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ATC-35

Provisional Message Formats and Protocols for the DABS IPC/PWI Display

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24 May 1974

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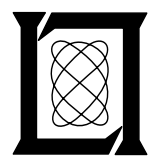

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16. Abstract

This document specifies provisional formats for the data link portion of the "signals-in-space" which are part of the DABS interrogations and replies. Also included is a discussion of the characteristics that these signals assume while transmitted from the transponder proper to the instrument which delivers the messages to the pilot. Specifically, formats, algorithms, and protocols are assigned to serve the IPC (Intermittent Positive Control), PWI (Proximity Warning Indicator), and ATC (numerical indicator) functions. The protocol and algorithm for the pilot acknowledgment link is also included in this paper.

17. Key Words

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SECTION 1

INTRODUCTION/SUMMARY

1.1 GENERAL

The DABS system provides, besides surveillance, a data link between the ground and any specific aircraft on the DABS roll-call. This capability is employed in the IPC system for the purpose of transmitting commands or advice to be displayed to the pilot. A display device has been described earlier [1] and includes numerical as well as symbolic indicators. This report assigns formats, bit patterns, and device address codes for the operation of a display of this type.

1.2 DISPLAY CONFIGURATION

The display face consists essentially of four different section: IPC, PWI, ATC, and the acknowledgment section. The IPC section contains command symbols to change the flight path. PWI is an indicator, locating nearby aircraft. The ATC section displays four sets of numerals for VHF frequency, altitude, heading, and airspeed. The acknowledgment section consists of three push buttons, two of which permit the pilot to reply to received information. The third button can be used to request a test sequence.

All four sections can be combined to result in a configuration as shown in Fig. 1. An instrument can be built which contains only the IPC, PWI, and acknowledgment sections, leaving out the four windows of the ATC section, which are not needed for IPC service as it is known today.

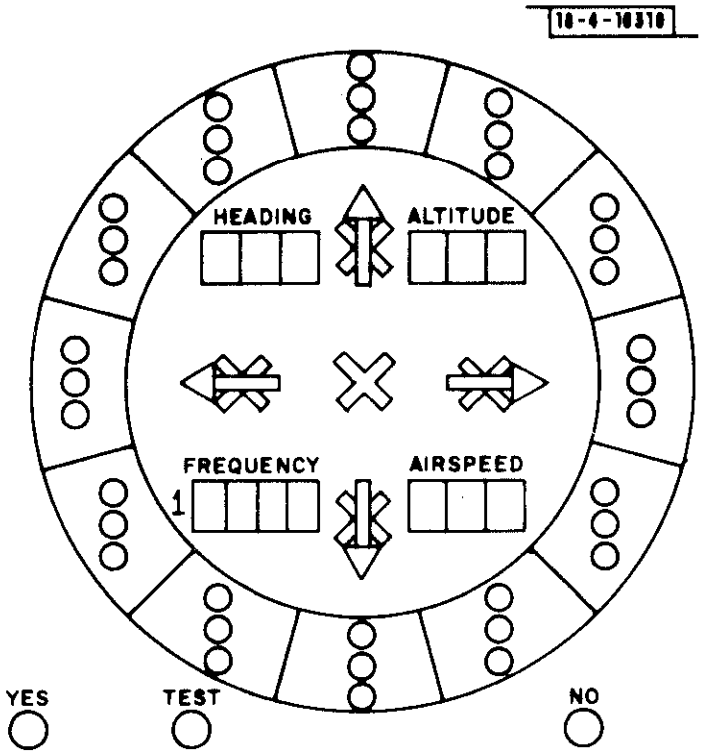


Fig. 1. Display face.

1.3 OPERATIONAL SIGNALS

The data to operate the display are contained in the message block of DABS Comm-A uplink transmissions (see Ref. [2], para. 4.2.3). The messages are shifted out of the transponder at the Standard Message (SM) interface as described in Ref. [3]. The display, connected to this SM interface recognizes its own code and then extracts, decodes, and displays the information.

Two codes are assigned to the instrument described here. A single format is not sufficient because the large information content, which can be displayed, does not allow all possible data to be compressed into a single Comm-A transmission. The data are formatted to permit a single transmission to include sufficient data to generate a meaningful collision avoidance

command. The format controls both the IPC and PWI sections of the display and permits any combination of arrow and X symbols, and up to five of the 36 PWI lights, to be energized.

