STE s.a.s. ELETTRONICA TELECOMUNICAZIONI
Via Maniago N.15 – 20134 – Milano – Italy
Tel.: +39.02.2153524 / 2153525 / 2157891 Fax: +39.02.26410928
www.stecom.com ste@stecom.com

PLL NBFM SYNTHESIZED VOICE/DATA TRANSCEIVER
433.05 – 434.79 MHz ISM BAND

BK77

OPERATING AND SERVICE MANUAL

Ver. 1.1

General Description

The BK77A5 and the BK77B5 are “PLL” synthesized UHF transceivers for use in Wireless “Voice” (Analogue Signal) or “Data” transmission applications.
The transceivers operate on the 433.05-434.79 MHz ISM Band and are designed to comply to the European Standards EN 300-220-3 (class I) and EN 301-489-3.
The transceivers employ NBFM (Narrow Band Frequency Modulation) with a 25 KHz channel separation. The programming frequency step is 12.5 KHz.

A) BK77A5

The BK77A5 is designed in accordance with CEPT-ERC/REC 70-03 recommendation (Annex 1 – Non specific short range devices) for applications employing a 10 mW max radiated power (ERP).

B) BK77B5

The BK77B5 has 500 mW output RF power (100mW in “ Low Power”) and it is programmable from 432 MHz to 436.1 MHz (to cover also the Italian 436.000-436.100 MHz Telemetry and Data transmission band).

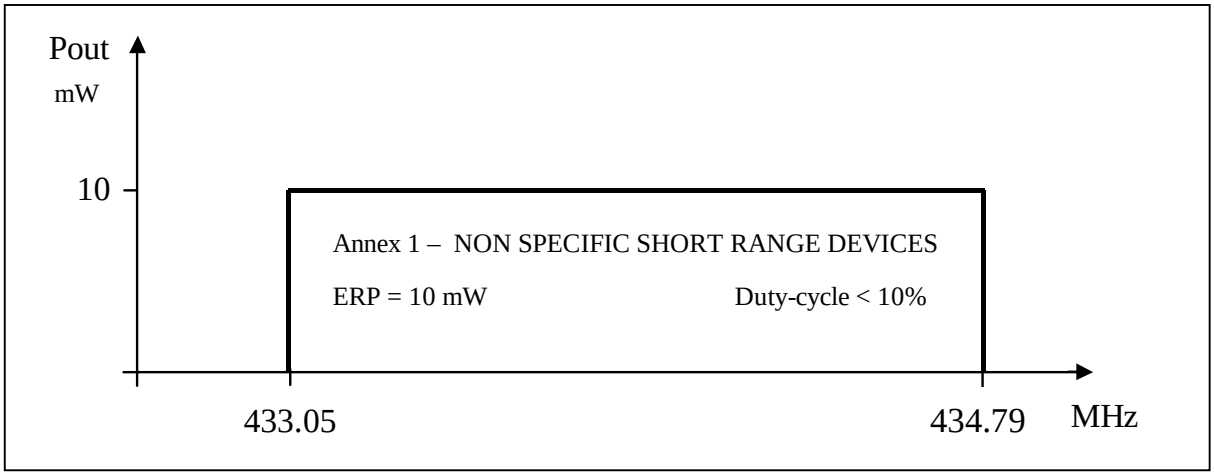

Fig. 1 CEPT ERC/REC 70-03 ISM 434 MHz Band.

