

### 3 - REQUIREMENTS

#### 3.1 - Remote Acquisition Unit General Description

##### 3.1.1 - RAU Definition

The Remote Acquisition Units (Subsystem/Experiment) constitute the interface between the subsystems/experiments and the data busses of the Spacelab Command and Data Management Subsystem.

According to its function, the RAU is connected either to the subsystem data bus or to the experiment data bus.

The RAU's are connected to the data busses via interconnecting stations.

The RAU's are located as closed as possible to the interfacing experiments or subsystems, i.e. in the Aft Flight Deck, Module, Igloo and on the Pallet.

The RAU's of the same type shall be independently and directly interchangeable.

The subsystem RAU shall have the capability to become an experiment one by adding the experiment module and changing the internal harness.

##### 3.1.2 - RAU General Block Diagram

Figure 3.1.2 sketches the general block diagram of the Remote Acquisition Unit Connections.

The address of the RAU shall be provided by a wired plug.

##### DATA BUS

Any RAU is linked to the relevant Input/Output Unit through redundant two-way simplex data busses and via interconnecting stations.

##### USER TIME CLOCK

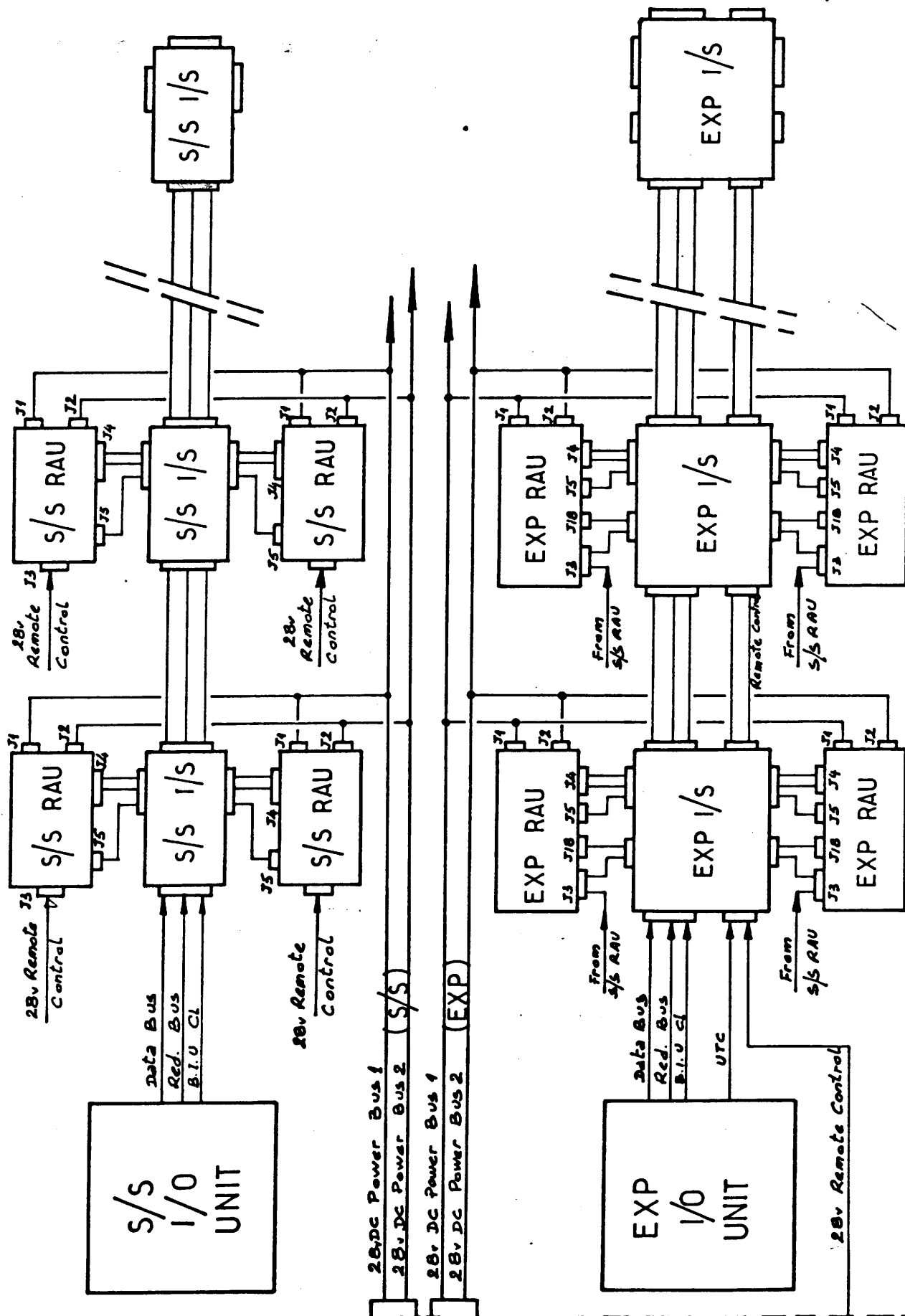
The Experiment type RAU shall be linked to the Experiment I/O Unit through a one-way simplex bus vehicling the user time clock via interconnecting stations.

##### POWER BUS

Any RAU is powered through 2 separate power DC busses.

FIG. 3.I.2. - GENERAL BLOCK DIAGRAM RAU CONNECTIONS

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3.1.3 - Remote Acquisition Unit Functions

