Digital Radio Projects

TKR901 Programming Modules

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References

[1] gnu.org, "General Public Licence," [Online]. Available: https://www.gnu.org/licenses/gpl-3.0.en.html. [Accessed 25th February 2018].

[2] Enjoy Digital, "LIteX," 05 06 2025. [Online]. Available: https://github.com/enjoy-digital/litex. [Accessed 05 06t 2025].

Revision Status

Revision	Date	Description
0.1	Sept, 2025	Initial Draft
0.2	Sept, 2025	Added PI Zero

Table 1 Revision status

Related Documents

Author	Issue Date	Description
Kenwood	1993-97	TKR-901 Service Manual
Fujitsu	1995	MB1501 Serial input PLL frequency synthesizer
Microchip	2017	PIC81F25K83 Data Sheet

Table 2 Related Documents

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This document is a preliminary release for a product still in development and may be subject to change in future revisions. The software described herein may be subject to unpredictable behaviour without notice. You are advised to keep a can of RAID™ Ant, Roach and Program Bug killer handy. Spray liberally on the affected area when needed.

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PIC based Programmer

The PIC based programmer is a self-contained module for the dedicated purpose of programming the transmit and receive synthesizers of the TKR901 repeater, and to aid in the tune-up and provisioning process. Figure 1 illustrates the module.

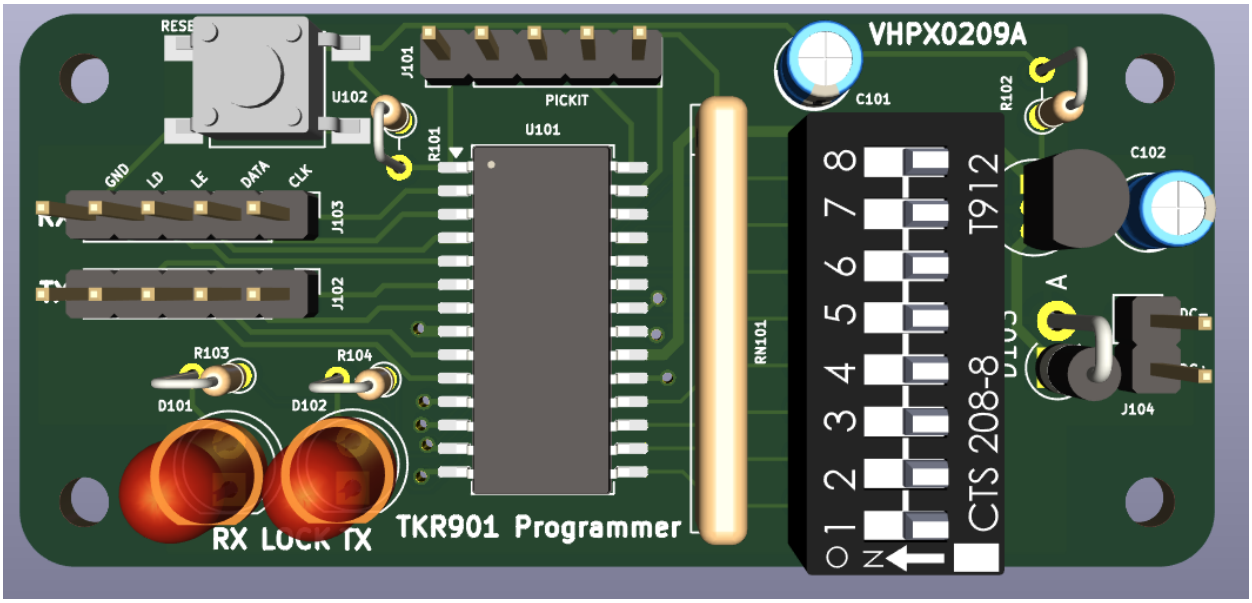

Figure 1 TKR901 Programming Module

The heart of the module is a PIC18F25K83 microcontroller, which is an 8-bit processor with up to 64K flash memory and 4K of SRAM and can run up to 64MHz. Connected to it is a DIP switch for input of frequency information, as well as two LEDs for status. There are two connectors for the transmit and receive synthesizers, and a self-contained 5v power supply, which is compatible with the MB1501 parts without any external level conversion. A polarity reversal diode ensures that it will not be damaged if connected with the wrong polarity.

