

Circuit Description

1 Frequency configuration

The reference frequency of frequency synthesizer is provided by 12.8MHz crystal oscillator X1 TCXO. The receiver adopts quadric mixing mode. The first IF is 51.65MHz, and the second IF is 450kHz. The first local oscillation signal of the receiver is produced by frequency synthesizer and the second local oscillation signal selects the 4th harmonics of 12.8MHz of crystal oscillator X1 TCXO. The signal of transmitter is produced by frequency synthesizer directly.

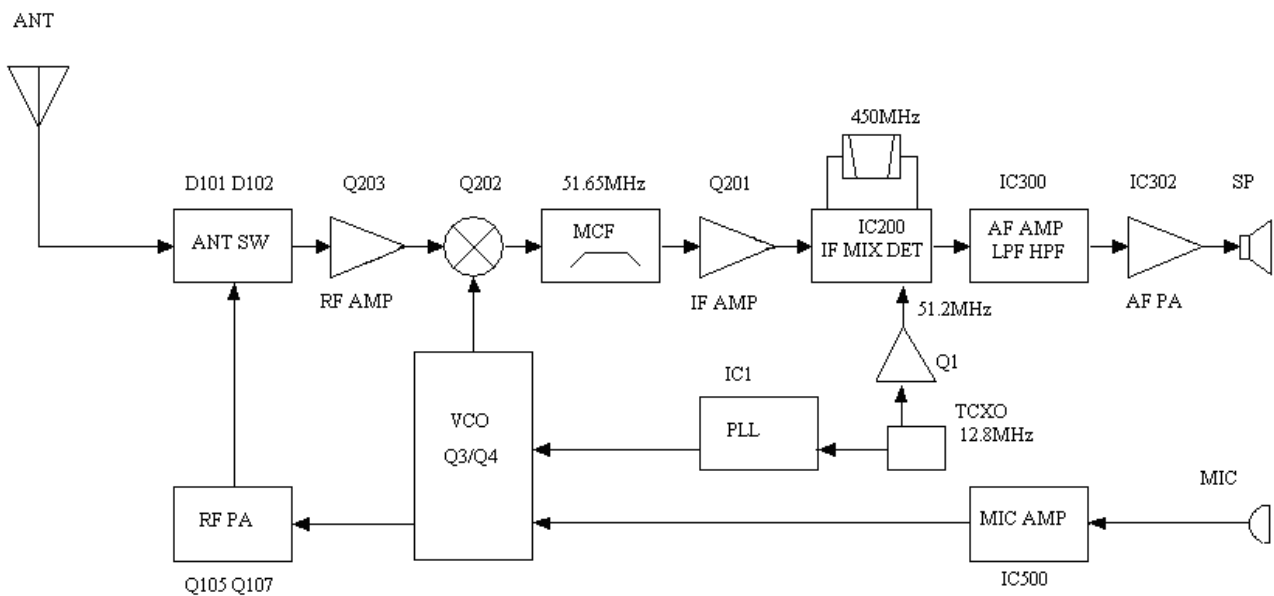


Figure 1 Frequency configuration

2 Receiver (Rx)

The receiver is double conversion superheterodyne, designed to operate in the frequency range of 136 to 174 MHz, The frequency configuration in Fig 1.1

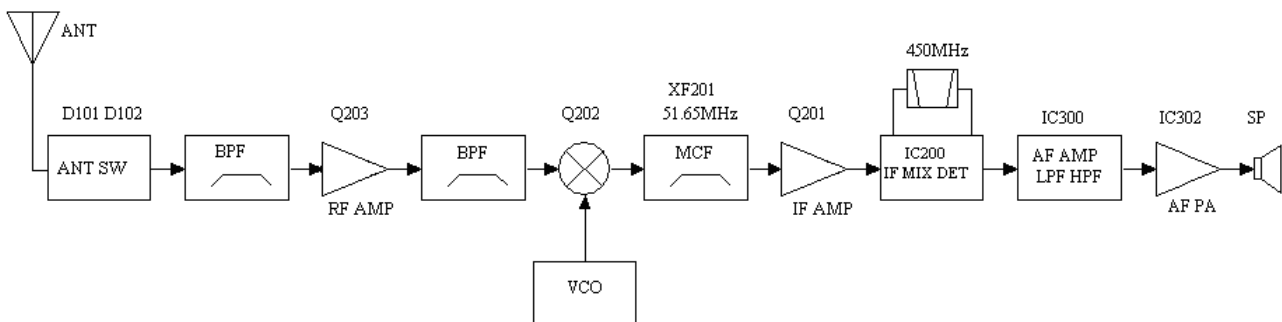


Figure 2 Receiver section configuration

Front End of Receiver

Signals from the antenna are filtered by BPF which consists of C235 C255 C233 C951 C254 C345 C234

L211 L219 L234 D202 and D204 via RX/TX switch (D101 D102 and D103). After being filtered out the useless out-of-band signals, the signals are amplified by LNA consisting of Q203 and external components.

