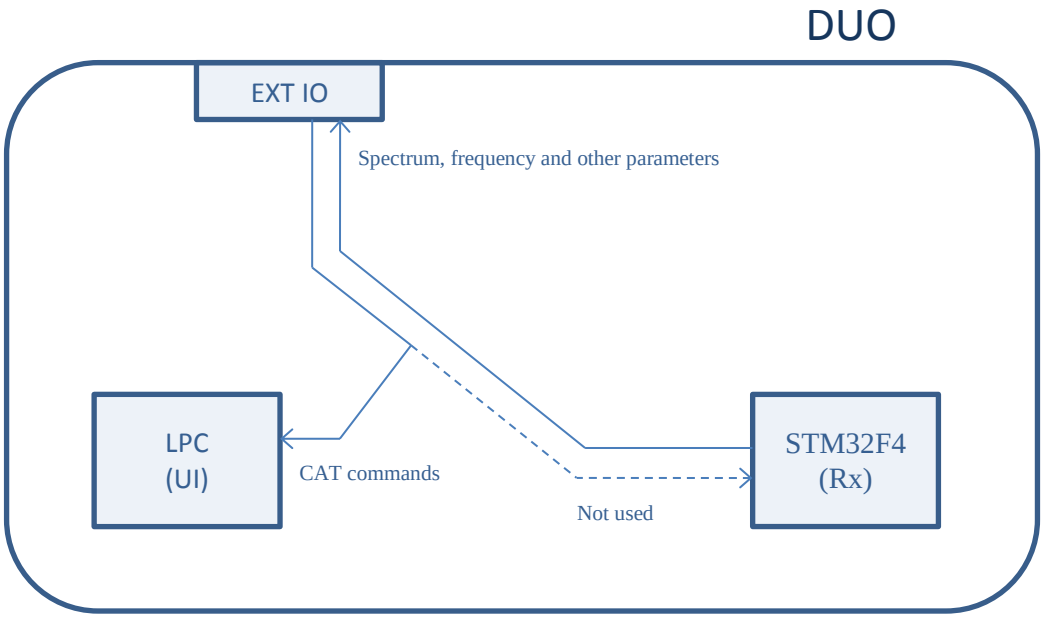
1. Hardware Description.

The serial link is connected between the EXT I / O connector and the STM32F4 (Rx) microcontroller with the receiving UART signal connected to the LPC UART receiving pin. The LPC receives the TS-480 type CAT commands and the STM32F4 sends data such as spectrum, frequency, status and other DUO settings.



The data sent by the STM32F4 are divided into two groups: the spectrum and the parameters (frequency, states and various settings). The parameters are sent every 250ms and the spectrum is sent every 150ms.

The tuning frequency is not sent, but the value of the VFOA and the value of the VFOB are sent alternatively (i.e. one frame on two). In other words, the STM32F4 sends:

- the VFOA every 500ms plus an initial offset of 0s,
- the VFOB every 500ms plus an initial offset of 250ms.

The frame has a bit that indicates which VFO is provided and which VFO is currently selected on the DUO. The value of the mode (modulation) of each VFO is also provided in the same way.

The volumes are supplied with the same principle with the difference that they are three: main volume, auxiliary volume and volume of the sidetone. Each value is provided every 750ms.

2. STM32F4 → EXTIO Protocol.

Data are transmitted in hexadecimal with the following structure:

- a 6 bytes control block,
- a series of data identified by the control block.

Control block description.

Byte	Description	Value
1°	Data descriptor	0x00 : spectrum 0x01 : parameters
2°	Descriptor modifier (coded in ascii to facilitate synchronization)	0x30 : spectrum 0x31 : parameters
3°, 4°, 5° e 6°	Length of the data following the control block (coded in ascii to facilitate synchronization) NB: this field is sent with the LSB first method.	Hexadecimal value encoded in ascii. Example: for a length of 1024 bytes (0x0400 in hex), 0x30303430 is sent.