It operates by monitoring the lock detect inputs from the synthesizer and reprogramming as required. Almost 256 frequency pairs have been programmed, including a subset of the commercial and a full range of amateur frequencies, with channel spacing of 12.5 KHz. Additional entries have been made to simplify the retuning process, and some debug modes to aid in debugging.

The module has the same form factor as Pi Zero and can replace it using the same mounting hardware. It can operate in the full temperature range of -40° to +85°C.

Installation

Before starting: read the switch settings in the repeater and find an entry in the commercial frequency Table 11. If an exact match cannot be found, find the closest entry. Set the three BCD switch settings on the Tx Unit to this value and test the receive sensitivity and transmitter output power. Use a dummy load to ensure that no on-air transmission takes place.

The module may be installed anywhere in the chassis, however in the middle equidistant from the transmit and receive modules is recommended. If a Pi Zero was previously used, it can be placed on the same mounts as it has the same dimensions. Install a 2-pin connector on the end of a pair of wires and connect one to the fuse after the power connector, and the other to a ground. Set the switch settings to all ON (11111111) and apply power. The LED's will flash alternately, indicating that the module is working.

Cut a 5-conductor ribbon cable (brown/red/orange/yellow/green) to approximately 50cm (20") and install a 5-pin connector at each end. Cut the cable mid-way and strip back about 5cm (2") of the brown and green connectors. Install the cable according to the table shown below.

Remove R248, 247 and 246 from the underside of the transmitter, strip back the ribbon cable and connect it as shown in Table 3. For the LD connection, the resistor does not need to be removed. The ground can be anything convenient.

Tx Unit Wiring

MB1501F	Original connection	Wire Colour	Function	Connector Pin
9 (1)	R248	Green	Clock	1
10 (2)	R247	Yellow	Data	2
11 (3)	R246	Orange	LE	3
7	R241/CPU pin 18	Red	LD	4
-	-	Brown	Ground	5

Table 3 Transmitter Wiring

Similarly, remove R248, 247 and 245 from the underside of the receiver, strip back the ribbon cable and connect it as shown in Table 3. For the LD connection, the resistor does not need to be removed. Connect as shown in Table 4.

Rx Unit Wiring

MB1501F	Original connection	Wire Colour	Function	Connector Pin
9 (1)	R248	Red	Clock	1
10 (2)	R247	Orange	Data	2
11 (3)	R245	Yellow	LE	3
7	R241/CPU pin 18	Green	LD	4
-	-	Brown	Ground	5

Table 4 Rx Unit wiring

Pi Zero Programmer

The Pi Zero programmer uses an off the shelf Pi Zero module to perform the programming function. A header needs to be installed to be able to connect to the synthesizers.

Installation

Installation is very similar to the PIC programmer. Install a 5V regulator and make up the same cable as discussed above. A level shifter as illustrated in Figure 2 is highly advisable, as the Pi has 3.3V outputs, and the MB1501 runs from 5V.

