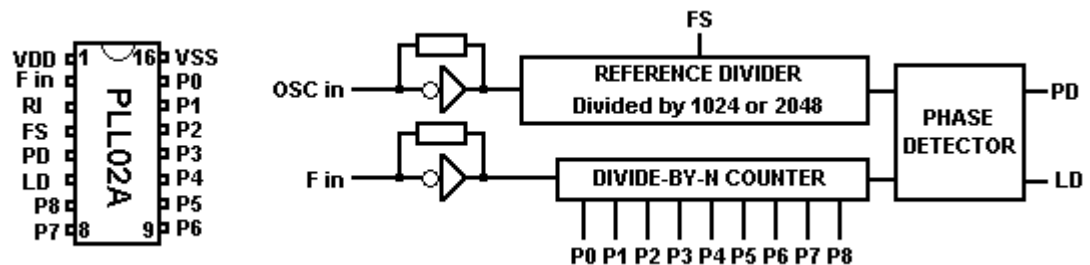


PLL02A, AN6040, MC145109, MM48141, MN6040, SM5109 and TC9100

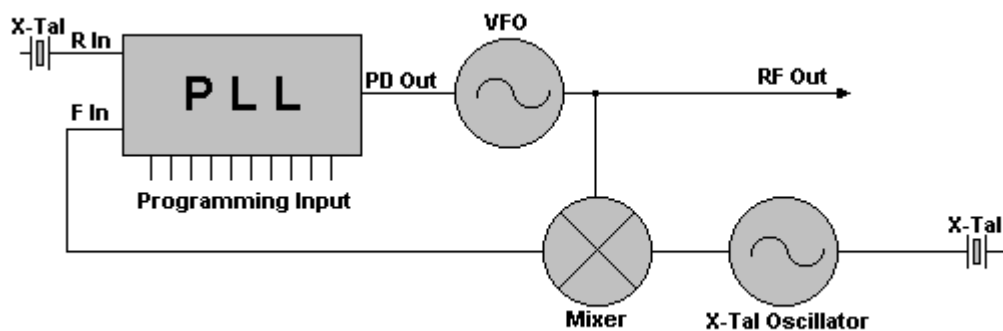
PLL frequency synthesizer



Overview

This PLL-circuit use a 9 bit BCD binary programmable divide-by-N counter.

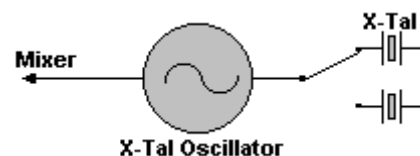
Down-converting of the frequency to the divider



This PLL circuit use a mixer and a XTAL oscillator to convert the output frequency f_{OUT} to the f_{IN} to the PLL Circuit.

The XTAL frequency is $f_{XTAL} = f_{OUT} - f_{IN}$

The output frequency can be changed by changing the mixing-XTAL or add a new mixing-XTAL to the oscillator.



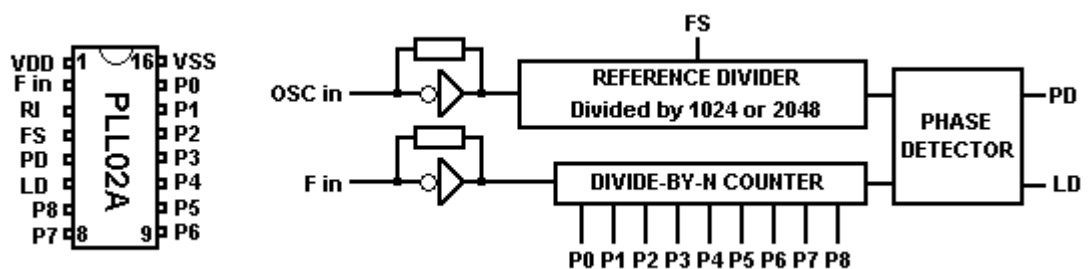
Pin Name	Description
1 VDD	Positive power supply
2 F in	VCO oscillator input

3	RI	Reference oscillator input (10.240MHz)
4	FS	High=10kHz - Low=5kHz (Frequency step)
5	PD	VCO voltage out
6	LD	Loop Detected - High=Locked, Low=Unlocked
7	P8	Programmable input (Binary)
8	P7	Programmable input (Binary)
9	P6	Programmable input (Binary)
10	P5	Programmable input (Binary)
11	P6	Programmable input (Binary)
12	P3	Programmable input (Binary)
13	P2	Programmable input (Binary)
14	P1	Programmable input (Binary)
15	P0	Programmable input (Binary)
16	Vss	Ground

PLL02A

MC145109 MM48141 AN6040 MN6040 SM5109 TC9100

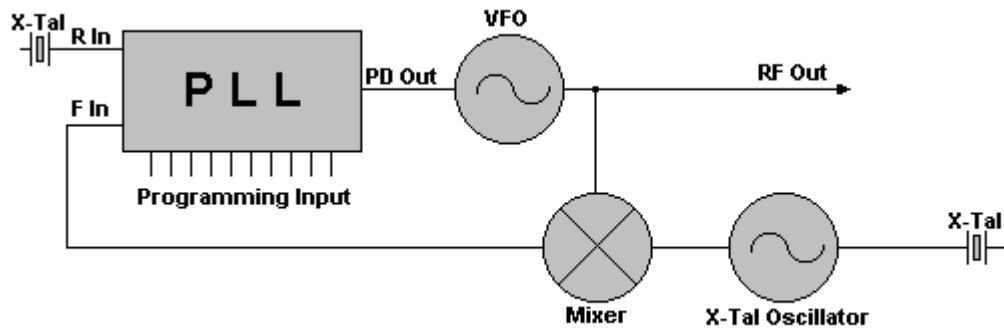
PLL Frequency Synthesizer



Overview

This PLL-circuit use a 9 bit BCD binary programmable divide-by-N counter.

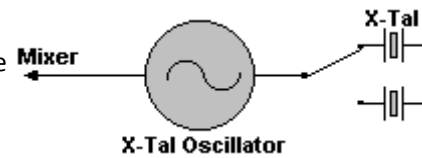
Down-converting of the frequency to the divider



This PLL Circuit use a Mixer and a X-Tal Oscillator to convert the output frequency f_{OUT} to the f_{IN} to the PLL Circuit.

