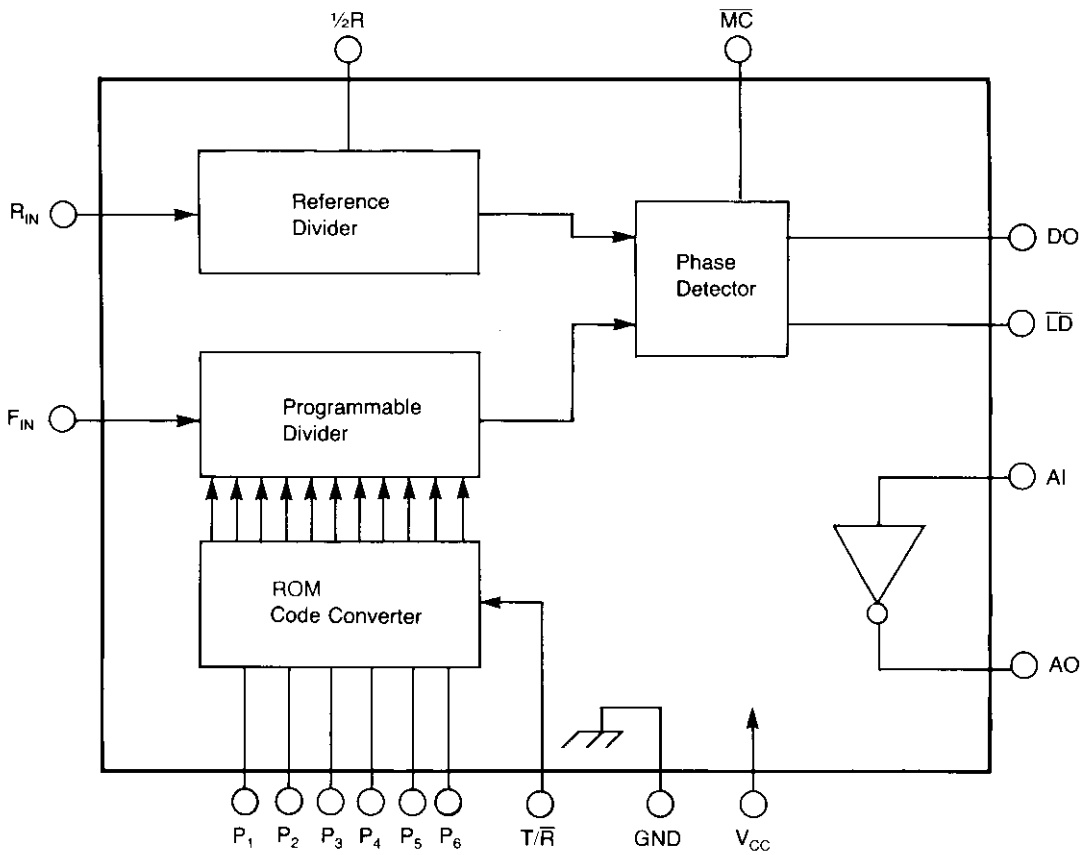
INTERNATIONAL EDITION

THE CB PLL DATA BOOK

Lou Franklin



A Repair & Modification Reference

Includes American, British, & European CB Radios
AM, FM, & SSB Circuits

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INTRODUCTION

The Phase-Locked-Loop or "PLL" Frequency Synthesizer used in CB radios is a marvelous device. It can generate all the signals needed to run a complex transceiver, is more accurate than crystal control, and more reliable because fewer parts are needed. However, understanding its operation seems to cause a lot of anxiety among CB operators as well as professional technicians. It's the purpose of this book to explain in the simplest, most non-technical terms possible how the PLL works. Anybody interested in the technical side of CB radio should find it quite helpful. I've tried to write this for both the casual CB hobbyist and the professional serviceman.

CB radio is now a worldwide hobby. As an American who's seen it change from vacuum tubes to transistors, from crystal synthesizers to PLL synthesizers, I'm in a unique position to explain the PLL's evolution. While many of the circuits and IC "chips" detailed here are actually obsolete now, there are still a lot of those radios out there needing repair! And since most countries have limited CB operation to only 18, 22, or 40 channels, a lot of interest these days is in knowing how to expand a CB rig to cover more than the "legal" channels or frequencies. Many of the older rigs are actually much better for this purpose. There is also a lot of interest among ham radio operators in converting the CB into a 10-Meter Ham rig. I will explain in these pages how PLL repairs and modifications are approached. In many cases the changes are quite simple; it's no accident that a lot of American and European transceivers using certain PLL circuits are so popular even today. On the other hand, you may be very disappointed to find out that the most recent generation of IC chips for U.S., U.K., and European CBs were designed to be almost completely non-modifiable. Better keep that older rig if you have one!

BRIEF HISTORY & DEVELOPMENT

The main reason for the development of PLL synthesizers was the American CB service expansion from 23 to 40 channels in 1976. Until then CBs used a method of frequency generation called "crystal synthesis" or "crystal-plexing". By electronically combining the signals of 2 or 3 quartz crystal oscillators in a common "mixer", all the various Receive/Transmit signals (which are normally not the same) could be created with only 12 or 14 crystals for AM and a few more for SSB. This was a great savings in cost, circuit complexity and space, because otherwise at least 46 different quartz crystals would be needed,

one pair per channel. There wasn't enough quartz left in the world to give it all to the CB manufacturers; they had to leave some for all those Seiko wristwatches!

With CB interest growing very rapidly, new methods were required because of the increased number of legal channels. Manufacturers had to figure out how to generate a large number of signals with a minimum of parts, space, complexity, and of course, cost. The answer was the PLL synthesizer. By the time the American FCC announced its CB expansion, "digital" electronic synthesizers were already well along. In fact the last generation of 23-channel U.S. equipment had already begun to use PLL techniques rather than crystals. Those first circuits were very complicated because they required as many as 9 discrete Integrated Circuit (IC) silicon chips. Soon more and more electronic functions were crammed into a smaller chip space. Today's PLL transceiver can perform all the needed functions of channel selection and signal generation using only a single LSI ("Large-Scale-Integration") device and a handful of external parts. As we'll see, this fact is both a blessing and a curse: Good because it increases reliability and keeps radio prices affordable, but bad because the darn bugs make modifications even harder!

The FCC and other authorities quickly found that because of the unexpected popularity of CB, with millions of people all competing for the same channels, the use of illegal and unauthorized frequencies was becoming the rule rather than the exception, and this is basically the situation today. Technicians soon discovered that the first generations of PLL rigs were simple to modify. The FCC then changed its rules to require CB manufacturers to use special PLL chips to prevent this. Since Australia, Holland, Britain, and other countries had legalized CB long after the U.S., their governments took the hint and started off directly with the more secure chip circuits. However through various legal loopholes, certain makes and models of CBs in the U.S. and other countries are still allowed to be imported using the "good" PLL chips, and this subject will be covered in great detail later.

In all fairness I should mention that the newest chips are capable of some interesting features not found in earlier generations. For example, automatic command of the Channel 9 Emergency Channel or Channel 19 Road Information Channel, scanning, memory, keyboard control, greater reliability, etc. This is basically where the state-of-the-art in PLL technology is today, and there is little more that governments can do to prevent any determined radio hobbyist from modifying a rig if he really wants to. I think it's safe to assume that information in this book detailing operation of the latest PLL devices will be accurate for many years to come. And since there are still millions of older rigs out there

BOOK ORGANIZATION

I've divided this book into three general sections. The first section describes basic PLL theory in "building block" form. We'll start with the simplest chips and proceed to the most complex, in chronological order because that's the way they have evolved. In this way, you'll begin to understand how the various IC changes affect servicing and modification. I'll assume that you have very little electronic knowledge, even though some of you may be very well-informed about other areas of CB electronics. The PLL circuits will only be illustrated in "black box" or block diagram form to keep things really simple. For example, a transistor switching circuit will be represented symbolically as a simple switch. Components like resistors, capacitors, etc. will rarely be shown at all unless very essential to the discussion. This way you'll never have to worry that you've gotten in over your head! Specific radio theory regarding AM, FM, or SSB communications not directly related to the PLL are left up to you for further study if interested. Some very basic radio theory must be included, but I've tried to keep it very uncomplicated. Since I want everybody to learn something about this subject, some areas are oversimplified, and I ask that you professional technicians out there have a little patience if something seems obvious to you.

The second section deals with modification methods as they apply to different generations of PLLs. We'll be discussing such things as Truth Charts, programming in binary, BCD and ROM, Loop Mixers, external oscillators, and tips on how to attack the various types of PLL circuits successfully.

The last section shows technical specs and block diagrams of the chips and circuits themselves. I've included every known chip of any importance. (There were a few very old chips that never lasted long enough to bother discussing.) To my knowledge this is the only book ever published devoted entirely to the subject of CB PLLs. Along with the chip pin diagrams is included a list of every radio make and model using that chip which was known at press time. Since several groups of chips work the same way, I've also included sample Truth Charts typical of such groups. I've tried to include special notations when a chip contains some unusual feature you should know about. All the specific pin functions were gathered from manufacturers' spec sheets, SAMS Fotofacts and other service manuals, and personal experience,

and are accurate to the best of my knowledge.

If you don't find your particular rig model included here, chances are that it's identical to some other rig, since there are basically now three Far East companies (Cybernet, Uniden and Maxon) that make 99% of the world's CB radios anyway. One particular chassis may be sold under dozens of brand names as most of you already know. For certain well-known chassis, I've included specific PC board numbers so that you might possibly identify an unknown rig by that number.

My two trips to England and Europe in 1981 to study the CB situation there helped greatly in gathering the special circuit information found in these pages. Most Americans will never see the "export" models of their favorite radios; information on the addition of another 80-120 channels and FM should help your own modification attempts when you see how they're done commercially. Information on the European versions of popular American rigs, as well as the newest "legal" U.K.-FM rigs, arrived just in time to appear in this book so that this is truly an international reference work. By press time, thousands of "export" rigs like the Cobra 148GTL-DX, Palomar 2400, Superstar 3600/3900, Galaxy 2100/Super Galaxy, and Ranger AR3500 had arrived in the U.S., and are included in Section III. (We have schematics on most of these if you need one.) In addition, the British CB system has changed over to the American FCC channel assignment. So UK radios are now using the American PLL chips anyway.

Obviously it's very difficult (and expensive!) to continuously update a book like this as new models appear, but the basic information for understanding any PLL circuit you'll ever see can be found here. I've personally managed to catalog literally thousands of makes and models over many years by the use of SAMS Fotofacts, factory service manuals, and schematics sent to me by my readers. I'm always anxious to add new radio models to my files for possible future revisions and to help my readers identify a specific chassis or PLL circuit. Photocopies of rig circuit diagrams are always appreciated. I welcome your comments and suggestions and hope this book helps you.

Good luck in the Battle Of The PLL!

Lou Franklin, K6NH
"Supersparks"

Phoenix, Arizona, U.S.A.