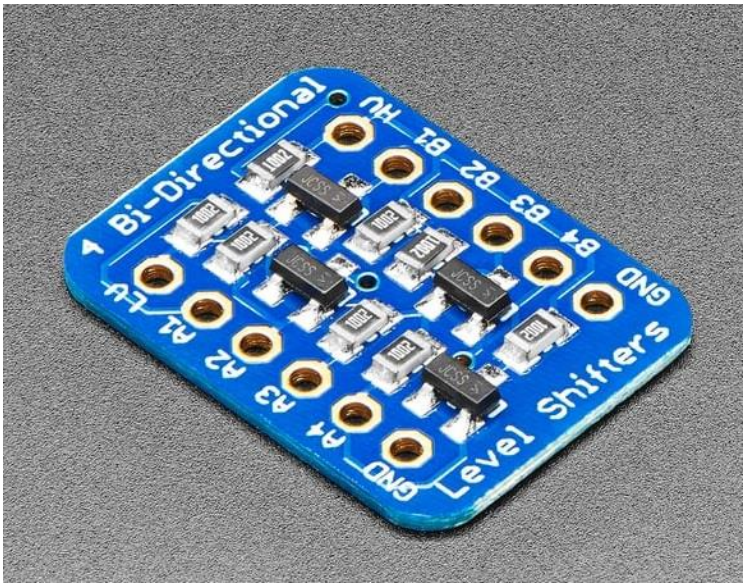

Figure 2 Level Shifter

Cut a 5-conductor ribbon cable (brown/red/orange/yellow/green) to approximately 50cm (20”) and install a 5-pin connector at each end. Cut the cable mid-way and strip back about 5cm (2”) of the brown and green connectors. Install the cable according to the table shown below.

For the transmitter, remove R248, 247 and 246 from the underside of the PCB, strip back the ribbon cable and connect it as shown in Table 3. For the LD connection, the resistor does not need to be removed. The ground can be anything convenient.

MB1501F Pin (Bus)	Original connection	Wire Colour	Function	Level Shifter	Source/Pi Pin	GPIO
11 (3)	R246	Red	LE	B4/A4	33	13
10 (2)	R247	Orange	Data	B3/A3	31	6
9 (1)	R248	Yellow	Clock	B2/A2	29	5
7	R241/CPU pin 18	Green	LD	B1/A1	35	19
-	-	Brown	Ground		25	-
-	-	Blue	3.3V	LV	1	-
-	-	Purple	5.0V	HV	Regulator	-

Table 5 Pi Zero Transmitter connections

For the receiver, remove R248, 247 and 245 from the underside of the PCB, strip back the ribbon cable and connect it as shown in Table 3. For the LD connection, the resistor does not need to be removed. Connect as shown in Table 6.

MB1501F Pin (Bus)	Original connection	Wire Colour	Function	Level Shifter	Source/Pi Pin	GPIO
11 (3)	R245	Yellow	LE	B4/A4	15	22
10 (2)	R247	Orange	Data	B3/A3	13	27
9 (1)	R248	Red	Clock	B2/A2	11	17
7	R241/CPU pin 18	Green	LD	B1/A1	18	26
-	-	Brown	Ground	GND	9	-
-	-	Blue	3.3V	LV	17	-
-	-	Purple	5.0V	HV	Regulator	-

Table 6 Pi Zero Receiver connections

Figure 3 illustrates the installation in the repeater chassis. The Pi board is in the centre, the level converters are mounted with double-sided tape on the side of the chassis. This particular installation also has an ethernet controller for remote access.