The X-Tal frequency is $f_{XTAL} = f_{OUT} - f_{IN}$

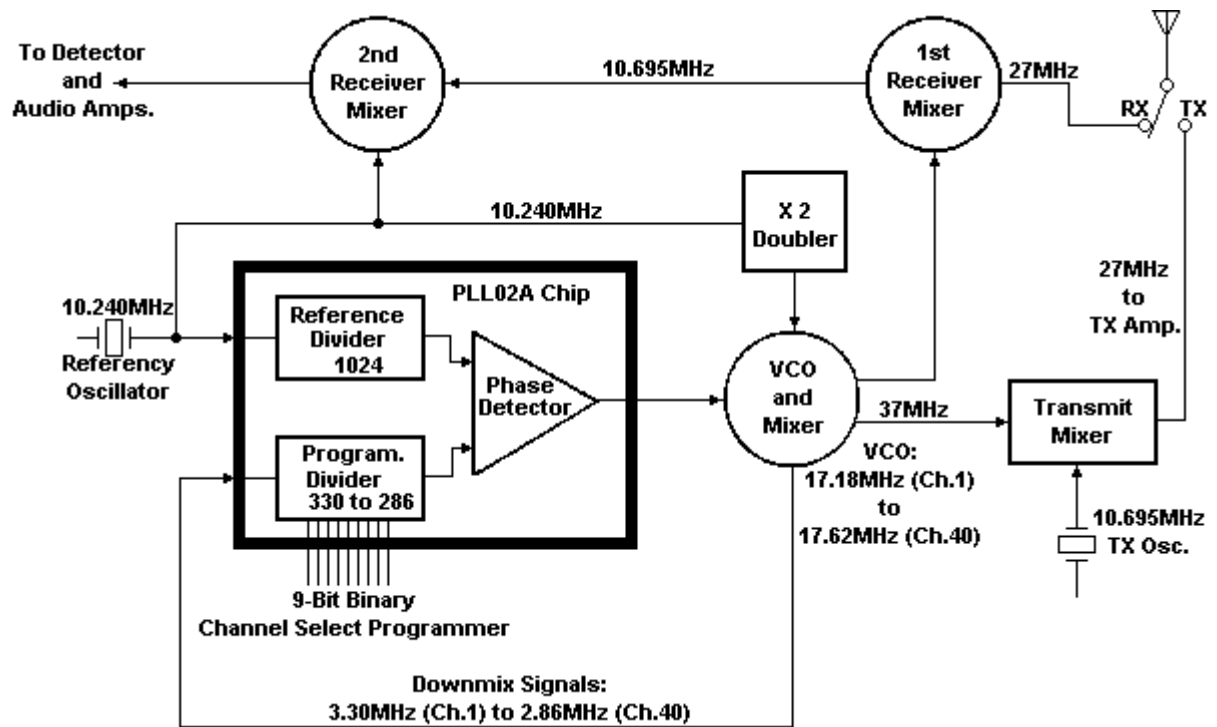
The output frequency can be changed by changing the mixing-xtal or add a new mixing-xtal to the oscillator.



Pin	Name	Description
1	VDD	Positive Power Supply
2	F in	VCO Oscillator Input
3	RI	Reference Oscillator Input (10.240MHz)
4	FS	HIGH=10kHz - LOW=5kHz
5	PD	VCO Voltage Out
6	LD	Loop Detected - HIGH=Locked LOW=Unlocked
7	P8	Programmable input (Binary)
8	P7	Programmable input (Binary)
9	P6	Programmable input (Binary)
10	P5	Programmable input (Binary)
11	P6	Programmable input (Binary)
12	P3	Programmable input (Binary)
13	P2	Programmable input (Binary)
14	P1	Programmable input (Binary)
15	P0	Programmable input (Binary)
16	Vss	Ground

Modification methods

A TYPICAL PLL SYNTHESIZER



Refer to the figure, which is the PLL circuit of perhaps the most common AM PLL rig ever made. It's been sold under dozens of brand names, and uses the ever-popular PLL02A IC. The SSB and export multimode versions of this circuit are very similar; there are only minor differences relating to the SSB offsets and FMing the VCO.

A PLL design may be categorized very generally by the number of crystals it uses, and by whether its VCO is running on the low or high side of 27 MHz. This particular example is actually the second generation of the PLL02A AM circuit; the original PLL circuit used a total of 3 crystals.

The key to synthesizing all of the required frequencies lies in the Programmable Divider. That's the only PLL section that you can control from the outside world by means of the Channel Selector. Which is where it all starts.

Suppose you choose Ch., 26.965 MHz. When setting Ch.1 the Programmable Divider (PD) receives a very specific set of instructions at all its programming pins, which are directly connected to the Channel Selector. This specific set which we have called its "N-Code", applies only to Ch.I. It's just a number by which any signal appearing at the PD input pin will be divided.

Binary Programing

Refer now to Programming Chart, which summarizes the important operating conditions by specific channel number. A chart like this one is normally included with the radio's service manual. Often though certain facts not directly related to the legal 40-channel operation are left

out, so I'll be filling in some missing blanks for you.