The other format is the ATC numeric format, which controls all the numeric windows of the ATC numeric display.

Any Comm-A uplink message can initiate the pilot acknowledgment cycle and any Comm-A or uplink Surveillance transmission can close out this cycle.

SECTION 2

DISPLAY CONFIGURATION

2.1 DISPLAY FACE

The display face has been describe in [1] and has been designed to present information to the pilot on the location of other aircraft in his vicinity, a set of maneuvering commands and a set of flight management commands. A sketch of the display face is shown in Fig. 1.

2.2 THE IPC SECTION

In the center of the display are four arrow and five X symbols; each symbol can be independently energized either steadily or intermittently (flash). An energized arrow is a command to change the flight path by turning or changing altitude, while an energized X is a command which prohibits a path change in the direction indicated.

2.3 THE PWI SECTION

Twelve sets of three lights each form the periphery of the display face. These sets represent the face of a clock on which the 12 o'clock position denotes the heading of the aircraft. The location of nearby aircraft is known to the DABS system and their position can be transmitted to the pilot via this ring of 36 lights. When the center light of one of the 12 three-light sets is energized, it warns of another aircraft at the indicated o'clock position and at the same altitude. Similarly, the upper light denotes an aircraft above and the lower light means an aircraft below. Each of the 36 lights can either be energized steadily or intermittently (flash). A flashing light should be interpreted as another aircraft on a collision course or in dangerous proximity.

2.4 THE ATC SECTION

In Fig. 1 four sets of numerals appear in the spaces between the arrows and X's; they are used to inform the pilot of the VHF frequency, altitude, heading and airspeed he is expected to use.

2.5 THE ACKNOWLEDGMENT-TEST-ALARM INTERFACE

The three push buttons, shown below the indicator face in Fig. 1, form the acknowledgment interface. By command from the ground, a light which is associated with each button can be energized to request an acknowledgment of a received message.

Two buttons are used to insert "YES" indicating intent to comply, or "NO" indicating inability to comply.

The third button initiates a request by the pilot for transmission of a test sequence.

An audible alarm can also be set off to alert the pilot to a change in the displayed information or to the necessity to actuate the reply buttons.

SECTION 3

FORMATS AND PROTOCOLS

This section describes the bit assignments in the DABS uplink transmissions which operate the symbols in the display. It also describes the operating protocols which the logic circuits in the display have to follow.

3.1 SIGNALS AND TIMING

The signals which operate the displays appear at the Standard Message interface of the transponder if, and only if, the message was addressed to this aircraft.

The entire content of the uplink transmission as received by the transponder, except the 24-bit address field, appears at the SM interface in serial form and in the same sequence as received. The data rate at the SM interface is 1 Mb/sec and is synchronized by a clock which starts only when a properly addressed transmission has been received. The clock stops after the transponder has replied to the interrogation. The levels and timing for the clock and data lines are described in Ref. [3].

3.2 FORMATS

The formats for DABS interrogations and replies are described in Ref. [2], Fig. 4.4-1. All interrogations contain either 56 or 112 bits, of which the last 24 bits are the address/parity field. After removal of the address/parity field by the transponder, either 32 or 88 bits appear at the SM interface. The data which operate the display are contained in the last 56 bits (the MA field) of the 88 bit pattern.

3.2.1 Control Codes

The first 32 bits of SM interface data contain mainly control information for the transponder and data for other displays; however, 3 of these bits are relevant to the IPC/PWI display.

Bit 1: A zero in this position indicates that a standard (not All-Call or ELM) transmission has been received. Although the transponder will not activate the SM interface unless a standard transmission is at hand, there is one exception: receipt of an All-Call. In that case, the automatic capability reporting circuit will be enabled. (See para. 3.6 and Ref. [3], para. 2.4.2.)

Bit 2: A zero in this position indicates that only 32 bits have been received, there is no MA field, and bits 3 (IT) and 14 (CP) are the only ones to be evaluated by the display.

Bit 3: A one in this position indicates that the transmission has originated from a standard DABS sensor. The initialization timer, described in 3.10, will be refreshed only if this bit is present.

Bit 14: This is the Clear Push button (CP) command, used in the acknowledgment protocol described in 3.5.

