GUVI

Telemetry Processor Software

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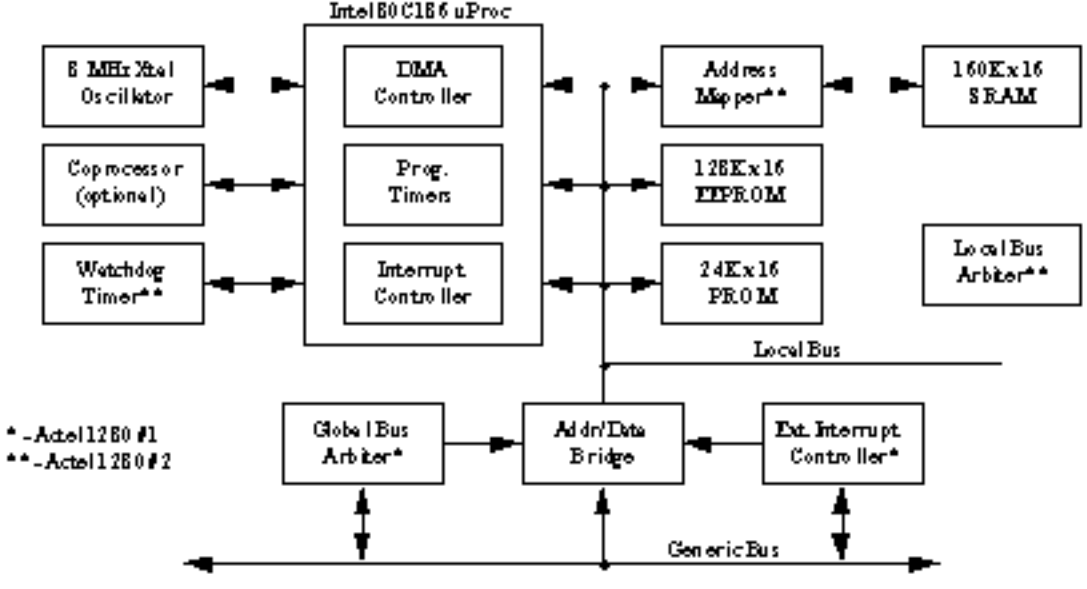
Telemetry Processor Software Requirements

- Mode Specific Operations
  - Scan mirror control and detector processor readout synchronization to support imaging and spectrograph modes
  - Pseudo-logarithmic data compression
  - Telemetry packet preparation
- General Operations
  - Receive and validate spacecraft commands for immediate, delayed, or absolute time execution
  - Provide analog monitor safeguarding for

Processor Board Overview



Maintenance Mode

- Maintenance mode is executed in response to watchdog timeout, power on event, or when a yaw maneuver is signaled by spacecraft broadcast message
- All maintenance mode software is executed from PROM
- Allows both Telemetry Processor and Detector Processor software to be modified
- Maintenance mode is exited in two ways

Imaging Mode

- Data collection operations
  - step scan motor
  - wait for stabilization
  - start integration
  - read and clear Detector Processor accumulators
- Data output and flyback operations
  - signal data buffer available
  - reverse step scan motor
- Reduced-Scan imaging mode can be commanded if sun would be in extended FOV
- Regardless of mode, the Telemetry Processor monitor detector output for sun illumination