Programming Chart for PLL02A

Ch. No.	Frequency (MHz)	"N" digital codes	VCO freq. (MHz)	RX 1st IF freq. (MHz)	P0	P1	P2	P3	P4	P5	P6	P7	P8
1	26.965	330	17.18	37.66	0	1	0	1	0	0	1	0	1
2	26.975	329	17.19	37.67	1	0	0	1	0	0	1	0	1
3	26.985	328	17.20	37.68	0	0	0	1	0	0	1	0	1
4	27.005	326	17.22	37.70	0	1	1	0	0	0	1	0	1
5	27.015	325	17.23	37.71	1	0	1	0	0	0	1	0	1
6	27.025	324	17.24	37.72	0	0	1	0	0	0	1	0	1
7	27.035	323	17.25	37.73	1	1	0	0	0	0	1	0	1
8	27.055	321	17.27	37.75	1	0	0	0	0	0	1	0	1
9	27.065	320	17.28	37.76	0	0	0	0	0	0	1	0	1
10	27.075	319	17.29	37.77	1	1	1	1	1	1	0	0	1
11	27.085	318	17.30	37.78	0	1	1	1	1	1	0	0	1
12	27.105	316	17.32	37.80	0	0	1	1	1	1	0	0	1
13	27.115	315	17.33	37.81	1	1	0	1	1	1	0	0	1
14	27.125	314	17.34	37.82	0	1	0	1	1	1	0	0	1
15	27.135	313	17.35	37.83	1	0	0	1	1	1	0	0	1
16	27.155	311	17.37	37.85	1	1	1	0	1	1	0	0	1
17	27.165	310	17.38	37.86	0	1	1	0	1	1	0	0	1
18	27.175	309	17.39	37.87	1	0	1	0	1	1	0	0	1
19	27.185	308	17.40	37.88	0	0	1	0	1	1	0	0	1
20	27.005	306	17.42	37.90	0	1	0	0	1	1	0	0	1
21	27.215	305	17.43	37.91	1	0	0	0	1	1	0	0	1
22	27.225	304	17.44	37.92	0	0	0	0	1	1	0	0	1
23	27.255	301	17.47	37.95	1	0	1	1	0	1	0	0	1
24	27.235	303	17.45	37.93	1	1	1	1	0	1	0	0	1
25	27.245	302	17.46	37.94	0	1	1	1	0	1	0	0	1
26	27.265	300	17.48	37.96	0	0	1	1	0	1	0	0	1
27	27.275	299	17.49	37.97	1	1	0	1	0	1	0	0	1
28	27.285	298	17.50	37.98	0	1	0	1	0	1	0	0	1
29	27.295	297	17.51	37.99	1	0	0	1	0	1	0	0	1
30	27.305	296	17.52	38.00	0	0	0	1	0	1	0	0	1

31	27.315	295	17.53	38.02	1	1	1	0	0	1	0	0	1
32	27.325	294	17.54	38.03	0	1	1	0	0	1	0	0	1
33	27.335	293	17.55	38.04	1	0	1	0	0	1	0	0	1
34	27.345	292	17.56	38.05	0	0	1	0	0	1	0	0	1
35	27.355	291	17.57	38.06	1	1	0	0	0	1	0	0	1
36	27.365	290	17.58	38.07	0	1	0	0	0	1	0	0	1
37	27.375	289	17.59	38.08	1	0	0	0	0	1	0	0	1
38	27.385	288	17.60	38.09	0	0	0	0	0	1	0	0	1
39	27.395	287	17.61	38.10	1	1	1	1	1	0	0	0	1
40	27.405	286	17.62	38.00	0	1	1	1	1	0	0	0	1

From this chart you see the N-Code for Ch.I is the number "330", with the numbers progressing down to "286" at Ch.40. This number 330 is the direct result of applying +DC voltages of about 5-10 VDC to certain PLL IC pins while grounding certain others. Thus, two possible voltage choices, and you'll recall that the PLL uses a digital or binary counting system instead of the decimal system people use.

In a binary number system each successive chip programming pin or "bit" (*binary digit*) is worth exactly double (or half) that of the pin next to it: 1, 2, 4, 8, 16, etc. Thus each pin can be defined by its Power-of-2. We can also call them "1's bit", "2's bit", "4's bit", etc.

A series of "1"s and "0"s appears in the chart for each of the 40 channels. A "1" means +DC is applied to that pin, and a "0" means that pin is grounded. The pin having the highest binary value or "significance" controls the number of possible channels that can be programmed. In this example the highest Power-of-2 is "256" at Pin 7, which is called the "Host Significant Bit"; the "Least Significant Bit" is Pin 15, which is only worth a "1" in binary. A chart like this showing the logic states of each PLL program pin for each channel is called a "Truth Chart" and is helpful for troubleshooting.

How exactly was the number "330" decided? In Chart you see the truth states for Ch.I only. Above each PLL program pin are numbers I've labelled "POWERS OF 2", such as 1, 2, 4, on up to 256 which is how a binary counter counts. By adding up the weight or significance of every pin showing a "1", the N-Code is determined. The "0" or grounded pins are always ignored. In this example we have: $256 + 64 + 8 + 2 = 330$.

Go back now to Programming Chart and notice how the logic states for Pin 7 and Pin 8 never change at all for any of the 40 channels. Then look again at Figure 11 and you'll see that those pins are Permanently hard-wired such that Pin 7 is always tied to +DC ("1"), and Pin 8 is always grounded ("0").

You'll often find that many service manuals won't even include these pin states in the Truth Chart because they never change when programming for the legal 40 channels only. This is a case of those missing blanks I'm filling in for you, and you can test this idea by checking the rig's schematic. Compare the total programming pins available to the total number needed for 40 N-Codes! it's an obvious modification source.

The original 18-channel Australian CB service was legally expanded recently to match the 40 FCC channels. Many of the older Aussie rigs, especially those with the Cybernet type PLL02A chassis,

are simply American rigs with a limited Channel Selector switch. These can be easily expanded by replacing the 18-position switch and wiring up the unused binary bits on the PLL chip.

For example, the original Australian Ch.1 was 27.015 MHz, which corresponds to U.S. Ch.5. The N-Code here is "325". The N-Code for their old Ch.18 (27-225 MHz) is "304". Reprogramming an old PLL02A rig for N-Codes greater than "325" or less than "304" expands the channels.

This particular IC, the PLL02A., has a total of 9 binary programming pins, pins 7-15. So it has what's called a "9-bit" binary programmer. Some quick math should tell you that the chip has a potential channel capacity of $2^9 - 1$, or 511 channels! ($1+2+4+8+16+32+64+128+256 = 511$). Only 40 channels are used for CB purposes but by proper connection and switching of unused pins, many more frequencies are possible.

The VCO Circuit

Refer back to Figure. This VCO runs in the 17 MHz range, from 17.180 MHz on Ch.1 to 17.62 MHz on Ch.40. The VCO is controlled by an error voltage received from the PD, which is constantly looking for a match at the output of the Reference Divider and Programmable Divider.

The Reference Divider is accurately controlled by a 10.240 MHz crystal oscillator whose signal is divided down digitally by 1,024 to produce the required 10 kHz channel spacings. If the Programmable Divider should also happen to output the exact same 10 kHz the result would be perfect; no correction from the PD, and the loop would be locked.

What would it take to produce a perfect 10 kHz output from the Programmable Divider? We've already seen that the Programmable Divider is set to divide any signal it sees by the number 330. For example if it should see a signal of exactly 3.30 MHz at its input, the resulting output would be $3.30 \text{ MHz} \times 330 = 10 \text{ kHz}$. So if we can somehow get an input signal of 3.30 MHz, everything will fall perfectly into place.