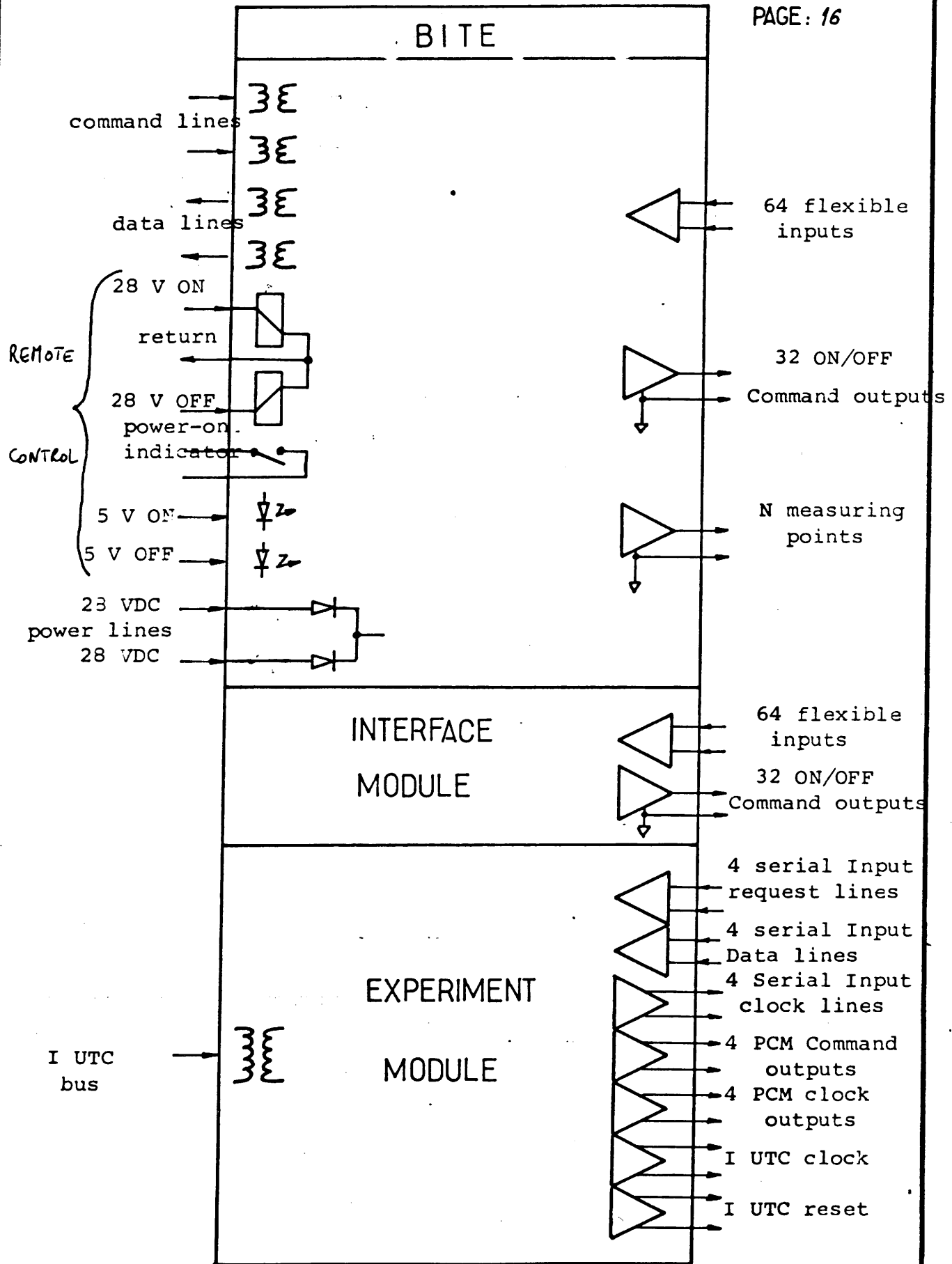
The Remote Acquisition Unit is an equipment which shall allow data acquisition and command from/to experiment/subsystem via the CDMS data busses.

Two types of RAU shall be provided. The subsystem RAU, which shall be the basis to build an experiment RAU, shall provide for the following functions :

- Address capability : 32 DCN
- Complete capability of decoding the 14 operation modes coming from the Input/Output Unit 02
- Acquisition of 128 flexible inputs in single or scanning mode
- 64 ON/OFF command outputs with power capability of 32 delivering 20 mA, 5V at a time DCN  
01
- Remote Control on and off
- Switch ON/OFF of the experiment module
- BITE and monitoring
- Electrical and mechanical capability to provide only for 64 flexible inputs and 32 ON/OFF command outputs by cancelling the so called interface module. DCN  
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The experiment RAU which shall be built-up by adding an experiment module to the subsystem RAU, shall provide for the S/S functions and the following :

- 4 serial input channels, each with gated clock output DCN  
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- 4 PCM command channels, each with gated clock output DCN  
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- 1 user time clock (UTC) channel 01



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### 3.2 - Remote Acquisition Unit Performances & Design Requirements

#### 3.2.1 - RAU Functional requirements

##### 3.2.1.1 - RAU operation

The data bus comprises two oneway lines (command and data) and is redundant. The first line is routing the command message coming from the I/O Unit and the other line is dedicated to data words coming from RAU's to the Input/Output Unit.

The data bus interfaces shall be redundant (BIU A & B) within the RAU, but only one shall be active. The activation control is performed by the BIU control line. On this line (TSP), the RAU receives either a short-circuit or an open circuit. If the short-circuit is present, the BIU A shall be powered on, and B OFF. If an open circuit is present, the BIU B shall be powered, and A OFF.

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The RAU address shall be defined by a wired plug on the connector J3, short-circuit pins in a binary code (5 bits).

##### 3.2.1.1.1 - Command Word

The command line is carrying the command message issued from the Input/Output Unit. This message is composed of one command word in acquisition modes and for test command and two words in command modes.

The command word is 17 bit-long, decomposed as follows :

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
RAU address					Operational code				Block number and sub-address							Pty

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Bits 0 - 4 : 5 bits for RAU address, binary-coded, M.S.B. first to arrive.

Bits 5 - 8 : Operational code.

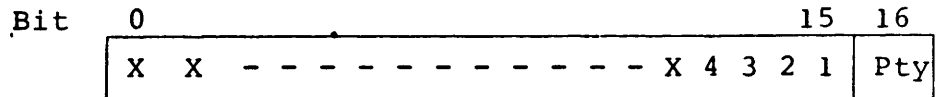
0000	OFF command
0001	ON command
0010	OFF command for modules
0011	ON command for modules
0100	PCM command <i>(used also as serial out)</i>
0101	TEST command
0110	Internal status word acquisition <i>(BITE)</i>
0111	Not used
1000	Serial input request acquisition
1001	Serial input acquisition
1010	Analog single mode
1011	Not used
110-	Analog scanning mode
111-	Discrete scanning mode

Bits 9 - 15: Input or output or input block address, binary-coded, MSB first to arrive.