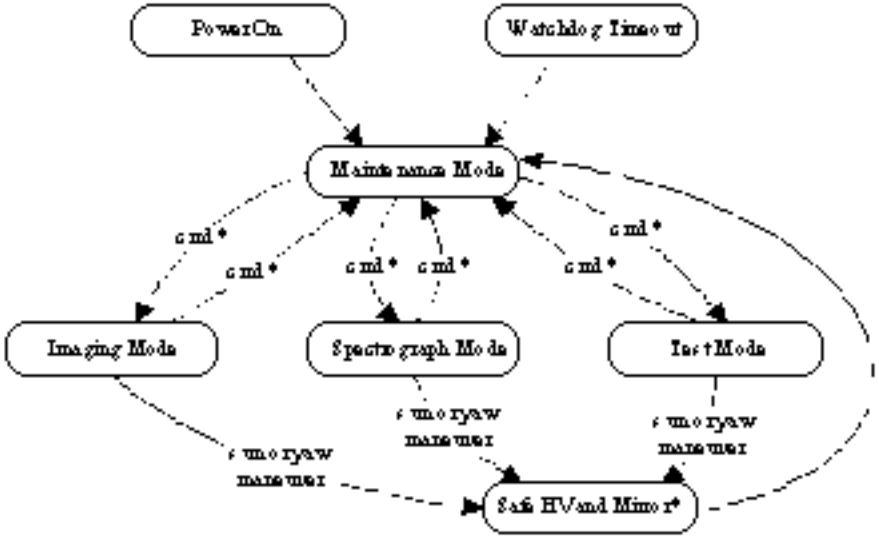
Spectrograph Mode / Test Mode

- Spectrograph Mode
  - Scan mirror set at a single angle for data collection
  - Integration period adjusted to provide overlapping "along track" pixels in telemetry stream
  - Sun illumination safing is active
- Test Mode
  - Detector Processor performs "pass-thru" operation, passes digitized W, S, I signals to

Special Operations

- High Voltage Activation
  - Command requests final value of high voltage setting
  - Telemetry processor raises high voltage according to maximum rate of change to avoid discharge
- Yaw Maneuver
  - Spacecraft broadcasts warning of upcoming yaw maneuver (60 second warning)
  - Telemetry processor safes high voltage and

Software Modes and Transitions



Software Overview

- Power On and Watchdog Timeout cause boot from PROM
- RAM contents are inspected using 16 bit CRC to ensure that "good" code RAM image is not overwritten
- Maintenance mode allows for code modification in RAM prior to start of execution
- One millisecond interrupt provides heartbeat for system
- Background task handles telemetry

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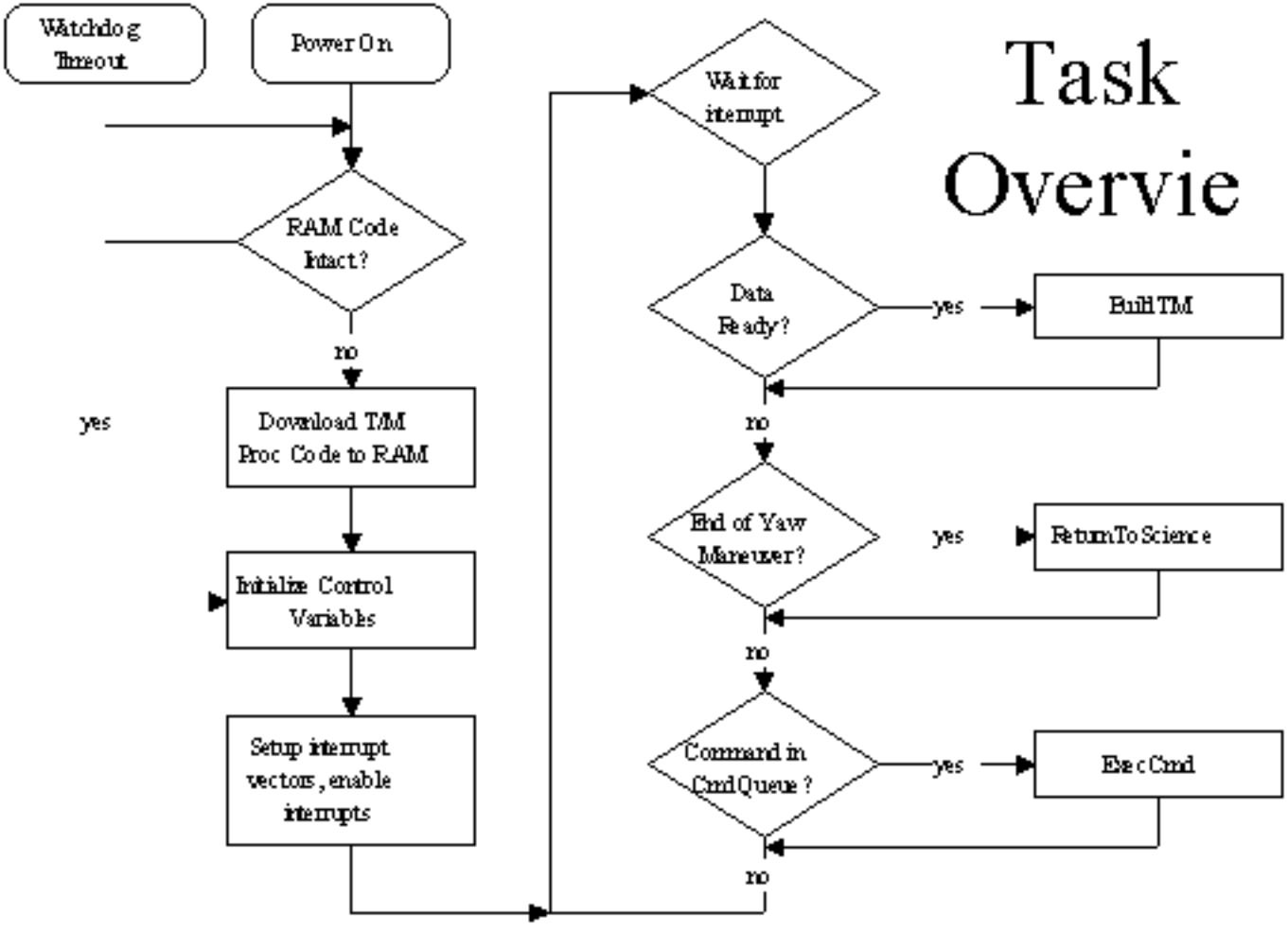