Loop Mixing

It so happens there's a very easy way to do this by cleverly borrowing a bit of existing circuitry. If some 10.240 MHz energy from the Reference Divider is taken off and passed through a tuned Doubler stage, the result would be $2 \times 10.240 = 20.480 \text{ MHz}$. Here's where that very important loop mixing principle enters; by mixing the 20.480 MHz signal with the Ch.1 VCO signal of 17.180 MHz, sum and difference frequencies are generated. The sum is $20.480 + 17.180 = 37.660 \text{ MHz}$. The difference is $20.480 - 17.180 = 3.30 \text{ MHz}$. Just what's needed to lock the loop. And the 37.660 MHz energy isn't wasted either; it's used as the high-side mixer injection signal that produces the first- RX IF: $37.660 - \text{incoming } 26.965 = 10.695 \text{ MHz IF}$.

Phase Detector Correction

What happens if the mixing product to the Programmable Divider isn't exactly 3.30 MHz? Let's find out. Since the N-Code is 330, a signal of other than precisely 3.30 MHz would produce a slightly different output to the PD. For example a signal of say, 3.10 MHz results in $3.10 \text{ MHz} \times 330 = 9.93393 \text{ KHz}$. The PD will sense this error and try to correct it by applying a DC voltage to the VCO. This correction voltage will drive the VCO up or down slightly in frequency, with the PD always comparing its two inputs, until an exact match occurs again. While this appears to be just a trial-and-error process, the whole thing happens in the time it takes you to change from Ch.1 to Ch.2 !

Receiver IF's

We've now seen how the Ch.1 PLL mixer signal of 37.660 MHz provides the RX first IF injection. Now note from Figure that we can make even a third clever use of the 10.240 MHz Reference Oscillator. By mixing that with the 10.695 MHz first IF, the result will be $10.695 - 10.240 = 455$ kHz, the second RX IF. (The sum product is ignored.) Pretty smart these engineers...

Almost all AM or FM CBs use this method of dual-conversion for their receivers. It's also commonly used in car radios, scanners, FM stereos, etc. where a lot of the circuit hardware already existed.

Transmitter Section

In this example the TX carrier frequency is produced very simply. A local oscillator of 10.695 MHz is also mixed with the 37.660 MHz Ch.1 PLL output. The difference is $37.660 - 10.695 = 26.965$ MHz, which is then coupled through various tuned circuits and the standard RF amplifier chain.

The Truth Chart is the most important first step in determining how a modification can be made, or if it can be made. Let's examine it in greater detail now.

The example just described was a very easy PLL circuit using the binary type of programming code. It's quite possible for the same chip to have different N-Codes depending upon how many crystals are used, or if it's AM or AM/SSB. The preceding circuit is one of several used with the PLL02A; this is the "2-crystal AM" loop. It used N-Codes from 330 Ch.1 to 286 Ch.40, because those were the numbers needed for exact division, correct IFs, etc. An earlier AM loop used 3 crystals and N-Codes which went up, from 224 Ch.1 to 268 Ch.40. And in the ever-popular SSB chassis the N-Codes were 255 down to 211.

Notice that these N-Codes can go up or down with increasing channel numbers. It depends on the VCO design.

Those Infamous Channel "Skips"

Meanwhile, let's return to a portion of Programming Chart to study some of its other features. Programming Chart is a simplification showing only the channel number, frequency, and N-Codes from the original full chart.

Notice anything unusual in the N-Code sequence going from Ch.1 to Ch.40? The codes aren't all consecutive and skip some points that aren't legal CB frequencies. For example, Ch.3 is 26.985 MHz, and Ch.4 is 27.005 MHz. So what the heck happened to 26.995 MHz? Gee, it's not a legal FCC channel. This is known to CB'ers as an "A" channel, in this case, Ch.3A. There are also skips at Channels 7, 11, 15, and 19. And Ch.23, Ch.24, and Ch.25 of the FCC CB band are assigned out of sequence. (That's left over from the old 23-channel days.)

What this means is that all the N-Codes as well as VCO and mixer frequencies are also out of order in the chart. Many European countries that originally allowed only 22 channels simply adopted the American scheme exactly for those first 22 channels. Australian had 18 channels whose numbers didn't correspond to American/EEC numbers, but many of the actual frequencies were the same. And the UK originally assigned 40 consecutive channels with no skips at all. Remember these points when studying an older model's Truth Chart, or you may think your math is wrong when it really isn't.

LOOP MIXER MODIFICATIONS

Now let's examine the second possible conversion method, that of changing the Loop Mixer frequency itself. This is one of the easiest ways to modify a PLL circuit having a downmix signal. A few chips like the PLL02A can be modified by either of the programming pin change or downmix change methods. The choice depends upon the total number of extra channels desired, and how much modification work you're willing to do.

Changing the mixer crystal is most commonly done when jumping up to the 10-Meter HAM band. Since there's no intention of ever using the rig again for CB, it can be permanently retune at the higher frequency. But many of you are still expanding from the CB band and adding an extra 40 or 80 channels. The European models like those from HAM International, Major, and SuperStar were basically just American model with the extra mixing crystals already there.

Add-on Sales page

This page contains the online version of the manual that comes
with the PLL02A-1 add-on board

Introduction

It is illegal in many countries to transmit outside of the normal CB band, this board is to be used for RX only, do not transmit out side of the legal band, you are responsible for the manner in which you use the conversion board.

This board will increase the possible frequency range by 4 bands, as follows:

- **Down band** - This will go down 1 band (45 channels).
- **Up band** - This will go up 1 band (45 channels).
- **NZ band** - This gives the New Zealand band, which is 63 channels below the FCC band (63.5 to be precise, clarify to 26.330).
- **UK band** - This gives the UK 40 band which is 64 channels above the FCC band and is 40 consecutive channels without the Alpha channel hops (clarified to 27.60125, FM radio needed).

- **10kHz shift** - All radios will have a 10kHz shift, for most it is +10kHz, for one type it is a -10kHz shift.

If the board is installed on a 40 channel radio you will get low, mid (FCC), high, NZ, UK and a 10kHz shift on all bands ! (assuming that the radio is broad band enough to be able to produce the full range), that is an extra 4 bands !

If the board is installed on a Export type 200 channel radio you will get L-L-low, L-low, low, mid (FCC), high, H-high, H-H-high (not on all models), NZ (down 63 channels), UK (up 64 channels) and a 10kHz shift on all bands !