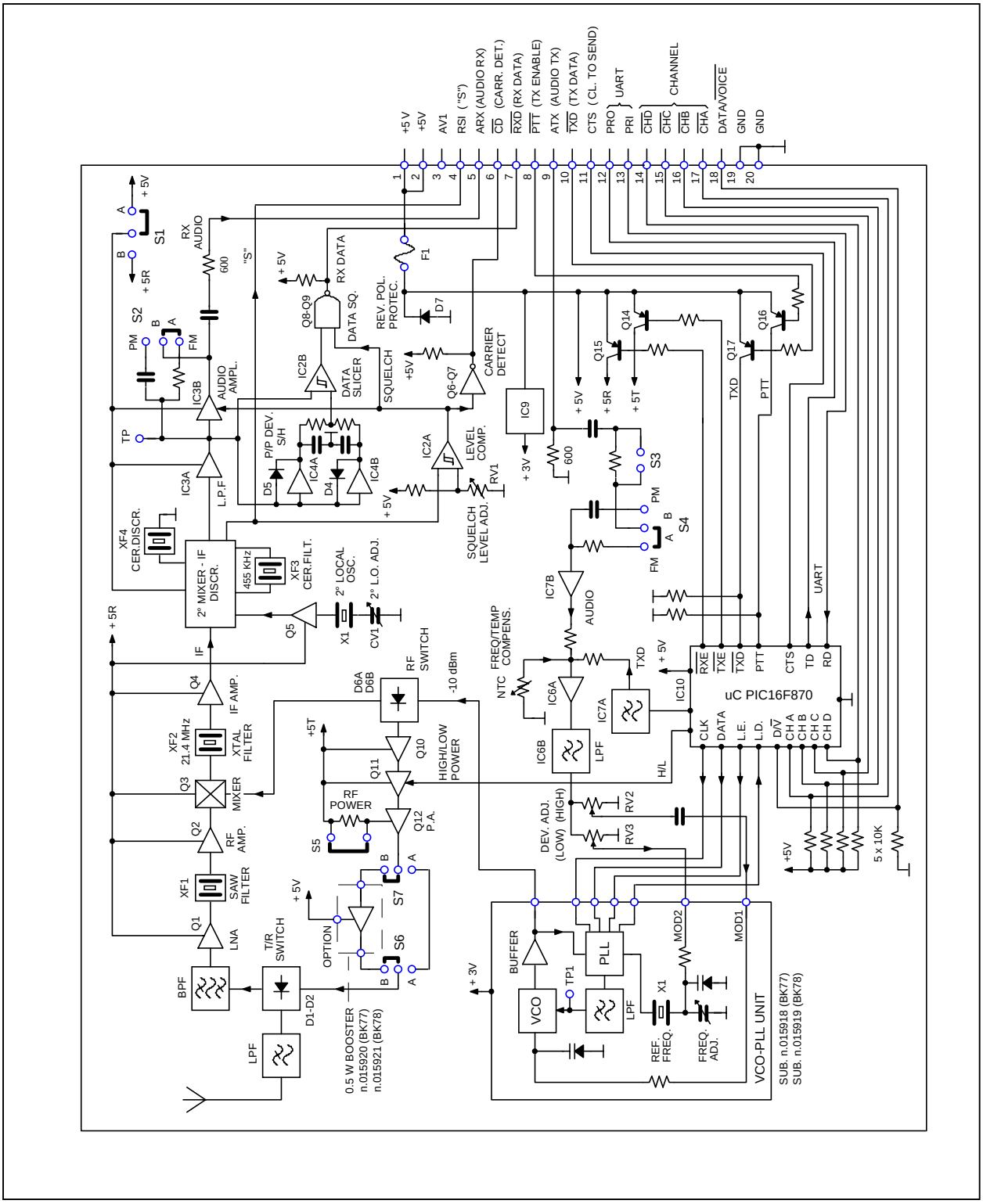

Fig. 2 - Block Diagram

BK77A5 – BK77B5 Specifications

	Min	Typ	Max	Units	Notes
GENERAL					
FREQUENCY RANGE	432.000		436.100	MHz	(1)
CHANNEL SPACING		25		KHz	
FREQUENCY PROGR. STEP		12.5		KHz	
FREQUENCY STABILITY		±2.5	±4	ppm	(2)
ANTENNA IMPEDANCE		50		Ω	
DATA RATE (DATA MODE)	1200		9600	Baud	
FREQ. RESPONSE (VOICE MODE)	100		7000	Hz	
SUPPLY VOLTAGE	4.75	5	5.25	V	
SUPPLY CURRENT - Rx MODE		35	40	mA	
SUPPLY CURRENT - Tx MODE : a) BK77A5 (100 mW) b) BK77B5 (500 mW)		 100 250		 mA mA	
OPERATING TEMPERATURE	- 20		+ 60	°C	
DIMENSIONS	95 x 50 x 7.5 mm				
WEIGHT	25 g				
TRANSMITTER					
RF OUTPUT POWER : a) BK77A5 low high b) BK77B5 low high	 10 80 80 400	 15 100 100 500		 mW mW mW mW	(3)
SPURIOUS EMISSION		-40	- 36	dBm	
FM DEVIATION		3	5	KHz	
R/T SWITCHING TIME		5	10	ms	(4)
MODULATION : VOICE MODE (PM MOD.) VOICE MODE (FM MOD.) DATA MODE (GMSK MOD.)	 100 50 DC		 3000 5000 4800	 Hz Hz Hz	 (5)
RECEIVER					
SENSITIVITY : VOICE MODE (PM MOD.) VOICE MODE (FM MOD.) DATA MODE (4800 Baud)		 -125 -115 -115		 dBm dBm dBm	 (6) (6) (7)
SELECTIVITY	65	70		dB	(8)
IMAGE REJECTION		50		dB	
DYNAMIC RANGE	100	110		dB	
BLOCKING	+84	+85		dB	(9)
T/R SWITCHING TIME		5	10	ms	(4)

NOTE :