Background Task Detail

- Runs only when interrupt service routines are not
- Interrupt Service Routine (ISR) completion occurs when any system interrupt routine is exited
- "Data Ready" is set when mode specific raw data is available for telemetry packet creation
  - Set by Background Task when telemetry dump is requested, start address and length are furnished to BuildTM routine
  - Set by 1 msec ISR for Spectrograph Mode and Imaging Mode when raw data buffers have been filled. BuildTM routine knows operation to

Background Task - BuildTM

- Inputs:
  - Word PixelData [191 x 5 x 14]
  - Byte RateData [191 x 2 x 2] x 2 (double buffered)
  - Word EventData [137 x 3]
  - Countrates for sun sensing and inclusion in telemetry
  - Data Ready Flag
- Outputs:
  - CCSDS Packets into Telemetry Queue
  - If telemetry hardware (1553) idle, writes data to both hardware buffers (T1-T5 and

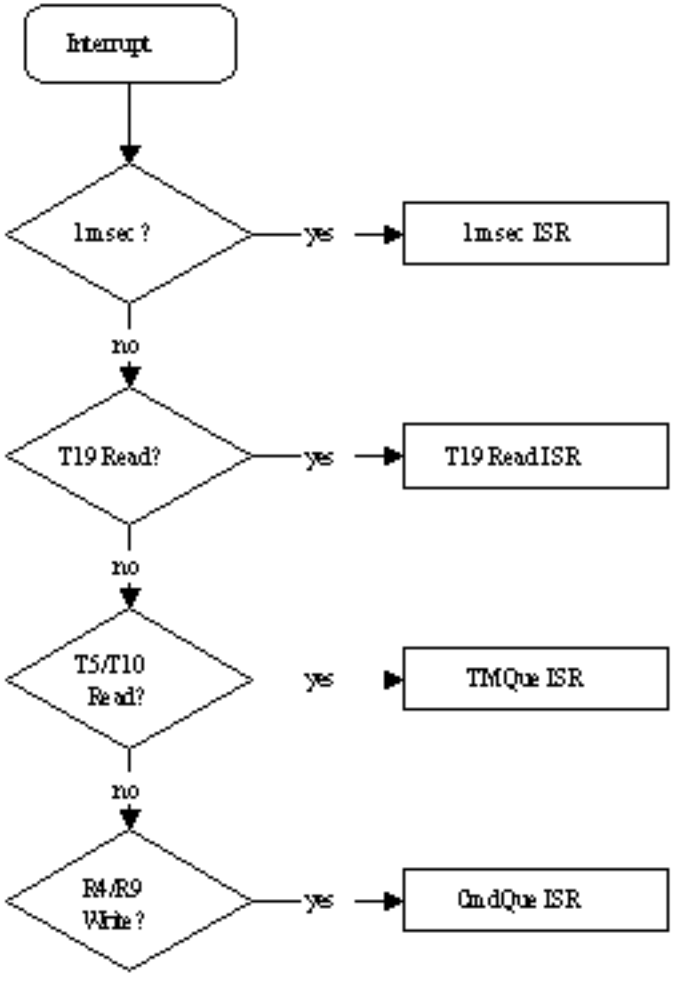
Interrupt Overview

1 msec interrupt used to derive integration times, scan periods, telemetry output rates, and HK data sampling

T19 interrupt is used as fiducial marker to synchronize GUVI to spacecraft time

T5/T10 interrupt(s) are used to thread telemetry packet outputs to the C&DH system

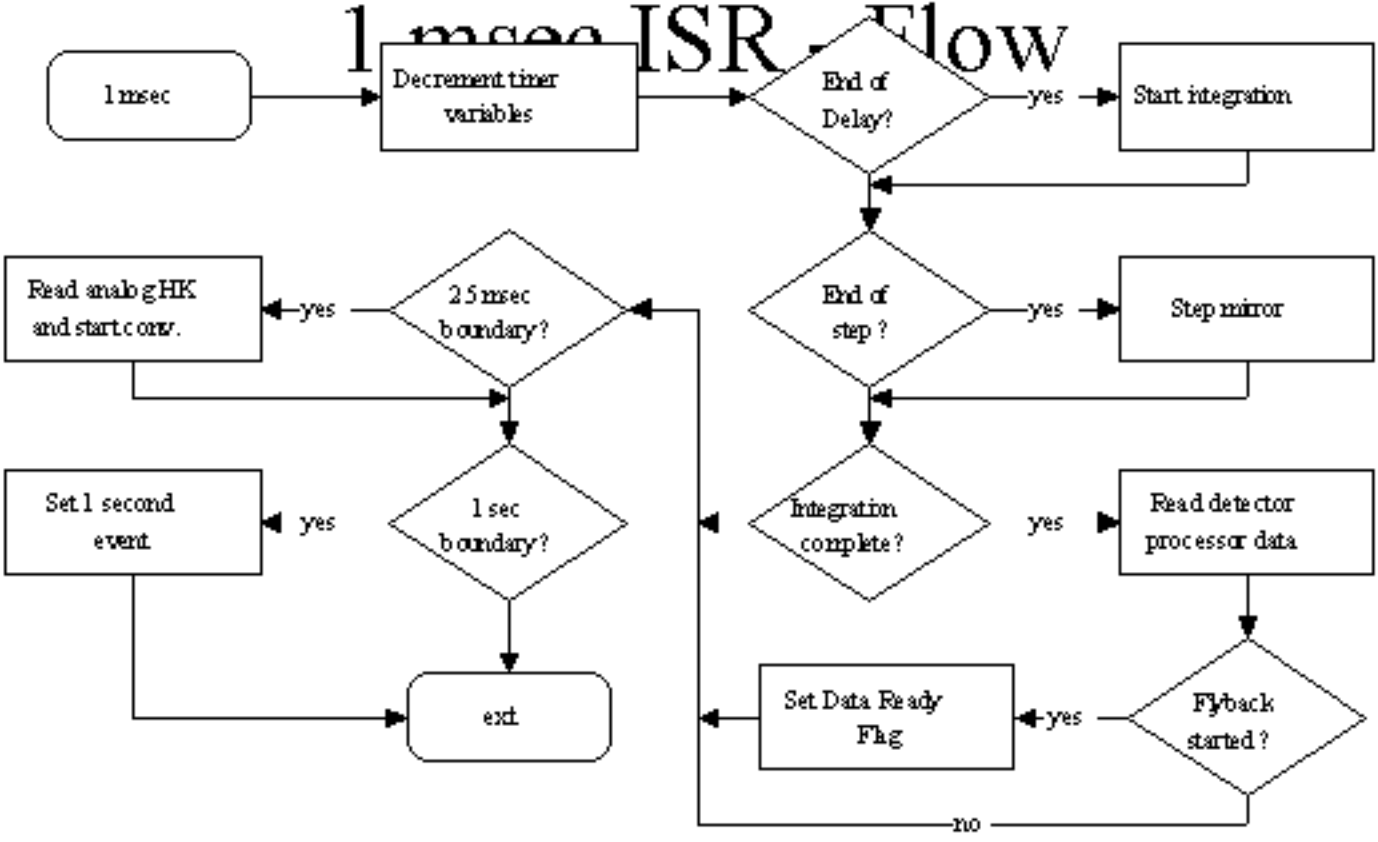
R4/R9 interrupt(s) are used to quickly remove C&DH commands to ensure no loss



