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RETE TELEMETRY LAYOUT

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IFSI-90-28 September 1990

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Frascati, May 16th 1990

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1. INTRODUCTION

The RETE (Research on Electrodynamic Tether Effects) experiment is a joint collaboration between the Italian IFSI in Frascati, the French Observatorie de Paris, and the Space Science Department of ESA. The objective of the instrument is to investigate the plasma AC and DC phenomena's surrounding the TSS satellite during the TSS-1 mission.

2. RETE CONFIGURATION

The RETE experiment consists of two canisters each mounted on the tip of the DRB's (Deployable / Retrievable Boom's). One canister, named the ACBP (AC Boom Package), measures the AC phenomena in the frequency range from 200Hz to 12 Mhz while the other canister, named the DCBP (DC Boom Package), measures the DC phenomena in the frequency range from DC to 200 Hz.

The controlling and the operation of the two canisters are done via two micro processor units mounted on the payload floor of the TSS satellite. One unit, named the DCE (DC electronics), controls the operation of the DCBP while the other unit, named the DPU (Data Processing Unit), controls the operation of the ACBP. The RETE AC and DC part can be regarded as two self-contained experiments that just share a common Telemetry format. The DCE unit will at the completion of its acquisition cycle, parse the data to the DPU for packing into the overall RETE Telemetry format. Likewise any Telecommands send to the RETE experiment concerning the DC part will be parsed from the DPU to the DCE for further execution.

3. SUMMARY OF RETE MODES OF OPERATIONS

An accurate description of the RETE modes of operation,the data which are acquired in each mode and the time resolution is contained in Ref. 1. Here we will give just a summary description of the main modes to be used in the baseline of RETE operations.All of these, except NM (Normal Mode), are accessible only by TLC.

SUMMARY OF RETE MODES OF OPERATION

NM :

When RETE is powered on it goes into a default mode of operation called Normal Mode (NM). In this mode simultaneous ac and dc measurements are taken. The ac measurements refer to the three different frequency ranges (LF,MF,HF) with a cyclical rotation between sensors on the different axes. With no other telecommand, RETE would remain in this mode of operation. If this mode is not interrupted by TLC,in the last 6 of every 64 formats,a change takes place automatically to Mode PP3 (200 Hz waveform mode) which is more DC dedicated (see below).

MODE 1 :

This is the Normal Mode NM except that the experiment does not switch automatically to PP3 in the last 6 of every 64 formats.

NM1:

By this we denote several possible variations on the mode NM.
a) a given sensor can be chosen in the LF range.
b) a given sensor pair can be fixed in the MF frequency range.
c) a given sensor can be fixed in the HF range.
d) we can fix a frequency in the HF range and have high resolution measurements around that frequency.
e) we can select the gain in the attenuators.

These possibilities will be denoted below by NM1a-e.

PP2:

Mode dedicated to mostly to plasma package data and, in particular, to a survey of the effect of varying the penthode equivalent resistance. AC data are acquired only in LF range, in the same way as in NM.

PP3:

Mode dedicated mostly to waveform samplying of E at 340 Hz rate. AC data are acquired only in LF range, in the same way as in NM.

WFC:

Waveform capture mode dedicated to fast data acquisition (either tether current or IF signals) using the DPU memory buffer. This mode is in turn divided into different submodes :

a) immediate acquisition
b) MF chain acquisition
c) tether current acquisition.

CAL:

Calibration mode: it can be actuated by telecommand. Otherwise, it is actuated, for 2 formats every 514 formats,when the experiment is in NM.

4. RETE TELEMETRY LAYOUT

The DPU is the interface between the RETE experiment and the OBDH (On Board Data Handling) Unit and as such responsible for the RETE Telemetry format. The RETE Telemetry format consist of 3520 bytes of data which is sent to the OBDH every 16 seconds. As one complete RETE acquisition cycle will last for 32 seconds it takes two RETE Telemetry formats before the data will repeat. The RETE acquisition cycle is mainly determined by the AC part as the DC part acquisition cycle has a shorter duration. Consequently, the DC acquisition cycle will be repeated several times in the overall RETE acquisition cycle.

The RETE telemetry record (2 TLM formats) has three different structures, depending on the operational mode, as indicated below.

TLM RECORD TYPE	OP. MODES
1	NM, NM1, NM2, NM3, CAL
2	PP2, PP3
3	WFC

Ref. [1] contains a detailed description of the operational modes of RETE experiment.
The basic structure of each type of TLM record is shown below.