(1) CEPT SRD BAND LIMITS = 433.05 – 434.79 MHz

(2) OVER OPERATING TEMPERATURE RANGE

(3) CEPT MAX ERP = 10 mW

(4) PLL LOCK-UP TIME

(5) SQUARE WAVE 0-5 Vdc LEVEL

(6) 12dB SINAD – 1KHz dev. 3KHz

(7) 1/10E2 BER

(8) ADJACENT CHANNEL SELECTIVITY

(9) Fc ± 1 MHz

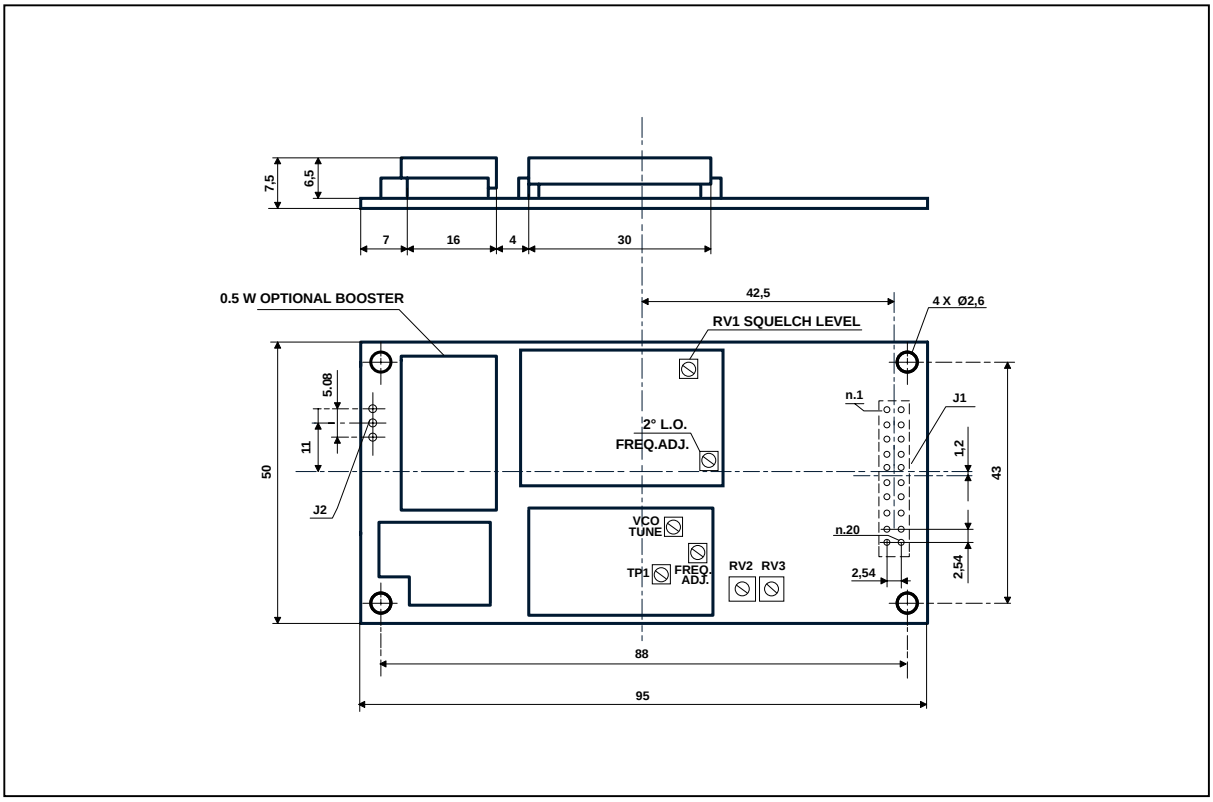