Signals from LNA are filtered again by BPF which consists of C226 C238 C239 C229 C947 C259 L214 L254 D905 and D203 before entering the 1st mixer (Q202).

The PWM wave is output by MCU composed of 58 foot and then commutated to adjustable voltage after filtering to change the capacity of varactor diode D905 D203 D202 and D204 to control the center frequency of BPF.

1st mixer

The first IF (51.65MHz) signal is produced after mixing of the receiving signal from LNA and the 1st local oscillation signal from frequency synthesizer. The first IF signal is filtered out adjacent channel and other useless signals by crystal filter (XF201).

IF Circuit

The 1st IF signal from crystal filter is amplified by the first IF amplifier (Q201) before processing of IC in IF(IC200, NJM2591V).

IF IC consists of the 2nd mixer, 2nd local oscillation, IF amplifier, limiter, frequency discriminator and noise amplifier.

Frequency (12.8MHz) produced by TCXO(X1) is amplified and then selects 4th harmonics (51.2MHz) as the second local oscillator signal source. The second IF signals (450kHz) are generated after signals mixing of the second local oscillation (51.2MHz) and the first IF (51.65MHz) in IC200. Audio signals are demodulated and outputted by IC200 after the second IF signals are amplified and limited in IC200 and then filtered by ceramic filter(450kHz).

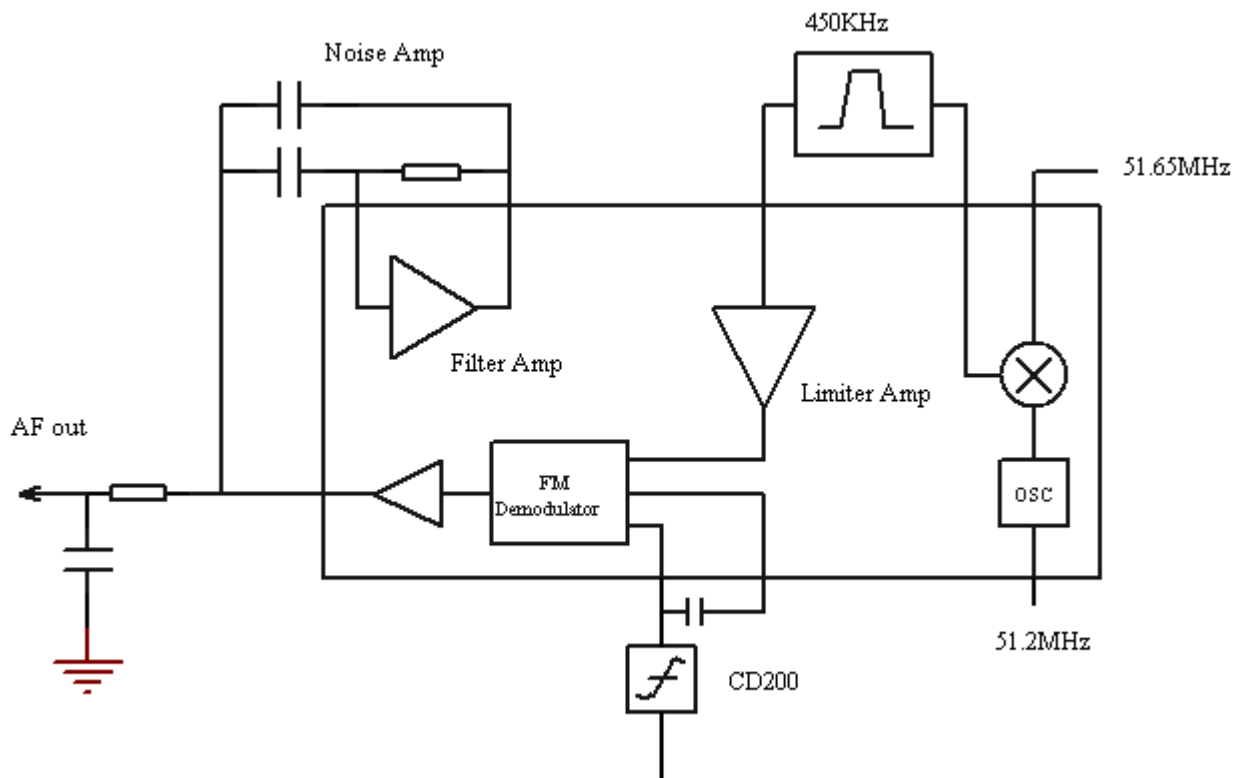


Figure 3 Schematic Diagram for IF System

Receiving Audio Signal Processing:

The audio processing circuit of receiver consists of IC300 and IC806. Voice signals from IC300 are sent to IC301 (CTCSS signaling filter circuit) and IC806. IC806 includes audio filter and de-emphasis.