Note: one word = 16 bit = 2 byte.

TLM RECORD 1

Normal and calibration mode (NM, NM1a-e, CAL)

FORMAT 0

1 w	Header format 0	1
28 w	Attenuator status table	2-29
1 w	Header 0	30
85 w	LF chain data	31-115
1 w	Header 1	116
3404 w	MF chain data	117-3520

FORMAT 1

1 w	Header format 1	1
1876 w	MF chain data (cont.)	2-1877
1 w	Header 2	1878
384 w	HF chain data	1879-2262
1 w	Header 3	2263
1050 w	Plasma package data	2264-3313
52 w	Spare	3314-3365
17 w	Housekeeping data (1)	3366-3382
128 w	Housekeeping data (2)	3383-3510
10 w	Error table	3511-3520

TLM RECORD 2

Mode PP2 and PP3

FORMAT 0

1 w	Header format 0	1
28 w	Attenuator status table	2-29
1 w	Header 0	30
85 w	LF chain data	31-115
1 w	Header 3	116
3404 w	Plasma Package data	117-3520

FORMAT 1

1 w	Header format 1	1
3364 w	PP data (cont.)	2-3365
17 w	Housekeeping data (1)	3366-3382
128 w	Housekeeping data (2)	3383-3510
10 w	Error table	3511-3520

TLM RECORD 3

Mode WFC

FORMAT 0

1 w	Header format 0	1
3519 w	AC waveform data	2-3520

FORMAT 1

1 w	Header format 1	1
3519 w	AC waveform data	2-3520

In the following, making reference to one or the other of the three basic double format structures shown above,we will detail,for each experiment mode how the various data are to be found in the telemetry.

==

4.1 HEADER AND HEADER FORMAT LAYOUT

HEADER FORMAT 0

bit

d15-d12: not significant

d11-d2 : page number. It specifies the format number in NM, PP3 and WFC. It ranges between 0-513 in NM and PP3, and between 0-4 in WFC mode.

d1-d0 : mode.

0 0	NM and PP3
0 1	WFC immediate acquisition
1 0	WFC MF chain acquisition
1 1	WFC tether current acquisition

HEADER 0

bit

d15-d13: 0 0 0

d12-d4 : not significant.

d3 : sensor activation mode.

0	automatic sensor selection
1	sensor forced by telecommand

d2-d0 : selected sensors.

	Automatic selection	Sensor forced by TLC
0 0 0	Bx Bx Bz Bz Ex	Ex
0 0 1	Bz Bz Ex Ex Ey	Ey
0 1 0	Ex Ex Ey Ey Ez	Ez
0 1 1	Ey Ey Ez Ez Bx	Bx
1 0 0	Ez Ez Bx Bx Bz	Bz
1 0 1	Calibration	
1 1 0	automatic. calibration	

HEADER 1

bit

d15-d13: 0 0 1

d12-d6 : not significant

d5-d3 : selected sensor 1 (see below)

d2-d0 : selected sensor 2 (see below)

The selected sensors (1 and 2) are identified by bits d5-d3 and d2-d0 according to the following scheme:

0 0 0	Ex
0 0 1	Ey
0 1 0	Ez
0 1 1	Bx
1 0 0	Bz
1 1 1	All combinations of sensor pairs, in the sequence: ExEy ExEz ExBx ExBz EyEz EyBx EyBz EzBx EzBz BxBz

---

HEADER FORMAT 1

Same structure as HEADER FORMAT 0.

HEADER 2

bit

d15-d13 0 1 0

d12-d3 not significant

d2 : sensor activation mode.
0 automatic sensor selection
1 sensor forced by telecommand

d1-d0 : selected sensors.

	Autom. selection	Sensor forced by TLC
0 0	Ez Bz Ex	Ex
0 1	Bz Ex Ey	Ey
1 0	Ex Ey Ez	Ez
1 1	Ey Ez Bz	Bz

HEADER 3

bit

d15-d13 0 1 1

d12-d2 not significant

d1-d0 Plasma package mode

0 0 mode 1 (PP1)
0 1 mode 2 (PP2)
1 0 mode 3 (PP3)

===

4.2 ATTENUATOR STATUS TABLE LAYOUT

For each sensor in each frequency band, an attenuation of 0 or 40 dB is automatically selected by the DPU or forced with a telecommand. 56 bytes are allocated for the attenuator status, according to the following table:

	A	B	C1	D1	E1	F1	C2	D2	E2	F2	HF
Ex	1	2	3	4	5	6	7	8	9	10	11
Ey	12	13	14	15	16	17	18	19	20	21	22
Ez	23	24	25	26	27	28	29	30	31	32	33
Bx	34	35	36	37	38	39	40	41	42	43	44
Bz	45	46	47	48	49	50	51	52	53	54	

The last two bytes (55 and 56) are not used and set to zero.