1 msec ISR - Overview

- Is highest priority interrupt to ensure time critical operations take precedence
- Re-entrant to allow operations (detector processor read) to take longer than 1 msec
- Directly handles sun safing of high voltage and scan mirror following read of Detector Processor high rate data
- Provides 1 msec accuracy for system control; timers provided separately for:
  - pre-integration settling delay (17 msecs)
  - integration period (17 msecs, 68 msecs, or 3 seconds)

1 msec ISR - Flow



1 msec ISR - Detail

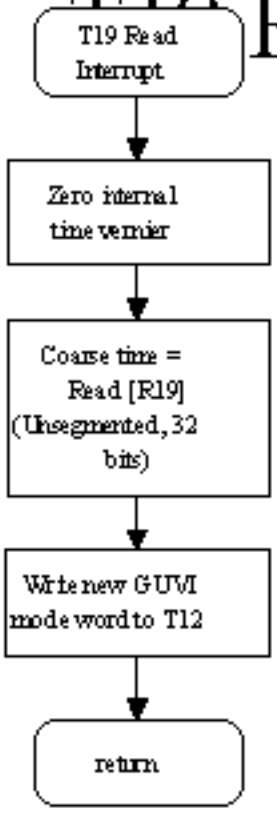
- Inputs
  - Timer variables for tracking mirror settling period, scan period, integration period, 25 msecs, 1 second and 3 seconds
  - Current system operating mode (maintenance, test, imaging, spectrograph)
- Outputs
  - Raw data matrices (PixelData, RateData, EventData)
  - Analog Housekeeping table
  - Flags indicating raw data ready and 1 second boundary
  - Potentially HV shutdown and scan mirror safing on sun event

T19 Read ISR - C&DH Time

- Time is broadcast by C&DH system during last 50 msecs of each second to R19 buffer
- Synchronization of time (fiducial)
  - caused by C&DH read of T19
  - accurate to 2 msecs according to GIIS
  - causes fine time vernier within the Telemetry Processor software to be zeroed
  - GUVI status word is rewritten in response to T19 interrupt

Fiducial

T19 Read ISR - Flow



Response to interrupt takes approximately 15 usecs

Vernier clear takes 4 usecs

1553 read takes 8 usecs

Write updated version of mode word takes 8 usecs

Reading after interrupt results in negligible additional latency of 35 usecs above C&DH uncertainty of 2 msecs