It is possible to enable the NZ and UK bands when in the range of normal bands (not on all models) to go up by 64 channels or down by 63, so on a 5 band model that will give you coverage from 25.435 – 28.905 (assuming that the radio is broad band enough).

Of course you do not need to enable every option on the board, you can choose which ones you wish to use, if you only want the UK band that is fine, or if you only want to have the down 1 band and up 1 band with +(-)10 kHz shift that is fine too, it is up to you.

I have built as much data into the EPROM as I could fit on it so that there are lots of options that can be used. This board is not suitable for some radios, please read further in this manual to see if your radio can use this version of the board, (I can make custom boards at an additional cost).

General Information

A degree of electronic skill is required to install this expansion board, also the radio may need to be tuned or broad banded to allow for the extra frequency coverage that this board will allow.

I have made a quite simple installation look complex, please do not be concerned about the complexity of this manual, once you know the binary code range(s) used in your radio you just cross check it against the

programming chart I have included, this will show what options and programming requirements there are for it.

I have tried to include as much information as possible in this manual to try and cover all possible requirements and radios, I am sure that there will be times when some people will need more information or assistance and when this occurs I can be contacted either through my web site at <http://www.radiomods.co.nz/> or by emailing me.

This board was designed to convert radios with these PCB numbers:

- PCBM121D4X
- PCBM125A4X
- PCBM131A4X
- PCBM133A4X
- PCMA001S
- PTBM027AOX
- PTBM033AOX
- PTBM036AOX
- PTBM038AOX
- PTBM039AOX

And others as long as the binary codes are correct (see below).

For the board to function correctly the PLL must be using one or more of these binary code ranges:

300-256 (CH1-CH40)

255-211 (CH1-CH40), this is the most common code.

210-166 (CH1-CH40)

224-268 (CH1-CH40) or 253 for 23 CH radios.

To work out the binary code just measure the voltage on pins 15 through to 7 of the PLL with the radio on channel 1 mid (FCC) band.

For a code of 300 pins 13, 12, 10 and 7 will be at 5 V. Pins 15, 14, 11, 9 and 8 will be at 0 V.

For a code of 255 pins 15, 14, 13, 12, 11, 10 and 8 will be at 5 V. Pin 7 will be at 0 V.

For a code of 210 pins 14, 11, 9 and 8 will be at 5 V. Pins 15, 13, 12, 10 and 7 will be at 0 V.

For a code of 224 pins 10 and 7 will be 5 V. Pins 15, 14, 13, 12, 11, 9 and 8 will be at 0 V.

Some radios use two sets of codes depending on the band, check the codes again on one of these bands, either: 255–211 on bands A, C, E and 210–166 on bands B, D, F. or 255–211 on bands C, D, E and 300–256 on bands A, B.

NOTE: some radios are not marked as A, B, C, D, E they may be L-Low, Low, Mid, High, H-High etc.

The extra coverage that should be gained is as follows:

For mostl radios:

Down 1 band, Up 1 Band, New Zealand 40 Channels (down 63 channels), UK 27/81 Channels (up 64 channels without Alpha channel hops) and +10kHz shift on all bands, .

The NZ and UK bands are operated from the mid (FCC) band (with the exception of radios that use the PTBM133A4X board, the NZ band is operated from the low band).

Exceptions to this are radios that use the code range of : 224–268, they will get a -10kHz step instead 210–166, they will not get the Up band.

Example of possible coverage

When I installed this board in my Superstar 2000 (PTBM131A4X) I got the following coverage:

25.615 – 26.055 L-L-Low- NEW band With Down band on

26.065 – 26.505 L-Low -A band

26.515 - 26.955 Low -B band

26.965 - 27.405 Mid, FCC -C band Normal bands

27.415 - 27.855 High -D band

27.865 - 28.305 H-High -E band

28.315 - 28.755 H-H-High -NEW band With Up band on

25.435 - 25.875 L-Low NZ band -NEW band With NZ band on band A

25.885 - 26.325 Low NZ band -NEW band With NZ band on band B

26.330 - 26.770 NZ band -NEW band With NZ band on, clarified

26.785 - 27.225 High NZ band -NEW band With NZ band on band D

27.235 - 27.675 H-High NZ band -NEW band With NZ band on band E

THESE BANDS DO NOT HAVE THE Alpha CHANNEL HOPS !

26.705 - 27.095 L-Low UK band -NEW band With UK band on band A

27.155 - 27.545 Low UK band -NEW band With UK band on band B

27.601 - 27.991 UK band -NEW band With UK band on, clarified

28.055 - 28.445 High UK band -NEW band With UK band on band D

28.505 - 28.895 H-High UK band -NEW band With UK band on band E

Also there is the +10 kHz shift on all bands.

Of course there is overlapping of most of these bands with the original frequencies but I thought you may like to know what it is capable of !

The most interesting part is when on the UK band as it gives 40 consecutive channels without the Alpha channel hops, but of course the +10kHz shift can sort those out for you !

Detailed Information

Here is a list of radios that I designed this board for, I got the binary code information from the great books written by Lou Franklin (<http://www.cbcintl.com>), the list is probably much bigger than this as the only critical factors are that the radio uses the correct binary codes and that the board will physically fit inside the radio.

PTBM125A4X / PTBM131A4X

Colt 1600DX, 2000DX, Hygain 8795 (V), Layayette 1800, Midland 7001 Export, Pacific 160, Superstar 2000, Tristar 777, 790.

PCMA001S

Alan 88S, Argus 5000, Cobra 148GTL DX (fake), CTE 88S, Colt 2400, Falcon 2000, Lafayette 2400FM, Mongoose 2000, Nato 2000, Palomar 2400, 5000, Starfire DX, Superstar 2200, Thunder 2000, Tristar 797, 848.

PTBM 133A4X

Ham International Concorde III, Jumbo III, Multimode III, Major M788.

PTBM121D4X

Cobra GTL150, Colt 320DX, 320FM, 1200DX (Excalibur), Ham International Concorde II, Jumbo II, Hygain 2795, 2795DX, Intek 1200FM, Lafayette HB870AFS, Tristar 747.