===

4.3 HOUSEKEEPING AND ERROR TABLE LAYOUT

4.3.1 HOUSEKEEPING DATA (1)

The following housekeeping signals are acquired by the DPU every 16 seconds (1 format) and converted into 8 bit data:

byte

1 WRA temperature monitor
2 SYNTH control voltage
3 +5V DCE monitor
4 +15V DCE monitor
5 -15V DCE monitor
6 +6V WRA digital filters monitor
7 -6V WRA monitor
8 -18V WRA monitor

9	+6V WRA receiver monitor
10	RETE current monitor
11	+5V DPU monitor
12	+12V DPU monitor
13	-12V DPU monitor
14	DPU internal temperature monitor
15	ACBP temperature monitor
16	DCE temperature monitor
17	Reference supply monitor

18-34 As above (second acquisition, 16 s later)

4.3.2 HOUSEKEEPING DATA (2)

The following housekeeping signals are acquired by the DPU every 0.512 seconds and converted into 12 bit data:

byte	
0-1	penthode current monitor (1 word - 12 bit used)
2-3	DCBP potential (1 word - 12 bit used)
4-5	penthode current monitor (1 word - 12 bit used)
6-7	DCBP potential (1 word - 12 bit used)
.	.
.	.
.	.
252-253	penthode current monitor (1 word - 12 bit used)
254-255	DCBP potential (1 word - 12 bit used)

4.3.3 ERROR TABLE

word	bit	
0 (DPU)	d15-d2	not significant
	d1	0 = ok; 1 = RAM address line error
	d0	0 = ok; 1 = checksum error
1 (DCE)	d15-d9	not significant
	d8	0 = ok; 1 = exceeding data
	d7-d3	not significant
	d2	0 = ok; 1 = overrun error
	d1	0 = ok; 1 = framing error
	d0	0 = ok; 1 = parity error
2 (TO)	d15-d3	not significant
	d2	0 = ok; 1 = HF time out
	d1	0 = ok; 1 = MF time out
	d0	0 = ok; 1 = LF time out
3 (TLM)	d15-d1	not significant
	d0	exceeding sampling

4 (TLM)	telecommand echo
5-9	spare

===

4.4 AC TELEMETRY LAYOUT (MODE NM)

4.4.1 LF CHAIN DATA

The active sensors are given in HEADER 0. The first sensor acquires data always in band A. The acquisition sequence of bands and sensors is:

A1 B1 A2 B2 A3 (see fig. 2 of Ref.[1]).

The LF chain data are organized as follows:

byte	
1-16	spectrum (16 channels) band A sensor 1
17	AGC level band A sensor 1
18-33	spectrum (16 channels) band B sensor 1
34	AGC level band B sensor 1
35-50	spectrum (16 channels) band A sensor 2
51	AGC level band A sensor 2
52-67	spectrum (16 channels) band B sensor 2
68	AGC level band B sensor 2
69-84	spectrum (16 channels) band A sensor 3
85	AGC level band A sensor 3

The data are stored in logarithmic form (mantissa + exponent) according to the scheme described in Note 1.

4.4.2 MF CHAIN DATA

In NM, MF chain data contain auto-spectra of each sensor and cross-spectra of all sensor pairs. Ten subcycles of 3.2s and 1056 byte each are performed in a complete acquisition cycle. Each subcycle contains the following number of acquisitions in each band:

Band	N. of acquisitions
C	1
D	1
E	4
F	10

The time ordering of the acquisitions is as above, i.e. C,D,E,F (see fig. 4 and 5 of Ref. 1).