Fig. 3 - Physical dimensions

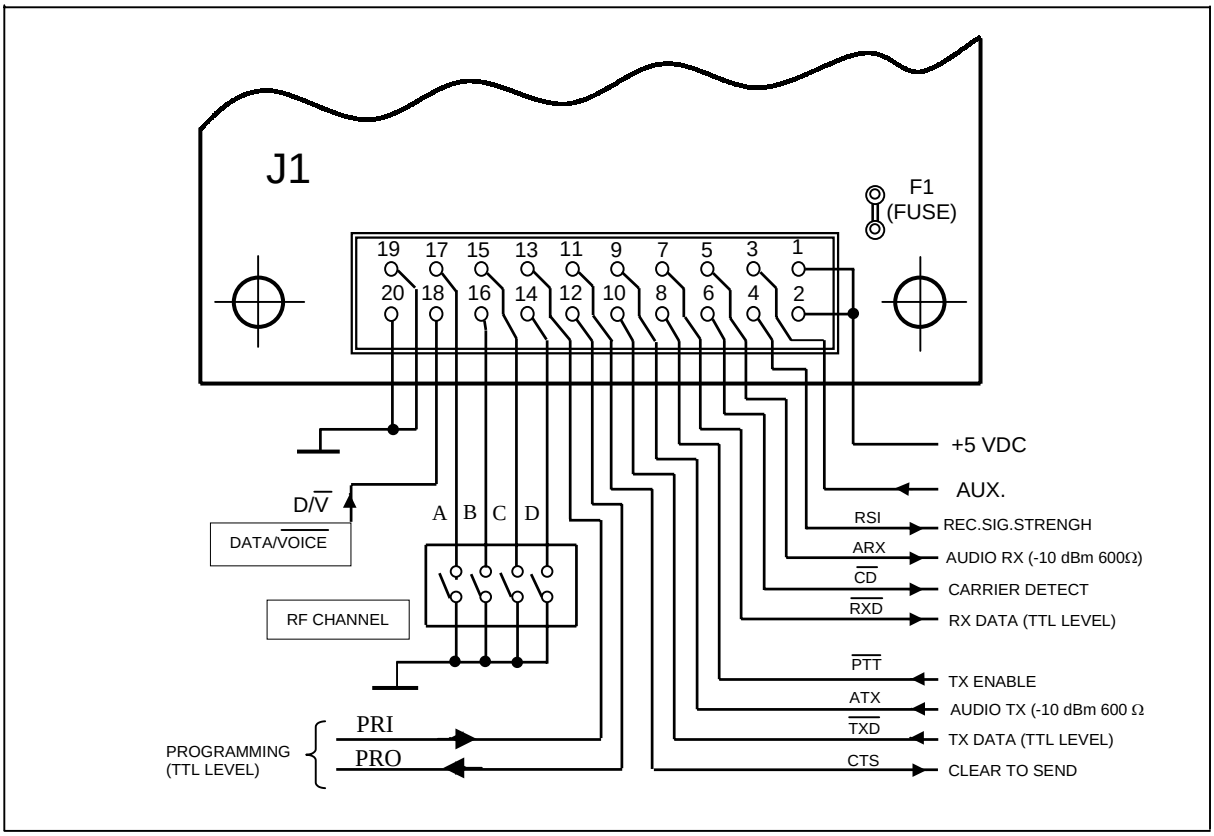

Fig. 4 - J1 connector

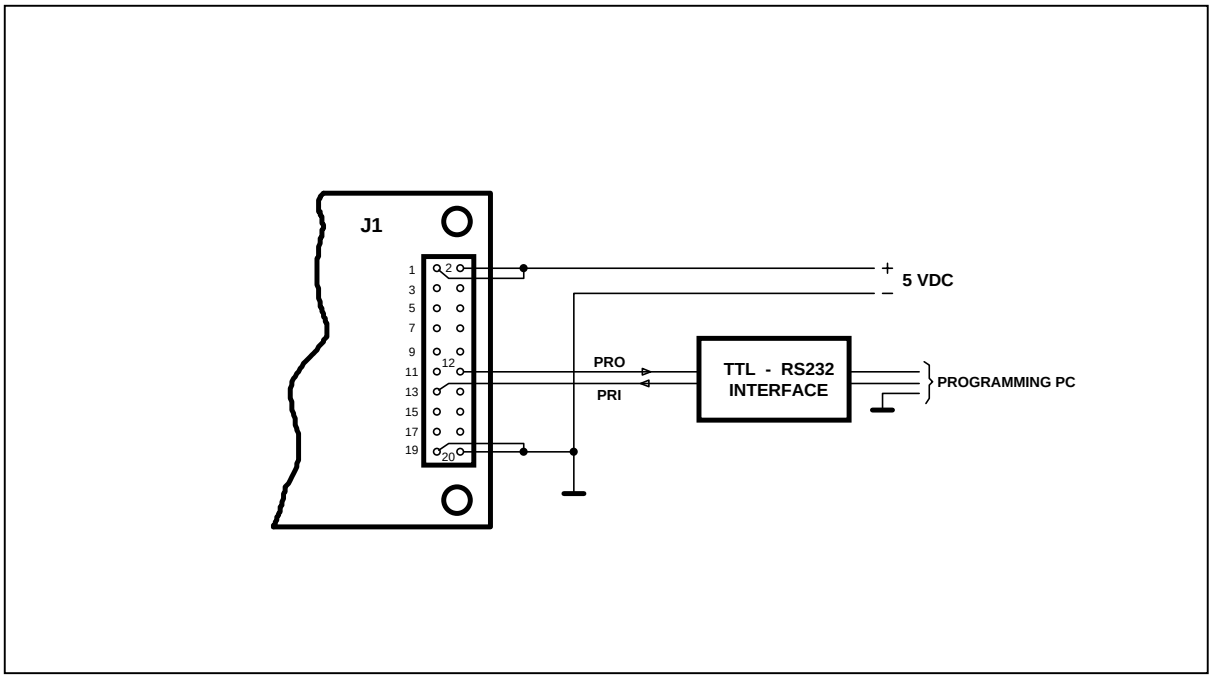

Fig. 5 PC "COM" port connection to program channels and TX power (HI/LO).

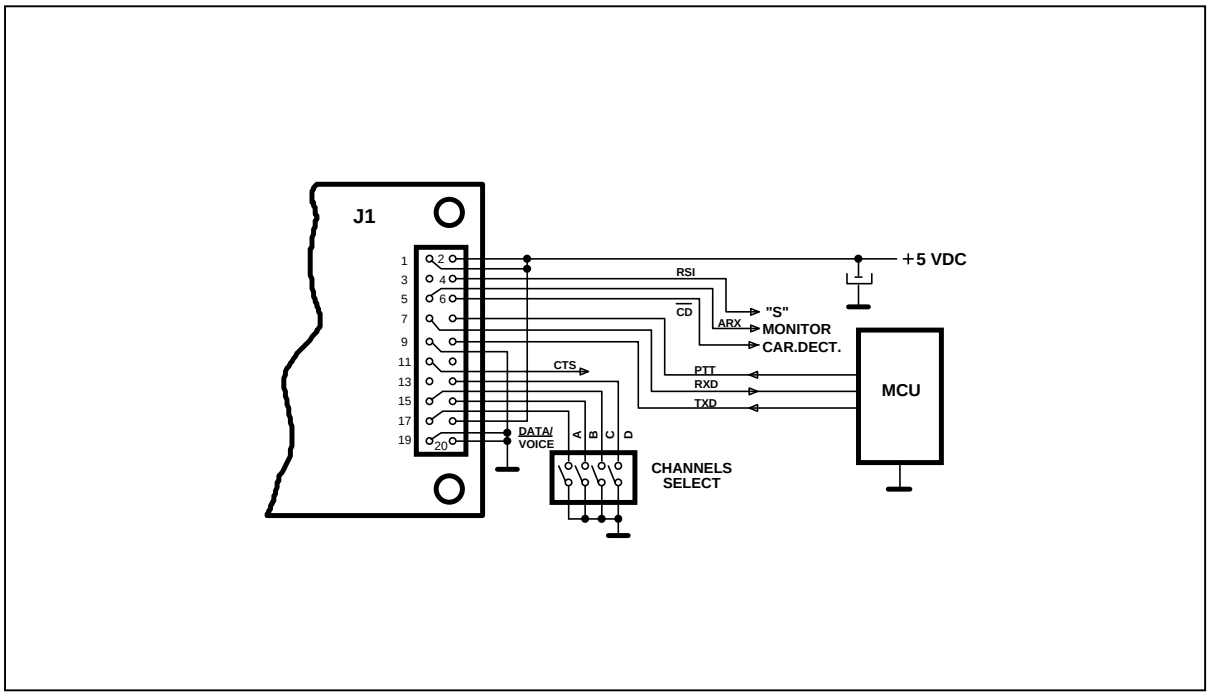

Fig. 6 "MCU" to transceiver typical connection ("Data" mode).