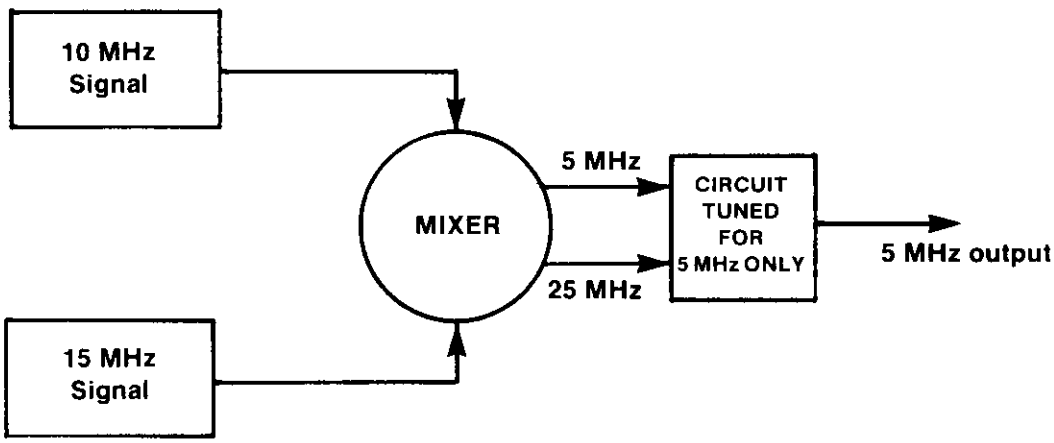
SECTION I

BASIC PLL BACKGROUND

This principle is so basic to radio theory, whether AM, FM, or SSB, that it must be discussed briefly before proceeding further. The reason is because mixing or "conversion" is a process that requires two or more signals, and if there are no longer any crystals used to provide such signals, we have to find them somewhere! And that "somewhere" is in the PLL circuit.

Whenever two signals are mixed together electronically, the result is two new frequencies in addition to the originals. These new frequencies are nothing more than the sum and difference of the original two, as seen in Figure 1. In this example, by mixing a 10 MHz and a 15 MHz signal together, the result will be 10 MHz, 15 MHz, 5 MHz (15 MHz - 10 MHz) and 25 MHz (15 MHz + 10 MHz). By then passing the signals through a selectively tuned circuit, only one of the mixing products will remain and the other will be rejected. The mixing process is important in PLL circuits because it provides other signals required to operate the radio that have nothing to do with the actual channel generation. Of course these other signals could be generated by individual crystal oscillators or tuneable oscillators, but this adds cost and complexity to the radio. The first generations of PLL circuits did use up to 6 individual crystal oscillators but they've now evolved to the point where a single 10.240 MHz crystal is all that's needed, at least for AM or FM.

FIGURE 1. BASIC SIGNAL MIXING PROCESS

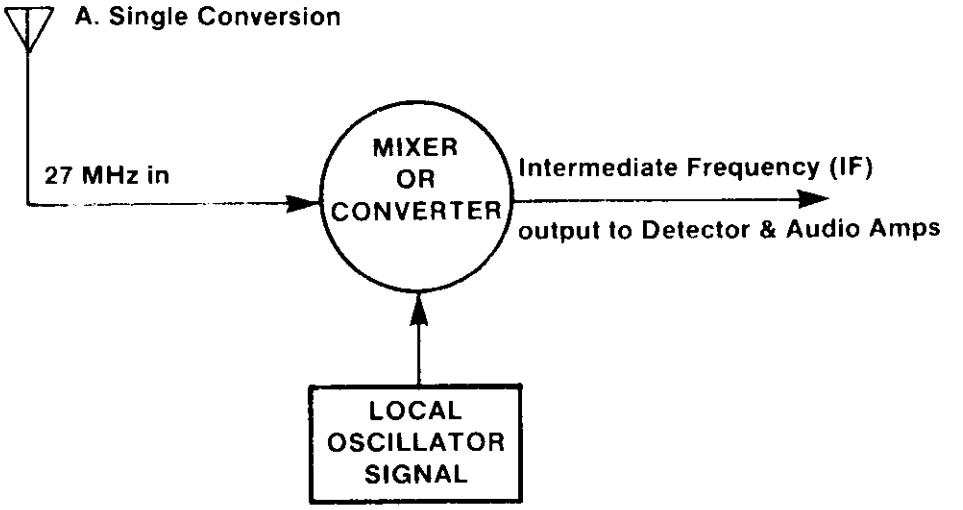


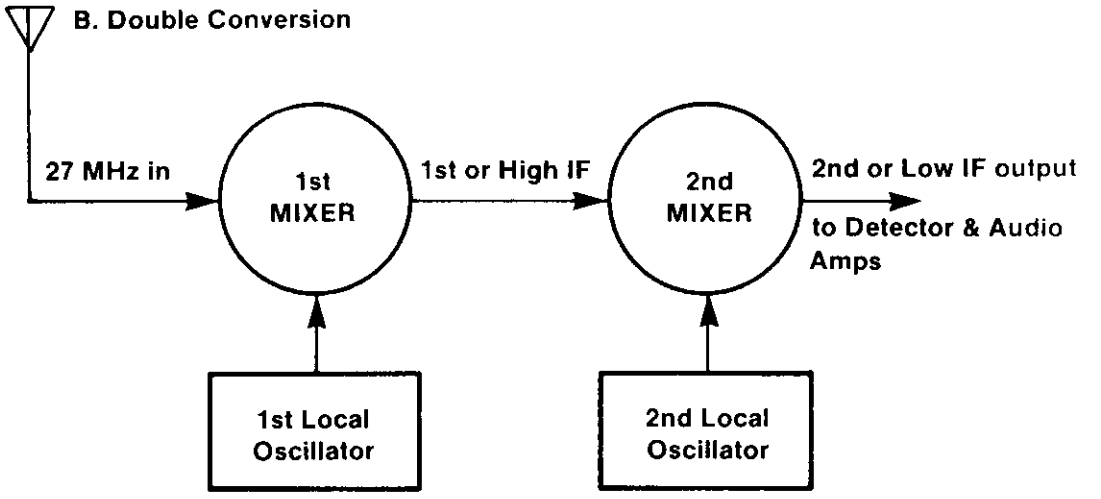
Why is the mixing process so important? The reason is because most of the signals needed in a 27 MHz CB rig are too difficult to process directly and economically while trying to maintain good performance. The CB/10M Ham band is considered a rather high frequency, and it's much better to convert a 27 MHz signal down to some lower frequency where the various Receive/Transmit circuits won't be so touchy. You've probably seen the terms "Single-conversion" or "Double-conversion" applied to receivers; this means that the 27 MHz signal is "converted", "mixed", or "heterodyned" down once or twice to a lower frequency that's easier to process. A typical AM or FM CB rig is generally of the "dual-conversion" type. For SSB, a single conversion is all that's needed but since there are no CB rigs having only SSB capability, the majority of multimode transceivers use dual conversion *for AM and FM only,* with the SSB circuits using only a single conversion. (Single-conversion is quite acceptable for SSB because the T/R signals are passed through a very sharp crystal filter, typically cut near 7.8 MHz, 10.695 MHz, or 11.275 MHz.) By converting signals up or down and passing them through sharply-tuned circuits, it's much easier to get good performance, especially in receivers. The more tuned circuits, the more selectivity and sensitivity during reception, and the more reduction of unwanted "spurious" signals during transmission.

INTERMEDIATE FREQUENCIES (IF)

The result of converting a 27 MHz signal down to a lower frequency during reception is an "Intermediate Frequency" or "IF". This stage is often the only IF, as shown in Figure 2-A. However when a double conversion occurs, the result is two IFs. These are called the "first" or "high" IF and the "second" or "low" IF, Figure 2-B. For CB use, these two IF frequencies are almost universally 10.695 MHz, and 455 KHz. This is partly because there was already a lot of existing electronic equipment using these IFs long before CB radios came along. (Eg, AM and FM broadcast receivers, portables, shortwave receivers, scanners, auto radios, etc.) Thus the needed parts were already available to manufacturers, proven reliable, and cheap. Another reason is because a very clever use of the PLL circuit, which is almost always based upon a 10.240 MHz Master Oscillator, can be made to provide these IF "injection" signals. When the injection signal is above the CB signal, it's called "high-side" injection, and "low-side" injection is when it's below the 27 MHz CB signal. Older PLLs used both methods but the very newest chips use low-side injection for reasons you'll see later.

FIGURE 2. FREQUENCY CONVERSION PROCESS





Several very popular CB chassis types use only a single IF of 7.8 MHz. (Eg, Cobra 140/142GTL or Superstar 360 with MB8719 PLL, Cobra 138/139XLR or President "Adams" with 858 PLL.) In doing this, receiver performance was cheapened and selectivity worsened. The fact that these particular chassis are still extremely popular today is because they are very easy to modify, not because of their great receiver performance! A deluxe version of the MB8719 chassis (Eg, Cobra 148/2000GTL, new President "Madison" and "Grant") offers not only an easy modification, but here the manufacturers took the trouble of using dual conversion *on AM* with a standard 455 KHz IF. They also charged you more for this feature. Separate filters could be used for each mode to increase selectivity, because an SSB signal only requires about half the bandwidth of AM or FM. Where in the first example a compromised IF filter bandwidth is used which is basically too wide for SSB and too narrow for AM/FM, in the "deluxe" chassis you get excellent selectivity in every mode. The use of separate SSB and AM/FM IFs is also found in all American and European versions of rigs using the very popular PLL02A PLL chip. This short background on design trade-offs will help your understanding of PLL mixing circuits to be described later.

SSB MIXING

Some unique problems occur with PLL or crystal rigs in the SSB mode. With AM and FM rigs, all we need to do is to generate (or receive) a carrier signal and then modulate (or demodulate) it. However for SSB, the only signal that exists is on a radio frequency but is changing at an *audio* rate, above and below the suppressed carrier. The voice intelligence is contained only in the upper (USB) or lower (LSB) "sidebands". For voice communications, these sidebands are limited to about 3 KHz above and below the main carrier frequency. (The limiting occurs by filtering in the mike amplifiers and the sharp IF crystal filter.) For example on U.S. Channel 1, 26.965 MHz, the USB signal would extend up as high as 26.965 MHz + .003 MHz = 26.968 MHz. The LSB signal would extend down as low as 26.965 MHz — .003 MHz = 26.962 MHz. (3 KHz = .003 MHz for those of you who didn't realize I converted to make the math easier.) The PLL circuits must therefore be able to offset themselves slightly, mixing with the other required signals during SSB reception or transmission. In addition, the carrier oscillator which provides the carrier for all modes (AM, FM, SSB) must also be detuned or offset slightly for SSB, (+) or (—) as appropriate. In this way the mixing process will produce the correct frequency for on-channel operation. The SSB offsets are done very easily by switching in a small bit of capacitance or inductance whenever you change the mode switch. (This same detuning idea is used on AM or FM rigs that have a front panel DELTA TUNE control.)