3.3 THE IPC SYMBOL TRANSMISSION

This transmission operates both the PWI and IPC sections of the display. AR is the Acknowledgment Request bit, used in the acknowledgment protocol described in 3.4. The next seven bits, 34 through 40, contain the destination and device codes. MDES is the Message Destination code and DDES is the Device Designator. The instrument described here is part of a group using MDES 111. DDES specifies a device or a section of an instrument; specifically, DDES 0001 addresses the IPC/PWI symbol section of the display, while DDES 0100 is assigned to the numeric section.

The bit assignments are presented in Fig. 2. The bits are numbered according to their natural sequence in the data stream; bits 1 through 32 are not shown. Bits 33 through 40 are the acknowledgment request and destination codes.

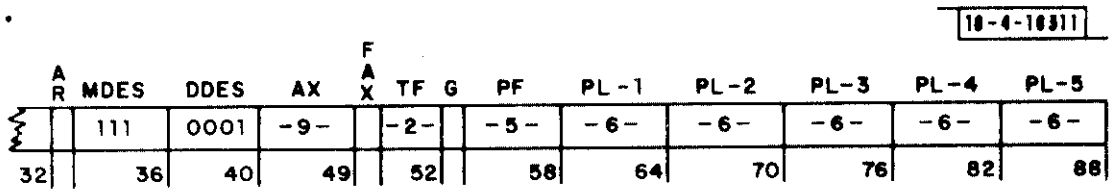


Fig. 2. Bit assignments for the PWI-IPC symbol transmission.

3.3.1 Control of the Arrow and X Symbols

The information which operates the display starts with bits 41 through 49; the AX field. Consecutive lower case letters are assigned to the arrow and X symbols as shown in Fig. 3. Each of the 9 bits controls one of the arrow or X symbols; symbol a is controlled by bit 41, b by bit 42, and so on. A one in any of these bit positions causes the appropriate symbol to be energized. Bit 50 determines whether the arrow and X symbols should be energized steadily or flashed. A one in position 50 indicates that the symbols should flash.

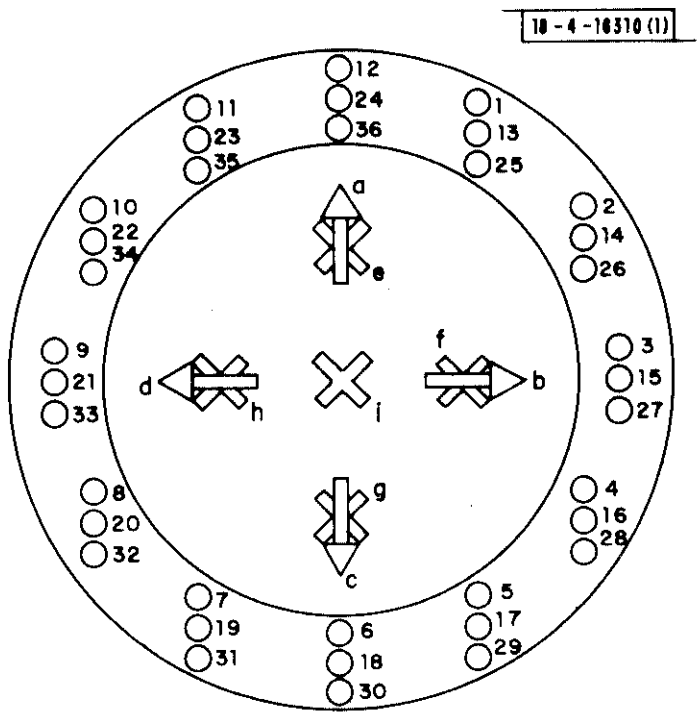


Fig. 3. Numbering convention for IPC/PWI symbols.

3.3.2 Control of the PWI Indicator

Consecutive numbers are assigned to the 36 lights in the PWI ring as shown in Fig. 3. The independent PWI Light fields, PL-1 through PL-5, are used to operate up to 5 of the 36 PWI lights. The six bits in each PL field are encoded in true binary from 00 0001 to 10 0100 corresponding to the number of the light to be energized. The code 00 0000 will not energize any light.

Each of the five bits in the PF (PWI-Flash) field corresponds to one of the PL fields (e.g., bit 54 corresponds to PL-1 and so on). If a one is received in a PF bit position, the light designated by the code in the corresponding PL field is flashed rather than turned on continuously.