3. STM32F4 → EXTIO Protocol Data.

3.1 Spectrum.

- Control block : 0x003030303430
  Descriptor : 0x00
  Modifier : 0x30
  Data length : 1024 bytes

- Data : 1024 values encoded on 1 byte are sent with this transformation :

```
Transmitted_Value = Value_in_dBm + 192
```

Example :

Received vlaue (in decimal)	**Corresponding Value** (in dBm)
255	63
192	0
50	-142

3.2 Parameters.

- Control block : 0x01313F313030
  Descriptor : 0x01
  Modifier : 0x31
  Data length : 31 byte

- Data :
  - 1 byte for VFO type, selected VFO and DUO type :

Byte	**1**							
Bit	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
Data	**1**	*DUO*	*VFO_USED*	*VFO_FRAME*	MODALITY		0	MEM_MODE

    - DUO : DUO type; 0 DUOr, 1 DUOtx
    - VFO_USED : selected VFO : 0 VFOA, 1 VFOB
    - VFO_FRAME : VFO type in frame : 0 VFOA, 1 VFOB
    - MODALITY : DUO operating mode :
      0 stand-alone (intern FPGA bitstream),
      1 mixed (extern FPGA bitstream, with data flux to RX arm)
      2 remote (extern FPGA bitstream, without data flux to RX arm)
    - MEM_MODE : go to 1 if memory mode is selected

  - 8 byte for VFO value (tuning frequency). VFOA and VFOB are provided alternately, so the VFO field is equal to VFOA one frame on two. The VFO is encoded in pseudo-ascii using its hexadecimal value. Example :
    - 14.072.000Hz : 0x30 0x30 0x3D 0x36 0x3B 0x38 0x3C 0x30,
    - 52.000.000Hz : 0x30 0x33 0x31 0x39 0x37 0x35 0x30 0x30.

    NB : when the memory mode is selected, VFO field value is equal to the frequency of the selected memory.

  - 1 byte for Tune and Split status and for the Mode :

Byte	**10**							
Bit	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
Data	**1**	*TUNE*	*SPLIT*	*SPLIT STD-ALONE*	*MODO_VFOx*			

    - TUNE : tune status; 0 OFF, 1 ON
    - SPLIT : split status (remote, activation from SW2)
    - SPLIT STD-ALONE : split stand-alone status (activation from DUO)

Bit 5 (split)	**Bit 4 (split std-alone)**	**Active Split**
0	0	None
0	1	-
1	0	Remote
1	1	Stand-alone

    - MODO_VFOx : mode of the VFO indicated from VFO_FRAME :
      - 1 : AM
      - 2 : LSB
      - 3 : USB
      - 4 : CW (CW+)
      - 5 : FM
      - 6 : CWR (CW-)

    NB : when the memory mode is selected, MODO_VFOx field value is equal to the mode of the selected memory.

- 1 byte for volumes status and transmission status :

Byte	**11**							
Bit	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
Data	**0**	**1**	*VOL_IND*		*MAIN*	*AUX*	*ST*	*PTT*

  - VOL_IND : indication of which volume is provided
    - 0 : main volume
    - 1 : aux volume
    - 2 : sidetone volume
  - MAIN : main volume; 0 OFF, 1 different from OFF
  - AUX : aux volume; 0 OFF, 1 different from OFF
  - ST : sidetone volume; 0 OFF, 1 different from OFF
  - PTT : PTT status; 0 rx, 1 tx

- 1 byte for Squelch and Tx status :

Byte	**12**							
Bit	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
Data	**0**	**1**	*ANT*	*PTTOUT_TUNE*	*SQL*			

  - ANT : antennas number; 0 one antenna, 1 two antennas
  - PTTOUT_TUNE : PTT OUT status when in tune mode; 0 OFF, 1 ON
  - SQL : Squelch; 0 OFF, 1 to 10 ON

- 2 byte for Gain :

Byte	**13**									**14**							
Bit	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**		**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
Data	**1**	*AGC_TH*				*GCT*	*AGC*			**0**	**1**	*MUTE*		*MGC*			

  - GCT : gain type; 0 automatic, 1 manual
  - AGC : automatic gain; 0 OFF, 1 SLOW, 2 MEDIUM, 3 FAST
  - MGC : manual gain; 0 OFF, 1 to 10 ON
  - AGC_TH : agc threshold; 0 a 10
  - MUTE :
    - for DUO tx : reception mute during transmission;
      - bit 5 : for CW (0 OFF, 1 ON)
      - bit 4 : for SSB, AM e FM (0 OFF, 1 ON)
    - for DUO r : reception mute; 0 OFF, 1 ON from CAT command, 2 ON from jack connector