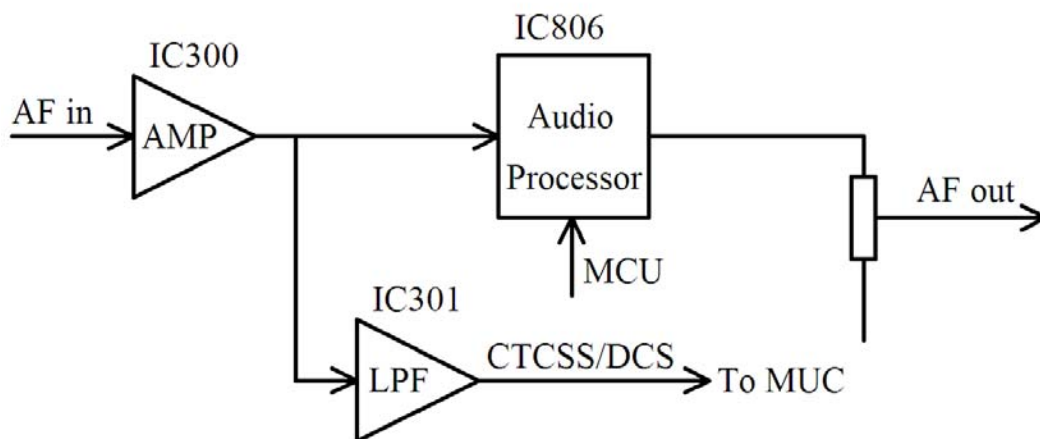


Figure 4 Schematic Diagram for Audio Processing of Receiver

Squelch Circuit

Part of the AF signal from the IC200 enters the FM IC again, and the noise component is amplified and rectified by a filter and an amplifier to produce a DC voltage corresponding to the noise level.

The DC signal from the FM IC goes to the analog port of the microprocessor (IC403). IC403 determines whether to output sounds from the speaker by checking whether the input voltage is higher or lower than the preset value.

To output sounds from the speaker, IC403 sends a high signal to the MUTE and AF CO lines and turns

IC302 on through Q302 Q304 and Q305.

Audio Power Amplification

The audio power amplifying circuit consists of IC302 and the peripheral components. The signals are amplified by audio power amplifier to drive the speaker after collecting the receiving audio signals, voice signals and warning tone signals. The warning tone has no volume limitation.

When AFCO is high level, Q304 is on, IC302 begins to work and the speaker sounds. Speaker Impedance: 16ohm

CTCSS Signal filtering

The audio signals after demodulation in IC200 may contain CTCSS (continuous tone control squelch system) or DCS (digital squelch) signals. The spectrum component of CTCSS/DCS is 67 to 250Hz. The filtering circuit composed of IC301 can filter out signals except CTCSS/DCS spectrum, which makes MCU decode the CTCSS/DCS more accurately.

3 Transmitter (Tx)

Transmitter Power Amplifier

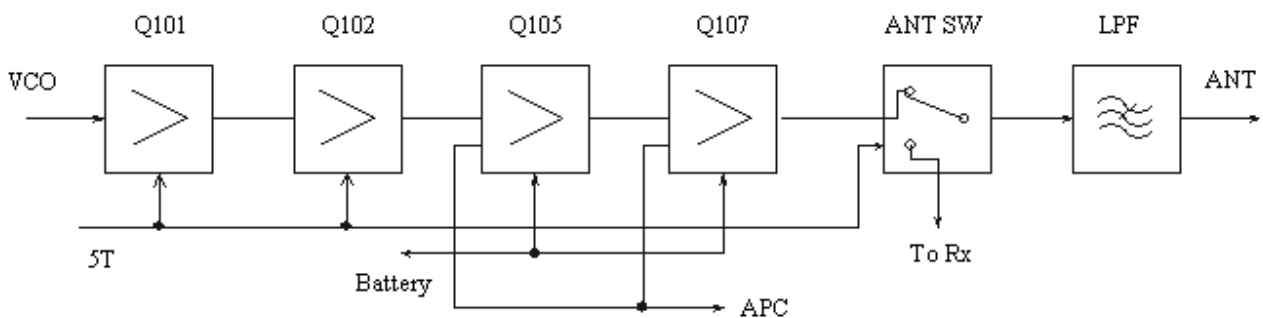


Figure 5 Schematic Diagram for Power Amplifier and Antenna Switch

The modulated RF signals from VCO are amplified by Q101, Q102 and Q105 before the power amplification in Q107.