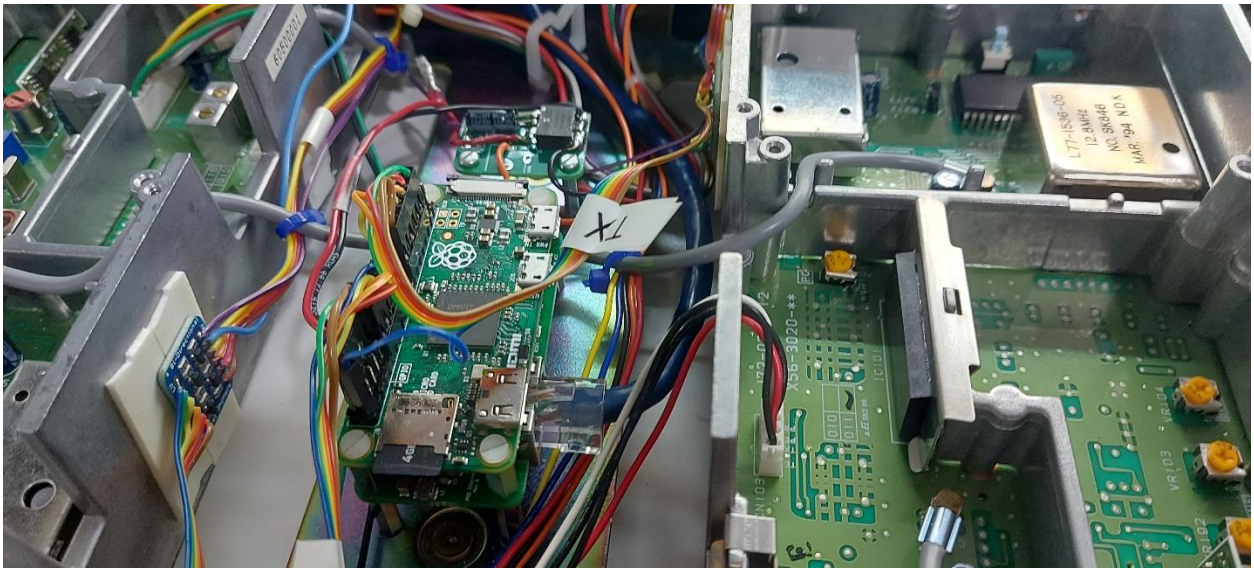

Figure 3 Pi Installation in TKR901

Building the software

Download the code from the GitHub site and copy it to a directory called ‘MB1501’. To build it, type ‘make’ on the command line.

To run the software, type ‘sudo mb1501 <nn>’, when nn is the ID as show in the frequency and test tables.

Debugging

There are several test modes that can be utilized for debugging and verification, as shown in Table 7. Setting the switches to 11110000 on the Pic or selecting ID 241 on the Pi will output a square wave on the TX_CLK signal, which can be traced with an oscilloscope. On the PIC module the TX LED will be on, and the RX LED will be off. Verify the presence of the signal as illustrated in Table 3. Repeat the test for each of the transmitter leads, and then for the receiver as illustrated in Table 4. When changing the switch settings, hit the reset button for the test to take effect.

ID	Dip SW	Test Type	Output	TX LED	RX LED
241	11110000	Square wave test	TX_CLK	ON Solid	Off
242	11110001		TX_DATA		
243	11110010		TX_LE		
244	11110011		RX_CLK	Off	On Solid
245	11110100		RX_DATA		
246	11110101		RX_LE		
256	11111111	LED Flash Test	-	Alternating	

Table 7 Test Modes

Tune Up

The first step is to bring up the transmitter and receiver on the original commercial frequencies. On the PIC, set the DIP switch setting to the value utilized in the pre-modification step and hit the reset key. On the PI enter the frequency ID. Ensure that the Tx and Rx lock LED's light on the PIC, and all the LEDs on the front panel of the TKR901 are no longer flashing. If they are, repeat the debugging step and check your wiring.

Tuning involves setting the VCO voltage. Attach a voltmeter to the test point beside the receiver VCO, it should read about 4V. Then, adjust the frequency **UPWARDS** to the end of the commercial chart (397), in small enough steps to keep the PLL locked. Adjust the VCO at each step. During this time the transmitter is not programmed and its LED if off.

ID	Dip SW	Tx Freq	Rx Freq	ID	Dip SW	Tx Freq	Rx Freq
114	01110001	-	900.0000	122	01111001	-	901.2000
115	01110010	-	900.1500	123	01111010	-	901.3500
116	01110011	-	900.3000	124	01111011	-	901.5000
117	01110100	-	900.4500	125	01111100	-	901.6500
118	01110101	-	900.6000	126	01111101	-	901.8000
119	01110110	-	900.7500	127	01111110	-	901.9500
120	01110111	-	900.9000	128	01111111	-	902.1000
121	01111000	-	901.0500				

Table 8 Receiver tune-down frequencies

The transmitter has the largest frequency change of almost 8 MHz. Using the commercial frequencies, adjust the frequency **DOWNWARDS** until you reach channel 1, then you can use the tune down settings to get closer to the amateur band.