In order to simplify the explanation of the MF telemetry, let us denote each sensor pair with an index j according to the following table:

ExEy	ExEz	ExBx	ExBz	EyEz	EyBx	EyBz	EzBx	EzBz	BxBz	sensor pair
1	2	3	4	5	6	7	8	9	10	id index

The two sensors of the sensor pair will be indicated with the indexes 1 and 2 respectively. The data of the n-th subcycle (0 <= n <= 9) are found from byte 1056*n to byte 1056*(n+1)-1 and are organized as follows:

```
byte

------------ band C  sensor pair n ----------------------------------------
0-15         spectrum (16 channels) band C sensor n1
16-31        spectrum (16 channels) band C sensor n2
32-47        cosine cross spectrum (16 channels) band C sensors n1n2
48-63        sine cross spectrum (16 channels) band C sensors n1n2
64           AGC level band C sensor n1
65           AGC level band C sensor n2

------------ band D  sensor pair n ----------------------------------------
66-81        spectrum (16 channels) band D sensor n1
82-97        spectrum (16 channels) band D sensor n2
98-113       cosine cross spectrum (16 channels) band D sensors n1n2
114-129      sine cross spectrum (16 channels) band D sensors n1n2
130          AGC level band D sensor n1
131          AGC level band D sensor n2

------------ band E sensor pairs j=mod(4*n+1,10), ..., j=mod(4*n+4,10) -----
132-147      spectrum (16 channels) band E sensor j1
148-163      spectrum (16 channels) band E sensor j2
164-179      cosine cross spectrum (16 channels) band E sensors j1j2
180-195      sine cross spectrum (16 channels) band E sensors j1j2
196          AGC level band E sensor j1
197          AGC level band E sensor j2

198-263      same as above but for sensor pair j=mod(4*n+2,10) (band E)
264-329           "    "    "     "      "   j=mod(4*n+3,10)     "
330-395           "    "    "     "      "   j=mod(4*n+4,10)     "

------------ band F sensor pairs 1-10 -------------------------------------
396-411      spectrum (16 channels) band F sensor Ex
412-427      spectrum (16 channels) band F sensor Ey
```

428-443	cosine cross spectrum (16 channels) band F sensors ExEy
444-459	sine cross spectrum (16 channels) band F sensors ExEy
460	AGC level band F sensor Ex
461	AGC level band F sensor Ey
462-527	same as above, but for sensor pairs 2 (ExEz) (band F)
528-593	same as above, but for sensor pairs 3 (ExBx) (band F)
594-659	same as above, but for sensor pairs 4 (ExBz) (band F)
660-725	same as above, but for sensor pairs 5 (EyEz) (band F)
726-791	same as above, but for sensor pairs 6 (EyBx) (band F)
792-857	same as above, but for sensor pairs 7 (EyBz) (band F)
858-923	same as above, but for sensor pairs 8 (EzBx) (band F)
924-989	same as above, but for sensor pairs 9 (EzBz) (band F)
990-1055	same as above, but for sensor pairs 10 (BxBz) (band F)

In other words, the following acquisitions (each containing two auto-spectra, cosine and sine cross-spectra and AGC words) are performed in a telemetry format (32 s) in MF chain:

Band C	Band D	Band E	Band F	
----------	----------	----------	----------	Subcycle 1
ExEy	ExEy	ExEy	ExEy	
		ExEz	ExEz	
		ExBx	ExBx	
		ExBz	ExBz	
			EyEz	
			EyBx	
			EyBz	
			EzBx	
			EzBz	
			BxBz	
----------	----------	----------	----------	Subcycle 2
ExEz	ExEz	EyEz	ExEy	
		EyBx	ExEz	
		EyBz	ExBx	
		EzBx	ExBz	
			EyEz	
			EyBx	
			EyBz	
			EzBx	
			EzBz	
			BxBz	
----------	----------	----------	----------	Subcycle 3
ExBx	ExBx	EzBz	ExEy	
		BxBz	ExEz	
		ExEy	ExBx	
		ExEz	ExBz	
			EyEz	
			EyBx	

			EyBz
			EzBx
			EzBz
			BxBz

--- Subcycle 4

ExBz	ExBz	ExBx	ExEy
		ExBz	ExEz
		EyEz	ExBx
		EyBx	ExBz
			EyEz
			EyBx
			EyBz
			EzBx
			EzBz
			BxBz

--- Subcycle 5

EyEz	EyEz	EyBz	ExEy
		EzBx	ExEz
		EzBz	ExBx
		BxBz	ExBz
			EyEz
			EyBx
			EyBz
			EzBx
			EzBz
			BxBz

--- Subcycle 6

EyBx	EyBx	ExEy	ExEy
		ExEz	ExEz
		ExBx	ExBx
		ExBz	ExBz
			EyEz
			EyBx
			EyBz
			EzBx
			EzBz
			BxBz

--- Subcycle 7

EyBz	EyBz	EyEz	ExEy
		EyBx	ExEz
		EyBz	ExBx
		EzBx	ExBz
			EyEz
			EyBx
			EyBz
			EzBx
			EzBz
			BxBz