These 7 bits shall allow to address the following :

Associated with 0000 or 0001 OP CODE	{ 64 ON/OFF command outputs, binary coded on the last six bits, i.e. the bit 9 is not used, M.S.B. first.
Associated with 0010 or 0011 OP CODE	{ 7 module address, N-of-7 coded. In particular, the experiment module address shall be 1000 000.
Associated with 0100 OP CODE	{ 4 PCM command outputs, binary-coded on the last two bits, M.S.B. first.
Associated with 0101 OP CODE	{ Test result which shall consist of 10 words.
Associated with 0110 OP CODE	{ 1 word defining the RAU internal status.

Associated with 1000 { 1 word defining the status of the serial  
OP CODE { input requests. Arranged as follows :



X = don't care

DCN  
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Associated with 1001 { 4 serial inputs, binary coded on the last  
OP CODE { two bits, M.S.B. first.

Associated with 1010 { 128 analog inputs, binary-coded as follows :  
OP CODE { first 3 bits for block number, last 4 bits  
for channel number, M.S.B. first.

Associated with 110 or 111 OP CODE, the bits 8 - 15 shall allow to  
address the following :

8 flexible input blocks, N-of-8 coded, i.e. :

- the bit 8 is relevant to the acquisition of the block n° 7
- the bit 9 is relevant to the acquisition of the block n° 6.
- the bit 15 is relevant to the acquisition of the block n° 0.

DCN  
0  
1

3.2.1.1.2 - Acquisition modes

The acquisition modes are those used to acquire data words from the RAU. The single mode shall allow to acquire one data word (2 analog channels or the internal status word or the S.I. request).

The internal status word shall be designed to isolate fault inside the main functions of the RAU. As a minimum, the internal status word shall contain the following :

- 5 bits RAU address
- 1 bit primary power undervoltage
- 1 bit UTC status
- 1 bit EXP module ON/OFF status
- 1 bit INT module connection status
- 1 bit ON/OFF command status in the core module
- 1 bit ON/OFF command status in the interface module
- 1 bit S.I. channel status
- 1 bit PCM command status
- 3 bits TBD.

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The internal status word shall be reset when sent to the data bus. The internal status word is acquired from two operational codes :

- 1) Internal status word acquisition (OP CODE 0110)
- 2) Test command (OP CODE 0101)

The scanning mode shall allow to acquire from 1 to 8 blocks of input channels. The acquisition shall be requested either in analog or in discrete sampling.

The serial input acquisition mode shall allow to acquire up to 32 data words from 1 out of 4 serial input.

#### 3.2.1.1.3 - Test Command

The test command shall initiate the Built-In-Test-Equipment (BITE) of the RAU. This shall generate analog voltages which shall be sampled, one per input multiplexer. Therefore 16 calibrated analog voltages, generated within the BITE, shall be scanned consecutively. The voltages shall be selected such that the linearity of the A/D converter is verified.

The BITE shall also generate a discrete word which shall be sampled, one bit per input multiplexer.

The connection of the BITE voltages to the input multiplexers shall be designed such that the greatest number of RAU input circuits are checked.

The test command shall also initiate the emission of the internal status word, which shall be reset after transmission onto the data bus.

Therefore the number of words emitted in test mode is 10 and they shall be arranged as defined in the figure 3.2.1.1.3.

#### 3.2.1.1.4 - Command modes

The command modes are used to send ON/OFF command or PCM command to an user.

An ON/OFF command shall create a logical level "1" or "0" at the addressed output line.

A PCM command shall allow to send on the addressed output line, up to 32 x 17 bit words.

Both command modes shall be acknowledged by the RAU.

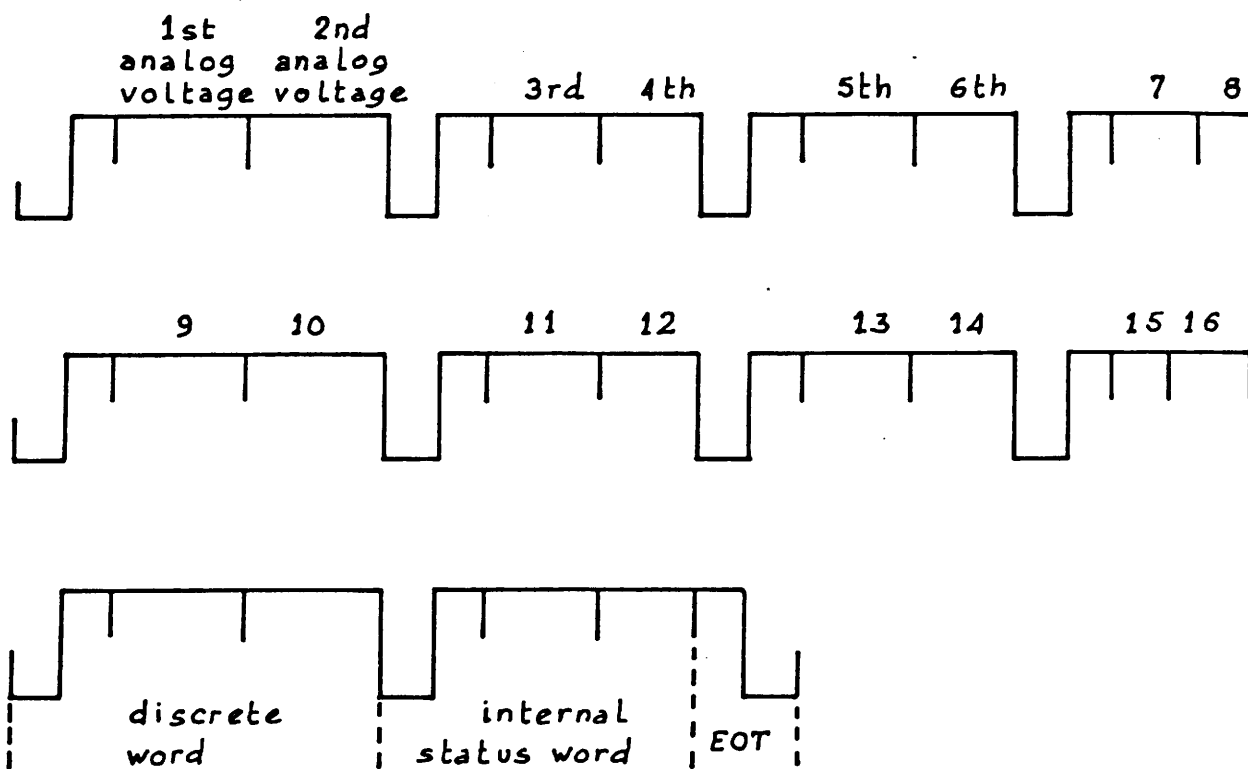


FIG. 3.2.I.I.3.

