

Software Uses of Apollo Channel Bits

Interest has recently been expressed in the uses which are made by the Apollo software (S2 mission) of the various channel bits, with the objective of identifying bits that make the software unduly sensitive to hardware malfunctions. As a result, the following list of areas where the software checks individual channel bits has been assembled (also included are points where output channel bits are sensed). Channels 11-14 and 30-33, of course, are sensed for telemetry purposes, but this use is excluded from the lists below.

<u>Channel</u>	<u>Bit(s)</u>	<u>Function</u>	<u>Comments</u>
<u>CSM Program</u>			
01	15-1	L register	Used for internal coding purposes (e.g. THERMIST processing). AGC failure if malfunction.
02	15-1	Q register	Used for internal coding purposes (e.g. bit setting in interpretive language). AGC failure if malfunction.
03	14-1	HISCALAR	Used in PO6 to determine part of clock information for standby. Backup is V33 or P27.
04	14-1	LOSCALAR	See channel 03. If low five bits stuck at 10000, would respect a hardware restart loop (due to "night watchman"), which crew can get out of manually, for PO6 uses.
05	8-1	RCS jets	In RCS DAP is sensed whenever update pitch or yaw pattern, since wish to retain jets firing in other axis. Hence if fails in such a way that output to jet reflects loading, but sensing by program is locked at "1" (a failed AND gate in channel reading logic, perhaps), then either PGMCS or jet itself would have to be disabled.
06	8-1(SM) 4-1(CM)	RCS jets	No reading found.
07	7-5	SUFERRRM	Read whenever change a job or do several interrupts (such as T3R017), to permit restoration after complete function. Hence if cannot read value or if read value not consistent with "actual" value (see channel 05), then AGC failure. Could keep a separate erasable memory cell with image of what is in channel, at cost of more program steps (can't protect against "actual" value failures impacting input to address selection logic, of course).

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<u>Channel</u>	<u>Bit(s)</u>	<u>Function</u>	<u>Comments</u>
10	15-1	OUTO	No reading found (DEMY drive).
11	15-1	Chan. 11	Individual bits (e.g. flash) set by a WCF command (copy channel into A, coving with what there, and then load A into channel). Hence a stuck bit for sensing becomes a stuck bit for loading (see channel 05).
13		SPS on	Checked several places (e.g. V37 processing), as summarized in Colossus Memo #255. PCN 995, approved at SCB meeting #36 for H3, replaces these checks with check of a flag bit.
1		ISS Warning	Checked in "TENDDER" to determine nature of "IMSTALL" return (get a 217 ₈ "CRITICALS" alarm if locked at 1).
12	15-1	Chan. 12	See Chan. 11 comment concerning NOR.
15		ISS turn-on delay complete	Checked as one criterion for 207 ₈ alarm in "TENDDER".
8		TVS Enable	To be used in H3 program to control optics rate drive (if 0, set to 1 and no further optics driving in TRUPT attempted; check made only if optics in Manual).
6		Enable IMU CDU error counters	Tested in FIM error display routine: if read-in locked at 0, never get any error display.
5		IMU Zero	Checked for verb 43: if 1, verb rejected.
4		IMU Coarse align	Checked for verb 43: if 1, verb rejected. Also tested to determine if pulse torquing allowable (if locked at 1, can't do torquing of large amounts). Tested at start of "SETDOARS": if 1, other conditions not set for coarse align entrance. No FIM error display if 1.
2		Enable Optics CDU error counters	Tested in "OPTTEST" before attempt made to move position of optics. Hence if stuck at 0 software will not drive optics.

<u>Channel</u>	<u>Bit(s)</u>	<u>Function</u>	<u>Comments</u>
13	15-1	Chan. 13	See Chan. 11 comment concerning WOI.
	7	Word order code bit	Checked at each telemetry interrupt: if 0, set-1, and then reset 0 again. If 1, bits either not assigned or no reading found.
5-1	MDC DENY	Read to determine MDC DENY keycode, when program interrupt received.	
7	Optics mark reject	If stuck at 1, could use P53/P54 for alignment (and could use R21 with V86E to reject). Sensing of Nav. panel DENY not done (hence if generate interrupt when not in optics program, get 112g alarm).	
6	Optics mark	See comments on bit 7, except V86E.	
5-1	Nav. panel DENY	Read to determine Nav. panel DENY keycode, if bits 7-6 are zero.	
15	IMJ temp.	Used to control setting of Temperature Caution light, when changes value.	
14	IMJ turn-on request	Controls turn-on sequencing for IMJ when change value; if goes to logic 0 can get 207g alarm.	
13	IMJ fail.	Generates 155 warning if appropriate. Included in Mission Rules (#5-54) as a no-go PGMCS alarm.	
12	IMJ CDU fail.	Generates 155 warning if appropriate. See bit 13.	
11	IMJ Cage	A binary 1 to 0 transition causes SPS cutoff and negating of [HEFEMOAT] status.	
10	LV Guidance	Checked during P11 to determine nature of boost-phase P1A1 outputs.	
9	IMJ on.	A binary 0 to 1 transition with IMJ being used causes 274g alarm, same effect as mentioned for bit 13 mission rule.	
7	Optics CDU fail	Controls setting of TRACKER light.	