PTBM027A0X, PTBM033A0X, PTBM036A0X, PTBM038A0X, PTBM039A0X

Delco (GM) CBD-10, 1977/78 series, GE 3-5810B, Hygain 681, 682, 2679, 2679A, 2680, 2681, 2682, 2683, 2701, 2710X, 2716, 2720, 3084B, Kraco KCB2310B, 2320B, 2330B, Lafayette Com-Phone 23A, HB650, HB750, HB950, LM400, Micro 223A, Telsat 1050, Midland 13-830, 13-857B, 13-882C, 13-888B, 13-955, Pearce Simpson Tiger 40A, Tiger MKII, RCA 14T300, 14T301, Robyn

GT410D, SX401, SX402D, Sears 242.3816, 60000, Truetone MCC4434B-67, CYJ4732A-77.

Please note that I am not able to test this unit in every make and model, but as long as the binary codes match the ones I listed you will have no problems.

OK, now on to the nuts and bolts (or is the resistors and capacitors ?)....

Installation Procedure

Be careful when handling the Eprom, it is a static sensitive device and may be damaged if care is not taken to avoid static build up, whenever you pick up or put down the device ALWAYS touch the surface first so that static does not pass through the device, the best thing is to use a antistatic wrist strap at all times.

1. Check for the correct binary code at the PLL pins, see note earlier in manual.
2. Decide what bands you require the board to produce (see note below), set the jumpers and cut the tracks on the EPROM board and to match.
3. Decide how you are going to control the new bands, existing panel switches, new toggle switches, replacing the rotary band switch (only for pros !) etc.
4. Cut the tracks that go to pins 15 through to 8 (or 7, see note on next page first !) to isolate them from the channel selector and jumper connections.
5. Solder the ribbon cable to the PLL pins (D0-D7, see picture later) and to the channel selector side of the cut tracks (A0-A6, see picture later).
6. Solder the EPROM board earth (0V) to pin 16 of the PLL of the any other good earth point on the main board.
7. Solder the +12V wire to the main radio supply, make sure that it is from after the on/off switch so that the board is not powered when the radio is turned off., On the PTBM131A4X board there is a PCB pin on the right hand side about half way back, it is marked as ?0?and it is next to Q26.
8. Connect the board to the switches to select the required bands and functions.
9. Go back to step 1 and double check everything on each step.
10. Triple check everything, I mean it !

After doing this you should have the board connected to +12V, earth, 8 outputs from the EPROM to the PLL (D0-D7), 7 inputs from the cut tracks

on the channel selector side to the inputs of the EPROM (A0-A6), the EPROM control lines connected to your switches:

A7 = DOWN band,

A8 = UP band,

A9 (+A7/A8) = NZ/UK,

A10 = +10kHz step.

Some radios may have **slightly different programming**, for radios with codes of **224-268** here are the differences:

A9 = UK band (others use A9 + A8),

A9, A8 and A7 = NZ band (others use A9 + A7),

A7 = UP band ,

A8 = DOWN band,

A10 = -10kHz

See the programming chart later in this manual for a completely comprehensive listing of control functions and binary codes required.

Testing and additional info

11. Turn the radio on and test everything thoroughly, all bands, both existing and new, Down band, Up band, NZ/UK and 10K shift on each.

Radios that use the PTBM133A4X board will need to activate the NZ band from band B (low band) and the UK band from band C (mid, FCC band) instead of NZ and UK being from the mid (C, FCC) band

Radios that have a code range of **255-211 and 210-166** (usually six band models) will not get any UP bands when using the 210-166 codes (bands B,D,F) , this is due to running out of programming options, also when on

bands B,D and F EPROM pins A7 and A8 need to be pulled high at all times, this can easily be done using diode steering:

Attach a diode to each of the band positions for B,D and F, so that when the radio is in any of those bands the diodes will pass a voltage through a resistor to drop the voltage to the EPROM pins down to about **5 Volts** (this is very important !), see the diagram for more information.

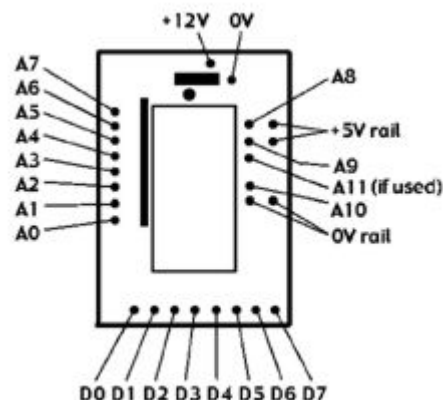
12. Tune or broad band anything that needs adjusting (see tips later in manual).

13. If all is OK and you did not make any mistakes, **CAREFULLY** heat shrink the EPROM board with the tube supplied, do not apply too much heat.

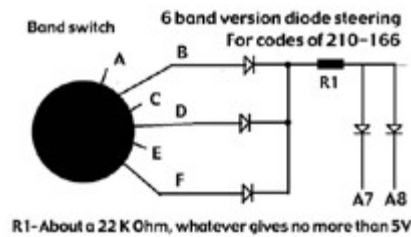
14. Close up the radio and enjoy your new frequencies !

Pictures and advanced info

This picture shows the EPROM board wiring diagram with its inputs (A0-A6) its programming/switch inputs (A7-A10, (or A 1 1 if fitted with a 2732 EPROM) and the 5V, 0V rails), its outputs (D0-D7) and its power supply connections (+12V and 0V).



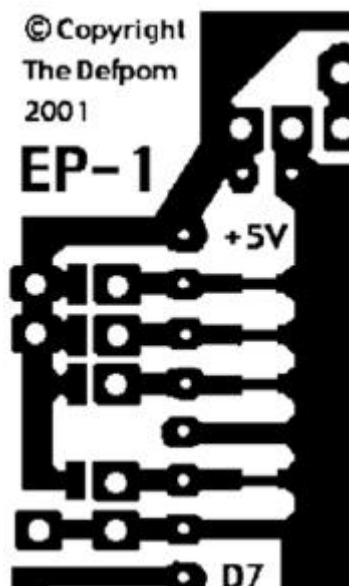
This diagram shows the diode steering that is required for use with radios with codes of 210-166 on bands B,D and F.



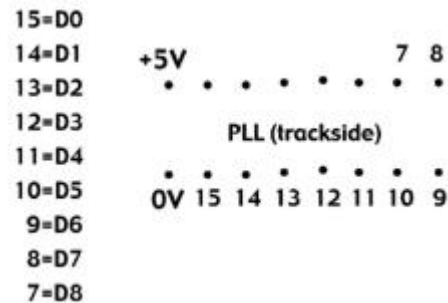
This picture shows the PCB jumpers that are on the board, as you can see the tracks narrow at a point where they are normally tied to ground, if you are not going to use 1 of the control lines leave the track intact, but if you are going to use 1 or more lines cut the track for the pin you are going to control.