TEST MODE

3.2.1.2 - RAU Dialogues3.2.1.2.1 - Message exchange between RAU and I/O

Any message coming from/to the Input/Output Unit is routed via the data bus at 1 MPBS rate. The response time is defined as the time between the last bit received by the RAU and the first sync pulse emitted by the RAU.

The RAU shall verify the validity of the message (command or data sync pulse, Manchester-coded data, parity). If the received command word(s) is not considered as valid, it shall be ignored. If it is valid, the RAU shall turn in stand-by mode within a time  $\tau_0$  inferior to TBD  $\mu$ s and then if addressed, the RAU shall execute the command contained in the coming message.

D  
C  
N  
0  
2

The shapes of the command and data sync pulses are described in paragraph 3.6.2.

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NOTA : Definition of stand-by mode.

The stand-by mode is the operation mode which leads the RAU to the following : all input/outputs shall be quiescent, and the ON/OFF command outputs shall keep the previous state (logical level 1 or 0). No RAU emission is authorized, except UTC signals.

3.2.1.2.1.1 - Data acquisition message

In the acquisition modes, one command word preceded by a command synchronization pulse is routed from the data bus to RAU. The bit 5 of the acquisition message is always a logical "1", except internal status word acquisition.

D  
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0  
21) Single mode (see figure 3.2.1.2.1.1)

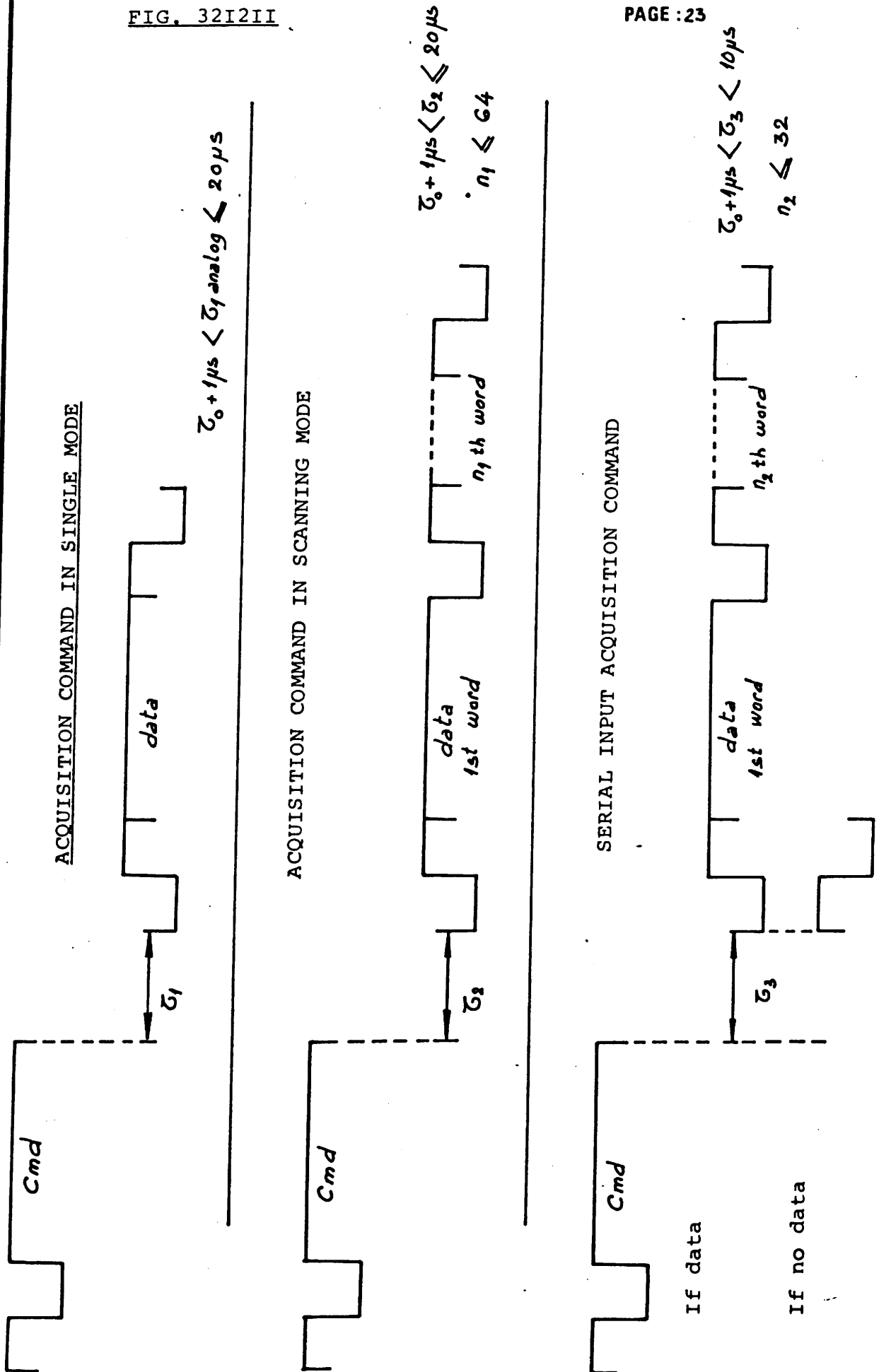
The RAU shall send back, into the data bus, a data word starting with a data sync pulse and finishing with a command sync pulse.

DCN  
01Analog acquisition (OP CODE 1010)

The data word is composed of the values of the analog consecutive even and odd channels, each one digitalized in 8 bits, plus the odd parity bit. The response time shall be less than 20  $\mu$ s, and more than  $\tau_0 + 1 \mu$ s.