GUVI Mode Word

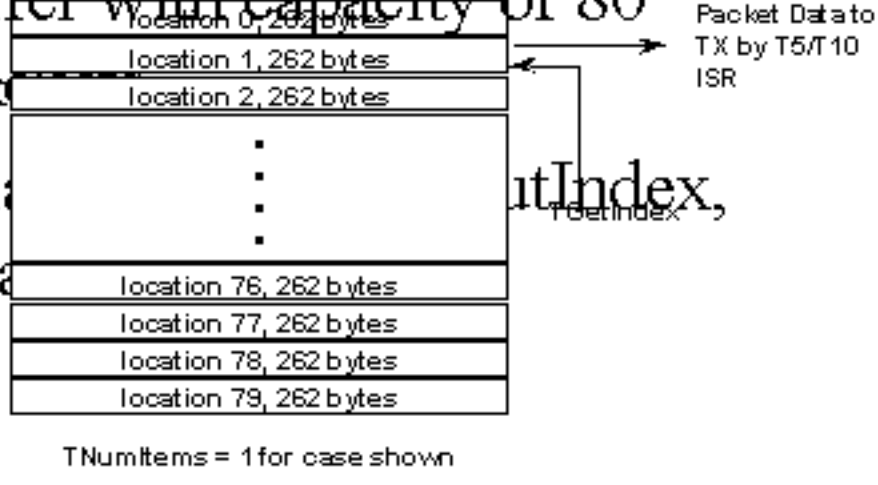
Start Bit	No. Bits	Parameter
63	2	GUVI Alive Indicator (Counts on second boundary)
61	2	Operating Mode
59	1	Primary Detector Power
58	1	Secondary Detector Power
57	1	Narrow Slit Position
56	1	Medium Slit Position
55	1	Pop-up Mirror Position
54	1	Scan Motor Drive
53	1	Cover Closed Indicator
52	1	Cover Full Open Indicator
51	1	Sun Sensor Trip
50	1	Yaw Maneuver Indicator
49	12	Mirror Position
37	3	Serial Command Counter
34	3	Serial Command Error Counter
31	8	Last Command Opcode
23	8	Fault Status Word
15	8	Detector High Voltage Monitor
7	8	SIS Temperature Monitor

T5/T10 (Telemetry) Read ISR - Telemetry Data

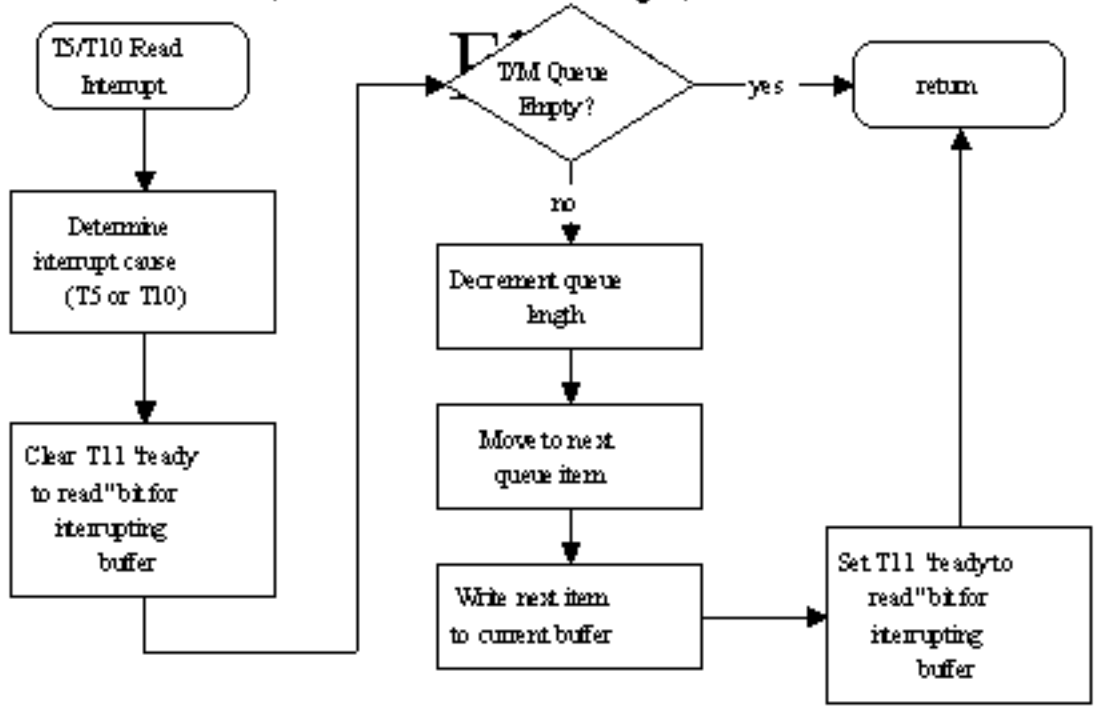
- GUVI Imaging Mode
  - Worst case telemetry needs for GUVI
  - Transmits 58 packets every 15 seconds
  - Requires 2 or fewer missed polls by C&DH per 15 second period if 4 polls per second is strictly enforced
- C&DH System polls GUVI telemetry buffer ready flags 4 times per second. Once per second C & DH will read both buffer 1 and buffer 2 contents
- Detection of C&DH read of T5 or T10 concludes previous packet read and signals to Telemetry Processor to queue another packet.