For example, the top one is A8, which is used for the UP band, if you did not want to use the UP band (or UK band as it uses that pin also) you would not have to do anything.

But if you wanted to use the UP (or UK) band you would need to cut the track that goes between the pin and the earth track (the big thick vertical one on the right), then you can solder the control wire into the provided hole and attach the 0V and 5V control wires for it as well, the 5V rail is the one going down the left side, the 0V is the one that is horizontal above D7 and connects to the main earth track, you can also see the pads that allow the pins to be tied high without having to attach jumper wires if a pin needs to be programmed to be high all of the time, you will notice that for boards using a 2716 EPROM (most of them) the A11 track is cut and the pin is pulled high.

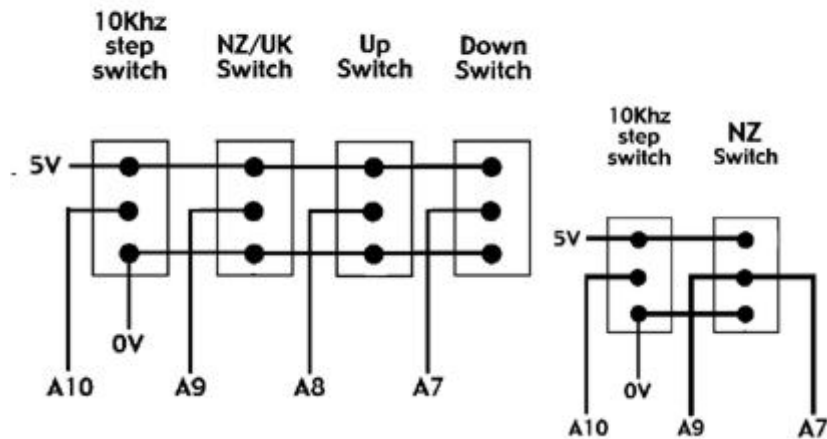


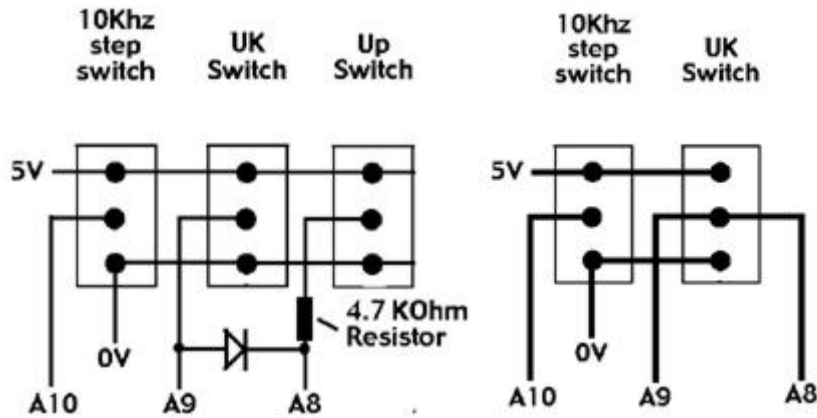
The picture below shows the pin-outs of the PLL as viewed from the track-side of the PCB, pin 1 of the PLL is at the top left corner and has a 5V supply going to it.



These pictures show various methods of band selection, any one of the switches can be omitted, the NZ/UK switch can be used without an Up / Down band switch, also you can have it set up so that it automatically turns on the Up (for UK) / Down (for NZ) band when you activate it (required for it to work), as long as diode steering is used to select either the A7 (for NZ) or A8 (for UK) lines when activated.

A typical band selection method





Notes

PLL Pin 7 switching

For radios with a code range of **255-211** ONLY on all bands you can just attach pin 7 directly to the switch wire that goes to the EPROM for the Low band, this pin must be high on the Low and NZ bands and low on all others, this does it nicely on these radios !

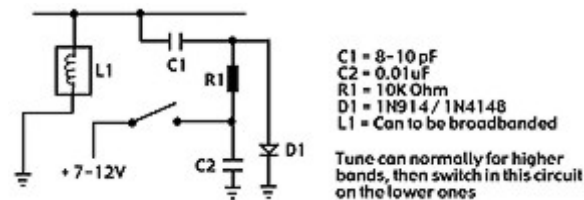
For radios with codes of **both 300-256** (L-Low and Low bands) and **255-211** (Mid, High and H-High bands) just leave the track alone do not cut it as it will give the correct voltage when needed anyway !

For radios with a code of **224-268** you must do a little extra work, when in normal bands (all extras turned off) pin 7 must be connected as normal as it changes from high to low in the normal range of codes, when the DOWN or NZ band is activated the pin must be low all of the time, so it must be disconnected from the track and pulled low, but when in the UP or UK bands it must be pulled high instead.

Radios that have a code range of **224-253** can just cut the track and control it by pulling it low in the DOWN, NZ bands and high in the UP, UK bands.

Broad banding

Most radios will not need it to be done, but you may need to, an easy way is to tune the radio for the upper frequencies (but as low as you can without problems) and then add the circuit below to the low bands to extend the tuning range of a problem tuning can, the PTBM131A4X board uses this type of circuit on its TX mixers !



Clarifier slide increase

The clarifier on most of the SSB radios gives about 5kHz of slide, which is enough for most purposes, but if you want to add a little more slide then add a 4.7 uH RF coil to the varactor diode, on the PTBM125A4X, PTBM131A4X and PCMA001S it is D6, on the PTBM133A4X it is D7, on the PTBM121D4X it is D1 on the crystal oscillator board (PTOS110A0X)

NATO 2000, UK FM Band

The NATO 2000 already has the UK40 as part of its own band structure, the binary code range of the UK FM band is **255-216** so it will work without any problems make sure that the EPROM is placed between the PLL and the two proms (IC601 and IC602), then just have the EPROM selected with normal mode (no extra bands enabled) to use the UK band, it will be unaffected by the presence of the EPROM board, but you will still gain a 10K shift, of course you can still use the UP and DOWN bands as well if you like.

+10kHz shift

For The Down band (and on the L-Low and Low bands of radios using a code of 300-256) the +10Khz shift will not work on Ch 40, this is due to the code changing from 8 bits to 9 and it is not worth the extra effort and expense for the sake of one channel that you can get by going to channel 1 on the next band up anyway !