D  
C  
N  
0  
2

FIG. 32I2II



2) Scanning mode (see the figure 3.2.1.2.1.1)

The RAU shall have an internal scanning scheme which scans successively all the input channel blocks which are addressed in the acquisition message by a N-of-8 code. The scanning mode shall achieve either a discrete acquisition (OP CODE 111) or an analog one (OP CODE 110). The data words are sent onto the data bus without gaps. The words are preceded by data sync pulses and the last word is followed by a command sync pulse. The response time shall be less than 20  $\mu$ s and more than  $\tau_0 + 1 \mu$ s. The RAU shall not answer if the block address is all "0", i.e. no block is addressed.

DCN  
033) Serial input acquisition (OP CODE 1001)

The RAU shall transfer back onto the data bus the serial input data coming from the serial input channel addressed, if the relevant request line is high and if no parity error is detected at the level of user's data words.

The user's data are formatted by the RAU into data words compatible with the data bus dialogue : consecutive data words (sync + data + parity) without gaps.

The words are preceded by data sync pulses and the last word is followed by a command sync pulse, called End of Transmission (EOT).

If a parity error is detected by the RAU at the level of user's data words, the RAU shall stop the transmission to the data bus, but shall not send any EOT.

The last word shall be formatted when the request input line falls down to zero or when the 32 word time out is finished.

If the request line falls down inside a word, the RAU shall accept the complete incoming user's word.

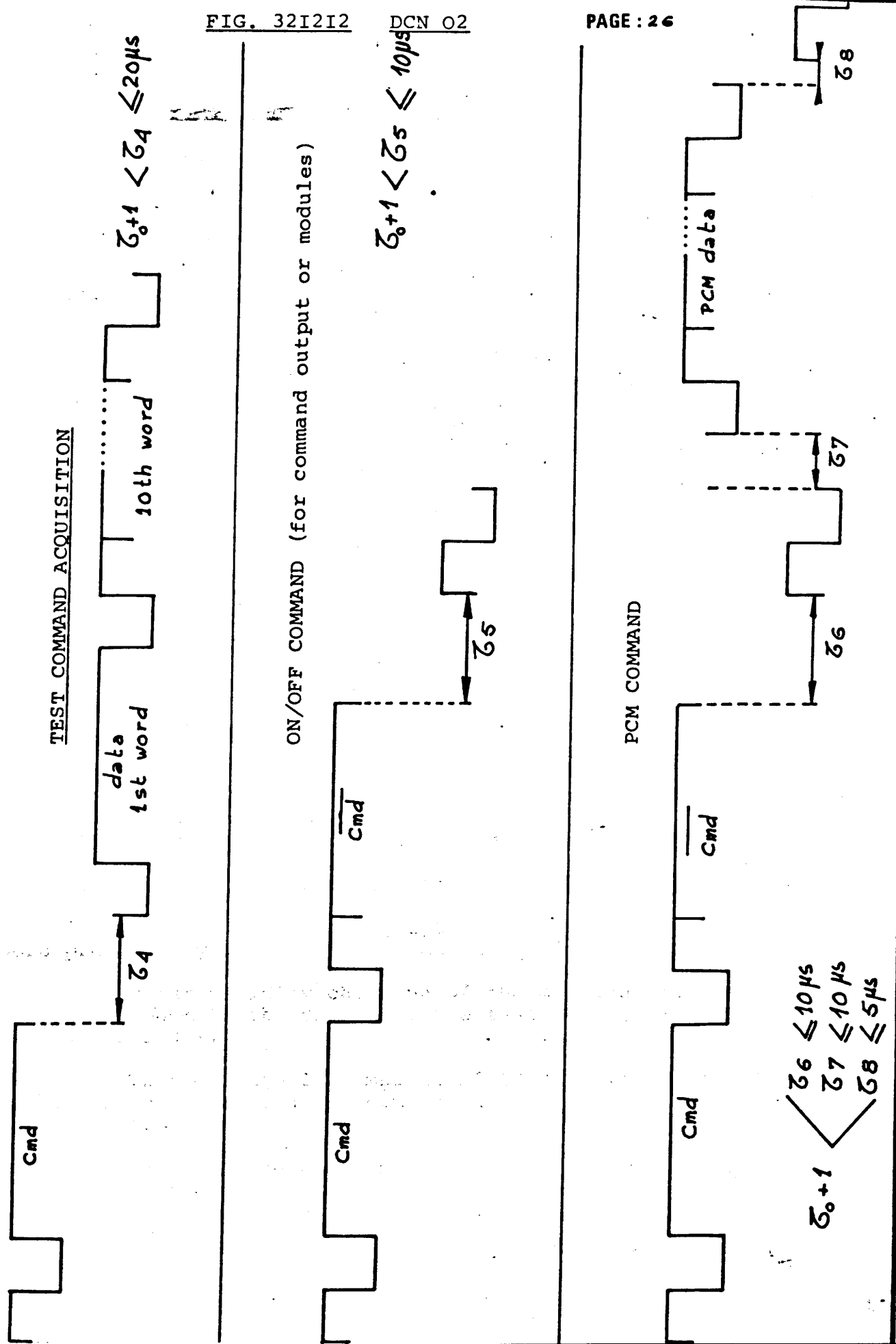
The response time shall be less than 10  $\mu$ s and more than  $\tau_0 + 1 \mu$ s.

DCN  
024) Serial input request acquisition

Upon reception of the OP CODE 1000, the RAU shall send back onto the data bus one data word containing the status of the four S.I. request lines.



FIG. 32I2I2 DCN 02



- 1) ON command (OP CODE 0001)  
OFF command (OP CODE 0000)

DCN  
002

The command order is transmitted on the addressed output line within a response time less than 10  $\mu$ s and held until the opposite order is issued by the Input/Output Unit.

- 2) PCM command (OP CODE 0100)

The RAU shall store the output line address decoded from the command word and then shall expect for PCM message coming from the command line.

DCN  
001

The RAU shall check the PCM message validity at the same time as the RAU transmits the PCM words (16 data bits + 1 parity bit) to the addressed output. If the message is recognized erroneous at any time, the RAU stops the transmission to the user. The PCM message is composed of data words (17 bits) preceded, each one, by a data sync pulse. The message is terminated by an end of transmission pulse which is a command sync pulse. This EOT shall initiate the interruption of the transmission RAU-USER. If the complete message is valid, the RAU shall send back to the data bus an acknowledgment pulse (command sync pulse). The response time for this acknowledgment pulse shall be less or equal to 5  $\mu$ s.