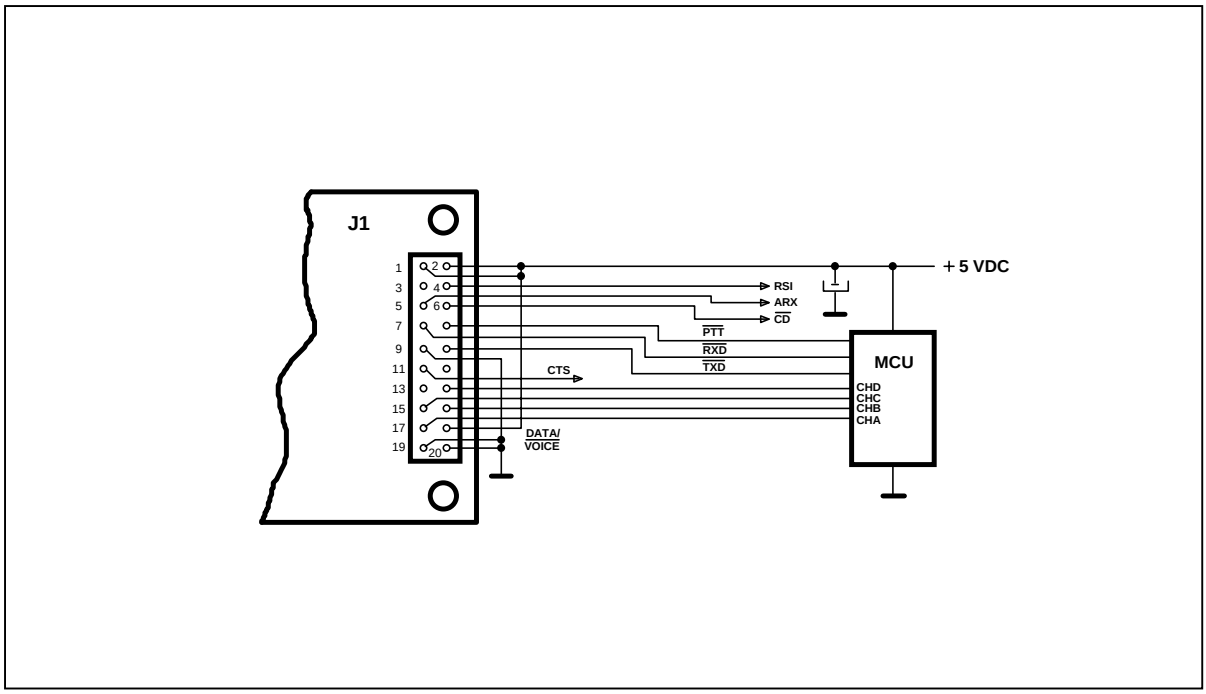

Fig. 7 "MCU" to transceiver typical connection ("Data" mode) with channel parallel programming.

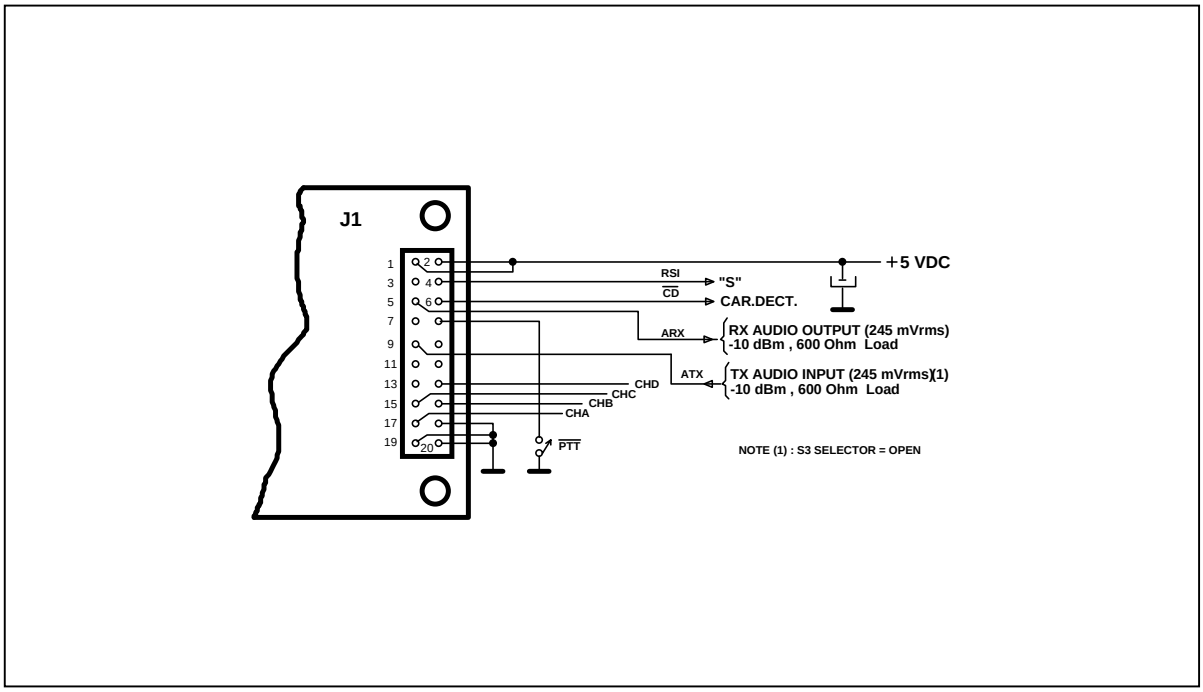

Fig. 8 Typical transceiver connections in "Voice" mode (analogue signals).