The operation of the PWI lights can be made cumulative or not cumulative, depending on the command indicated by the Test Field (TF) code. It is possible to energize more than 5 of the lights by sending successive transmissions with the appropriate TF code to designate that additional lights are to be added to those already displayed. If the noncumulative TF code is received in a transmission, the previously displayed pattern if cleared before the new pattern is presented to the pilot.

The test field consists of bits 51 and 52 and is designed to provide a full test of the DABS links and the intervening logic circuitry. If the TF code is 00, no test occurs and PWI is cumulative. TF = 01 overrides all other bit patterns and causes all lights, PWI as well as arrow and X symbols, to be lighted steadily. TF = 10 has the same function, except all lights are flashed. TF = 11 makes PWI operation noncumulative.

The PWI lights as all other indications are also subject to clearing upon initialization or loss of DABS contact as described in 3.7.

3.3.3 Control of the Audible Signal

The presence of a one in bit 53 actuates the aural alerting device, which may be a horn, whistle, bell, or gong. The audible signal will be generated for 3 to 5 sec, after receipt of bit 53. The actual sound maker, a speaker or other transducer, will be mounted at a suitable location in the

cockpit. Another implementation would be to feed the tone into the audio system in the cockpit.

Appendix A is a short form summary of the codes and protocols of the IPC-PWI Transmission.

3.4 THE ATC NUMERIC TRANSMISSION

The transmission is identified by DDES = 0100 and operates four numerical indicators for VHF frequency, altitude, heading, and airspeed. A diagram of an ATC numeric display is shown in Fig. 4. Each digit position is identified by a Roman numeral.

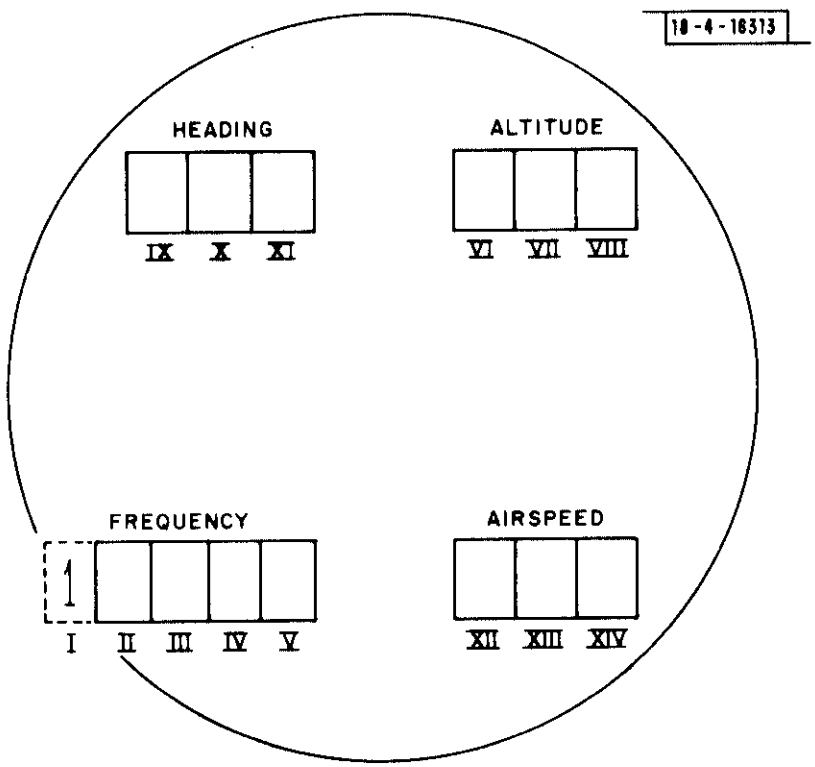


Fig. 4. ATC display windows.