DCN  
002

The propagation time  $T_p$  between the PCM message incoming into the RAU and the PCM message outgoing towards the user shall be less than 5  $\mu$ s.

DCN  
003

- 3) ON command for modules (OP CODE 0011)  
OFF command for modules (OP CODE 0010)

The RAU shall execute the order by switching ON or OFF the addressed module. The experiment module (address 1000 000) is the only module addressed.

DCN  
002

### 3.2.1.2.1.3 - Test command message (OP CODE 0101)

The test command message is composed of one command word preceded by a command sync pulse.

After validity checking of the message, the RAU shall send back to the data bus, the test message as defined in chapter 3.2.1.1.

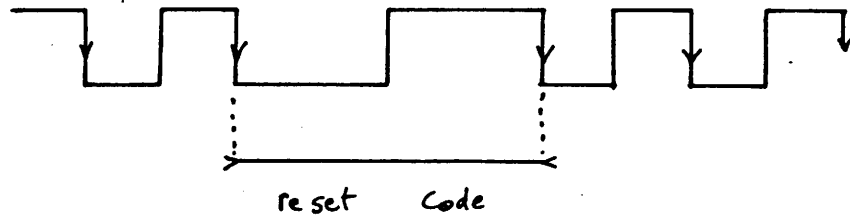
This message is composed of 10 data words preceded by data sync pulse, and is terminated by a command sync pulse (EOT).

The response time shall be less than 20  $\mu$ s and more than  $\tau_0 + 1 \mu$ s.

DCN  
001

**3.2.1.2.1.4 - Time clock message**

The time clock message is a continuous 1024 kHz clock signal including every 250 ms a reset code which has the following shape :



with an overall duration equal to 2 clock periods.

### 3.2.1.2.2 - Message exchange between RAU and User

Besides the flexible inputs, the RAU interfaces with the user via the ON/OFF command outputs, the PCM outputs and the serial Input channels and the User Time Clock.

#### 1) ON/OFF command (see the figure 3.2.1.2.2.1)

When the RAU decodes a command ON, it shall rise a logical "1" level at the addressed output line and hold this level until an opposite order is decoded.

In case of command OFF, the RAU shall set to zero level the addressed output line and hold this level until an opposite order is decoded.

#### 2) PCM command (see the figure 3.2.1.2.2.2)

The PCM command lines shall be associated with the PCM clock lines. The clock and the PCM message shall be sent to the user, NRZ-coded and synchronised: the down transition of the clock shall be at the middle of the bit with a tolerance of  $\pm 10\%$ . The addressed output line shall be switched-on when the first acknowledgment pulse is sent to the I/O Unit and switched-off when the RAU receives the EOT from the I/O Unit.

The data and the clock shall be sent by burst of 17 { bits (data + parity) on the PCM outline } separated with  
{ clock pulses on the clock outline }  
gaps of  $3 \mu s \pm 0.1\%$ . The frequency is  $1 \text{ MHz} \pm 0.1\%$ . | DCN  
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#### 3) Serial Input Transfer (see the figure 3.2.1.2.2.3)

Each serial input data line shall be associated with a clock line and a request line.

The request signal is a logical "1" level as long as the user wants to send data, and falls down to the logical "0" level when the user stops transmission.

The clock signal is a burst of 17 clock pulses at  $1 \text{ MHz} \pm 0.1\%$  separated with gaps of  $3 \mu s \pm 0.1\%$  sent by the RAU when the serial acquisition command is decoded by the RAU.

The clock signal shall be stopped from two reasons:

- The request signal is at the "zero" level
- A parity error is detected inside user's data words.

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The data coming from the user shall be NRZ-coded and synchronized with the RAU clock as follows : the bit transition occurs at the up transition of the clock, -0/+200 ns.

The first bit of the serial data word shall be present on line before the emission of the clock signal from the RAU.

The data word shall be 17 bitlong. The RAU shall check the odd parity bit (17th) of the incoming word. As soon as a parity error is found the RAU stops the exchange with the user by stopping the emission of the clock pulses.

#### 4) User time clock

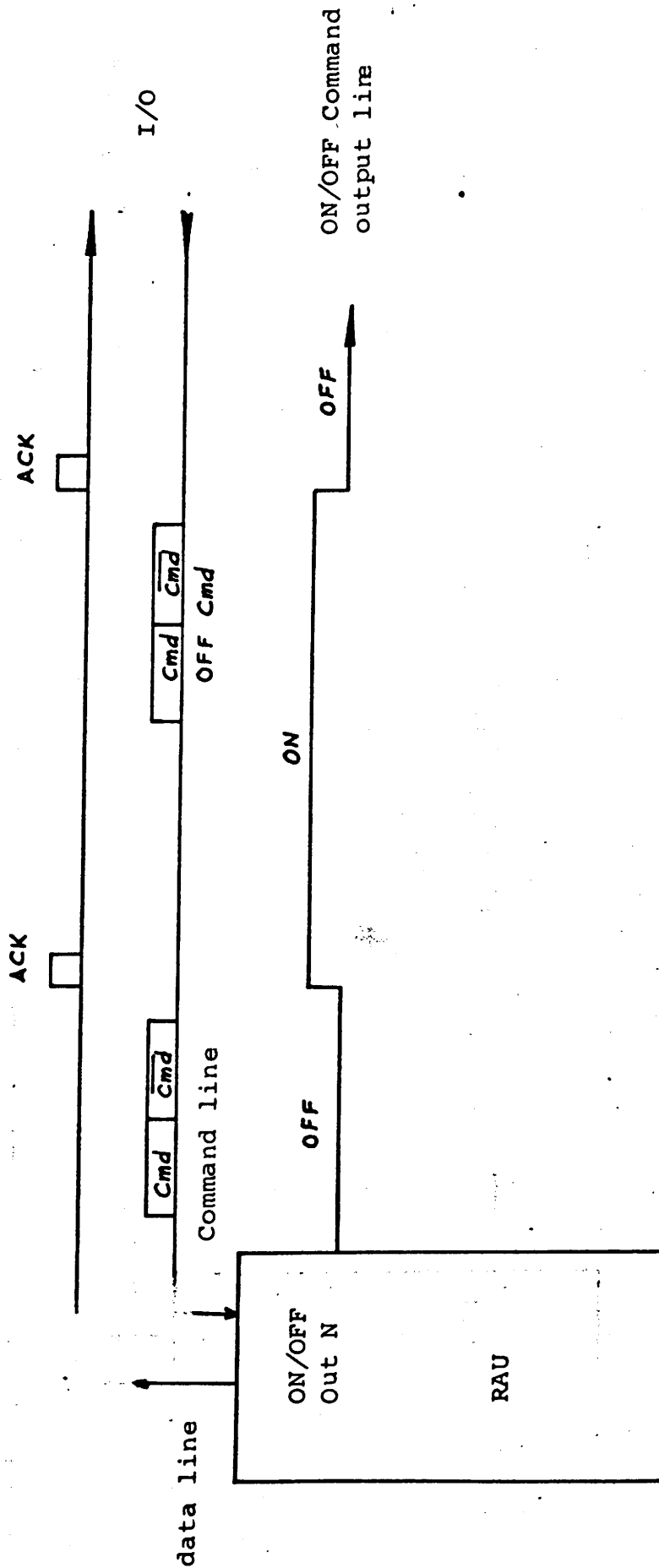
The RAU shall send to the user time clock line a continuous 1024 kHz clock, delayed by less than 500 ns with respect to the incoming clock signal from the clock bus.