Gate bias of Q105 and Q107 is controlled by APC circuit, so the output power of transmitter can be controlled conveniently by changing the gate bias voltage.

APC (Automatic Power Control)

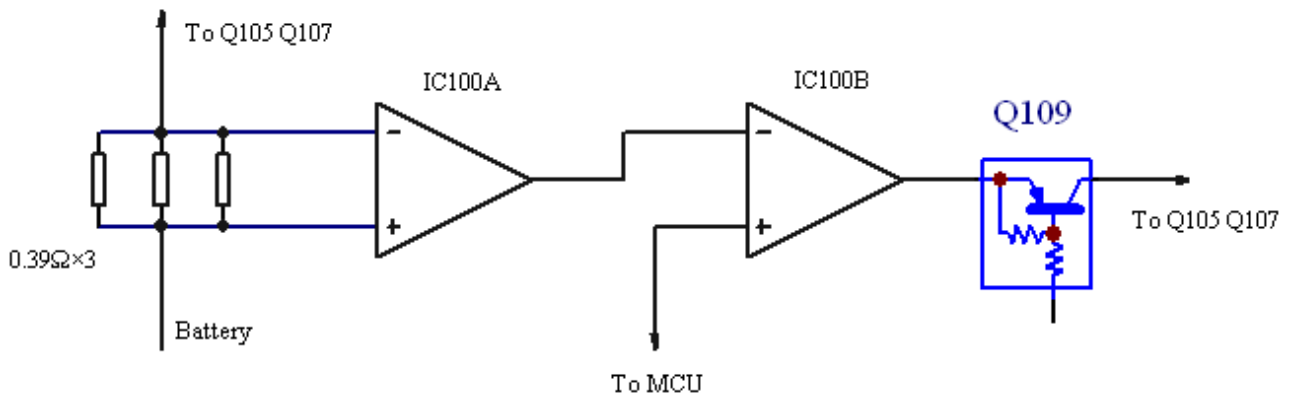


Figure 6 Schematic Diagram for APC Circuit

R130 R131 and R132 are power amplification current detector, IC100A is power amplification current sampling amplifier and IC00B is power comparison amplifier.

The power amplification current and IC100A output will increase with oversized output power of transmitter. When the output voltage of IC100B decreases, the bias voltage of Q105 and Q107 will decrease, finally the output power of transmitter will decrease or vice versa. Thus, the output power of transmitter will keep stable under any different working condition.

MCU can set the power by changing the voltage input to IC100B.