ID	Dip SW	Tx Freq	Rx Freq	Freq ID	Dip SW	Tx Freq	Rx Freq
81	01010000	927.0000	-	98	01100001	931.2500	-
82	01010001	927.2500	-	99	01100010	931.5000	-
83	01010010	927.5000	-	100	01100011	931.7500	-
84	01010011	927.7500	-	101	01100100	932.0000	-
85	01010100	928.0000	-	102	01100101	932.2500	-
86	01010101	928.2500	-	103	01100110	932.5000	-
87	01010110	928.5000	-	104	01100111	932.7500	-
88	01010111	928.7500	-	105	01101000	933.0000	-
89	01011000	929.0000	-	106	01101001	933.2500	-
90	01011001	929.2500	-	107	01101010	933.5000	-
91	01011010	929.5000	-	108	01101011	933.7500	-
92	01011011	929.7500	-	109	01101100	934.0000	-
93	01011100	930.0000	-	110	01101101	934.2500	-
94	01011101	930.2500	-	111	01101110	934.5000	-
95	01011110	930.5000	-	112	01101111	934.7500	-
96	01011111	930.7500	-	113	01110000	935.0000	-
97	01100000	931.0000	-				

Table 9 Transmitter tune up frequencies

Finally, choose the operational frequencies for the repeater, enter the value on the DIP switch, and hit the reset key. The repeater will now be on the correct frequency.

Amateur Frequencies

The first 80 settings represent amateur frequencies from 926-927/902-903 in steps of 0.0125MHz. When unlocked, the Rx and Tx lock LED's will flash, and be on solid when locked.

ID	Dip SW	Tx Freq	Rx Freq	ID	Dip SW	Tx Freq	Rx Freq
1	00000000	927.0000	902.0000	33	00100000	927.4000	902.4000
2	00000001	927.0125	902.0125	34	00100001	927.4125	902.4125
3	00000010	927.0250	902.0250	35	00100010	927.4250	902.4250
4	00000011	927.0375	902.0375	36	00100011	927.4375	902.4375
5	00000100	927.0500	902.0500	37	00100100	927.4500	902.4500
6	00000101	927.0625	902.0625	38	00100101	927.4625	902.4625
7	00000110	927.0750	902.0750	39	00100110	927.4750	902.4750
8	00000111	927.0875	902.0875	40	00100111	927.4875	902.4875
9	00001000	927.1000	902.1000	41	00101000	927.5000	902.5000
10	00001001	927.1125	902.1125	42	00101001	927.5125	902.5125
11	00001010	927.1250	902.1250	43	00101010	927.5250	902.5250
12	00001011	927.1375	902.1375	44	00101011	927.5375	902.5375
13	00001100	927.1500	902.1500	45	00101100	927.5500	902.5500
14	00001101	927.1625	902.1625	46	00101101	927.5625	902.5625
15	00001110	927.1750	902.1750	47	00101110	927.5750	902.5750
16	00001111	927.1875	902.1875	48	00101111	927.5875	902.5875
17	00010000	927.2000	902.2000	49	00110000	927.6000	902.6000
18	00010001	927.2125	902.2125	50	00110001	927.6125	902.6125
19	00010010	927.2250	902.2250	51	00110010	927.6250	902.6250
20	00010011	927.2375	902.2375	52	00110011	927.6375	902.6375
21	00010100	927.2500	902.2500	53	00110100	927.6500	902.6500
22	00010101	927.2625	902.2625	54	00110101	927.6625	902.6625
23	00010110	927.2750	902.2750	55	00110110	927.6750	902.6750
24	00010111	927.2875	902.2875	56	00110111	927.6875	902.6875
25	00011000	927.3000	902.3000	57	00111000	927.7000	902.7000
26	00011001	927.3125	902.3125	58	00111001	927.7125	902.7125
27	00011010	927.3250	902.3250	59	00111010	927.7250	902.7250
28	00011011	927.3375	902.3375	60	00111011	927.7375	902.7375
29	00011100	927.3500	902.3500	61	00111100	927.7500	902.7500
30	00011101	927.3625	902.3625	62	00111101	927.7625	902.7625
31	00011110	927.3750	902.3750	63	00111110	927.7750	902.7750
32	00011111	927.3875	902.3875	64	00111111	927.7875	902.7875