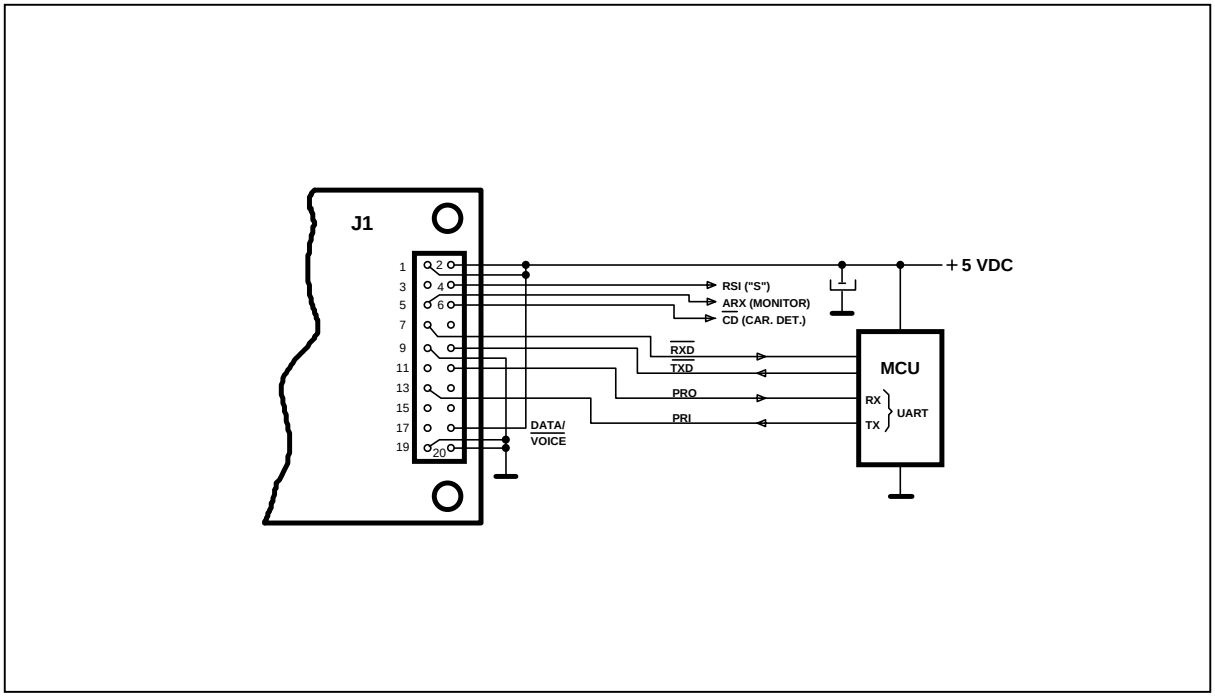

Fig. 9 Transceiver total control (“DATA” mode) by external host microcontroller (TX , RX, frequency, power).

DATA/$\overline{\text{VOICE}}$ input (D/$\overline{\text{V}}$ - J1 pin n.18)

The transceiver has two main operating modes, depending on D/$\overline{\text{V}}$ input :

1) D/$\overline{\text{V}}$ = Low (0 V)

"Voice" (analogue) signals can be transmitted with narrow band frequency modulation (NBFM).
Depending on the selectors S2 and S4 ("A" or "B" position), PM (phase modulation with 6 dB/oct emphasis) or FM (frequency modulation with flat frequency deviation) can be selected.

PM , with an optimum audio response from 300 Hz to 3KHz, is best suited for voice or telephone grade signals (DTMF, AFSK slow speed Modems, selective call, etc.) and has the best "S/N" ratio with an Rx sensitivity of - 120 dBm (12 dB SINAD).

FM with 3 KHz fixed deviation can be the best choice for audio signals ranging from 50 Hz to 5 KHz (Fast Modems, V/F converters, etc.).
Receiver sensitivity is –110 dBm (12 dB S/N).

Note : During "Voice" operating mode the Tx data input (TXD) is disabled .

2) D/$\overline{\text{V}}$ = High (5 V).

Digital Data can be transmitted (max data rate = 9600 Baud) and the modulation system is changed to "GMSK".
The transceiver employs a Two Point Modulation system (VCO plus PLL Reference Oscillator – see block diagram Fig. 2) to provide a flat response from 4.8 KHz down to DC.

During "DATA" operating mode the TX has only two discrete transmitted frequencies :
Bit "0" ("$\overline{\text{TXD}}$" input= 5V) corresponds to a transmitted frequency $F_L = Fc – 3KHz$
Bit "1"("$\overline{\text{TXD}}$" input = 0V) corresponds to a transmitted frequency $F_H = Fc + 3KHz$
(Fc is the nominal RF channel center frequency).

Note : In "DATA" operating mode the TX "VOICE" analog input "ATX" (J1- pin n.9) is not disabled. Signal on "ATX" input must be avoided.

PRO, PRI (J1 pins n.12-13) programming input-output

$\overline{CH}$ $\overline{A}$-$\overline{B}$-$\overline{C}$-$\overline{D}$ (J1 pins n.14-15-16-17) channel select input

PRI and PRO are connected to the IC10 microcontroller USART input-output (see block diagram Fig.2) and are used to program the transmit and receive frequencies and the TX output RF power (“High” or “Low”).