The bit assignments are presented in Fig. 5. The bits are numbered according to their natural sequence in the data stream; bits 1 through 32 are

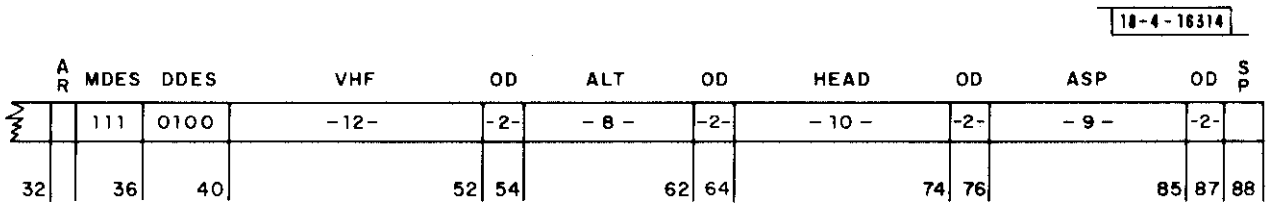


Fig. 5. Bit assignments for the ATC transmission.

not shown. Bit 33 through 40 are the acknowledgment request and the destination codes.

3.4.1 The VHF Frequency Field

The information which operates the display starts with bits 41 through 54, the VHF field. Four decimal digits are required to cover the range from 118.000 through 135.975 MHz in increments of 0.025 MHz.

The first digit (I) is always a "one" and can be permanently shown on the indicator face.

The second digit (II) can only take on the values 1, 2, or 3. Bits 41 and 42 are used to code the value in straight binary, where bit 42 is the least significant bit.

The third digit (III) can take on all values from zero through 9. It is encoded in BCD by bits 43 through 46, where bit 46 is the least significant bit.

The fourth (IV) digit also takes all decimal values and is encoded by bits 47 through 50, where bit 50 is the least significant bit.

The fifth (V) digit can only take on the values 0, 2, 5, and 7. It is encoded by the two bits 51 and 52 as follows: 00 = 0; 01 = 2; 10 = 5; 11 = 7. A standard BCD decoder can be used if the most significant input to the decoder is set to zero, the second and the least significant decoder inputs are set to the value of bit 51 and the remaining decoder input is set to the value of bit 52.

Display of the sixth digit, which would be either a zero or a 5, is not required because the indication as presented is not ambiguous. The next two bits, 53 and 54, comprise the OD (Operation Determinant) field for the frequency display window. A 00 code in this field commands that a blank shall be shown. A 01 code means that the old content shall be replaced with the new and that the numerals shall be lighted continuously. A 10 code has the same meaning as 01, except that the numerals shall be flashed. A 11 code overrides any present content of the VHF field and directs that whatever was previously displayed shall remain.

3.4.2 The Altitude Field

Bits 55 through 62 contain the code for the altitude window. Three decimal digits are used to show altitude from 0 to 79 500 ft in increments of 500 ft.

The first digit (VI), which can only take the values from 0 through 7, is encoded as a 3 bit BCD word in bits 55 through 57. The second digit (VII) is encoded as straight BCD in bits 58 through 61. The third digit (VIII) can only take the values 0 or 5 and is encoded in bit 62. If this bit is a one, the numeral 5 will be displayed, otherwise, a zero will be shown.

Bits 63 and 64 comprise the OD field for the altitude indication and have the same function as the OD field for the frequency display previously discussed.

3.4.3 The Heading Field

Bits 65 through 74 contain the code for the three window display showing heading from 0 to 359 degrees in increments of one degree.

The first digit (IX), which can only be 0, 1, 2, or 3, is encoded in bits 65 and 66 in straight binary. The next two digits (X, XI) are encoded in straight BCD in bits 67 through 70 and 71 through 74, respectively. The heading OD field is encoded in bits 75 and 76 and has the standard function.

3.4.4 The Airspeed Field

The airspeed window displays a range of speeds from 0 to 995 knots, in increments of 5 knots and is encoded in bits 77 through 85. The first two digits (XII, XIII) are encoded in straight BCD in bits 77 through 80 and 81 through 84, respectively. The last digit (XIV), which can only be either zero or five, is encoded in bit 85 using the same rules which are used for bit 62. The airspeed OD field is encoded in bits 86 and 87.

Bit 88 is not used.

Appendix B is a short form summary of the codes and protocols of the ATC numeric transmission.

3.5 THE PILOT ACKNOWLEDGMENT/TEST CIRCUIT

Bits are provided in each uplink and downlink DABS transmission which provide an acknowledgment capability between the pilot and the sensor. The pilot input to this signalling channel consists of three push buttons which control the setting of the PBUT field (bits 14 and 15) in the DABS surveillance and communication reply formats. The uplink bits used in this acknowledgment channel are CP (bit 14 in the uplink surveillance and Comm-A formats) and AR (bit 33 in the Comm-A format).