Audio Signal Processing of Transmitter

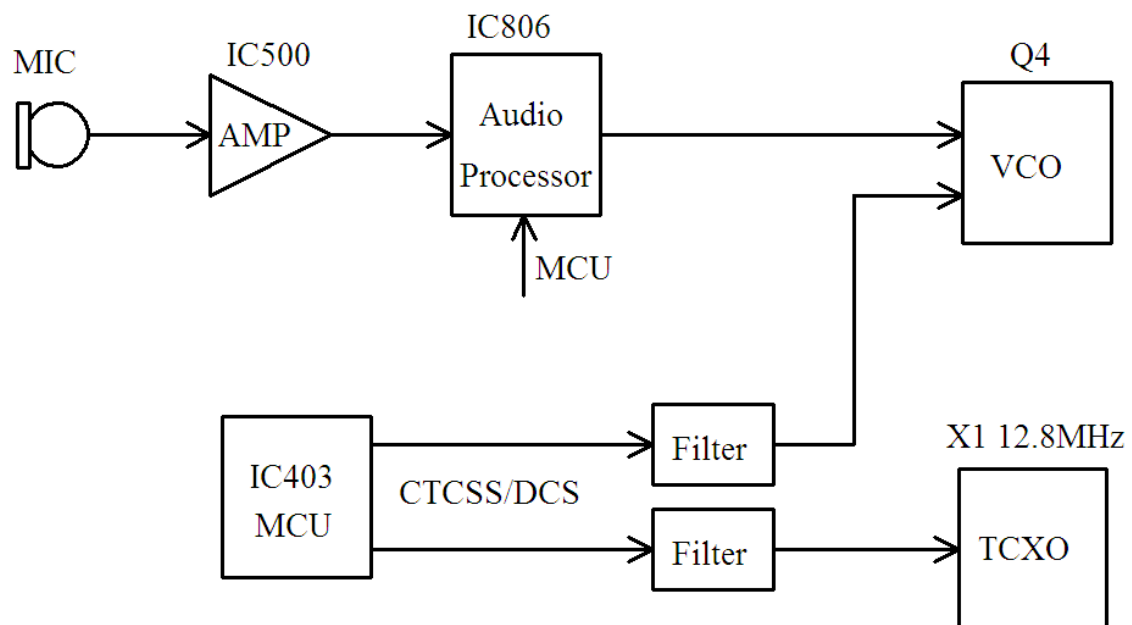


Figure 7 Schematic Diagram for Audit Circuit of Receiver

The audio signal processing circuit of Transmitter consists of IC500 and IC806. Voice signals from MIC are sent to VCO for modulation together with CTCSS/DCS after amplification, limitation and filtering. IC806 includes amplifier, filter, limiter and pre-emphasis.

AGC circuit consists of D800, D801 and Q801,Q802. The signal amplitude is reduced to ensure no distortion in case of oversized MIC signal.

Q504, the power switch of voice processing circuit, controlled by MCU, will give power supply to IC500 only during transmission.

J501 is the socket for external MIC, and the internal MIC will disconnect automatically when using external MIC, but the internal PTT is still effective.

4 PLL Frequency Synthesizer

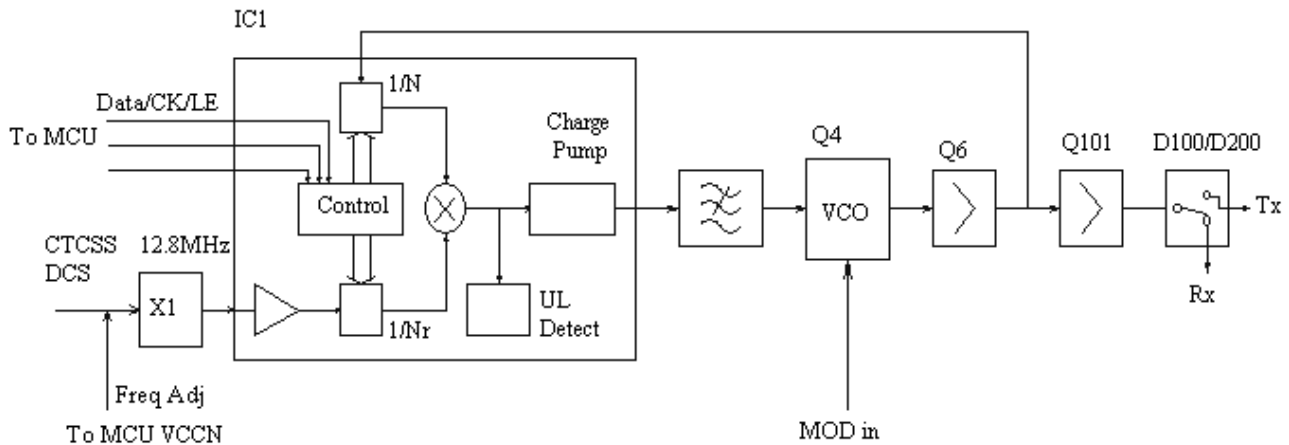


Figure 8 Schematic Diagram for Frequency Synthesizer

The CU780-1 adopts PLL frequency synthesizer.

Frequency synthesizer consists of reference oscillator, voltage controlled oscillator (VCO), programmable frequency divider (PFD), phase comparator and low pass filter (LPF).

RX VCO Unit consists of Q14 D2 D4 D8 D9 L14 C44 C45 and C35.

TX VCO Unit consists of Q3 D1 D3 D10 D11 L13 C38 C39 and C34, D12 is the modulation circuit of VCO.

IC1 (MB15E03) is PLL integrated circuit and contains programmable parametric frequency divider (PPFD), programmable frequency divider (PFD), phase comparator and charge pump, etc.

Low pass filter consists of R7 R9 R10 R173 R188 C177 C456 C15 and C18.

Reference frequency is provided by X1 (TCXO, 12.8MHz).

Reference frequency of TCXO (Temperature-controlled Crystal Oscillator) is divided by PPFD in IC1 to produce reference frequency of 5kHz or 6.25kHz (controlled by MCU based on the set channel frequency).

The oscillation frequency of VCO is compared with reference frequency to produce error signal after divided by PFD in IC1. The error signal is filtered by low pass filter before changing the VCO frequency to the set value in VCO (it is locking).

$$N = F_{VCO} / F_R$$

N: Division Frequency

F_{VCO} : VCO Oscillation Frequency

F_R : Reference Frequency

Lock lost detection: When PLL is out of lock, IC pin14 will output low level signal to MCU, and then MCU prohibit transmitter from transmitting with a warning tone.