<u>Channel</u>	<u>Bit(s)</u>	<u>Function</u>	<u>Comments</u>
30 (cont.)	5	Liftoff	Backup is V75B. If stuck at binary 0, gyrocompassing can't be done (program PO2 transfers to P11); could set MOIRES = 7 and rely upon V75B.
31	15	Computer in control of S/C	If stuck at binary 1, RCS DAP usable only in Free mode; entry and TVC DAPs ignore the bit.
	14	Free mode	If stuck at binary 0, RCS DAP usable only in Free mode; entry and TVC DAPs ignore the bit.
	13	Hold mode	If stuck at binary 0, with bits 15 and 14 = 01, RCS DAP usable in Hold mode (R60 never generate the 0618 display, for example). Ignored by TVC/Entry DAPs.
	12-7	Translation inputs	Checked by RCS DAP and generates jet-on commands if deflected (subject to jet selection logic, of course).
	6-1	RNC inputs	Used by RCS DAP only; if one or more stuck at binary 0, automatic maneuvers prevented and rate/acceleration (minimum impulse for changes in H3, Free mode) spacecraft commands generated by software depending on DAP mode.
32	14	FRD button	Binary 1 to 0 transitions give effect of V338 (which would be a backup if stuck at one value).
	6-1	Minimum impulse controller	Sensed only in Free mode of RCS DAP, causing minimum-impulse firing for a 1 to 0 transition. Starting with H3 (PCR 289) RNC also serves this function.
33	15	Oscillator stop (flip-flop)	If locked at binary 1, and bit 14 is a zero, a hardware restart turns into a fresh start.
	14	CMC Warning	If locked at binary 0, and bit 15 is 1, a hardware restart turns into a fresh start.
	13	PIPA fail	1 to 0 transitions generate ISS warning or Z12g alarm, both of which are, per mission rule#3-14, cause for PGNCS no-go.

<u>Channel</u>	<u>Bit(s)</u>	<u>Function</u>	<u>Comments</u>
33 (cont)	12	Telemetry and pulses too fast.	1 to 0 transitions generate alarm 1105 _g . An NO9/NO7 procedure could be used to clear the alarm system (error reset causes previous value to be "1").
	11	Uplink too fast.	1 to 0 transitions generate alarm 1106 _g . See bit 12 comment.
	5-4	Optics Mode Switches	If bit 4 stuck at 1, cannot internally carry out zeroing of optics (11 _g means manual, 01 _g means computer control, and 10 _g means zero mode). If bit 5 is stuck at zero, therefore, can only specify computer control.
	2	VHF Data good	Status of VHF data quality as used by R22. If stuck at 1, no VHF data used.
34	15-1	EXTM1	First of 2 words downlinked, no reading found.
35	15-1	EXTM2	Second of 2 words downlinked, no reading found.

<u>Channel</u>	<u>Bit(s)</u>	<u>Function</u>	<u>Comments</u>
<u>LM Program</u>			
01	15-1	L register	See CSM discussion.
02	15-1	Q register	See CSM discussion.
03	14-1	HISCALAR	See CSM discussion.
04	14-1	LOSCALAR	See CSM discussion. In LM, channel also used for channel 13 stall logic, a more in-line function (if bits 5-1 are stuck at binary 0, for example, a TC TRAP would result).
	1		Used in LMV as "semi-random" number generator (see page 3.4-20 of Section 3 Rev. 3 CSOP) for jet to be used for minimum-impulse duration firings.
05	8-1	RCS jets	See CSM discussion. Also used to check for initiating gimbal trim drive (if a bit locked at 1, would not do gimbal trim).
06	8-1	RCS jets	No reading found.
07	7-5	SUPERMAN	See CSM discussion.
10	15-1	OUTO	No reading found (DEHY drive).
11	15-1	Chan. 11	Individual bits set by WCR order (see CSM discussion).
	1	ISS Warning	See CSM discussion.
12	15-1	Chan. 12	See Chan. 11 comment concerning WCR.
	15	ISS turn-on delay complete	See CSM discussion.
	14	Enable RM lockon.	Checked in R22: if locked at 0, no sampling of RM for state vector update takes place.
	12-9	GTS drive	Examined in "I/ACCS" routine to set DAP parameters.
	6	Enable IMU CPU error counters	See CSM discussion.

