DPU that it can write new data to this port.





DPU to TMP Data Transfer Timing Spec.





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Analog Housekeeping

- Digitizes 16 analog input ports to 8-bits resolution
 - HS1840 analog multiplexor
 - AD573 ADC chip
 - 30 μ s conversion time
- On-board calibration reference
 - AD584 stable 2.5V reference monitor
- Analog Housekeeping Inputs
 - ECU +5V monitor
 - FPE/HV current monitors
 - HVPS voltage monitors
 - Scan motor current monitor
 - FPE temperature monitors
 - ECU housing temperature monitor
 - HVPS temperature monitors
 - SIS detector temperature monitor
 - Scan mirror temperature monitor
 - SIS drive board temperature monitor



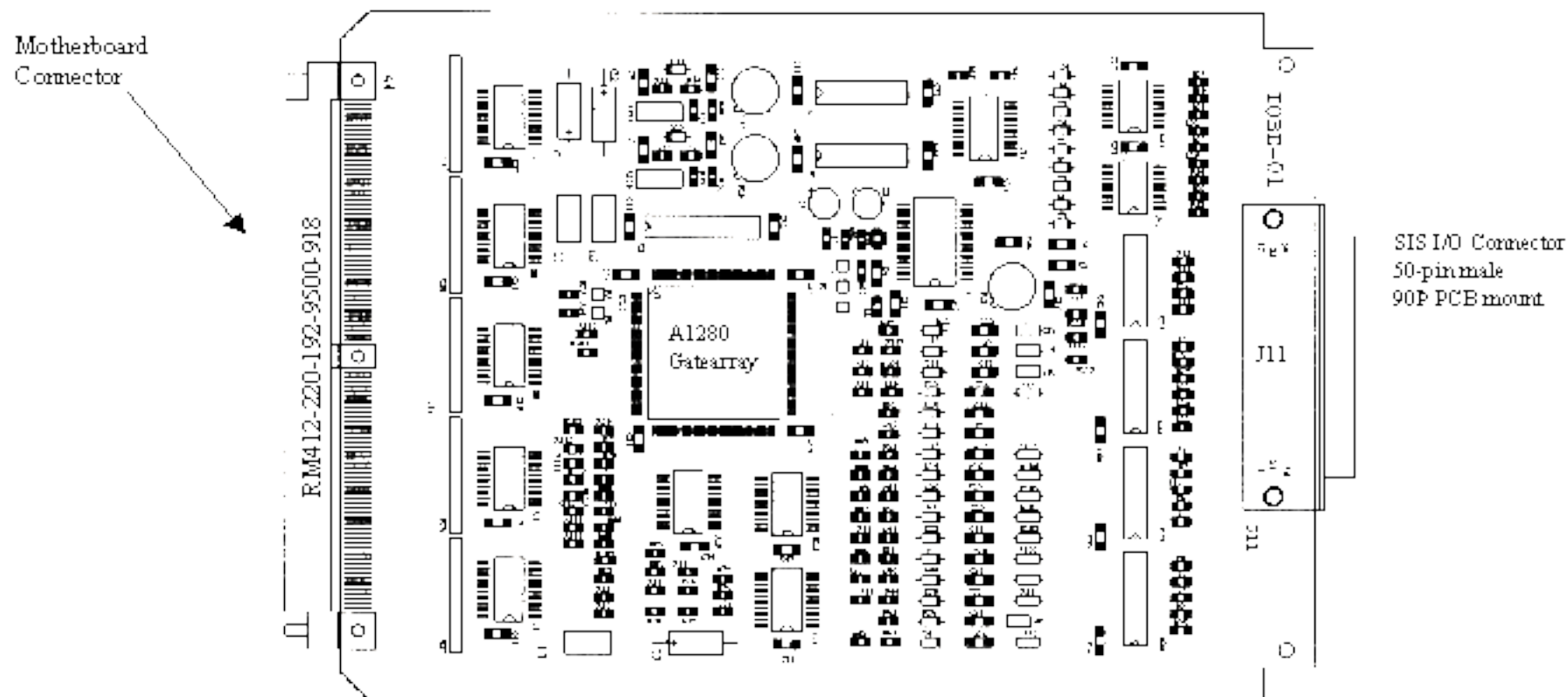
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I/O PCB Layout