Telemetry Queue

- Written by BuildTM, read by T5/T10 ISR
- Circular buffer with capacity of 80 complete packets
- Control variables TPutIndex, TGetIndex, and TNumItems



T5/T10 (Telemetry) Read ISR -



Execution Time (when queue not empty = 1.36 msecs)

Telemetry Readout Timing

- Assumes C&DH reads packet in 2.1 msecs (262 bytes X 8 bits per byte @ 1 MHz rate) after detecting packet buffer ready during poll
- To ensure all GUVI packets are available when polled (250 msecs), tally all components of interpacket latency
  - C&DH read following successful poll: 2.1 msecs
  - T5/T10 ISR telemetry reload time: 1.36 msecs
  - Assume collision with detector processor readout: 0.74 msecs
  - Therefore latency of 4.2 msecs out of 250 msecs gives huge timing margin
- Telemetry bandwidth requirements:

Telemetry Packet Description

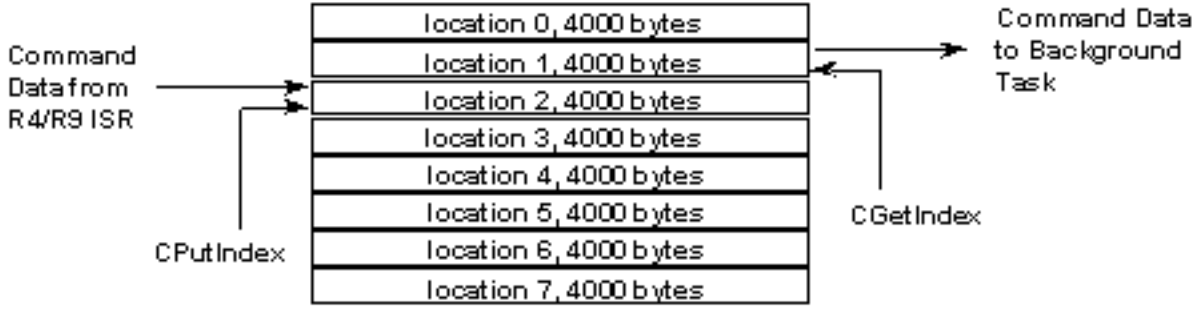
	Start Byte	End Byte	Bit	Contents
Primary	0	0	71	Version Number (=0)
	0	0	44	Type Indicator (=0)
	0	0	33	Secondary Header Flag (=1)
	0	1	100	ApID:
				480H=Housekeeping Data
				481H=Non-Housekeeping Data
	2	2	76	Group Flags:
				01= First packet of message 00= Continuation of message
				10=Last packet of message
	2	3	130	Source Sequence Count (incremented for each packet output)
	4	5	150	Packet Length (=255)
Secondary	6	9	310	CCSDS Unsegmented Time Code
	10	11	150	Time Vernier (fine time, res=15 microseconds)
	12	12	76	Message Type:
				00=Imaging
				01=Spectrograph
				10=Test 11= Maintenance
	12	12	50	Subpacket Number
	13	13	70	Checksum - computed as the bytewise XOR of packet
				bytes in secondary header and source data
Source Data	14	261	all	Source Data Field (248 bytes)