The sequence of events in a typical acknowledgment cycle is as follows:

When sending a tactical command to the IPC/PWI display, the ground may require pilot confirmation or reaction. To this end, the AR is included in the transmission. Receipt of AR, after a delay of approximately 1 sec to avoid misinterpretation, flashes the lights associated with the YES-NO buttons, alerting the pilot to reply by pushing one of the buttons.

When the pilot pushes either the YES or NO button, the acknowledgment light associated with it becomes steady rather than flashing, and the light on the unused button goes off. This is an indication to the pilot that his acknowledgment has been inserted into the transponder for transmission to the ground. Also, the appropriate PBUT bit is set and is ready to be included in the next downlink transmission. After the PBUT code has been read on the ground,

the acknowledgment transaction is terminated by the inclusion of the CP bit in a subsequent interrogation. When this is read by the transponder, the acknowledgment light goes out, signalling to the pilot that his reply has been noted. Upon receipt of CP, both PBUT bits are cleared.

The test sequence can be initiated by the pilot by pushing the test button. The ground then finds both PBUT bits set and sends a sequence of one or more test patterns in subsequent Comm-A transmissions. The last test pattern transmission contains AR. After examining the test pattern(s), the pilot pushes either the YES or NO button to indicate that he is ready for the ground to terminate the test routine. The test pattern and acknowledgment are then cleared by the ground to complete the test cycle.

The time delay is used to assure that the pilot acknowledges a new, rather than an old message. Upon receipt of an acknowledgment request, the buttons are disabled and the flashing of the YES-NO lights is delayed to assure that the new message has entered the consciousness of the pilot, before the reply buttons can be operated. This delay is generated by the acknowledgment timer which runs for about 1 sec and must be retriggerable, i.e., restart must be possible even while the timer is running.

3.6 OPERATIONAL STATES OF ACKNOWLEDGMENT CIRCUITS

The acknowledgment circuits can assume six distinct states. They are listed in Table 1.

3.6.1 Operational signals

The operational signals are the events which cause transfers between operational states. They are listed in Table 2.

3.7 TRANSFER BETWEEN STATES OF ACKNOWLEDGMENT CIRCUITS

Table 3 summarizes the events which initiate transfer between operational states. The table includes "transfers" from state n to state n; i.e., on occurrence of the events listed, the circuit remains in the present state.

Table 1. Operational states of acknowledgment circuits.

State		YES-NO Buttons	Test Buttons	Lights		Test Light	Acknowledgment Timer	PBUT	
No.	Description			YES	NO			Bit 14	Bit 15
1	NORMAL	Disarmed	Armed	Off	Off	Off	Off	Low	Low
2	AR REC'D	Disarmed	Disarmed	Off	Off	Off	Running	Low	Low
3	YN ACTIVE	Armed	Disarmed	Flash	Flash	Off	Off	Low	Low
4	Y SELECT	Disarmed	Disarmed	On	Off	Off	Off	High	Low
5	N SELECT	Disarmed	Disarmed	Off	On	Off	Off	Low	High
6	TEST REQ'D	Disarmed	Disarmed	Off	Off	On	Off	High	High

Table 2. Operational signals (events) of acknowledgment circuits.

Event Symbol	Description
A	AR bit receipt
CP	CP bit receipt
I	Initializing signal receipt
E	Acknowledgment timer timeout
Y	YES button contact
N	NO button contact
T	Test button contact

Table 3. Events causing transfer between states of acknowledgment circuits.

From State No.	To State					
	1	2	3	4	5	6
1	CP, I, Y, N	A*				T
2	1	A*, CP, Y N, T	E			
3	1	A*	CP, T	Y	N	
4	CP, I	A*		Y, N, T		
5	CP, I	A*			Y, N, T	
6	1	A*				CP, Y, N, T

*Receipt of A restarts the acknowledgment timer in any case.

It should be noted that event A, receipt of the AR bit, in all cases causes the acknowledgment timer to restart, even if it should be running. This calls for the use of a "retriggerable one-shot" in that circuit.

Appendix C is a short form summary of the operation and protocol of the pilot acknowledgment channel.