Q8, the power filter, can provide PLL with more purified power to reduce the noise of frequency synthesizer.

5 Voice Circuit:

The station is equipped with Voice Prompt Function, which is very useful during night or under dark condition.

The speaker will voice the current channel number when changing the channel every time because of the voice memory chip (IC401), which stores channel voice prompts. It will repeat the current channel number once pressing "Voice Prompts".

The speaker will voice the current channel number under standby state if the Voice Prompt Function is set. Press "Voice Prompts" for reset to switch voice types. Press "Voice Prompts" repeatedly for power connection, then the voice types will be switched in circle in the order of "Chinese male voice—English male voice—Chinese female voice—English female voice—no prompts".

6 Power Supply:

The station use lithium battery (7.4V, 1700mAh), while transmitter amplifier circuit (Q105 Q107) and receiver audio amplifier (IC302) use battery directly for power supply, and other circuits use regulated voltage (5V and 3V).

IC404: micro-power voltage stabilizer of 3V LDO, provides power (3V) of heavy current for the station together with Q10 and Q30.

IC902: 5V LDO

Q405: 5T switch (controlled by MCU)

5T: supply power for the front end of transmitter

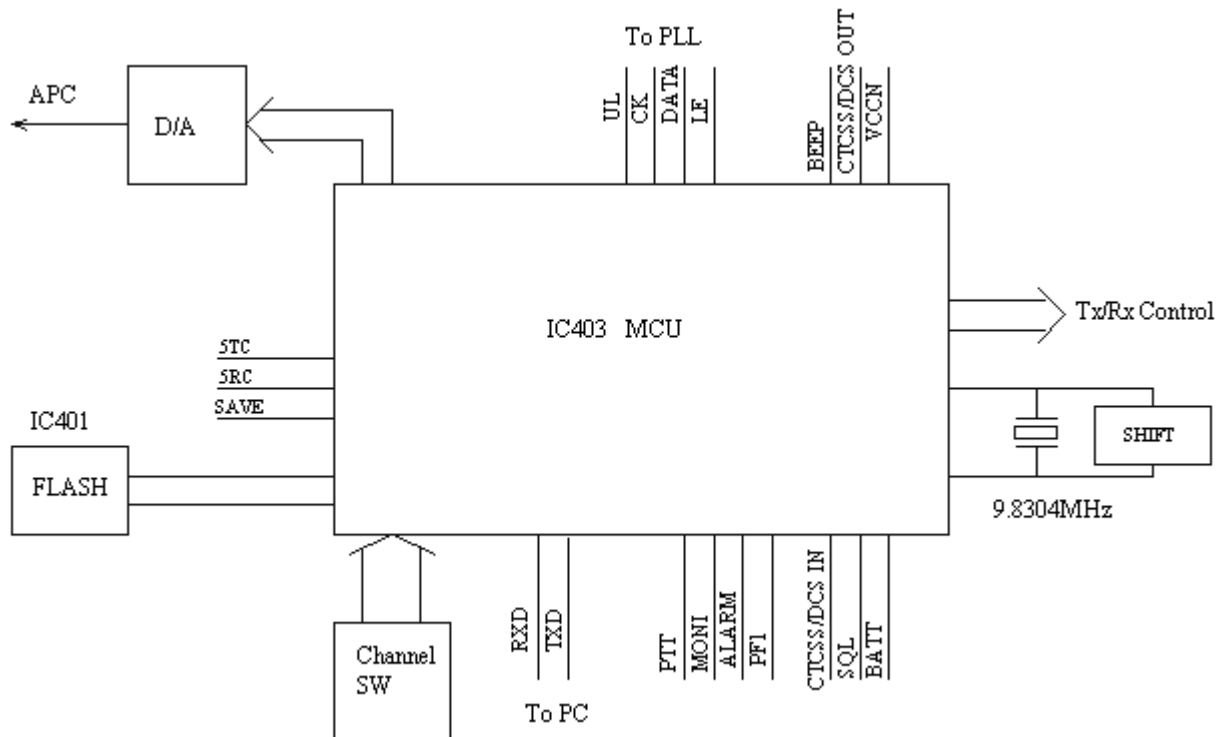
Q408: 5R switch (controlled by MCU)

5R: supply power for the units such as RF amplification, mixing, IF processing and audio signal processing.

Q910: 5C switch (controlled by MCU)

5C: the power (5V), controlled by power-down mode, is the supply power of frequency synthesizer.

7 MCU Unit:



9 Schematic Diagram for MCU Unit

MCU Unit controls the operation of every unit to realize all functions of the CU780-1.