<u>Channel</u>	<u>Bit(s)</u>	<u>Function</u>	<u>Comments</u>
12 (cont.)	5	D40 Zero	See CSM discussion.
	4	D40 Coarse align	See CSM discussion.
	2	Enable FM CIO error counters	Checked in "SETUPFORM": if binary 0, set in binary 1 and present value image of error counters zeroed. Also checked in H10: if locked at 0, no analog displays of any sort during descent. (including no tape meters from PGNCS).
13	15-1	Chan. 13	See Chan. 11 comment concerning WCR.
	7	Word order code bit	See CSM discussion.
	4	Radar sampling	If locked at 0, "Q13STALL" logic not effective; if locked at 1, always engaged.
	3-1	Radar selection	Sensed to determine processing to be done for radar sample in radar reading routine. Improper processing (e.g. decision on high/low rescaling or data flags checked) if bit stuck.
14	15-1	Chan. 14	See Chan. 11 comment concerning WCR. Otherwise, bits either not assigned or no reading found.
15	5-1	DSKY input	Read to determine DSKY keycode.
16	7	ROD increase	If stuck at 1, any ROD input, or an optics input, increases rate of descent cell. Optics use disabled.
	6	ROD decrease	If stuck at 1 (with bit 7 at 0), gives decrease of rate of descent. Optics use disabled.
	5	Optics mark reject	If stuck at 1, only optics mark reject input processed (even if want to mark), provided bits 7-6 = 0.
	4	Optics Y mark	If stuck at 1, Y marks cannot be processed.
	3	Optics X mark	Is last bit that is checked in sequence, so if it is stuck at 1 but still get interrupt generated when press it, no inflight difficulty.

<u>Channel</u>	<u>Bit(s)</u>	<u>Function</u>	<u>Comments</u>
30	15	D80 temp.	See DSM discussion.
	14	D80 turn-on request	See DSM discussion.
	13	D80 fail.	Generates IES warning if appropriate. Included in Mission Rules (#5-464) as a temp. no-go for PGNS.
	12	D80 OTO fail	See DSM discussion.
	11	D80 Cage	See DSM discussion (turns off descent/ascent engines).
	10	PGNS in control	Disables DAP if stuck at binary 1. To have effect decreased by PCR 303 for R3 (as modified during SCB #36).
	9	D80 on.	See DSM discussion.
	7	EM CMU fail	Controls setting of TRACKER light and alarm 515 _g if changes under suitable circumstances.
	6	Display inertial data	If locked at binary 1, no RIO displays generated.
	5	Auto throttle	Used as a criterion for checklist 203 _g generation. Also used (now) in P66 to set desired rate equal to present rate if binary 1 (logic 0).
	4	Abort Stage	Causes entrance to P71 during descent or P70. Backup is via V37.
	3	Engine Armed	If binary 1, DAP is idled in P66 now after a non-V34E response to F V06 R60 has been received.
	1	Abort.	Causes entrance to P70 during descent. Backup is via V37.
31	15	ACA out of detent	Used in DAP to control processing of ACA information.
	14	PGNS Mode Control Auto	If binary 0, automatic commands generated. If binary 1, a 203 _g checklist criterion.
	13	PGNS Mode Control Hold	If stuck at binary 1, cannot enter P66 by clicking ROD. PCR 303 (SCB #36) causes lowest mode of DAP to be hold even if bits 14-13 = 11 ₂ (effective for R3). Also checked several other places in program.

<u>Channel</u>	<u>Bit(s)</u>	<u>Function</u>	<u>Comments</u>
31 (cont)	12-7	Translation inputs	See CSM discussion.
	6-1	ACS inputs.	Used for rotational control. Bits 6, 5, 2, and 1 also used for LPD. If one or more stuck at binary 0, no redesignation would be performed.
32	14	PRO button	See CSM discussion.
	9	Gimbel off	If stuck at 0, no gimbel use attempted.
	8-1	RCS pair failures	Transitions cause RCS pairs to be disabled. DSNY NO7 techniques exist to permit manual disabling/enabling if bit permanently stuck at wrong value.
33	13	PIPA fail	Similar to CSM discussion.
	12	T/R End pulses too fast	See CSM discussion.
	11	Uplink too fast	See CSM discussion.
	9	LR on low scale	Controls processing of LR altitude data (factor of 5 difference).
	8	LR velocity "good"	Condition of LR velocity data.
	7	LR position 2	Various alarms, most of which deleted by PCN 1022 (SCB #36, H3 mission).
	6	LR position 1	See bit 7.
	5	LR range "good"	Condition of LR altitude data.
	4	RR data "good"	Condition of RR data.
	3	RR on low scale	Controls processing of RR range data (factor of 8 difference).
	2	RR auto	Checked for the Apollo 11 RR CDU counter "fix"; if locked at 1 can't get PZO running.
34	15-1	DNIM1	Downlink word #1, no reading found.
35	15-1	DNIM2	Downlink word #2, no reading found.