3.8 THE PBUT SIGNAL

This signal, which represents the downlink bits generated by pilot action is transmitted from the display to the transponder by one of two methods described in detail in Ref. [3], para. 2.3.3 and 2.4. In the first method, TTL signal levels, representing the PBUT bits can be generated and fed on wires to the transponder. A TTL "high" denotes that the bit has been set. The second option for inserting PBUT signals into the transponder uses the SM interface. The SM interface data line is inherently a two-way line, although inbound data transfer is not used in the IPC/PWI display. However, if a transponder is equipped with an SM interface which accepts inbound data, then the acknowledgment circuit logic can insert the PBUT code directly into the inbound data stream at the appropriate time.

The protocol of the acknowledgment link requires that the resetting of the PBUT bits occurs in direct and immediate response to the interrogation which carried this command. If the first method, above, is used, it becomes important that the PBUT level changes to zero before interface clock pulse 92 so that this information can be included in the reply.

3.9 CAPABILITY REPORTING

A circuit which, on receipt of an All-Call interrogation, automatically reports the presence of the IPC/PWI display can be incorporated in the display. The details are described in Ref. [3], para. 2.4.2.

3.10 INITIALIZATION AND LOSS OF DABS CONTACT

Ordinarily, the symbols and numerals on the display face are updated only upon receipt of new Comm-A transmissions. Therefore, their meaning

loses validity as the aircraft leaves DABS airspace. A timing circuit is included in the display and is refreshed each time a logical one is received in bit position No. 3 in the received data stream (see 3.2). This initialization timer runs for at least one sensor scan interval after each retriggering. If the circuit runs out, the initializing signal is generated, which clears all symbols or numbers which have been displayed.

The same initializing signal is internally generated in the display after power is initially turned on and the supply voltage has stablized. This is in accordance with standard practice.

APPENDIX A

SUMMARY SHEET FOR IPC TRANSMISSION

18-4-16311

	AR	MDES	DDES	AX	FAX	TF	G	PF	PL-1	PL-2	PL-3	PL-4	PL-5
		111	0001	-9-		-2-		-5-	-6-	-6-	-6-	-6-	-6-
32		36	40	49		52		58	64	70	76	82	88

AR = Ackn. Request

MDES: must be 111

DDES: must be 0001

AX: energize symbol according to bit

FAX = Flash energized symbols

TF = Test Field:

00 not test, PL's are cumulative

01 light all AX and PWI

10 flash all AX and PWI

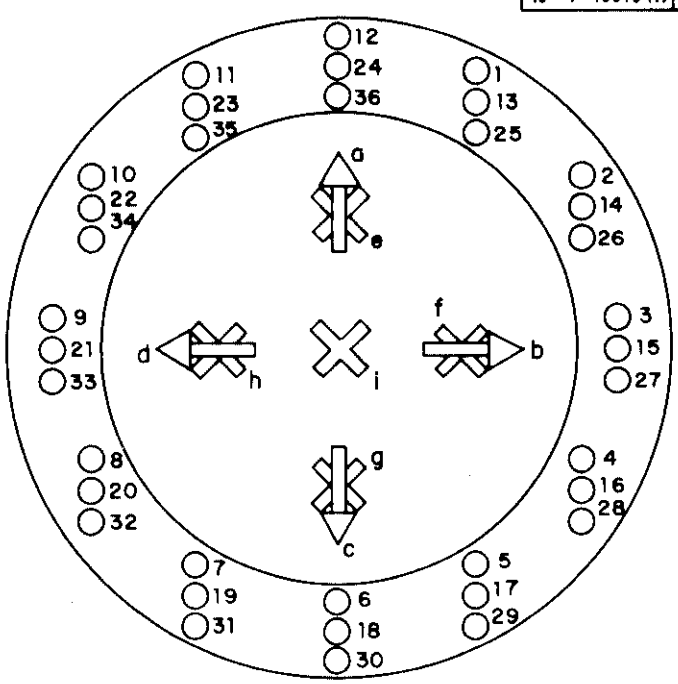
11 no test, PL's are not cumulative

G = Gong

PF = Flash PWI light addressed by corresponding PL field

PL - 1 through PL - 5 = energize PWI light which aggrees with binary code in any PL field

18-4-16310 (1)



Additional Rules:

1. Arrows and X's are not cumulative.
2. A new command to an already energized PWI light takes precedence over previous state.
3. PWI lights are cumulative unless TF = 11.
4. Gong can be retriggered while active.
5. Initializing signal wipes display.