--- Subcycle 8

EzBx	EzBx	EzBz	ExEy
		BxBz	ExEz

		ExEy	ExBx
		ExEz	ExBz
			EyEz
			EyBx
			EyBz
			EzBx
			EzBz
			BxBz

-- Subcycle 9

EzBz	EzBz	ExBx	ExEy
		ExBz	ExEz
		EyEz	ExBx
		EyBx	ExBz
			EyEz
			EyBx
			EyBz
			EzBx
			EzBz
			BxBz

-- Subcycle 10

BxBz	BxBz	EyBz	ExEy
		EzBx	ExEz
		EzBz	ExBx
		BxBz	ExBz
			EyEz
			EyBx
			EyBz
			EzBx
			EzBz
			BxBz

From the above scheme, it appears that, in band C and D, only one sensor pair is selected in each subcycle, simply following the order:

subcycle n --> sensor pair n

In band F, all ten sensor pairs are acquired in each subcycle. For band E the sensor rotation is more complicated, with four sensor pairs cyclically selected among the standard set of ten sensor pairs.

MF chain data are found at the bottom of FORMAT 0 and at the top of FORMAT 1. 10560 byte are allocated for MF chain in NM: 6808 are found in FORMAT 0 and 3752 in FORMAT 1. FORMAT 0 ends with the channel 10, Ex auto-spectrum of sensor pair ExEz, band F, subcycle 6.

The data are stored in the form mantissa+exponent as indicated in the Note 1.

4.4.3 HF CHAIN DATA

It contains auto-spectra (256 channels each) measured by three sensors. The possible combinations are listed above (HEADER 2 bits d1-d0).

byte		
1-256	256 channel spectrum	sensor 1
257-512	"	sensor 2
512-768	"	sensor 3

No conversion in logarithmic form is performed.

NOTE 1

The LF and MF autocorrelation data are compressed into floating-point form according to the following formula:

N = (8+M) * 2**[E-3]

E (exponent) is the decimal value of the 5 MSB's of the telemetered byte and M (mantissa) is the decimal value of the 3 LSB's. The "8" can be considered as an understood "1" before the mantissa bits. AS N can be a very large number, it is preferred to convert it into a pseudo-logarithmic scale. The simplest law is to take the log base 2 (indicated as log2 in the following). This is multiplied by a factor of 10 in order to remain with integer arithmetic.
One can proceed as follows:

```
We desire:          I = 10 * log2 N =
                      = 10 * (E-3) + 10 * log2 (8+M) =
                      = 10 * E + 10 * log2 (1+M/8)
```

The second part of the expression is obtained by an 8-entry lookup table. A sample FORTAN code could be:

```
      implicit integer (a-z)
      dimension table(8)
      data table /0,2,3,4,5,6,7,8,9/
      E = (tmword.and."370)/8        ! 370 = 11111000 binary
      M = (tmword.and."7)            !   7 = 00000111 binary
      j = M+1
      I = 10*E+table(j)
```

The MF cross-correlation data are signed 8-bit floating-point data. The formula is the same as for the (unsigned) auto-correlation data, with the sign bit transmitted in place of the LSB. The above sample program could be modified as follows:

```
      implicit integer (a-z)
      dimension table(8)
      data table /0,2,3,4,5,6,7,8,9/
```

```
sign = 1
E = (tmword.and."370)/8
M = (tmword.and."7)
if(xcorr.eq.'y') then
 M = M.and."6
 sign = 1-2*(tmword.and."1)
endif
j = M+1
I = 10*E+table(j)
```

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4.5 AC TELEMETRY LAYOUT (MODE NM1a-d)

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The above description of AC telemetry for the normal mode NM holds also for modes NM1a-d, with the following variations:

mode NM1a: all measurements in LF are carried out by a sensor selected with a telecommand; the selected sensor is indicated in HEADER 0. Hence, all LF telemetry data refer to that sensor when RETE is in mode NM1a.

mode NM1b: all measurements in MF are carried out by a sensor pair selected with a telecommand; the selected sensor pair is indicated in HEADER 1. Hence, all MF telemetry data refer to that sensor pair when RETE is in mode NM1b.

mode NM1c: all measurements in HF are carried out by a sensor selected with a telecommand; the selected sensor is indicated in HEADER 2. Hence, all HF telemetry data refer to that sensor pair when RETE is in mode NM1c.

mode NM1d: Ordinarily,the HF chain spans over the frequency range 500 kHz - 12 MHz in 256 channels each channel corresponding to a frequency band of approximately 45 kHz. Mode NM1d corresponds to choosing,by telecommand one of the 256 channels and then acquiring a full spectrum in a single 45 kHz channel. The resulting spectrum contains again 256 channels, but now the resolution is 256 times higher, i.e. 170 Hz. Hence, it must be taken into account that the frequency resolution in HF chain changes between NM and NM1d. The only way to discriminate between normal and high resolution acquisition is to monitor the telecommand echo contained in the error table.