No active components on back side



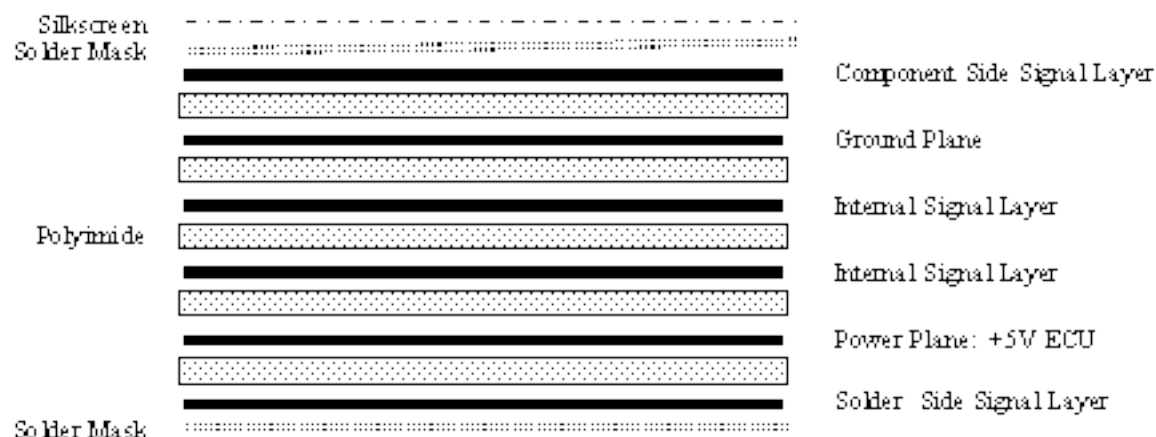
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I/O PCB Layout



- 6 layers ———
- 0.062 in. total thickness
- Polyimide material [dotted pattern]
- 1 oz. copper thickness
- Manufactured per MIL-P-55110 w/ test coupons



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I/O Board - Power & Weight

- Estimated Average Power (+/- 10%)
 - +5V ECU @ 119.3 mA
 - +15V ECU @ 9 mA
 - -15V ECU @ 23 mA
 - Total avg. power => 1.077 W
- Measured Weight (+/- 10%)
 - 0.420 lbs
- No Thermal Issues
 - All parts are operational within -55°C to 125°C



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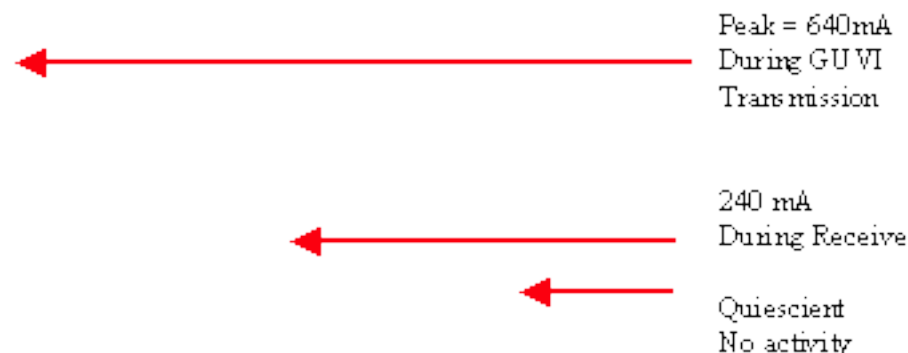
Instantaneous Power Measurement TIM4-4 Action Item

1553 Data

Transmitting

I_{VCC}

200 mA/div





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TM Processing Timing

- Calculation to show that the TM Processor / Summit 1553 circuitry will keep up with GUVI telemetry rate
 - TM rate = 8105 bits / sec.
 - $(8105 \text{ bits/sec}) \times (1 \text{ packet} / 2096 \text{ bits}) = 3.87 \text{ packets / sec}$
or about 250 ms per packet
 - Time to load a packet in TM buffers on S/C interface board
 $(3 \mu\text{s} / \text{word}) \times (131 \text{ words}) = 393 \mu\text{s}$
 - Time lost in sharing memory with Summit chip
 $(4 \mu\text{s} / 32 \text{ words}) \times (131 \text{ words}) = 16.4 \mu\text{s}$
 - Sum the two: $393 \mu\text{s} + 16.4 \mu\text{s} = 409 \mu\text{s}$ for hardware interface
 - Hardware impact is negligible
Software has nearly 250 ms to process each TM packet



GUVI

Global Ultraviolet Imager
Critical Design Review



Radiation Effects Summary

Actel 1280 (per SOR-5-97052)

2.82×10^{-13} SEU/device/day

Latchup immune

4.3 Krads

Intel 80C186RP (SEI)

1.0×10^{-4} SEU/device/day

Latchup immune

30 Krads

Honeywell HX6256 SRAM

1.0×10^{-10} SEU/device/day

Latchup immune

100 Krads

Harris HS1-6664 PROM

SEU immune

Latchup immune

100 Krads

Hitachi HN58C1001 EEPROM (SEI28C010TRP)

SEU immune

Latchup immune

100 Krads

UTMC Summit UT69151E

55×10^{-6} SEU/device/day

Latchup immune

100 Krads

UTMC UT63M147 Transceiver

SEU immune

Latchup immune

100 Krads

Harris CD4000 Series, HCS Series

SEU immune

Latchup immune

100 Krads

Analog Devices AD573 ADC, AD558 DAC

$SEU < 1.0 \times 10^{-4}$ SEU/device/day

Latchup immune

20 - 30 Krads

Analog Devices AD584 REF

SEU immune

Latchup immune

100 Krads