On the other line, called reset pulse line, the RAU shall send to the user a four clock pulse pattern, an integer number of clock <sup>transitions</sup> after the reception of the reset code on the clock bus, when the reset code is considered valid. This number shall be less than two.

The signals delivered to the user are sketched in the figure 3.2.1.2.2.4, with the associated response times.

The validity of the received reset pulse is specified in paragraph 3.2.2.1.8.

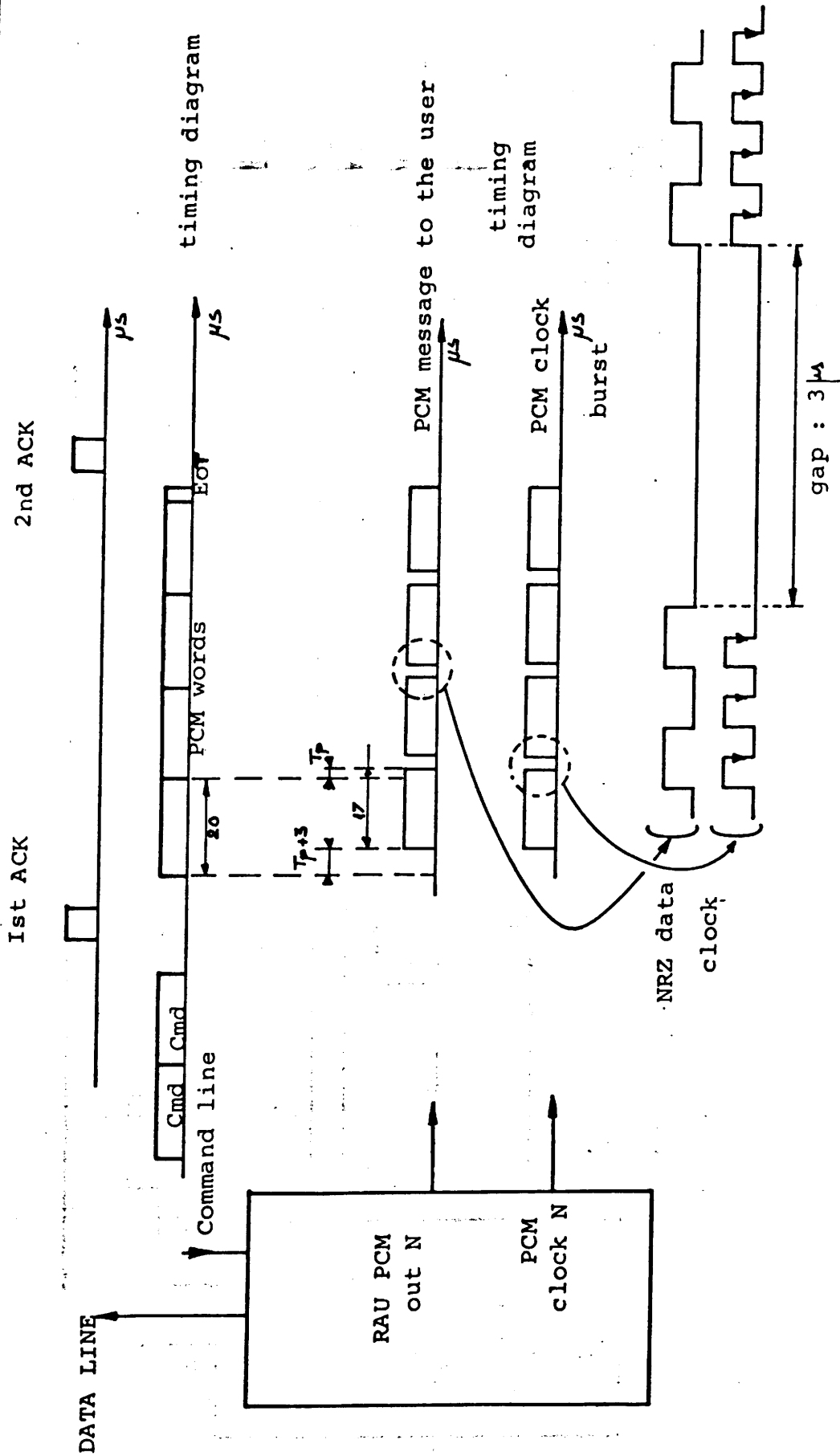
DCN  
001



ON/OFF COMMAND

RAU - USER DIALOGUE

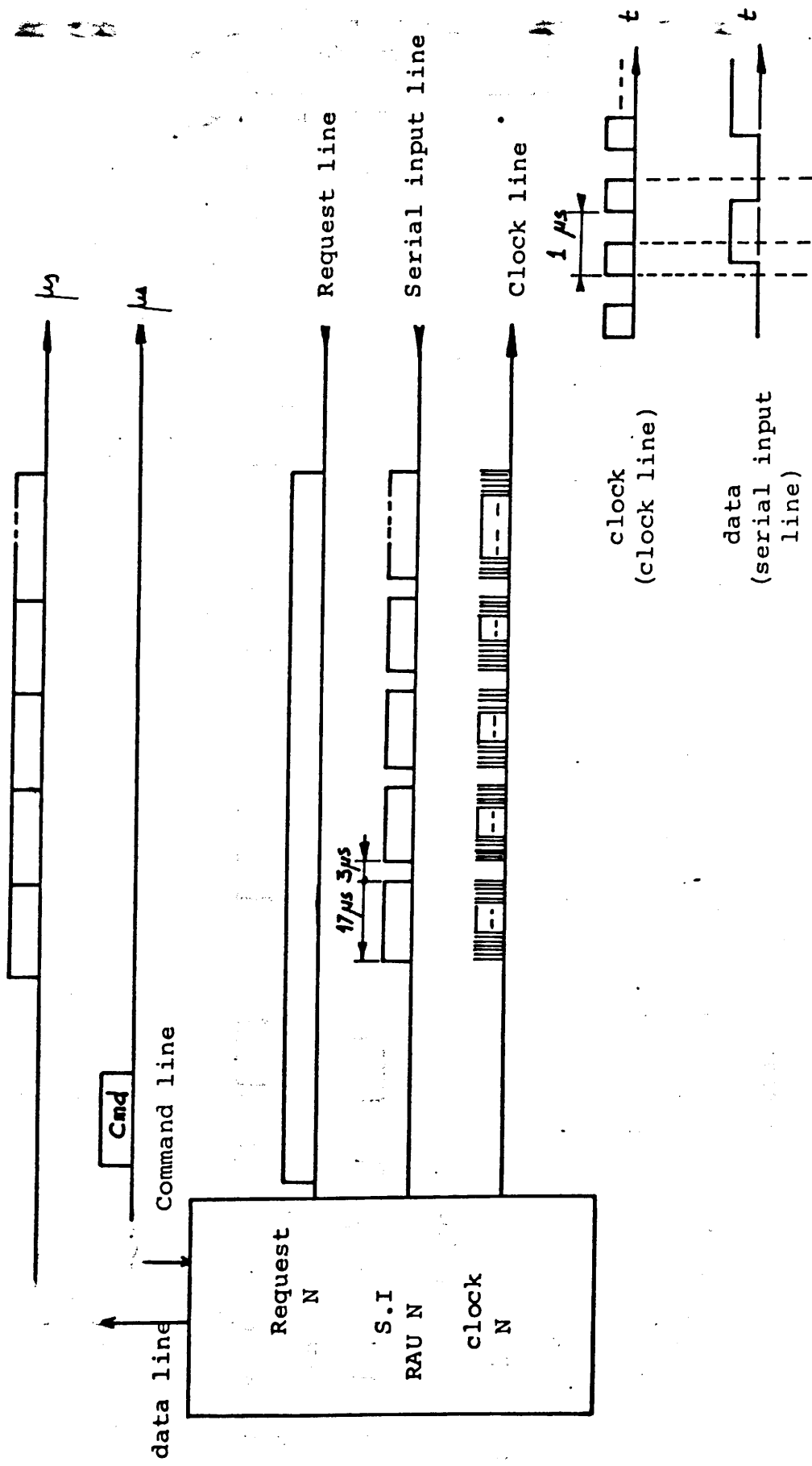
FIG. 32I24I



PCM COMMAND RAU- USER DIALOGUE

fig. 32I 222

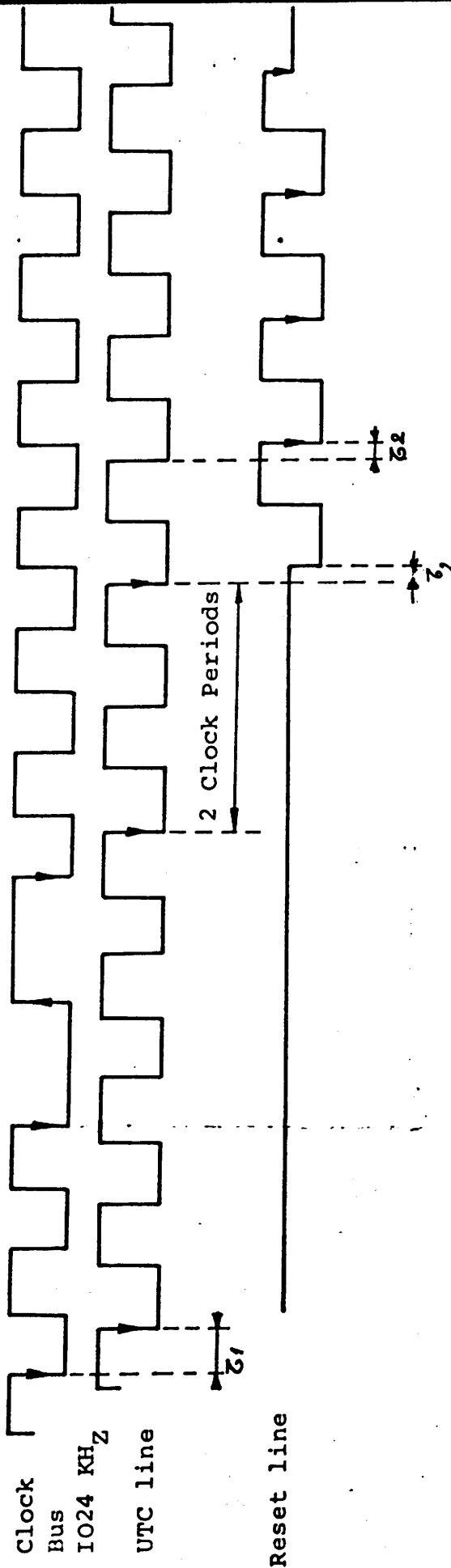
DCN  
01



SERIAL INPUT TRANSFER

RAU - USER INTERFACES

FIG. 32I233



$0 < T_1 < 500 \text{ ns}$   
Jitter -  $50 \text{ ns} < T_2 < 50 \text{ ns}$

UTC TIMING

FIGURE 3.2.1.2.2.4.

DCN  
01