4.5 DC TELEMETRY LAYOUT

The DC data collected by the DCE during a DC acquisition cycle will be called a "DC Telemetry Frame" and will always consist of 210 bytes of DC data. The content of this Telemetry frame will depend on the mode of the RETE experiment and the DC experiment configuration which can be changed by telecommands.

4.5.1 DC TELEMETRY IN NORMAL MODE (TELEMETRY RECORD 1)

In the RETE normal mode where the AC part occupies most of the Telemetry, the DC part will have room for 10 "DC Telemetry Frames" for every two RETE Telemetry formats as it is indicated in TABLE 1.Notice that all references to Telemetry locations are relative to the RETE DC data position and are quoted in bytes (8 bits words). Telemetry measurement points (TLM Pn) are illustrated in figure 1.

TABLE 1

DC Telemetry layout in RETE Normal Mode.

Byte 0	DC Telemetry Frame 1. (RETE Normal Mode)	210 bytes long
Byte 210	DC Telemetry Frame 2. (RETE Normal Mode)	210 bytes long
Byte 420	DC Telemetry Frame 3. (RETE Normal Mode)	210 bytes long
.	.	.
.	.	.
Byte 1890	DC Telemetry Frame 10. (RETE Normal Mode)	210 bytes long

In Normal Mode the DPU will therefore collect, from the DCE, a "DC Telemetry Frame" for every 3.2 seconds. Note that in RETE Calibration mode the layout of the DC data is the same as in RETE Normal Mode. Each DC telemetry frame of Table 1 is in turn structured as it is indicated in Table 2.

TABLE 2

Layout of DC Telemetry Frame (RETE Normal Mode)

Byte 0	Frame Header	18 Bytes long
Byte 18	Langmuir Probe Samples	128 Bytes long
Byte 146	Fix sweep Langmuir probe samples	16 Bytes long

Byte 162	ION collector samples	32 Bytes long	
Byte 194	V1-V2 Samples	16 Bytes long	

4.5.2 DC TELEMETRY IN MODES PP2 and PP3 (TELEMETRY RECORD 2)

In both modes PP2 and PP3 the DC part has room for 64 "DC Telemetry Frames" every two RETE Telemetry formats which means that the DPU will collect a "DC Telemetry Frame" for every 0.5 seconds.This is shown in Table 3.

TABLE 3

DC Telemetry layout in Modes PP2 and PP3

Byte 0	DC Telemetry Frame 1. (RETE 200 Hz Mode)	210 bytes long
Byte 210	DC Telemetry Frame 2. (RETE 200 Hz Mode)	210 bytes long
Byte 420	DC Telemetry Frame 3. (RETE 200 Hz Mode)	210 bytes long
.	.	.
.	.	.
Byte 13230	DC Telemetry Frame 64. (RETE 200 Hz Mode)	210 bytes long

On the other hand,the layout of each DC Telemetry Frame is different in modes PP2 and PP3 and given in Tables 4 and 5 respectively.

TABLE 4

Layout of DC Telemetry Frame in Mode PP2

Byte 0	Frame Header	18 Bytes long
Byte 18	Langmuir Probe Samples	128 Bytes long
Byte 146	Fix sweep Langmuir probe samples	16 Bytes long
Byte 162	V1-V2 samples	16 Bytes long
Byte 178	ION Samples	16 Bytes long
Byte 194	V1, V2 Samples	16 Bytes long

TABLE 5

Layout of DC Telemetry Frame in Mode PP3

Byte 0	Frame Header	18 Bytes long
Byte 18	V1-V2 samples	4 Bytes long
Byte 22	Fix sweep Langmuir probe samples	4 Bytes long
Byte 26	ION collector samples	4 Bytes long
Byte 30	AC Samples	180 Bytes long

4.5.3 DETAILED DESCRIPTION OF DC TELEMETRY DATA

Having outlined the general structure of the DC data in the three main modes of operation of RETE (NM,PP2,PP3),we go to a step by step description of what is contained in the DC telemetry frames.