EPROM band and function selection codes and programming

This section show you all of the possible programming arrangements with this EPROM and what input codes allow which outputs from the EPROM board, just look up the input code range(s) that your radio uses and look at the possible operating bands and programming information for the board.

Input code	A6	A7	A8	A9	A10	Output Code	Band
255-211	1	0	0	0	0	255-211	Normal
	1	1	0	0	0	300-256	Down
	1	0	1	0	0	210-166	Up
	1	1	0	1	0	319-275	NZ
	1	0	1	1	0	191-151	UK
	1	0	0	0	1	254-210	Normal +10kHz
	1	1	0	0	1	299-256	Down +10kHz
	1	0	1	0	1	209-165	Up +10kHz
	1	1	0	1	1	318-274	NZ +10kHz
	1	0	1	1	1	190-150	UK +10kHz
300-256	1	0	0	0	0	300-256	Normal
	1	1	0	0	0	345-301	Down
	1	1	0	1	0	319-275	NZ
	1	0	0	0	1	299-256	Normal +10kHz
	1	1	0	0	1	344-300	Down +10kHz
	1	1	0	1	1	318-274	NZ +10kHz
210-166 *	1/0	1	1	0	0	210-166	Normal

	1/0	1	1	0	1	209-165	Normal +10kHz
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* Important note !

A7 and A8 need to be pulled high at all times when in the 210-166 code range!

Input code	A6	A7	A8	A9	A10	Output Code	Band
224-268 (*253)	1/0	0	0	0	0	224-268 (*253)	Normal
*2	1/0	0	1	0	0	179-223	Down
*2	1/0	1	0	0	0	269-313	Up
*2	1/0	1	1	1	0	160-204	NZ
*2	1/0	0	0	1	0	288-327	UK
	1/0	0	0	0	1	223-271	Normal -10kHz
*2	1/0	0	1	0	1	178-222	Down -10kHz
*2	1/0	1	0	0	1	268-312	Up -10kHz
*2	1/0	0	0	1	1	159-203	NZ -10kHz
*2	1/0	0	0	1	1	287-326	UK -10kHz

* code goes up to 253 for 23 channel radios.

***2** please notice the reversal of A7 and A8 and the different NZ/UK band programming for this code range.

Also notice the difference in 10 kHz shift, in this code range it is a -10kHz shift !

NOTE: the output codes may say a figure greater than 256, the EPROM can only supply a code as high as 255, that is why we must pull the PLL pin 7 high/low as needed to give the final code of over 256, for example, a code of 300 requires all 8 bits from the EPROM and 1 more bit (the 256 bit) to be high as well, so we pull pin 7 high as it is the pin for a code of 256, I hope this helps to explain it for those people who know that EPROM's only have a possible output code of 255.

Programming

Here are the general functions of the EPROM's A6, A7, A8, A9 and A10 inputs (may vary with input code range of radio, see above chart for more details):

A6 = 7th line of programming from channel selector, also is responsible for correct codes, normally just tied high or connected to 7th line of the channel selector output.

A7 = Down band selector (Up band for radios using 224-268 code range).

A8 = Up band selector (Down band for radios using 224-268 code range).

A9 = NZ/UK band selector (used in conjunction with A7 (NZ) and A8 (UK)

A10 = + 10 kHz shift (- 10kHz shift for radios using 224+268 code range).

Calculating the binary code

If you do not know how to calculate the binary number (also known as N code) read this.

PLL pin number	15	14	13	12	11	10	9	8	7
Binary weight	1	2	4	8	16	32	64	128	256

So if pins 8, 9, 11, 14 and 15 where high (at 5V) and the rest where low (at 0V) you would have a binary code of 211 (128+64+16+2+1=211), you just ignore the pins that are low.

7. I connected the EPROM inputs to the channel selector side of the cut tracks as shown below (this is for A0-A5, A6 can be tied high at 5V on the EPROM board):

PLL pin number -->	15	14	13	12	11	10
Tracks ----->						
Cut in tracks --->	===	===	===	===	===	===
Tracks ----->						
EPROM inputs A0-A5-->	A0	A1	A2	A3	A4	A5
Tracks ----->						

Tracks -----> | | | | | |
Connections | | | | | |
to channel selector --> 0 0 0 0 0 0

8. I connected the EPROM outputs (D0–D7) to the PLL pins as follows:

PLL pin number	15	14	13	12	11	10	9	7
EPROM output number	D0	D1	D2	D3	D4	D5	D6	D7

9. Then I connected the power wires (+12V and 0V) from the board to the radio.

10. I double checked all of my wiring, checked that I had cut the tracks correctly on the EPROM and radio boards and that I had got the input and output connection the correct way around etc.

11. I slipped the EPROM board into its heat shrink tube to protect it.

12. I turned on the radio and checked for both normal operation and the new expanded functions I set up (+10kHz step and the Down band).

13. I checked to make sure that the EPROM board was not receiving a 12V supply after I turned the radio off.

14. All was working correctly so I applied heat to the heat shrink tube to finish the installation.

15. I did not need to broad band the radio, so I have finished the installation.

16. I closed the radio back up.

Trouble shooting

EPROM is not working at all

Check jumper on pin 21, for a EPROM marked as a 2716 the track to it should be cut and the pin should be jumpered to the +5V rail on the board.

Check that you have not miss-programmed the jumpers or switches, 1 incorrect jumper or selection setting could stop the EPROM from recognizing the binary codes

The radio does not use the correct binary codes required for the EPROM to work in it, see note about binary codes that are supported earlier in this manual.

Only some bands are working

There could be a mistake with the programming switches not giving the EPROM either a 5v or 0V signal, or a jumper has not been cut or added correctly.

You did not notice that the radio uses more than one set of binary codes and you have not set the switches / jumpers for the other codes.

Some channels do not work on a certain band

If there is a large gap of channels missing it may be a jumper or switch programming problem.

The EPROM may have been damaged by static electricity during handling.

The EPROM may have been damaged by incorrect wiring.

Note: All EPROM's are checked after I have programed them to ensure that they have accepted the programming information correctly and that the EPROM is not faulty.

[E-mail me](#) if you have any questions or concerns about installation.

All boards are installed at your own risk,
(it is not my fault if you make a mistake and damage your equipment).

I build and test these circuits myself before shipping them, so I know that the boards are working correctly when you receive them.

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