Refer to Fig.5 for the programming set-up.
Sixteen channels can be programmed and stored in the IC10 EEPROM memory.
In operation one of the 16 channels is selected using parallel control lines $\overline{CHA}$, $\overline{CHB}$, $\overline{CHC}$ and $\overline{CHD}$ (negative logic).

The transceiver can be also programmed (Through PRI and PRO) during normal operation on default channel n.1 .Serial mode programming software is available for the BK7XX transceiver – for further details contact the STE sales office.

TABLE 1

CHANNEL	$\overline{CHD}$	$\overline{CHC}$	$\overline{CHB}$	$\overline{CHA}$
1	1	1	1	1
2	1	1	1	0
3	1	1	0	1
4	1	1	0	0
“	“	“	“	“
“	“	“	“	“
15	0	0	0	1
16	0	0	0	0

Note : $\overline{CHA}$-$\overline{CHB}$-$\overline{CHC}$-$\overline{CHD}$ inputs have internal pull-up (10 KΩ) to + 5 V.

IC10 (see Fig. 2) is a PIC16F870 flash microcontroller whose function is to control the general functions of the transceiver and to program the channel frequency (transmit or receive) in the “PLL” integrated circuit (IC11 –Fujitsu MB15E03SL).
The microcontroller has inside an EEPROM where are stored program configurations for up to 16 channels (transmit and receive frequency, in 12.5 KHz step , and RF output power).
One of these 16 channels is selected using parallel control lines via the terminals CHA,CHB,CHC and CHD of J1 connector

BK77x FREQUENCY-POWER PROGRAMMING

At "Power On" the radio memory (IC10 EEPROM) is loaded with the " DEFAULT " channels (see Table 2).
The radio can be programmed on different RF channels (TX frequency , RX frequency and TX output power level) via "PRI" and "PRO" terminals (J1 connector) connected to the serial "COM " port of a "PC".
"PRI" and "PRO" pins must be connected respectively to the "TD" and "RD" lines of the RS232 port with a suitable "TTL" to "RS232" driver (fig. 10).
Data are exchanged between the radio and the "PC" as "ASCII" characters : programs such as "HyperTerminal" can be used to send and receive the "ASCII" strings of characters.

Serial protocol format : 9600 Baud , 8 data bit , 1 stop , no parity .

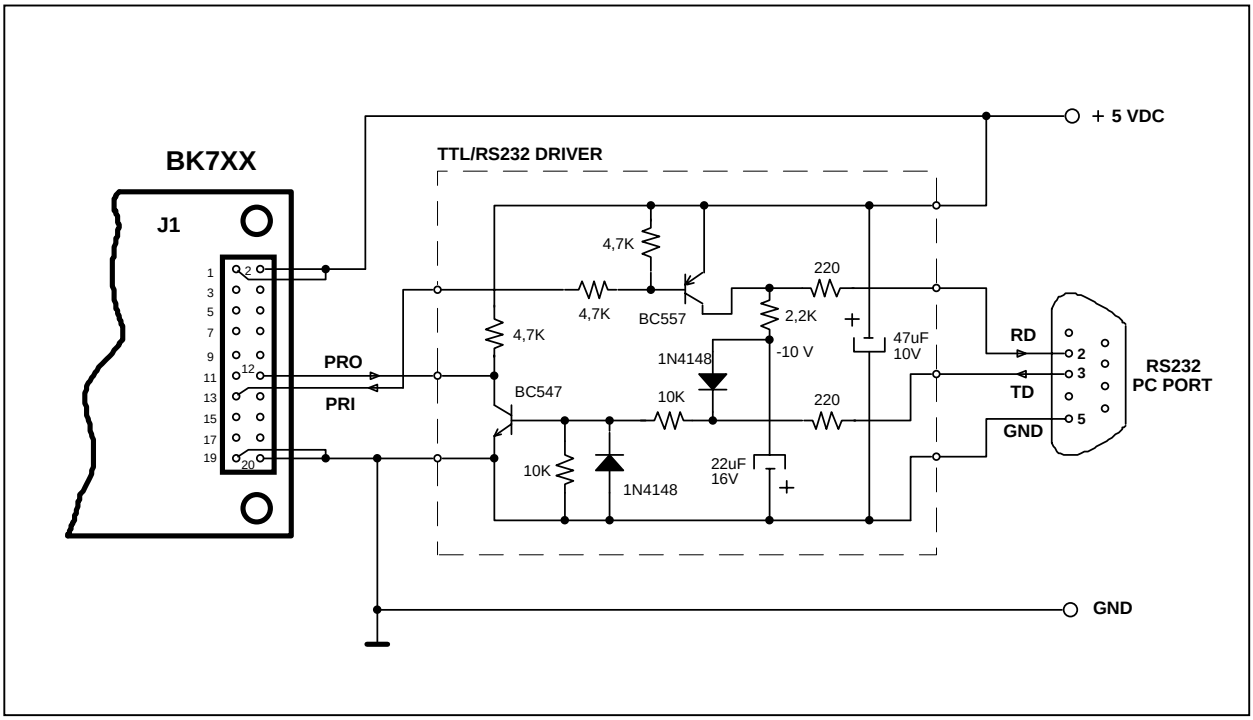

Fig . 10 PC/RADIO programming with TTL/RS232 driver.