A very sharp IF crystal filter is needed for SSB which will only pass one of the two sidebands. This filter is usually a large rectangular metal can on the main PC board. The newer Uniden chassis has its filter actually built on a small PC board which sticks up vertically from the main PC board. These filters are *very* expensive because they use up to 8 quartz crystals to get their sharp selectivity. Since you would need two of these very expensive filters, one for USB and one for LSB, it's much cheaper to offset the PLL and carrier oscillators through the appropriate switching rather than use two filters for two slightly different IF frequencies. In other words, a *constant* IF is maintained during SSB use. The cost of a few resistors, capacitors, transistors, or even a second crystal oscillator is only a fraction of the cost of that second IF filter.

The offset process will be very obvious as you study the SSB block diagrams in Section III, and is also the reason you will see slightly different VCO frequencies shown in the rig's service manual charts. The offset detuning in SSB is still not quite good enough during reception, which is why SSB rigs must also have a front panel control called a "Clarifier", "Fine-Tune", "Voice Lock", etc. The more common CB term is "slider" or "KC shifter". This circuit is nothing more than an additional tuning inductance or capacitance wired in parallel with the main USB/LSB offset mixers. Think of it as an extra-fine-tune adjustment to the offset mixing process. The range of most sliders is factory-limited to about ± 1 KHz from channel center, and only works in the Receive mode. A very common modification is to "strap over" the slider so that it will also shift during the Transmit mode. It's not only very easy to do this, but also to increase the slide range up to about ± 5 KHz. (Detailed methods for doing this are described in our book, THE "SCREWDRIVER EXPERT'S" GUIDE.) Later you'll see exactly how the offset SSB mixers and clarifiers are connected in the PLL circuit.

THE "ODD" BRITISH CHANNELS

Many people have asked how the unusual U.K. CB channels affect PLL operation. The channels are 27.60125 MHz at Channel 1 up to 27.99125 MHz at Channel 40, with standard 10 KHz channel spacings. The answer is that the PLL itself has practically *nothing* to do with it! Surprised? A big fuss was made over the belief that when CB was recently legalized in Britain, the rigs would need special PLL chips. As it happens, most rigs do have special chips but not because of the unusual frequency assignment. It would have been just as easy to use existing chips. The fact that U.K. Channel 1 is 27.60125 MHz rather than a nice round number like 27.600 MHz is easily accomplished in the offset mixing process like that just described for SSB. This process is *external* to the PLL chip itself. A PLL is only intended to synthesize or

generate the channel *spacings*. The additional 1.25 KHz above 27.600 MHz (or 3.5 KHz *below* 27.605 MHz if you prefer) can be set by tuning coils in the rig at the factory, or by you with an external slider control. The new U.K. chips are identical to most of the latest American chips, literally pin-for-pin the same functions. The only difference is in the chip's "N-Code" set and the 1.25 KHz offset detuning of all transceiver stages shown in Figure 3. (N-Codes will be explained in great detail later.)

THE PLL FOR FM USE

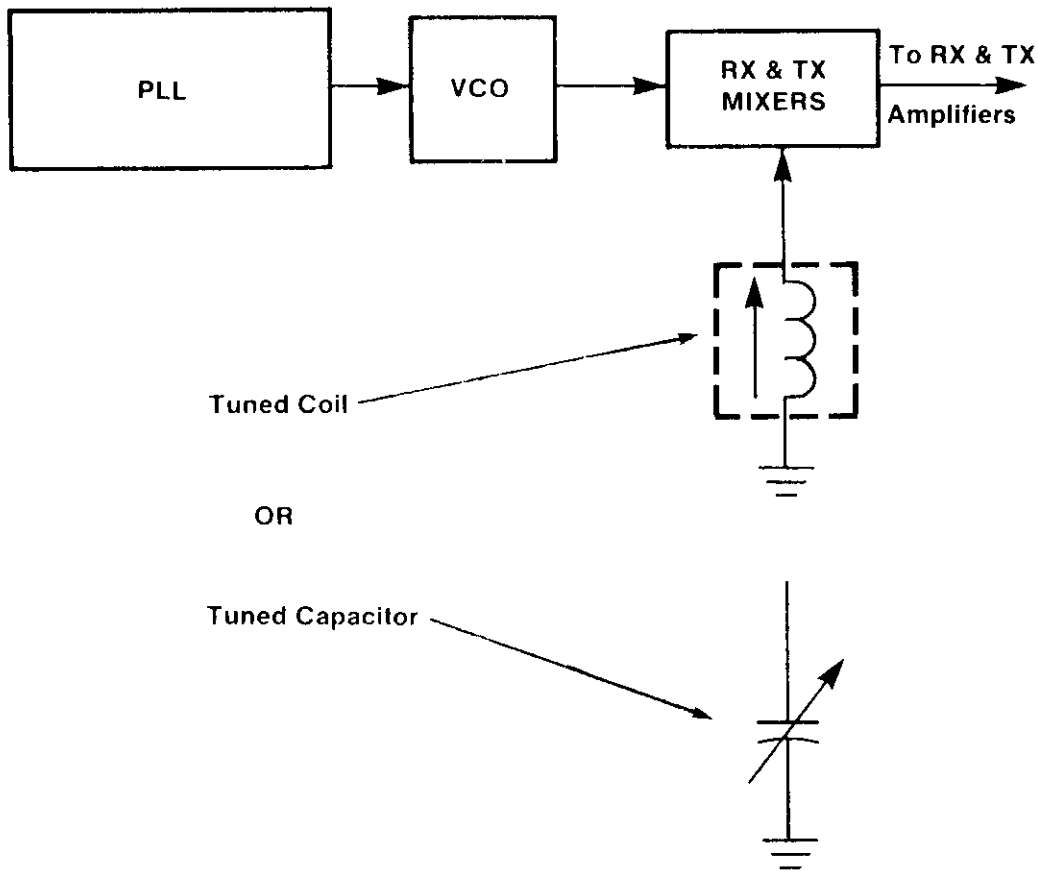
The use of FM over AM or SSB is legally required in many countries. Ironically it's now becoming popular in the U.S. where it is officially illegal! Most of the very popular European rigs (Eg, Ham International, Major, Superstar) are simply the basic American chassis with extra channels and FM already wired in. The most popular current American manufacturers such as Cobra, Midland, President, and Colt have jumped at the chance to expand their markets by adding the same circuits to their American chassis and exporting them abroad. The PLL circuits of all these rigs are basically identical and the differences will be pointed out as we progress. First though, let's see how the PLL is used for FM operation.

During reception, the FM/PLL circuit is identical to any other AM or AM/SSB rig. The PLL is only needed to provide the channel spacing and selection, and the IF injection frequencies. To receive FM, a special FM detector circuit is switched in. This circuit is typically a single IC and a few external parts having nothing at all to do with the PLL. FM, AM, and SSB are all detected *after* the PLL has done its job on the RF carrier by IF mixing. (Special PLL chips such as the NE561 are actually used as FM detectors, but that's another subject entirely!)

FM transmission is where our PLL's flexibility is used. The PLL circuit uses a very sensitive stage called a "Voltage-Controlled Oscillator" or "VCO". The smallest change in the DC control voltage to a VCO circuit will make it change its frequency. For the moment, just think of FM transmission as a means of adding this small voltage fluctuation to the VCO. The fluctuating voltage is taken from the mike amplifier circuit and is *very* small compared to the amount of voltage that would shift the rig to a completely different channel.

In addition this FM voltage is changing *at an audio rate*, literally rising and falling up to 3,000 times per second. (Assuming the audio is limited to the 3 KHz maximum typical of two-way radio systems.) The

FIGURE 3. OFFSET TUNING FOR NON-STANDARD U.K. RIGS, SSB, etc.



Tuning circuits offset VCO frequencies by proper amount to produce desired frequencies, external to the PLL chip itself.

word "modulation" simply means changing something in proportion to something else. Instead of changing the RF carrier *power* in proportion to the mike audio as in AM/SSB, the carrier *frequency* is being changed in proportion to the mike audio. With FM transmission we are simply taking advantage of the fact that the PLL's VCO is so sensitive.

A BASIC CRYSTAL SYNTHESIZER

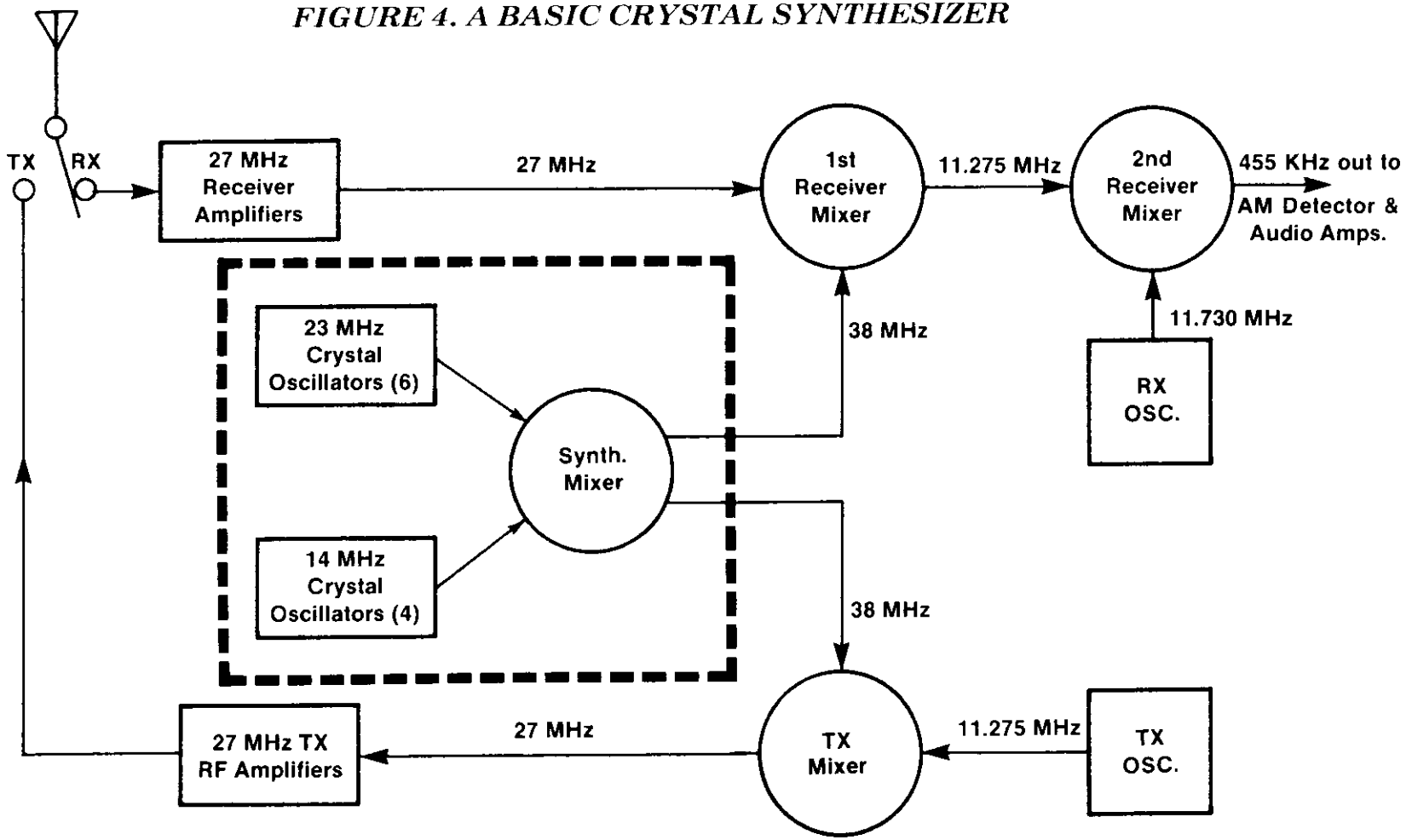
To better understand what a PLL does, let's first compare it to the older crystal-synthesized method of signal generation. This is easy to do if you think of the entire crystal or PLL synthesizer as a "black box" within a larger black box, namely the whole radio. Figure 4 illustrates a very common AM crystal synthesizer in block diagram form. It uses 12 crystals to synthesize 23 channels. View the synthesizer within the dotted lines as a single box rather than the three smaller blocks which comprise it. In the next step we'll just replace the internal workings of the big box with a PLL instead.