APPENDIX B

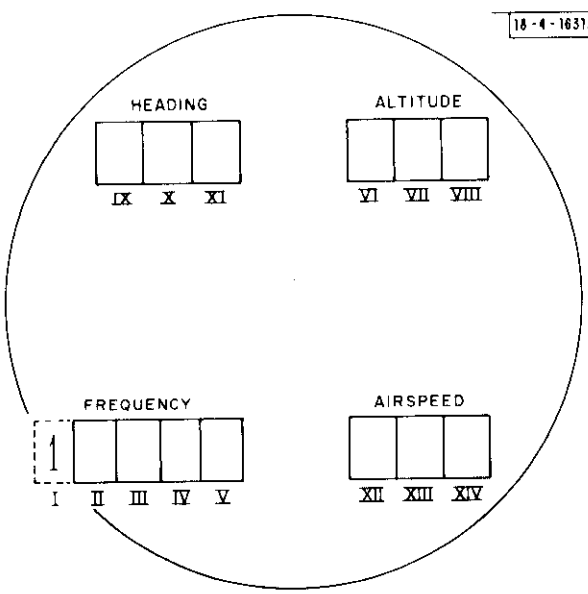
SUMMARY SHEET FOR ATC TRANSMISSION

18-4-16314

	A R	MDES	DDES	VHF	OD	ALT	OD	HEAD	OD	ASP	OD	S P
		111	0100	-12-	-2-	- 8 -	-2-	- 10 -	-2-	- 9 -	-2-	
32		36	40	52	54	62	64	74	76	85	87	88

Bit No.	Window	Dec. digits	Decoder inputs A	B	C	D	Other functions
33							AR
34...36							MDES alpha = 111
37...40							MDES beta = 0100
41...42	II	1...3	0	0	41	42	
43...46	III	0...9	43	44	45	46	VHF Frequency
47...50	IV	0...9	47	48	49	50	
51...52	V	0, 2, 5, 7	0	51	52	51	
53...54							OD
55...57	VI	0...7	0	55	56	57	
58...61	VII	0...9	58	59	60	61	Altitude
62	VIII	0, 5	0	62	0	62	
63...64							OD
65...66	IX	0...3	0	0	65	66	
67...70	X	0...9	67	68	69	70	Heading
71...74	XI	0...9	71	72	73	74	
75...76							OD
77...80	XII	0...9	77	78	79	80	
81...84	XIII	0...9	81	82	83	84	Airspeed
85	XIV	0, 5	0	85	0	85	
86...87							OD
88							Not used

18-4-16313



OD:

00 show blanks
01 update, steady light
10 update, flash
11 leave as found

Additional Rules:

Display indication remains until either updated or wiped by initializing signal.

APPENDIX C

SUMMARY SHEET FOR PILOT ACKNOWLEDGMENT CHANNEL

Operational states of acknowledgment circuits.

State No.	State Description	YES-NO Buttons	Test Buttons	Lights YES	Lights NO	Test Light	Ackn. Timer	Bit 14	PBUT-N Bit 15
1	NORMAL	Disarmed	Armed	Off	Off	Off	Off	Low	Low
2	AR REC'D	Disarmed	Disarmed	Off	Off	Off	Running	Low	Low
3	YN ACTIVE	Armed	Disarmed	Flash	Flash	Off	Off	Low	Low
4	Y SELECT	Disarmed	Disarmed	On	On	Off	Off	High	Low
5	N SELECT	Disarmed	Disarmed	Off	Off	Off	Off	Low	High
6	TEST REQ'D	Disarmed	Disarmed	Off	Off	On	Off	High	High

Events causing transfer between states of acknowledgment circuits.

From State No.	To State 1	2	3	4	5	6
1	CP, I, Y, N	A*				T
2	I	A*, CP, Y N, T	E			
3	I	A*	CP, T	Y	N	
4	CP, I	A*		Y, N, T		
5	CP, I	A*			Y, N, T	
6	I	A*				CP, Y, N, T

Operational signals (events) of acknowledgment circuits.

Event Symbol	Description
A	AR bit receipt
CP	CP bit receipt
I	Initializing signal receipt
E	Acknowledgment timer timeout
Y	YES button contact
N	NO button contact
T	Test button contact

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