Layout of Frame Header

Byte 0	Sync word. Should be AA Hex otherwise frame data not valid
Byte 1	Bits 0-1: Frame counter Recycles between 0 and 3 (one increment per frame) used for decoding the House keeping information in byte 14-17 of the frame header. Bits 2-7: Software status
Byte 2	Bits 0-1: DC mode indicator mode = 0 : DC experiment in Mode 1 mode = 1 : DC experiment in mode PP2 mode = 2 : DC experiment in mode PP3 Bits 2-7: Software status.
Byte 3	Sweep start value : Initial start value for the Langmuir probe sweep. Value between 0 - 32 , where 0 = -5volt and 32 = +15volt on a linear curve. (Setting commandable by Telecommand).
Byte 4	Bits 0-1: Number of samples per sweep. (Setting commandable by Telecommand) 0 : 32 samples per sweep 1 : 64 samples per sweep 2 : 128 samples per sweep Bits 2-7: Software status
Byte 5	Sweep decrement value : 0-32 (Setting commandable by TLC)

	This is the value by which the Langmuir probe sweep will decrement per step according to: Decrement value = (20Volt/(32*x))*y where : x = 32 when there is 32 samples per sweep (Byte 4) : x = 64 when there is 64 samples per sweep (Byte 4) : x = 128 when there is 128 " : y = Sweep decrement value (This byte)
Byte 6	Bits 0 : Langmuir probe fine sweep (Setting commandable by TLC) 0 : Fine sweep off. 1 : Fine sweep on. Bits 1-7 : Software status.
Byte 7	Fix sweep value : 0-31 where 0=-5volt and 31=+15volt on a Linear scale. (Setting commandable by TLC).
Byte 8	Bits 0-1 : Langmuir probe gain setting. (Setting commandable by TLC). 0 : Langmuir probe in low gain. 1 : Langmuir probe in high gain. 2 : Langmuir probe in auto gain. Bit 2 : Langmuir calibration.(Setting commandable byTLC) 0 : Calibration off. 1 : Calibration on. Bit 3 : Shunt capacitor. (Setting commandable by TLC). 0 : Shunt capacitor off. 1 : Shunt capacitor on. Bits 4-7 : Software status.
Byte 9	Bits 0-1 : E-field probe bias. (Setting commandable by TLC) 0 : Bias off. 1 : Bias = 40 nano Amp. 2 : Bias = 70 nano Amp. 3 : Bias = 140 nano Amp. Bit 2 : Pentode operation mode (Commandable by TLC). 0 : Pentode in constant current mode. 1 : Pentode in Voltage mode. Bits 3-7 : Software status.
Byte 10	Pentode Current/Resistor Setting (Sett. Commandable by TLC) In current mode: 0 = No current. 255 = Max current. In Voltage mode: 0 = Max Voltage. 255 = 0 Voltage
Byte 11	Bit 0 : AC gain setting (Sett. Commandable by TLC) 0 : AC in low gain. 1 : AC in high gain. Bit 1 : E-field gain setting (Sett. Commandable by TLC) 0 : E-field in low gain. 1 : E-field in high gain. Bits 2-7 : Software status.
Byte 12	Pentode Cathode current sample. (Sampled in TLM P1)

Byte 13	Pentode Grid voltage sample.	(Sampled in TLM P2)
Byte 14-17	House keeping information	(Sub-commentated)

Layout of Housekeeping information.

The four byte House keeping information in the frame header will vary with the frame counter (see byte 2 in the frame header) as follows:

Frame counter = 0

Byte 14	Sample of V1.	(Sampled in TLM P3)
Byte 15	Sample of V2.	(Sampled in TLM P4)
Byte 16	Sample of Pentode Plate voltage	(Sampled in TLM P5)
Byte 17	Sample of +50 Volt supply line	(Sampled in TLM P6)

Frame counter = 1

Byte 14	Sample of +25 volt supply line.	(Sampled in TLM P7)
Byte 15	Sample of +12 Volt supply line.	(Sampled in TLM P8)
Byte 16	Sample of +5 Volt supply line.	(Sampled in TLM P9)
Byte 17	Sample of -5 Volt supply line	(Sampled in TLM P10)

Frame counter = 2.

Byte 14	Sample of -12 Volt supply line	(Sampled in TLM P11)
Byte 15	Sample of -25 Volt supply line	(Sampled in TLM P12)
Byte 16	Overrun counter (internal Timer)	
Byte 17	Watch dog counter (internal Timer)	

Frame counter = 3.