Communication with external PC

State data access

Control PLL for the generation, receiving and transmitting of local oscillation frequency

Access to the current channel state

Control LED status indicator

Control power supplied condition of every unit

Detect action of every function key

Produce CTCSS signal

Produce DCS signal

Produce power controlled signal

Finish CTCSS decoding

Finish DCS decoding

Squelch detection and control

Control voice prompt content

Memory (FLASH)

Channel data, CTCSS/DCS data and other function setting data and parameter adjustment data.

CTCSS/DCS signal coding and decoding:

CTCSS/DCS signals from MCU (pin16 and pin17 output) are sent to VCO and TCXO for modulation respectively after filtering by R500 R501 C500 C501 and R504 R503 C920 C921.

CTCSS/DCS signals from receiver are sent to MCU(pin52) for decoding, and then MCU test if there are CTCSS/DCS signals with the same setting of the station to decide whether open the speaker or not.

CTCSS (continuous tone control squelch system, hereinafter referred to as CTCSS), is a kind of squelch control system with modulation on carrier and continuous sub-audio signals as pilot tone. If CTCSS function is set, the call is available only at the same CTCSS frequency of both receiving and transmitting parties to avoid the disturbance of other signals.

The station has 39 groups of standard CTCSS frequency for your selection, such as Table 1.

CTCSS signals produced by MCU are sent to VCO for modulation after filtered the HF components over 300Hz in low pass filter composed by RC.

Table 1 CTCSS Frequency Table

No.	Frequency [Hz]	No.	Frequency [Hz]	No.	Frequency [Hz]	No.	Frequency [Hz]
1	67.0	11	94.8	21	131.8	31	186.2
2	69.3	12	97.4	22	136.5	32	192.8
3	71.9	13	100.0	23	141.3	33	203.5
4	74.4	14	103.5	24	146.2	34	210.7
5	77.0	15	107.2	25	151.4	35	218.1
6	79.7	16	110.9	26	156.7	36	225.7
7	82.5	17	114.8	27	162.2	37	233.6
8	85.4	18	118.8	28	167.9	38	241.8
9	88.5	19	123.0	29	173.8	39	250.3
10	91.5	20	127.3	30	179.9		

DCS signaling:

DCS (Digital code squelch), is a kind of continuous digital code modulated on carrier with voice signal and used for squelch control. If DCS function is set, the speaker is available only when receiving the same DCS code to avoid the disturbance of useless signals.

The station has 83 kinds of standard codes including positive and inverse code for your selection, such as Table 2.

DCS signals produced by MCU (PWM waveform) are sent to VCO and TCXO for modulation (the HF components of DCS signals are modulated by VCO, while the LF components by TCXO) after filtered the HF components over 300Hz in low pass filter composed by RC.

CTCSS/DCS signals from receiver are sent to MCU for decoding, and then MCU test if there are DCS codes with the same setting of the station to decide whether open the speaker or not.

Table 2 DCS Coding Schedule

023	114	174	315	445	631
025	115	205	331	464	632
026	116	223	343	465	654
031	125	226	346	466	662
032	131	243	351	503	664
043	132	244	364	506	703
047	134	245	365	516	712
051	143	251	371	532	723

054	152	261	411	546	731
065	155	263	412	565	732
071	156	265	413	606	734
072	162	271	423	612	743
073	165	306	431	624	754
074	172	311	432	627	

8 Description of Semiconductor Devices

The distribution of each pin goes as the table 3.

Table 3---Definition of CPU Base Pin:

Pin No.	Port Name	Pin Name	I/O	Active Level	Function
1	PCTV	DA1	O	-	APC/BPF control output
2	DTMF	DA0	O	-	DTMF/Beep output
3	TONI	P92	I	-	TONE data input
4	F_CS	P91	I	L	FLASH chip select output
5	F_DI	P90	O	-	FLASH data input
6	BYTE	BYTE	-	-	GND
7	CNVSS	CNVSS	-	-	GND
8	F_CLK	P87	O	-	FLASH serial clock
9	F_DIO	P86	I/O	-	FLASH data input/output
10	RESET	RESET	I	-	CUP RESET
11	XOUT	XOUT	O	-	CUP CLOCK
12	VSS	VSS	-	-	GND
13	XIN	XIN	I	-	CPU CLOCK
14	VCC	VCC	-	-	+3V
15	NC	P85	I	-	NC
16	NC	P84	I	-	NC
17	RDT	P83	I	-	Base Band IC data input
18	A-TCLK	P82	I	-	Base Band IC clock input
19	A-DI/O	P81	I/O	-	Base Band IC Data Input/Output
20	A-TDATA	P80	O	-	Base Band IC data output
21	A-DIR	P77	O	-	Base Band IC data output
22	VCCN	P76	O	-	Frequency regulation output (PWM)
23	A-SCLK	P75	O	-	Base Band IC clock output
24	DCSVCO	P74	O	-	CTCSS/DCS output (VCO)
25	ST-Reset	P73	O	H	SMARTRUNK Board Reset
26	DCSTCXO	P72	O	-	CTCSS/DCS output (TCXO)
27	RXD2	P71	I	-	Serial data (PC, Wired Clone)
28	TXD2	P70	O	-	Serial data (PC, Wired Clone)
29	TXD1	P67	O	-	TXD1
30	RXD1	P66	I	-	RXD1
31	NC	P65	-	-	NC
32	BSHIFT	P64	O	H	Beat Shift Enable