In this arrangement there are two banks of crystals operating in the 14 MHz and 23 MHz range. Changing the channel simply combines a different pair of crystals together. When each crystal bank's oscillator is combined in a mixer and passed through tuned circuits, the sum frequency of approximately 38 MHz is chosen. This 38 MHz signal is sent to both a Transmit Mixer stage, and the First Receiver Mixer stage. In the Receiver Mixer, the incoming 27 MHz signal is combined with the 38 MHz signal from the synthesizer. The difference frequency in the 11 MHz range (38 MHz — 27 MHz = 11 MHz) is chosen this time by tuned circuits and becomes the first receiver IF. This 11 MHz IF is then passed along to a second mixer where it's combined with the output from a separate 11.730 MHz crystal oscillator. The difference frequency is chosen again; this difference is the standard 455 KHz second IF which is then detected and amplified in the audio chain.

The transmit mixing is much simpler. The 38 MHz signal sent to the Transmit Mixer from the synthesizer is mixed with a separate 11.275 MHz Transmit Oscillator. The difference frequency of 27 MHz is chosen, passed through tuned circuits, amplified and modulated.

Here's a specific example: For U.S. Channel 1, 26.965 MHz, the Channel Selector switch will connect crystals of 23.290 MHz and 14.950 MHz. These two signals mix to produce a signal of 23.290 MHz + 14.950 MHz = 38.240 MHz. In the Transmit Mixer, this 38.240 MHz signal will mix

FIGURE 4. A BASIC CRYSTAL SYNTHESIZER



with the 11.275 MHz Transmit Oscillator, producing a difference of 26.965 MHz which is the correct on-channel frequency. (38.240 MHz —11.275 MHz = 26.965 MHz.) Notice that the transmitted signal is only converted once in frequency, and this will also be true for PLL circuits. However the receiver, being AM, uses dual-conversion for best performance. So its signal is converted down once more. The incoming signal of 26.965 MHz first mixes with the 38.240 MHz synthesizer signal, the difference is chosen, and the result is the first IF of 11.275 MHz. (38.240 MHz — 26.965 MHz = 11.275 MHz.) When this first IF is then mixed with the separate 11.730 MHz Receiver Oscillator, the result is 455 KHz. (11.730 MHz — 11.275 MHz = 455 KHz.)

Earlier I mentioned that PLLs use IF frequencies that are usually 10.695 MHz and 455 KHz partly because a lot of existing tuning coils were available. In this example the first IF is obviously 11.275 MHz but in fact the tuning coils are still the same as they would have been for 10.695 MHz; these coils can cover a wide frequency range. Remember this when examining specific PLL circuits because you may find that the math for the IFs doesn't compute exactly; if the IF appears to be slightly different from that calculated or shown on the circuit diagram, it's because these tuning coils are often detuned slightly to pass the correct frequency.

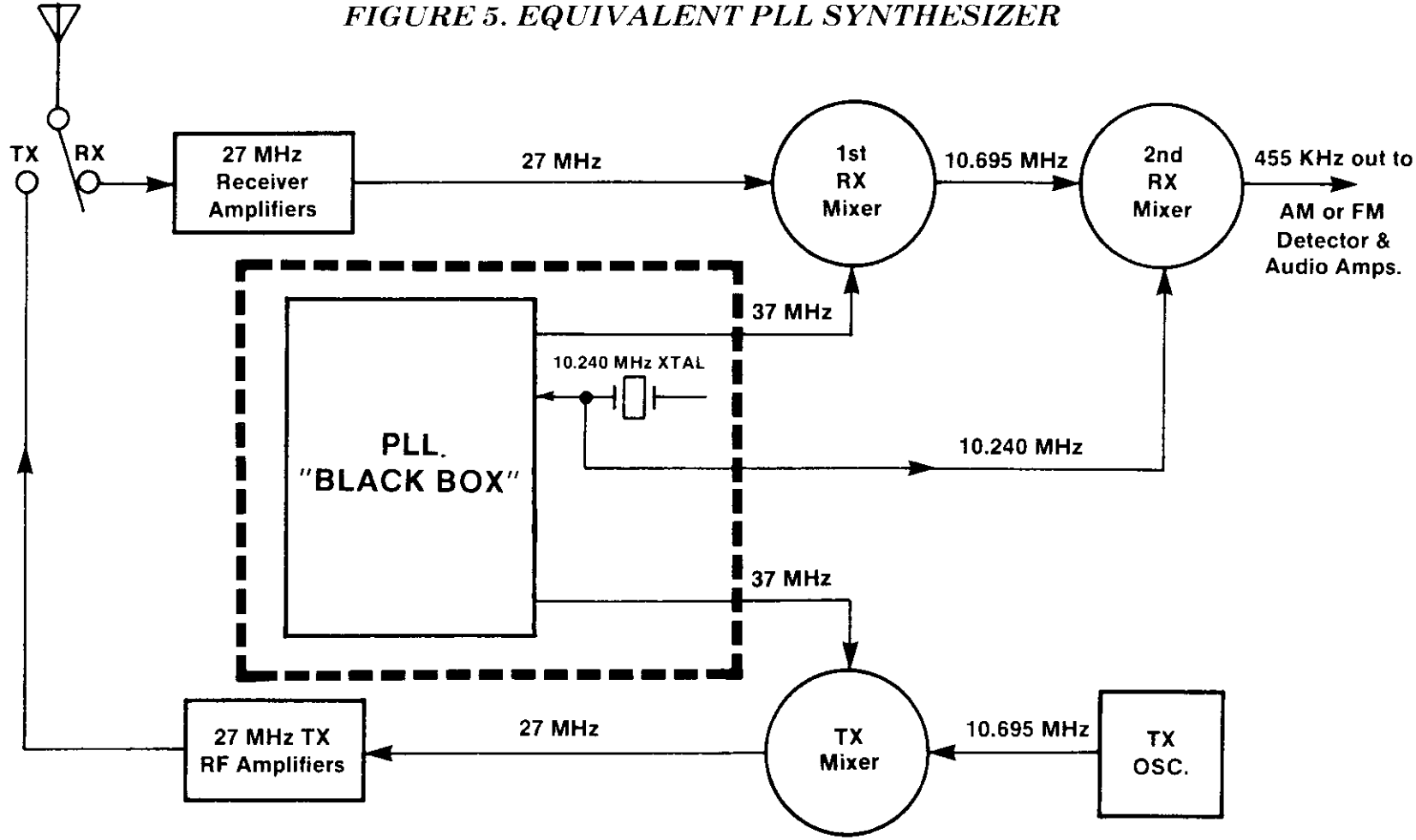
EQUIVALENT PLL SYNTHESIZER

Now let's substitute a new "box" for that of the crystal synthesizer. The internal workings of the box itself will be saved for later. For the moment, just picture it as a total unit and you'll understand it more easily. Figure 5 shows a circuit which is almost identical to the crystal synthesizer of Figure 4. All the mixers and conversions are the same. The PLL synthesizer simply produces an exact signal in the 37 MHz range, depending upon the setting of the Channel Selector switch. This signal goes off in two directions again, to the Transmit Mixer and First Receiver Mixer.

During Transmit, this 37 MHz PLL output is mixed with a signal coming from a separate 10.695 MHz crystal oscillator circuit. The mixture passes through tuned circuits which select the difference frequency in the 27 MHz range and is the actual on-channel frequency, similar to the previous example.

During Receive, the 37 MHz signal from the PLL mixes with the

FIGURE 5. EQUIVALENT PLL SYNTHESIZER



incoming 27 MHz signal to produce the first or high IF, which in this case is 10.695 MHz. This signal then passes to the Second Receiver Mixer. In this stage, a very clever extra use is made of the PLL box. It so happens that almost all PLLs require a "reference oscillator" circuit of 10.240 MHz to operate. By borrowing a bit of that 10.240 MHz energy and sending it up to the Second Receiver Mixer, guess what happens? Here's the math: 10.695 MHz — 10.240 MHz = 455 KHz! Once again, we've managed to make a dual-conversion receiver, and with standard tuning circuits.

Notice a small but subtle difference in my labeling on the right-hand side of Figures 4 and 5. In the crystal synthesizer, the second receiver mixer output says "455 KHz to AM Detector" while in the PLL synthesizer it says, "455 KHz to AM *or FM* Detector. Why not FM for the crystal version? Disregard the fact that FM CB is not legal in the U.S. and that CB had not yet been discovered in the rest of the world where it often is legal. The reason is purely technical. It's very difficult to frequency-modulate a crystal oscillator for 27 MHz use; the crystals can't be "pulled" far enough away from their cut frequencies for proper FM deviation to occur. Commercial two-way FM radios that operate in the VHF or UHF bands can be easily crystal-controlled because the crystal is multiplied up many times in frequency for final operation. When such a signal is multiplied up, any change in the controlling crystal frequency will also be multiplied by the same amount. With the PLL, we use a VCO circuit that's very sensitive, and can easily generate FM where a crystal-synthesized rig could not.