Byte 14	Sample of +5 Volt Reference.	(Sampled in TLM P13)

Byte 15	Sample of -5 Volt Reference	(Sampled in TLM P14)
Byte 16	Sample of DCE Temperature	(Sampled in TLM P15)
Byte 17	Sample of DCBP Temperature	(Sampled in TLM P16)

Layout of Langmuir probe samples.

The Langmuir probe samples will vary dependant on the number of samples per sweep (See frame header byte 4) as follows :

Samples per sweep = 128

Byte 18	One full sweep containing 128 bytes of samples

Samples per sweep = 64

Byte 18	First full sweep containing 64 bytes of samples
Byte 82	Second full sweep containing 64 bytes of samples

Samples per sweep = 32

Byte 18	First full sweep containing 32 bytes of samples
Byte 50	Second full sweep containing 32 bytes of samples
Byte 82	Third full sweep containing 32 bytes of samples
Byte 114	Fourth full sweep containing 32 bytes of samples

Notes: The sampling point for the langmuir probe is TLM P17, and the duration of one full sweep is about 100 mseconds independently of the number of sweep samples. In the RETE normal mode the sweep repetition rate will be as follows:

Sweep repetition rate

One sweep per 0.8 seconds when sample rate = 32.
One sweep per 1.6 seconds when sample rate = 64.
One sweep per 3.2 seconds when sample rate = 128.

In the RETE Mode PP2 the repetition rate is:

One sweep per 125 msecond when sample rate = 32.
One sweep per 250 msecond when sample rate = 64.
One sweep per 500 msecond when sample rate = 128.

An example of a sweep is given in the following :

Sweep start value (Frame Header byte 3) = 32 is converted to engineering values : 15 Volt. , sweep samples (Frame Header Byte 4) = 0 => 32 samples per sweep, sweep decrement value (Frame Header Byte 5) = 32 is converted to engineering values : ((20Volt/(32*32))*32) = 0.625 Volt, Fix sweep value (Frame Header Byte 7) = 10 is converted to engineering values : ((15-(-5))/32)*10-5Volt)) Volt. = 1.25 Volt.
As a result : The sweep will start at +15 Volt hereafter the sweep is decremented by 0.625 Volt in 32 steps down to -5 Volt and one sample is taken on each of the steps. When the sweep is completed the probe is biased to 1.25 Volt.

Layout of Fix sweep langmuir probe samples.

The Fix sweep sample point is the same as for the Langmuir Probe samples (TLM P17), but is measured between the sweeps with a Fixed voltage applied to the Probe (See frame header byte 7).

Layout of ION samples.

The ION samples are sampled in TLM P18 and are equidistant spaced over the frame duration.

Layout of V1-V2 samples.

The V1-V2 samples are sampled in TLM P19 when the E-field gain is in high gain and in TLM P20 when the E-field gain is in low gain (See frame header byte 11). These samples are equidistant spaced over the frame duration.

Layout of AC samples.

The AC samples are sampled in TLM P21 when the AC gain is in high gain and in TLM P22 when the AC gain is low (see frame header byte 11). These samples are equidistant spaced over the frame duration.

Layout of V1, V2 samples.

These samples are alternated trough out the frame starting with V1 then V2,V1,V2,V1... etc. The sampling point for V1 is TLM P3 and TLM P4 for V2. The samples are equidistant spaced over the frame duration.

Housekeeping data.

All the house keeping data (Frame header bytes 14-17) are sampled at the end of the frame.

5.WAVEFORM CAPTURE MODE (TELEMETRY RECORD TYPE 3)

Referring to telemetry record type 3 (see Sect.4),it must be pointed out that:

a) The specification of the mode (WFC),as \well as that of the submodes (a,b,c see Sect.3) is contained in the header format 0 and header format 1 as described in Sect.4.1.

b) The ac waveform data,occupying 3519 words in both format 0 and format 1 according to telemetry record type 3, are data from the MF receivers where both band (C,D,E,F) and sensor couple have been fixed by telecommands. However, the specification of both frequency band and sensor couple is not contained in the telemetry record. In addition, contrary to what we have in telemetry record of rtype 1, the WFC telemetry record does not contain the echo of the telecommands either. Therefore the real nature of the data cannot be recognized from the telemwetry format but only a posteriori keeping track of the telecommand issued.

REFERENCES

[1] M.Dobrowolny and U.Guidoni: "Modes of operation of the RETE experiment-Revision 1", IFSI-CNR internal report, 1989, Frascati.