- 2 byte for Noise Reduction and Noise Blanker :

Byte	**15**									**16**							
Bit	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**		**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
Data	**0**	**0**	**1**	**1**	*NR*					**0**	**0**	**1**	**1**	*NB*			

  - NR : Noise Reduction; 0 OFF, 1 a 10 ON
  - NB : Noise Blanker; 0 OFF, 1 a 10 ON

- 2 byte for SSB modes filters :

Byte	**17**									**18**							
Bit	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**		**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
Data	**0**	**1**	**1**	*LSB*						**0**	**1**	**1**	*USB*				

  - LSB e USB : SSB filters values; from 0 to 21, see section 4

- 2 byte for CW, AM and FM modes filers :

Byte	**19**									**20**							
Bit	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**		**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
Data	**0**	**0**	**1**	**1**	*CW*					0	1	1	*AM*			*FM*	

  - CW : CW filters values; from 0 to 9, see section 4
  - AM : AM filters values; from 0 to 7, see section 4
  - FM : FM filters values; from 0 to 2, see section 4

- 1 byte for Auto Notch and RIT status :

Byte	**21**							
Bit	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
Data	**0**	**1**	*ATT*		*LP*	*AN*		*RIT*

  - AN : Auto Notch; 0 OFF, 1 and 2 ON
  - RIT : RIT status ; 0 RIT to 0Hz, 1 RIT different from 0Hz
  - LP : LP filter status; 0 OFF, 1 ON
  - ATT : attenuator value :
    - for DUO tx : 0 OFF, 1 ON
    - for DUO r : 0 0dB, 1 10dB, 2 20dB e 3 30dB

- 1 byte for RSSI :

Byte	**22**							
Bit	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
Data	*RSSI*							

  - RSSI : value in dBm of the coded RSSI value (+192).
    The current value of the RSSI is calculated as follows :
    actualRssi = RSSI – 192 + factoryOffset + attenuatorValue
    with :
    - factoryOffset = -31
    - attenuatorValue :
      - DUO rtx : 0 or 12
      - DUO r : 0, 10, 20 or 30

- 1 byte for volumes :

Byte	**23**							
Bit	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
Data	**1**	*VOL*						

  - VOL : volumes, 0 OFF, 1 to 100 ON :
    - if VOL_IND = 0 : main volume
    - if VOL_IND = 1 : aux volume
    - if VOL_IND = 2 : sidetone volume

- 3 byte for pitch value, the hexadecimal value is coded in pseudo-ascii.
  Example : for 1000 Hz, 0x333E38 is sent.

- 5 byte for RIT value, the hexadecimal value is coded in pseudo-ascii.
  Example :
  - for +100 Hz, 0x3030303634 is sent,
  - for -2300 Hz, 0x3F3F373034 is sent.

4. Annex.

*** Encoding of filters values.**

Parameter value	Mode			
	LSB/USB	CW/CWR	AM	FM
0	1600Hz	2600Hz	2500Hz	Voice Narrow
1	1700Hz	1500Hz	3000Hz	Voice Wide
2	1800Hz	1000Hz	3500Hz	Data
3	1900Hz	500Hz	4000Hz	-
4	2000Hz	300Hz	4500Hz	-
5	2100Hz	100Hz	5000Hz	-
6	2200Hz	100Hz & 1	5500Hz	-
7	2300Hz	100Hz & 2	6000Hz	-
8	2400Hz	100Hz & 3	-	-
9	2500Hz	100Hz & 4	-	-
10	2600Hz	-	-	-
11	2700Hz	-	-	-
12	2800Hz	-	-	-
13	2900Hz	-	-	-
14	3000Hz	-	-	-
15	3100Hz	-	-	-
16	4000Hz	-	-	-
17	5000Hz	-	-	-
18	6000Hz	-	-	-
19	DATA 300Hz	-	-	-
20	DATA 600Hz	-	-	-
21	DATA 1000Hz	-	-	-