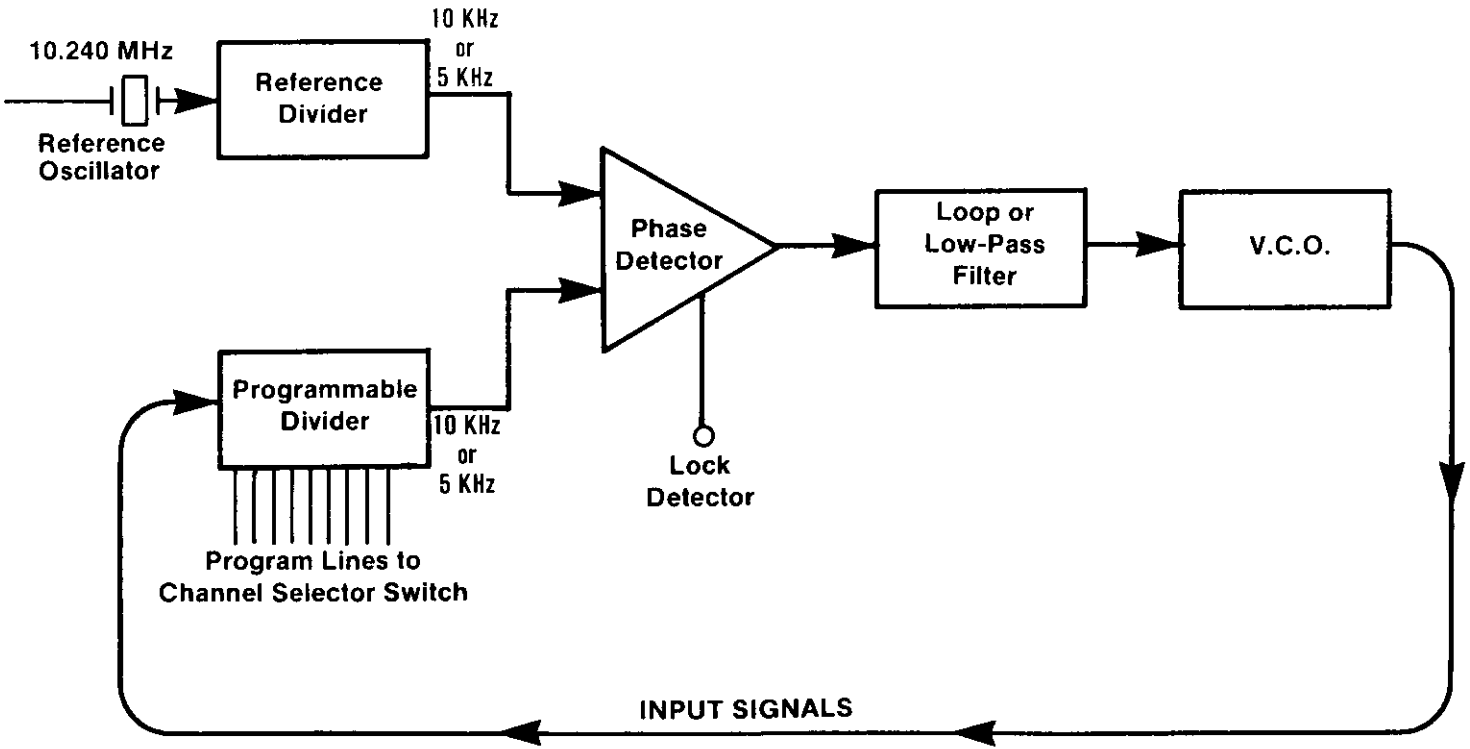
ELEMENTS OF THE PLL SYSTEM

Time now to look inside the mysterious "black box"; I can't avoid it any longer! If you're with me so far you'll have little trouble. The description will be very basic here, getting more specific as we progress.

Trying to describe PLL operation is a little like the situation of giving somebody a very small gift wrapped up in a very large box. There's a box within a box within a box, all covered with wrapping paper. So far we've only looked at the wrapping; time to see what's inside! Part of the problem lies in the name, Phase-Locked-*Loop*. There's no real beginning to a loop or circle, so it's possible to jump in anywhere. Once you understand what each main PLL element does, you can pick the starting point that you prefer.

Figure 6 shows the basic elements of any PLL system. Arrows show the direction of signal flow. It's obvious that the signal goes around in one

FIGURE 6. BASIC ELEMENTS OF ANY PLL SYSTEM



big circle or loop. The order I've chosen to describe each element is one which I think is the easiest to understand. The major building blocks are:

1. Reference Oscillator & Divider;
2. Programmable Divider;
3. Phase Detector;
4. Loop or Low-Pass Filter;
5. Voltage-Controlled Oscillator (VCO)

REFERENCE OSCILLATOR & DIVIDER

This circuit connects to the outside world through an ordinary crystal oscillator. The very newest chips have internal oscillators where all that's needed is the crystal itself and a few capacitors. However the majority of chips in current use still need an actual transistor oscillator circuit with the crystal. This oscillator operates almost universally at a frequency of 10.240 MHz. (A few very old designs used other crystals such as 5.12 MHz or 10 MHz.) The reason is because with "digital" electronic circuits, it's very easy to divide a signal of 10.240 MHz by the number "1,024". If this is done, the result is an output from the divider of 10 KHz, (10.240 MHz ÷ 1,024 = 10 KHz) which just happens to be the required channel spacing for most of the world's CB services. Sometimes a few channels skip around by 20 or 30 KHz but this is accounted for in the next section, the Programmable Divider.

I said digital techniques were used with PLLs. This word "digital" refers to any electronic circuit that can only recognize one of two distinct states, which are typically called "1" and "O", "HIGH" and "LOW", or "ON" and "OFF". Think of a digital device as simply a switch, such as the ON/OFF switch on the rig. The electronic opposite of digital is "analog", which is a circuit that can change its values *continuously* from each possible extreme and theoretically has thousands of possible values. The VOLUME control is an analog device.

Many of the most recent chips actually use the 10.240 MHz reference signal to divide down by 2,048, giving a divider output of 5 KHz rather than 10 KHz. And some chips can select either division ratio. The 5 KHz steps make certain PLL functions easier to accomplish, as we'll see later.

The purpose of the Reference Divider is to provide a very stable comparison signal against which all other signals will be synthesized. It's obvious that if the 10.240 MHz signal is not exactly on frequency, none of the other PLL signals will be either. So all PLL circuits have some way to trim their outputs to the correct frequency. The majority of PLLs use a small value trimming capacitor or coil in the reference crystal circuit, although a few PLLs make the adjustments later in the loop.

PROGRAMMABLE DIVIDER

This is really the heart of the PLL synthesizer, and a common source of frequency modifications and expansions in most older chips. By connection to the outside world at the Channel Selector switch, a command is made to divide down whatever signal it's receiving from the VCO by a precise number. This number is generated using digital techniques and is called an "N-Code", "÷ N", or "Divide-By-N" number. The N-Code is a number based upon the digital or "binary" number system rather than the common decimal system used by people. The word "binary" refers to a pair of two things and it was already pointed out that a digital circuit can only recognize two states.

Each position of the Channel Selector switch changes the N-Code slightly by connecting either a positive DC voltage ("1") or ground ("O") to the appropriate IC pins on the PLL's Programmable Divider circuit. There are typically 6 to 10 pins on the chip devoted to the programming function. On the cover of this book is a chip's Block Diagram showing "P_1" to "P_6"; the "P" stands for "Program". The programming pins are called "bits" and the total number of programming pins or bits has a direct relation to the number of possible channels which can be synthesized. Many times a special type of N-Code called "Binary-Coded-Decimal" or "BCD" is used instead of the ordinary binary code. This is partly because there's a lot of electronic support hardware around using BCD inputs, such as keyboard controls and LED number displays. It's also because when used with the very newest chips, BCD programming helps make modifications almost impossible.

PHASE DETECTOR

This circuit is the decision-maker in the PLL. It receives two signals from both the Reference Divider and Programmable Divider and

compares them, looking for an exact match in the divided-down frequencies. The Reference Divider will usually be exactly 10 KHz or 5 KHz. (10.240 MHz ÷ 1,024 or 2,048.) However the input from the Programmable Divider may not necessarily be these exact frequencies, in which case an error exists. The Phase Detector is intended to sense this error and do something about it. When inputs to the Phase Detector are not matched, the loop is said to be "unlocked" or "searching." The Phase Detector must bring the loop into lock by an appropriate output command to the VCO. This command is in the form of a very small DC correction voltage, (+) or (—) as required. Most phase detectors have a second output called a "Lock Detector". If a great error exists between the compared signals that can't be corrected in the normal way, the Lock Detector switches to its opposite logic state. For example, if the Lock Detector is normally at a logic "1" or high DC voltage, the out-of-lock condition will cause it to switch over to the "O" or grounded state. This change is sensed by an external switching circuit that's usually wired to turn off the transmitter (and sometimes even the receiver), preventing off-frequency or unstable operation. How far the loop can vary within its normal lock-up frequencies is called its "capture range."

LOOP OR LOW-PASS FILTER

This circuit immediately follows the Phase Detector, and is designed to smooth out the digital waveform entering the VCO circuit. Because the Phase Detector is sampling and comparing inputs at a digital rate, literally millions of times per second, there will always be high-intensity "spikes" coming out of it. It's impossible for any electrical or mechanical device to switch on and off instantaneously; you can't go from zero to some higher value just like that. (No doubt you've seen your house lamps dim slightly when a large motor like an air-conditioning compressor suddenly switched on; it took time for things to equalize.) If these spikes were allowed to pass on to the VCO, they could cause the oscillator's frequency to "jitter" around unstably. The spikes are of a higher frequency than the normal digital pulse, and that's why this element is often called a Low Pass Filter. It stops high frequencies from passing through it. This is exactly the same idea as the Low Pass filter used on the back of a rig which prevents high frequency harmonics from causing TVI.

The Loop Filter may be a circuit as simple as a capacitor/resistor combination at the output of the Phase Detector, or it can take the form of an actual "active filter" inside the chip itself. The active filter is now more common as engineers figured out how to cram more and more functions into the chip structure itself. This simplifies design (and cost!)

by reducing the number of external circuit parts needed. The Loop Filter is sometimes called a "Charge Pump" because its input capacitor charges up to help keep the output waveform very pure.

VOLTAGE-CONTROLLED OSCILLATOR (VCO)