R4/R9 (Command) Write ISR

- R4/R9 interrupt results from C&DH write of GUVI command to 1553 buffer
- C&DH can send up to 8 command packets per second; one packet can be sent per minor frame
- C&DH will potentially overwrite (reuse) the command buffer after 0.25 seconds during high GUVI command activity
- Input commands are supported by a command queue to ensure that

Command Queue

- Written by R4/R9 (Command) Write ISR, read by Background Task
- Circular buffer has capacity of 8 complete command packets (up to 4000 bytes per packet)
- Control variables include: CPutIndex, CGetIndex, and CNumItems



CNumItems = 1 for case shown

Command Overview

- GUVI will utilize telecommand packets with lengths from 256 bytes to 4000 bytes
- A 16-bit checksum (algorithm TBD) is included within each telecommand packet and is checked prior to command execution
- Command macros including timetagged commands and delayed commands will be built into single telecommand packets. Requires whole macro length < 4000 bytes

Command Packet Overview

Primary Header				
	Start Byte	End Byte	Bits	Contents
	0	0	7:5	Version Number (=0)
	0	0	4:4	Type Indicator (=1)
	0	0	3:3	Secondary Header Flag (=0)
	0	1	10:0	ApID (=480H)
	2	2	7:6	Group Flags (??)
	2	3	13:0	Source Sequence Count (incremented for each command packet)
	4	5	15:0	Packet Length (minimum = 249, maximum = 3993)
Source Data				
	6	7	15:0	Packet checksum
	8	3999 max	all	GUVI Timetagged Commands (Command Blocks)

Command Block Detail

Position	Size (bytes)	Contents
1	1	Timetag lenght to follow (0 to 4)
		=0 implies immediate execution
		=1 indicates byte which follows is 8 bit second delay from previous command
		=2 indicates 2 bytes which follow are 16 bit second delay from previous command =3 indicates 3 bytes which follow are 24 bit second delay from previous command
		=4 indicates CCSDS time which follows is desired absolute execution time
2	0 - 4	Timetag (see above, most significant byte first)
3	1	Command opcode
4	0 - 3990	Command arguments

Memory Usage versus Allocation

- RAM Requirement: 129.8K bytes
  - Queues: 52.5K bytes
  - Data Bufs: 28.3K bytes
  - Lookup Tables: 32K bytes
  - T/M Proc. Code: 16K bytes
  - Variables: 1K bytes
- RAM Available: 320K bytes
- EEPROM Req: 80K bytes
  - Det. Proc. Code: 32K
- EEPROM Available: 256K bytes

Software Development Tools

- Software Development
  - Watcom C++, 80C186 Assembler, Profiler, Debugger
- In-circuit Emulator
  - Applied Microsystems' CodeTAP-XA emulator
  - Paradigm CT/XA-Debug real-time debug kernel

Configuration Control (CC)

- Prior to CC, documentation regarding software configuration will be maintained in development notebooks
- Telemetry Processor Software will undergo configuration control following instrument-level integration at APL
- Following activation of CC, software changes will require approval of the Principal Investigator (or his designee) and the GLAST System Engineer

Verification and Validation

- Real-time software will be single-stepped to validate functionality under all boundary conditions
- Test steps and results will be maintained in development notebooks
- Ground Support Equipment (GSE) simulators will be provided to simulate the detector processor, SIS electronics, FPE electronics, and spacecraft functions. The GSE will serve as the testbed for the telemetry processor

Issues

- Firm definition of telecommand packet headers (like GIIS Table 3.3-1 for telemetry) needed to ensure compatibility between GUVI and C & DH