33	TXD0	P63	O	-	TXD0
34	RXD0	P62	I	-	RXD0
35	RXVCO	P61	O	-	T/R VCO switch
36	NC	P60	-	-	NC
37	RXMUTE	P57	O	L	RX audio mute
38	BEEP_AF	P56	O	L	Local Beep Control Pin
39	NC	P55	-	-	NC
40	PLL-CLK	P54	O	-	PLL clock output
41	PLL-DATA	P53	O	-	PLL data output
42	PLL-EN	P52	O	-	PLL Enable output
43	PLL-UL	P51	I	H	PLL locked input
44	NC	P50	-	-	NC
45	NC	P47	-	-	NC
46	5TC	P46	O	H	Transmitting power control
47	NARROW	P45	O	H	Narrow Band Control
48	MIDDLE	P44	O	H	20KHz Band Control
49	GPS-ON	P43	O	-	GPS Control
50	SAVE	P42	O	H	Power Save Control
51	SPKSW	P41	O	L	Audio Amplification Switch
52	ALARMC	P40	O	L	Alarm switch control (H: Controlled by Volume Switch L: Emergency siren maximum volume)
53	AFCO	P37	O	L	Audio Amplification Power
54	5RC	P36	O	H	Receiving power control
55	RLED	P35	O	H	Red LED control
56	GLED	P34	O	H	Green LED control
57	TOPKEY	P33	I	L	PKEY1 Input
58	EXTPTT	P32	I	L	External PTT input
59	MIC-MUTE	P31	O	L	Internal MIC mute
60	VCC	VCC	-	-	
61	APCSW	P30	O	H	APC switch
62	VSS	VSS	-	-	GND
63	PTT	P27	I	L	PTT switch input
64	SK1	P26	I	L	SK1 Input
65	SK2	P25	I	L	SK2 Input
66	LAMP	P24	O	H	LCD Backlight Control
67	LCD-5	P23	O	-	LCD data output
68	LCD-4	P22	O	-	LCD clock output
69	B_SD	P21	I	-	Decoder data input
70	B_ACK	P20	O	-	Decoder ACK control
71	B_EST	P17	I	-	Decoder data input
72	NC	P16	-	-	NC
73	EN0	P15	I	-	Channel knob input
74	EN1	P14	I	-	Channel knob input
75	NC	P13	-	-	NC

76	LCD-3	P12	O	-	LCD A0 control
77	LCD-2	P11	O	-	LCD RS control
78	LCD-1	P10			
79	K8	P07			
80	K7	P06			
81	K6	P05			
82	K5	P04			
83	K4	P03			
84	K3	P02			
85	K2	P01			
86	K1	P00			
87	BATT	P107			
88	RSSI	P106			
89	BUSY	P105			
90	VOX	P104			
91	DCS-IN	P103			
92	DTMF-IN	P102			
93	R_AUDIO	P101			
94	AVSS	AVSS			
95	L_AUDIO	P100			
96	VREF	VREF			
97	AVCC	AVCC			
98	RX_WN	P97			
99	MANDOWN	P96			
100	NC	P95			

Table 4 Functional description of semiconductor device

Item	Model	Function Description
IC1	MB15E03	Frequency Synthesizer
IC100	NJM2904	APC, Voltage Comparison, Driving
IC200	NJM2591V	Receiver 2 nd Local Oscillation, 2 nd IF Amplification, Limitation, Demodulation, Noise Amplification
IC300	NJM2902V	Receiver demodulated signal Amplification, Filtering
IC500	NJM2100V	MIC Amplification, Limitation, Filtering
IC302	TDA2822D	Audio Frequency Power Amplification
IC401	W25Q80	FLASH, Channel Frequency Data Storage, Function Setting Parameter, Debug Mode Parameter
IC403	M3062	MCU
IC400	PST9124NR	MCU Reset Circuit
IC805	BU8872FS	DTMF receiver
IC805	AK2346	Audio Processor