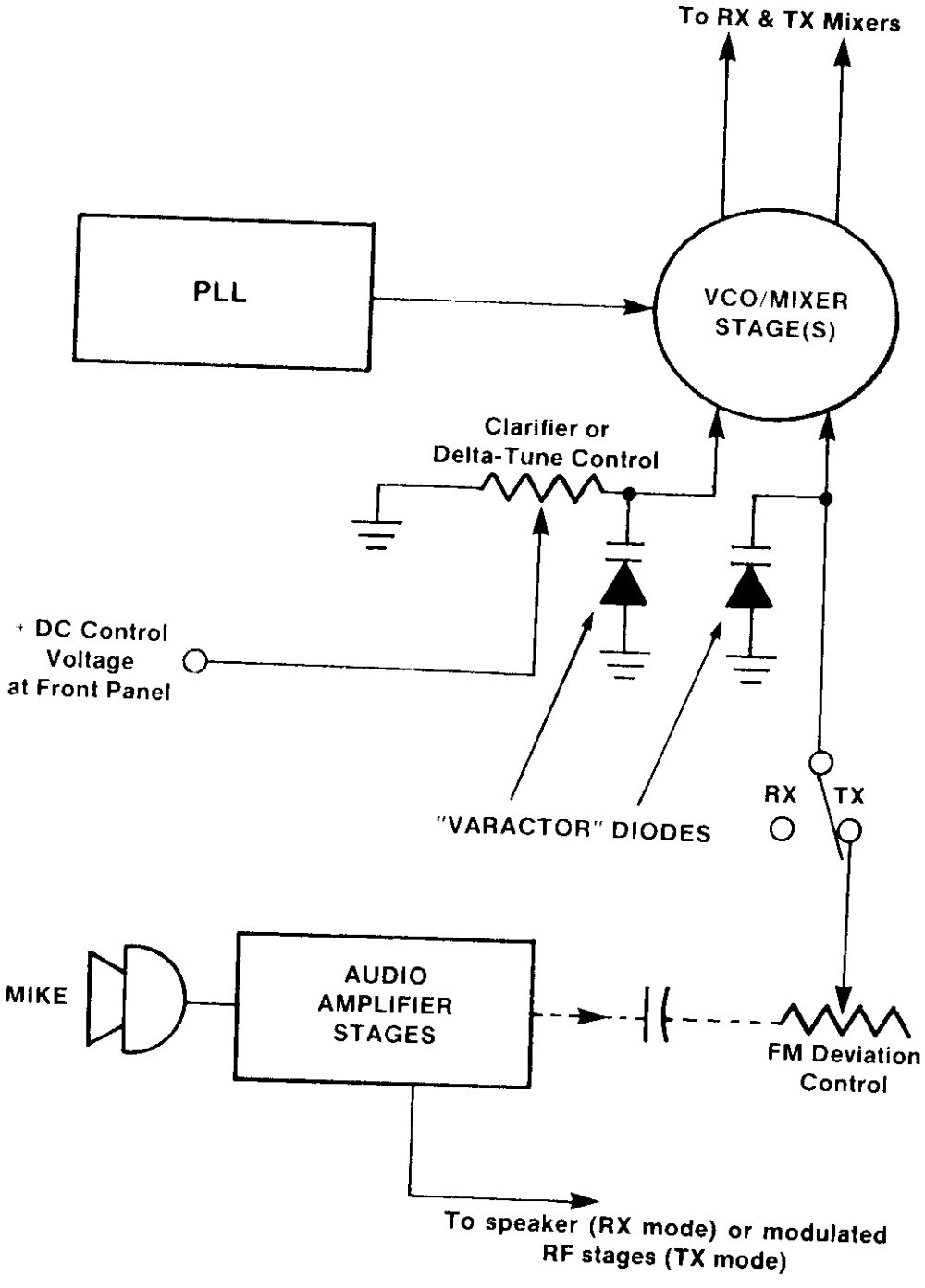
The VCO is a very interesting circuit that has many uses in electronics besides CB radios, such as the Automatic Fine Tuning (AFT) in a TV or stereo receiver. The VCO is an oscillator whose frequency is determined not by the usual coils, capacitors, or quartz crystals, but rather by a special device called a "varactor" or "varicap" diode. It's extremely sensitive to the slightest change in DC voltage applied across it. As the voltage increases, the diode's internal capacitance decreases, changing the VCO's frequency. Increasing the voltage can make the frequency go up or down depending upon how the varactor is wired in the circuit, and both methods have been used in CB VCOs. The output of the Phase Detector looks exactly like a "staircase" of DC voltage levels when going through the range of channels, and the tiniest step up or down will shift the VCO to the next channel. If you measured this voltage at the chip with a voltmeter, you'd find a change as small as .05 volts DC will shift an entire 10 KHz over to the next channel!

Because the VCO is so sensitive to voltage changes, we can make very good use of this fact for FM transmission, SSB slider circuits, and Delta-Tune controls on AM/FM rigs. If you study the schematic diagram of such a rig, you'll always find an extra varactor diode somewhere in addition to the one used in the VCO itself. Figure 7 shows this general idea. For the SSB slider or Delta Tune, a control on the rig's front panel is used to change a DC voltage across a varactor diode; this in turn changes the varactor's capacitance slightly and therefore the frequency too. (A much more detailed explanation of slider circuits and specific popular chassis modifications can be found in THE "SCREWDRIVER EXPERT'S" GUIDE.)

For FM transmission, some of the audio from the mike amplifier circuit is sampled off to be used as a control voltage. This voltage, which remember is changing at an *audio* rate, is applied to another varactor in the VCO or Mixer stage at a sensitive place. The result is FM rather than AM or SSB.

Continuing around the loop, you'll see that the VCO's output is fed right back into the Programmable Divider and then to the Phase Detector. The Phase Detector then decides whether or not a 10 KHz (5 KHz) match

FIGURE 7. USING THE SENSITIVE VCO STAGE TO PRODUCE SSB/DELTA-TUNE OFFSETS OR FM



exists between the Reference Divider and the Programmable Divider. If so, the loop is locked on frequency. If not, the Phase Detector senses this difference and outputs a DC correction voltage to the VCO. This drives the VCO up or down slightly in frequency until an exact match is found and the loop locks. This entire PLL process can be compared to a self-correcting mechanical servo system for those of you who are mechanically inclined. Although it may take many comparison cycles before an exact match is found, the entire process happens in the wink of an eye!

You really begin to appreciate the accuracy of any PLL system when you can compare it to the older crystal-synthesized rigs. For example, using an 8-digit Frequency Counter, I compared the carrier frequency accuracy of both types. Where the crystal rig might indicate say, 26.965316 MHz on Channel 1 and 26.975124 MHz on Channel 2, the PLL rig will typically show something like 26.965004 MHz on Channel 1, 26.975004 MHz on Channel 2, and 27.405004 MHz on Channel 40. In other words, the PLL is accurate all the way down to the last decimal place!

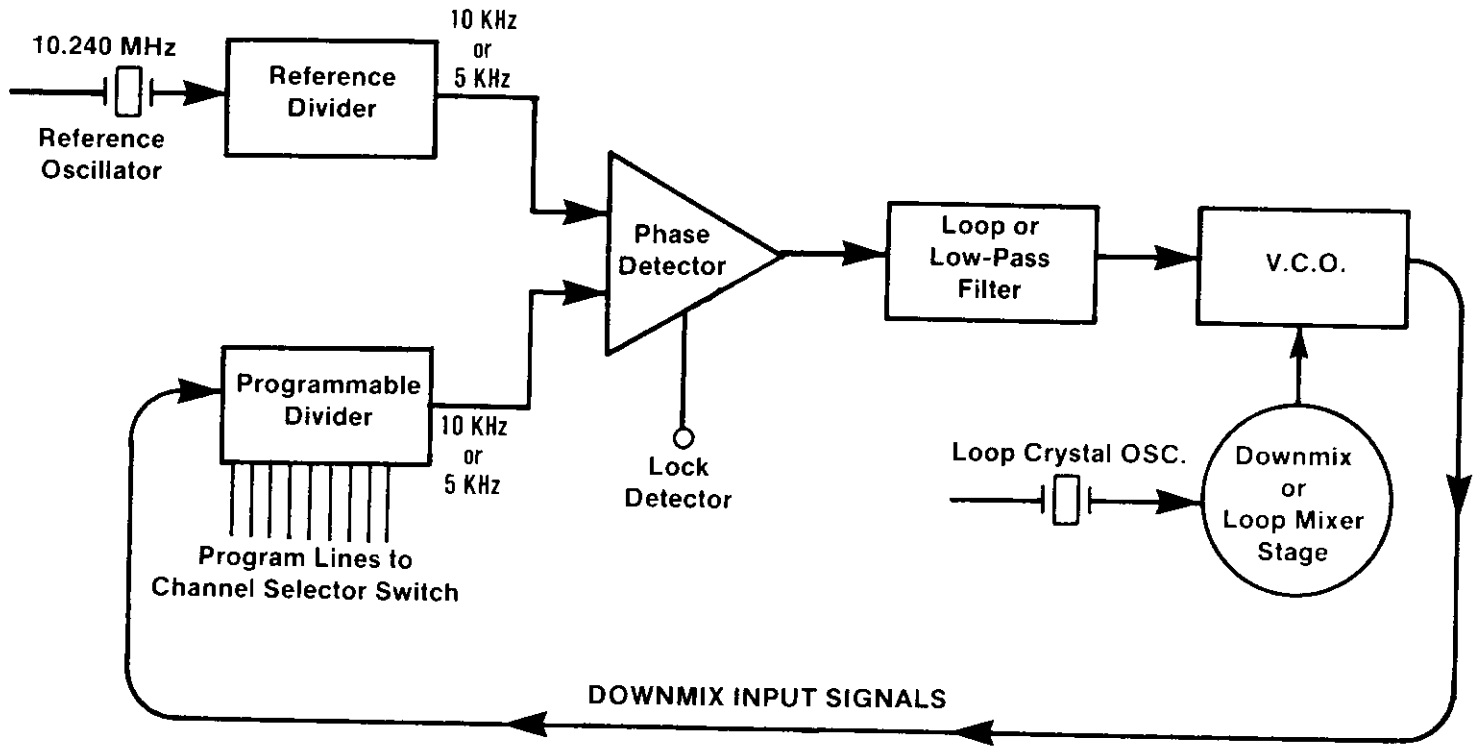
We've now come full circle around the loop and hopefully you're still there. It's now necessary to complicate things a bit more because certain other PLL circuit functions must be explained to complete your basic understanding.

THE LOOP MIXER OR DOWN CONVERTER

The need for Intermediate Frequencies and SSB offset mixing has been explained. You've also seen how the very sensitive VCO circuit can change the carrier frequency, slide an SSB clarifier, and generate FM transmission. However there's still one more basic mixing process required in the majority of rigs that use the older chip technology. While this process complicates the circuitry, it also makes modifications a lot easier!

The extra mixing circuit is called the "Loop Mixer", "Down Mixer", or "Down Converter". Figure 8 shows its addition to the basic PLL circuit. Notice that except for the addition of this extra mixer, the PLL circuit is identical to that of Figure 6 on Page 17. A separate crystal-controlled oscillator provides the extra mixing signal, and may be used directly or multiplied up to get it close to the VCO frequency.

FIGURE 8. A BASIC PLL SYSTEM WITH DOWNMIX STAGE ADDED



The reason many older PLLs require this extra mixing process is that they were not able to directly divide down the incoming VCO signal to the Programmable Divider. Most common VCOs run in the 16 MHz or 37 MHz range, and a frequency this high was impossible for older digital dividers to handle; they just weren't fast enough. Nowadays the newest "CMOS" PLL chips have been improved to the point where they are able to divide down a signal as fast as 20 MHz. Such chips are typically found only in AM or FM dual conversion rigs. You'll eventually learn to hate this particular technological improvement, because the Down Mixer stage was one of those perfect spots to modify the rig's frequencies by injecting a different mixer signal with another crystal.

For SSB use, the Down Mixer is again offset slightly in frequency, as seen in Figure 9. When you switch to LSB or USB, separate coils and/or capacitors are placed in the circuit whose values will detune the main loop oscillator by the correct amount. The offset circuits are typically switched in by diodes or transistors, and may have fixed values or factory-adjusted trimmers. In most rigs the varactor circuit which slides the Clarifier is also connected here. However there is one current SSB chassis (with uPD2824 chip) where the 10.240 MHz crystal connects to the Clarifier but a separate oscillator crystal is the one offset for the carrier itself. (Eg, Cobra 146GTL, President AR-144, Realistic TRC451, Sears 663.3810.)