ID	Dip SW	Tx Freq	Rx Freq	ID	Dip SW	Tx Freq	Rx Freq
33	00100000	927.4000	902.4000	65	01000000	927.8000	902.8000
34	00100001	927.4125	902.4125	66	01000001	927.8125	902.8125
35	00100010	927.4250	902.4250	67	01000010	927.8250	902.8250
36	00100011	927.4375	902.4375	68	01000011	927.8375	902.8375
37	00100100	927.4500	902.4500	69	01000100	927.8500	902.8500
38	00100101	927.4625	902.4625	70	01000101	927.8625	902.8625
39	00100110	927.4750	902.4750	71	01000110	927.8750	902.8750
40	00100111	927.4875	902.4875	72	01000111	927.8875	902.8875
41	00101000	927.5000	902.5000	73	01001000	927.9000	902.9000
42	00101001	927.5125	902.5125	74	01001001	927.9125	902.9125
43	00101010	927.5250	902.5250	75	01001010	927.9250	902.9250
44	00101011	927.5375	902.5375	76	01001011	927.9375	902.9375
45	00101100	927.5500	902.5500	77	01001100	927.9500	902.9500
46	00101101	927.5625	902.5625	78	01001101	927.9625	902.9625
47	00101110	927.5750	902.5750	79	01001110	927.9750	902.9750
48	00101111	927.5875	902.5875	80	01001111	927.9875	902.9875
49	00110000	927.6000	902.6000	81	01010000	928.0000	903.0000
50	00110001	927.6125	902.6125	82	01010001	928.0125	903.0125
51	00110010	927.6250	902.6250	83	01010010	928.0250	903.0250
52	00110011	927.6375	902.6375	84	01010011	928.0375	903.0375
53	00110100	927.6500	902.6500	85	01010100	928.0500	903.0500
54	00110101	927.6625	902.6625	86	01010101	928.0625	903.0625
55	00110110	927.6750	902.6750	87	01010110	928.0750	903.0750
56	00110111	927.6875	902.6875	88	01010111	928.0875	903.0875
57	00111000	927.7000	902.7000	89	01011000	928.1000	903.1000
58	00111001	927.7125	902.7125	90	01011001	928.1125	903.1125
59	00111010	927.7250	902.7250	91	01011010	928.1250	903.1250
60	00111011	927.7375	902.7375	92	01011011	928.1375	903.1375
61	00111100	927.7500	902.7500	93	01011100	928.1500	903.1500
62	00111101	927.7625	902.7625	94	01011101	928.1625	903.1625
63	00111110	927.7750	902.7750	95	01011110	928.1750	903.1750
64	00111111	927.7875	902.7875	96	01011111	928.1875	903.1875

ID	Dip SW	Tx Freq	Rx Freq	ID	Dip SW	Tx Freq	Rx Freq
65	01000000	927.8000	902.8000	73	01001000	927.9000	902.9000
66	01000001	927.8125	902.8125	74	01001001	927.9125	902.9125
67	01000010	927.8250	902.8250	75	01001010	927.9250	902.9250
68	01000011	927.8375	902.8375	76	01001011	927.9375	902.9375
69	01000100	927.8500	902.8500	77	01001100	927.9500	902.9500
70	01000101	927.8625	902.8625	78	01001101	927.9625	902.9625
71	01000110	927.8750	902.8750	79	01001110	927.9750	902.9750
72	01000111	927.8875	902.8875	80	01001111	927.9875	902.9875

Table 10 Amateur Frequency settings

Commercial Frequencies

Commercial frequencies, 1 to 197. The channel number matches that on S201-S203 on the transmitter board in the TKR901.