Each channel can be individually programmed on new frequencies (and RF power level) : the new data will be retained into the radio memory (EEPROM).
At any time, if necessary, a "RESET" command reloads the memory with the "DEFAULT" channels.

PROGRAMMING COMMANDS AND PARAMETERS

[CH] WRITES IN "EEPROM" TX FREQUENCY, TX POWER LEVEL (HIGH**,** LOW) AND RX FREQUENCY.

FORMAT : CH (§ , &&&& , $$$$) [CR] [LF]

§ = CHANNEL NUMBER (HEX FORMAT, FROM 0 TO F)
& = 4 HEX DIGITS , " NT" NUMBER.
$ = 4 HEX DIGITS , " RT" NUMBER.
[CR] = CARRIAGE RETURN (ASCII CODE 0D)
[LF] = LINE FEED (ASCII CODE 0A)

[RESET] GENERAL RESET WITH "EEPROM" RELOADED WITH "DEFAULT" CHANNELS

FORMAT : RESET [CR] [LF]

[#] DATA REQUEST

FORMAT : # [CR] [LF]

AT RECEPTION OF " # " COMMAND , THE RADIO ANSWERS BACK THE ACTUAL PROGRAMMED DATA AND OPERATION MODE.

ASWER FORMAT : # α β § XXXX [CR] [LF]

α = RADIO STATUS (T = TRANSMISSION, R= RECEPTION)
β = RADIO MODE (V = VOICE, D = DATA)
§ = SELECTED CHANNEL (HEX FORMAT , 0 TO F)
X = 4 HEX DIGITS , " NT" OR " RT" NUMBER.
[CR] = CARRIAGE RETURN (ASCII CODE 0D)
[LF] = LINE FEED (ASCII CODE 0A)

NOTES :

1) Characters must be sent as written : capital letters, Hex numbers, commas and round brackets.
2) A two seconds "Time-Out" is active between character typing.
3) In case of error or "Time-out" the radio answer-back " ? " character.
4) The 16 channels are numbered 1-16 (see table 1). When programmed with "CH" command channels must be entered as hexadecimal number from "0" to "F".
5) [CR] and [LF] (if correctly configured into "HyperTerminal program) are automatically sent by pressing " ENTER ".

NT and NR number calculation (BK 77x)

"NT" and " NR" are 16 bit binary numbers used to program the "PLL" N-divider in TX and in RX mode.

"NT" and "NR" are entered into the radio in hexadecimal format. The "MSB" bit of "NT" is used as a flag to program the RF output power : 1 = HIGH POWER , 0 = LOW POWER.

"NT" is calculated dividing the required TX frequency (KHz) by 12.5 (12.5 KHz is the frequency programming step).
"NR" is calculated from the required RX frequency (KHz) subtracting 21400 (21400 KHz is the first conversion intermediate frequency) and then dividing by 12.5.
The "PLL" IC (a FUJITSU MB15E03) when programmed for 64/65 prescaler divide ratio, has an internal register ("N" register) where bit n° 6 of "N" word must be set to 0 and ignored. To do this a 0 bit must be inserted as n° 6 bit into the calculated "NT" and "NR" binary numbers.

A) "NT" calculation :

1) nT number : nT = TX FREQ.(KHz) / 12.5
2) Write down nT in binary format (16 bit).
3) Insert a 0 into nT as bit n° 6.
4) Write down the new binary number and eliminate the "MSB"
5) Convert in Hexadecimal format.
6) For "HIGH POWER" the MSB bit of the first Hex number must be set to "1".

B) "NR" calculation :

1) nR number : nR = [RX FREQ.(KHz) - 21400] / 12.5
2) Repeat point 2 to 5 as above.

EXAMPLE :

A) TX FREQ. = 433.7125 MHz

nT NUMBER = 34697 = 8789 H =	1000 0111 1000 1001		
New bin. Number with 0 at n° 6 bit =	10000 1111 0000 1001		
NT NUMBER (LOW POWER) =	0000 1111 0000 1001	=	**0F09 H**
NT NUMBER (HIGH POWER) =	1000 1111 0000 1001	=	**8F09 H**

B) RX FREQ. = 433.7125 MHz

nR NUMBER = 32985 = 80D9 H =	1000 0000 1101 1001		
New bin. Number with 0 at n° 6 bit =	10000 0001 1001 1001		
NR NUMBER =	0000 0001 1001 1001	=	**0199 H**

"CH" command format to program channel n° 2 on 433.7125 MHz (transmit and receive) , high power :

CH (1,8F09,0199) [CR] [LF]

TABLE 2

BK77x DEFAULT CHANNELS					
CH. N°	**CH. HEX**	**FREQ. MHz**	**POWER LEVEL**	**“ NT ”**	**“ NR “**
1	0	433.2125	L	0EA1	0131
2	1	433.2375	L	0EA3	0133
3	2	433.2625	L	0EA5	0135
4	3	433.2875	L	0EA7	0137
5	4	433.3125	L	0EA9	0139
6	5	433.3375	L	0EAB	013B
7	6	433.3625	L	0EAD	013D
8	7	433.3875	L	0EAF	013F
9	8	434.3125	L	0F39	0209
10	9	434.3375	L	0F3B	020B
11	A	434.3625	L	0F3D	020D
12	B	434.3875	L	0F3F	020F
13	C	434.4125	L	0F81	0211
14	D	434.4375	L	0F83	0213
15	E	434.4625	L	0F85	0215
16	F	434.4875	L	0F87	0217