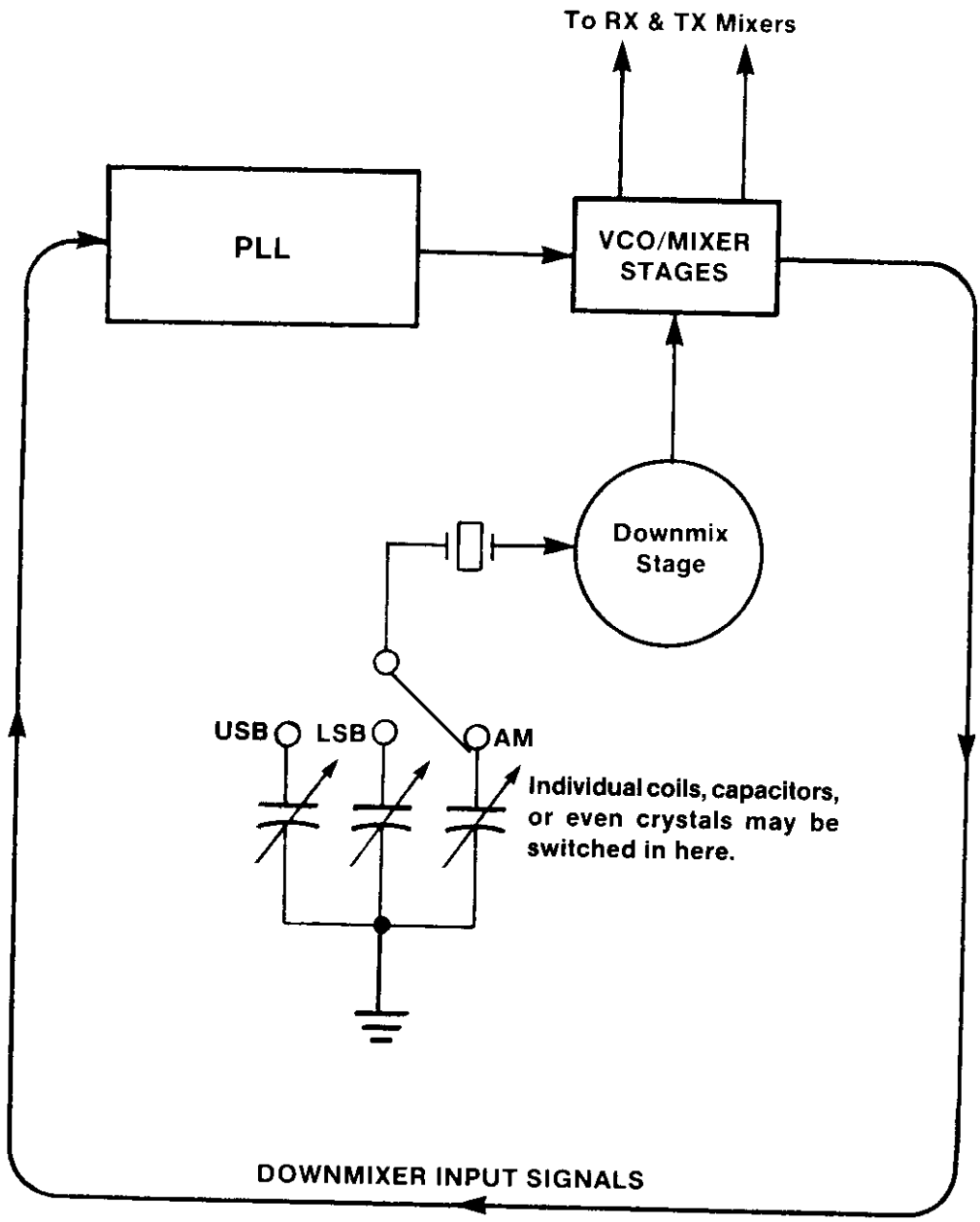
The Loop Mixer usually takes a signal generated from some other oscillator and mixes it with the VCO signal. Tuned circuits then pass only the difference frequency on into the Programmable Divider. This difference frequency is low enough to be handled by the older type of chip dividers, and is generally in the 910 KHz to 4 MHz range.

The crystal-controlled oscillator signal that's injected into the Down Mixer can come from several possible sources. The most obvious is an actual crystal oscillator using a transistor, and this is still the most common method. In many cases, this crystal frequency must be multiplied up by tuned circuits to get it close to the operating range of the VCO. The most common multiplication is by a tuned coil designed to double or triple the crystal frequency, although higher multiplications have been observed in some rigs.

THE 5.12 MHz LOOP MIXING OUTPUT

In many newer chips, there's a provision right on the chip itself for a signal that can be used for loop down-mixing. This signal is typically

FIGURE 9. OFFSETTING PLL FOR SSB MIXING



NOTE: The Carrier Oscillator stage is normally offset also in a similiar way. This maintains a single IF frequency for all modes and thus only a single IF filter is required.

half the 10.240 MHz Reference Oscillator frequency, or 5.12 MHz. The 5.12 MHz signal comes off a pin right on the IC chip; it's already been amplified and buffered internally. The 5.12 MHz signal is normally tripled to 15.360 MHz (5.12 MHz x 3) by a tuned coil, which places it very close to a VCO running in the 16-17 MHz range. In a few Motorola rigs using the TC9105 chip, the VCO is running in the 37 MHz range, so the 5.12 MHz is multiplied up by 7 times to get it near this frequency. And in another very common arrangement, the 10.240 MHz master oscillator itself can be doubled. Borrowing this 10.240 MHz energy is a simple way to provide not only receiver IF injection as we saw earlier, but can also be used to run the loop mixer itself.

CURRENT TECHNICAL TRENDS

Loop mixing is one easy place for frequency modifications. Unfortunately the newest chips (Eg, LC7131, LC7136, TC9109, TC9119) which are used for dual-conversion AM or FM rigs have no loop mixing because they are capable of direct VCO division in their Programmable Dividers. In addition they use special programming tricks to further prevent modifications. If you own a rig with one of these chips, you're out of luck at the moment. There are however still millions of rigs out there using loop mixers. Many are obsolete now but the most notable exceptions are the PLL02A, MB8719, and uPD858 chassis, which are the most popular rigs in worldwide use, for obvious reasons! The AM versions of these rigs have generally disappeared because the newer chips are more foolproof. But the SSB versions are very common and still being marketed almost everywhere. That's because SSB usually requires loop mixing at this point in PLL technology, and details of common modifications can be found later in this book.

SPECIAL CHIP FUNCTIONS

There are several more options which may be found on PLL chips. Most deal with resistance to illegal modifications, ease of circuit design, and operator convenience features. I'll briefly summarize some of these here because you'll need to understand them whenever you're studying the pin diagram of a particular chip.

THE TRANSMIT/RECEIVE (T/R) SHIFT

This is a function found only in the very latest generation of chips

designed mostly for AM or FM with dual-conversion receivers. Examples are the LC7120, LC7130/31, LC7136/37, TC9106, TC9109, TC9119, uPD2814, and uPD2816. A special IC pin shifts the N-Code to the Programmable Divider when that pin goes to its opposite logic state.

For example, the chip may have one set of N-Codes when the T/R pin is grounded ("O") and a different set of N-Codes when the T/R pin is high with +DC voltage applied ("1"). You'll find the chips with this feature in any rig having only a single 10.240 MHz Reference Oscillator crystal.

Because there is no other signal present in the loop that can be used for mixing, receiver IF injection, etc., it's necessary for the chip itself to generate the 455 KHz shift used for the receiver's second IF stage. The T/R pin is connected through transistor switching circuits to the mike and senses the T/R change. When this change happens, the output of the Programmable Divider entering the Phase Detector is of course no longer matching the Reference Divider's output. The Phase Detector then outputs its correction voltage to the VCO , driving it up or down to lock the loop. Generally the VCO is driven 455 KHz higher in the Transmit mode.

Chips with the T/R shift are rarely used with multimode rigs having SSB, because SSB doesn't require the second 455 KHz receiver IF conversion. One exception at the moment is the U.S. versions of the Midland 6001/7001. They use the uPD2816 chip, which has a T/R pin, *but the pin is not connected;* instead a separate crystal downmixer oscillator is used, which makes modification easy again. So it's possible, depending upon *how* the chip is used, to modify rigs that are generally non-modifiable. (Later versions of the 6001/7001 use the uPD2824, which is pin-for-pin identical to the uPD2816 minus the T/R pin function.)

The T/R families of chips are among those first mentioned using an internal 5 KHz Reference Divider output signal rather than 10 KHz. The standard 10.240 MHz crystal is used, but this time it's divided down by 2,048. (10.240 MHz ÷ 2,048 = 5 KHz.) This is necessary because it's easy to get the 455 KHz shift; by increasing the N-Code 91 counts from the Receive N-Codes, the result is 91 × 5 KHz = 455 KHz. Some chips shift 5 KHz/2.5 KHz for T/R purposes. (Eg, PLL08A, PLL03A, TC9109.)

I've observed two other variations of the T/R shift idea. In the U.S. rigs with the TC9109 chip, the N-code shifts up by 2,139 counts in the Transmit mode while at the same time the Reference Divider shifts from 5 KHz steps to 2.5 KHz steps. This drives the VCO down from the 16 MHz range used in the Receive mode to the 13 MHz range, where it's doubled to produce the direct on-channel frequency. In the LC7136/37 U.K. rigs, the Reference Divider never changes its 5 KHz steps, but instead simply shifts down by enough counts to drive the VCO from its 16 Mhz Receive range to the 13 MHz range where it's then doubled in the same way to produce the direct on-channel 27 MHz frequency. Both designs use an IC mixer where the various VCO outputs can either be peaked (16 MHz Receive mode) or doubled (27 MHz Transmit mode) by tuned coils. The PLL03A (now obsolete) worked on this same idea but was way ahead of its time; when people discovered the rig couldn't be modified, sales of that chassis disappeared. The chip appeared long before the FCC made manufacturers use such advanced ideas!

MISPROGRAM CODE (MC) PIN

Many of the newer chips have special N-Code protection to prevent illegal modifications. If you try to force an illegal program code on the program pins with non-acceptable voltages and grounds, this pin function is activated. It's very similar to the Lock Detector in that it can be used to turn off the transmitter unless a legal program code exists. So once again, some of the extra "features" in the newer PLLs are for the benefit of the manufacturer and the licensing government, not for you!

FREQUENCY SELECT (FS) PIN

This pin, available in some older chips, allows selection of 10 KHz or 5 KHz Reference Divider steps. The division is chosen by the appropriate "1" or "O" on this pin. Don't confuse this function with the need for the 5 Khz division used with the T/R shift; it's not for the same purpose. The feature when used in the new ROM chips allows designers to synthesize frequencies in 5 KHz offsets for SSB use in addition to AM/FM use. Remember, the earlier chips were applied to CB synthesizers *and* many other kinds of equipment such as VHF marine radios, aircraft radios, and signal generators. It was only when people went wild with CB modifications that manufacturers were forced to make special "dedicated" ICs for CB synthesizers only.

Before you get all excited and think you can turn your rig into one having 5 KHz channels by changing the voltage on this pin, consider the fact that the N-Code programming must also change to produce 5 KHz steps in the Programmable Divider circuit as well. It can't be done easily! This pin for CB circuits will either be left unconnected on the printed circuit board, or connected to ground or +DC as needed to produce 10 KHz channel spacings. (NOTE: Frequency Expanders like the MICROMONITOR and MICROSCAN have their own PLL circuits which will replace the rig's PLL circuits, and that's why they can produce continuous 5 KHz steps.)