ID	Chan	Dip SW	TX Freq	Rx Freq	ID	Chan	Dip SW	TX Freq	Rx Freq
129	1	10000000	935.0125	896.0125	154	101	10011001	936.2625	897.2625
130	5	10000001	935.0625	896.0625	155	105	10011010	936.3125	897.3125
131	9	10000010	935.1125	896.1125	156	109	10011011	936.3625	897.3625
132	13	10000011	935.1625	896.1625	157	113	10011100	936.4125	897.4125
133	17	10000100	935.2125	896.2125	158	117	10011101	936.4625	897.4625
134	21	10000101	935.2625	896.2625	159	121	10011110	936.5125	897.5125
135	25	10000110	935.3125	896.3125	160	125	10011111	936.5625	897.5625
136	29	10000111	935.3625	896.3625	161	129	10100000	936.6125	897.6125
137	33	10001000	935.4125	896.4125	162	133	10100001	936.6625	897.6625
138	37	10001001	935.4625	896.4625	163	137	10100010	936.7125	897.7125
139	41	10001010	935.5125	896.5125	164	141	10100011	936.7625	897.7625
140	45	10001011	935.5625	896.5625	165	145	10100100	936.8125	897.8125
141	49	10001100	935.6125	896.6125	166	149	10100101	936.8625	897.8625
142	53	10001101	935.6625	896.6625	167	153	10100110	936.9125	897.9125
143	57	10001110	935.7125	896.7125	168	157	10100111	936.9625	897.9625
144	61	10001111	935.7625	896.7625	169	161	10101000	937.0125	898.0125
145	65	10010000	935.8125	896.8125	170	165	10101001	937.0625	898.0625
146	69	10010001	935.8625	896.8625	171	169	10101010	937.1125	898.1125
147	73	10010010	935.9125	896.9125	172	173	10101011	937.1625	898.1625
148	77	10010011	935.9625	896.9625	173	177	10101100	937.2125	898.2125
149	81	10010100	936.0125	897.0125	174	181	10101101	937.2625	898.2625
150	85	10010101	936.0625	897.0625	175	185	10101110	937.3125	898.3125
151	89	10010110	936.1125	897.1125	176	189	10101111	937.3625	898.3625
152	93	10010111	936.1625	897.1625	177	193	10110000	937.4125	898.4125
153	97	10011000	936.2125	897.2125	178	197	10110001	937.4625	898.4625

The remaining commercial frequencies up to 397.

ID	Chan	Dip SW	TX Freq	Rx Freq	ID	Chan	Dip SW	TX Freq	Rx Freq
179	201	10110010	937.5125	898.5125	204	301	11001011	938.7625	899.7625
180	205	10110011	937.5625	898.5625	205	305	11001100	938.8125	899.8125
181	209	10110100	937.6125	898.6125	206	309	11001101	938.8625	899.8625
182	213	10110101	937.6625	898.6625	207	313	11001110	938.9125	899.9125
183	217	10110110	937.7125	898.7125	208	317	11001111	938.9625	899.9625
184	221	10110111	937.7625	898.7625	209	321	11010000	939.0125	900.0125
185	225	10111000	937.8125	898.8125	210	325	11010001	939.0625	900.0625
186	229	10111001	937.8625	898.8625	211	329	11010010	939.1125	900.1125
187	233	10111010	937.9125	898.9125	212	333	11010011	939.1625	900.1625
188	237	10111011	937.9625	898.9625	213	337	11010100	939.2125	900.2125
189	241	10111100	938.0125	899.0125	214	341	11010101	939.2625	900.2625
190	245	10111101	938.0625	899.0625	215	345	11010110	939.3125	900.3125
191	249	10111110	938.1125	899.1125	216	349	11010111	939.3625	900.3625
192	253	10111111	938.1625	899.1625	217	353	11011000	939.4125	900.4125
193	257	11000000	938.2125	899.2125	218	357	11011001	939.4625	900.4625
194	261	11000001	938.2625	899.2625	219	361	11011010	939.5125	900.5125
195	265	11000010	938.3125	899.3125	220	365	11011011	939.5625	900.5625
196	269	11000011	938.3625	899.3625	221	369	11011100	939.6125	900.6125
197	273	11000100	938.4125	899.4125	222	373	11011101	939.6625	900.6625
198	277	11000101	938.4625	899.4625	223	377	11011110	939.7125	900.7125
199	281	11000110	938.5125	899.5125	224	381	11011111	939.7625	900.7625
200	285	11000111	938.5625	899.5625	225	385	11100000	939.8125	900.8125
201	289	11001000	938.6125	899.6125	226	389	11100001	939.8625	900.8625
202	293	11001001	938.6625	899.6625	227	393	11100010	939.9125	900.9125
203	297	11001010	938.7125	899.7125	228	397	11100011	939.9625	900.9625

Table 11 Commercial frequencies