AUTOMATIC CH.9/CH.19 COMMAND

This is a special feature found only in the very latest chips, like the LC7130/31 for American rigs, LC7135 for 22-channel EEC rigs, and LC7136/37 for British rigs. By applying a +DC voltage to these two special pins, Channel 9 or Channel 19 is automatically recalled without changing the Channel Selector. You can just push a button, or the pins can be connected to a scanning circuit to stop on these channels when a signal is present. In addition they're connected internally to the MIS-PROGRAM CODE pin. If the MC pin is not used, as in some chassis variations, attempts to force an illegal program code will cause either Ch.9 or Ch.19 to be recalled instead of killing the transmitter. When these features are included in the rig model, the MC pin will be tied to the Lock Detector pin to kill the transmitter. If these features are not included in your rig model but you'd like to have them, it's a simple matter of fitting a SPDT switch between these pins and a +DC voltage source. (See Figure 12, Page 47.)

SCANNING INTERFACE

Certain chips such as the LC7120 and those just mentioned can be connected to special scanning chips to scan up and down the legal band, search for an unused channel, etc. These are useful features for some people and are often found in rigs having all controls in the mike and the main radio "guts" remotely hidden elsewhere in the car. (Eg, Realistic TRC462 "One-Hander".) The advantages and disadvantages should be obvious by now.

SECTION II

BACKGROUND FOR MODIFICATION METHODS

Now we're ready to get to the good part you've probably all been waiting for! Several ways to "trick" CB rigs into getting those high and low "funny" channels, as well as 10 Meter Ham conversions, will be explained in this section.

There are still two basic methods of changing frequencies in the majority of CBs. At this writing, the foolproof designs have not exactly flooded the market, especially for SSB use, and therefore most rigs can be modified using these tricks. These tricks are:

1. Change the Programming N-Code on the PLL chip's pins;
2. Change the Loop Mixer signal.

It's not the purpose of this book to teach the basics of aligning transmitters and receivers, so if you're planning a large frequency conversion such as up into the 10 Meter Ham band, realignment of other circuits will also be required. A schematic circuit diagram of the rig is essential. However for adding one or two additional 40-channel segments to most rigs, the only alignment usually required is in the PLL's tuning circuits themselves. This part is left up to you to figure out with the aid of the circuit schematic or a more experienced friend.

Before getting more specific, I think it's important to describe an actual PLL circuit to make sure you understand its complete operation. Let's walk through the complete circuit, step by step.

A TYPICAL SYNTHESIZER CIRCUIT

Refer to Figure 10 on page 34, which is the PLL circuit of perhaps the most popular AM PLL rig ever made. It's been sold under dozens of brand names and uses the ever-popular PLL02A PLL chip. The AM/SSB or AM/FM/SSB variations of this chassis are very similar when you consider the minor changes needed for SSB offsets and sliders and FMing the VCO circuit. You'll also be referring to Chart 1 on page 35, which is a breakdown of all the important operating conditions by channel number. Such a chart is normally included with the radio's service manual but certain facts not related directly to 40-channel operation are often left out. I'll be filling in the missing blanks for you.

A PLL circuit may be categorized very generally by the number of crystals it uses and by whether its VCO is running for low-side or high-side receiver IF injection. This example is actually the second generation PLL02A AM circuit; the first one used a 3-crystal loop and can be found in Section III. The newest chips use a single 10.240 MHz crystal and low-side VCO operation in the 16-17 MHz range where the VCO can be directly divided without a loop Down Mixer.

The key to synthesizing all the required frequencies is in the Programmable Divider, which is the only PLL section that you can control from the outside world at the Channel Selector switch. That switch is where the whole process begins.

Suppose you choose U.S. Channel 1, 26.965 MHz. (This description applies to all circuits and chips.) In the Channel 1 position, the Programmable Divider receives a very specific set of instructions at its programming pins, which are directly connected to the Channel Selector. This particular instruction set, called an "N-Code", applies only to Channel 1 and is nothing more than a number which will divide down any signal appearing at the Programmable Divider input by that number.

BINARY PROGRAMMING

Referring now to Chart 1, you see the N-Code for Channel 1 is the number "330" and the numbers progress down to "286" at Channel 40. The number 330 is the direct result of applying a +DC voltage of typically 4-8 volts to certain PLL program pins while grounding certain other pins at the same time. Recall that the PLL requires a digital or binary counting system rather than the common decimal system used by people.

In a binary number system, each successive programming pin or "bit" is worth exactly twice (or half) that of the pin next to it, such as 1, 2, 4, 8, 16, etc. A series of "1s" and "Os" appears in the chart for each of the 40 channels. The "1" means +DC is applied to that pin, and the "0" means that particular pin is grounded. The greater the "Power-of-2" controlled by a pin, the greater its "significance". As you'll see next the greatest Power-of-2 for this example is 256 on Pin 7. Therefore Pin 7 is called the "Most Significant Bit" (MSB) and the "Least Significant Bit" (LSB) is Pin 15, which only has a weight of 1. A chart like Chart 1 that shows the logic states ("1" or "0") of each PLL program pin for each channel is

FIGURE 10. A TYPICAL SYNTHESIZER CIRCUIT FOR AM
(PLL02A, 2-XTAL HIGH-SIDE INJECTION)

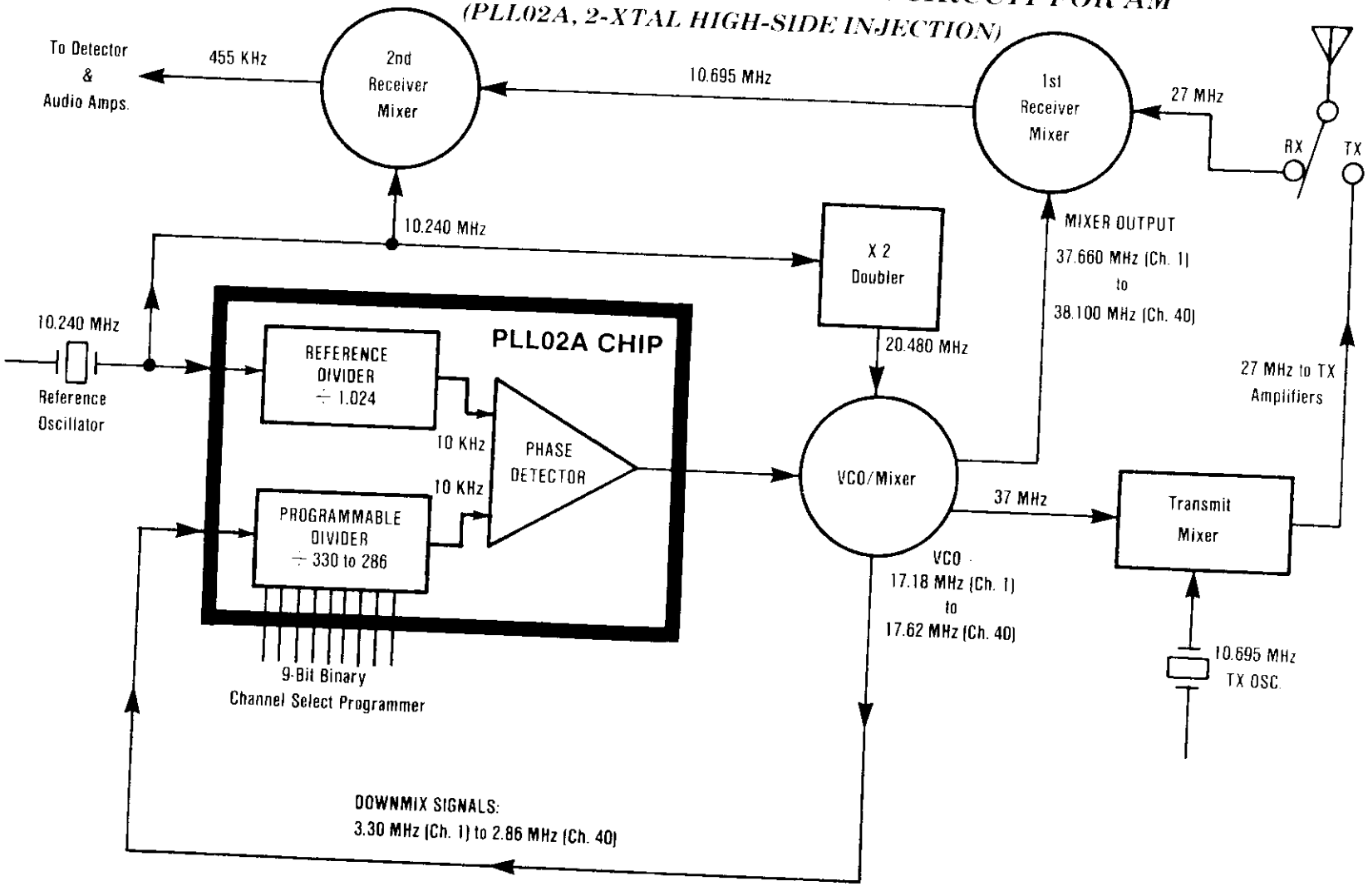


CHART 1

Circuit Constants & Truth Chart For Sample PLL Synthesizer Described in Text

Channel No.	Channel freq. (MHz)	"N" digital codes	VCO freq. (MHz)	Rx 1st IF freq. (MHz)	IC Program Pins								
					15	14	13	12	11	10	9	8	7
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	27.205	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	38.01	1	1	1	0	0	1	0	0	1
32	27.325	294	17.54	38.02	0	1	1	0	0	1	0	0	1
33	27.335	293	17.55	38.03	1	0	1	0	0	1	0	0	1
34	27.345	292	17.56	38.04	0	0	1	0	0	1	0	0	1
35	27.355	291	17.57	38.05	1	1	0	0	0	1	0	0	1
36	27.365	290	17.58	38.06	0	1	0	0	0	1	0	0	1
37	27.375	289	17.59	38.07	1	0	0	0	0	1	0	0	1
38	27.385	288	17.60	38.08	0	0	0	0	0	1	0	0	1
39	27.395	287	17.61	38.09	1	1	1	1	1	0	0	0	1
40	27.405	286	17.62	38.10	0	1	1	1	1	0	0	0	1

NOTES: 1) HIGH Level ("1") = 4.5 to 5.5 VDC; LOW Level ("0") = GND.

2) Pins 7 & 8 permanently wired HIGH & LOW respectively for all 40 channels and are often not even shown in the TRUTH CHART.

3) Australian 18 Channel rig frequencies are U.S. Channel 5 to U.S. Channel 22.

called a "Truth Chart".

How exactly was the number "330" decided? Chart 2 shows the truth states for Channel 1 only. Above each PLL program pin are numbers I've labelled "POWERS OF 2", such as 1, 2, 4, 8 up to 256 because this is exactly how a binary counter counts. By adding up the weight or significance of every pin where a "1" appears, the N-Code is determined. (The "0" pins are always ignored.) In this example, we have 256 + 64 + 8 + 2 = 330. Figure 11 shows the actual voltage switching. Try the math for a few other channels yourself; you'll be using this knowledge eventually!

CHART 2

Channel 1 Binary Programming Code of PLL02A AM Synthesizer Described in Text

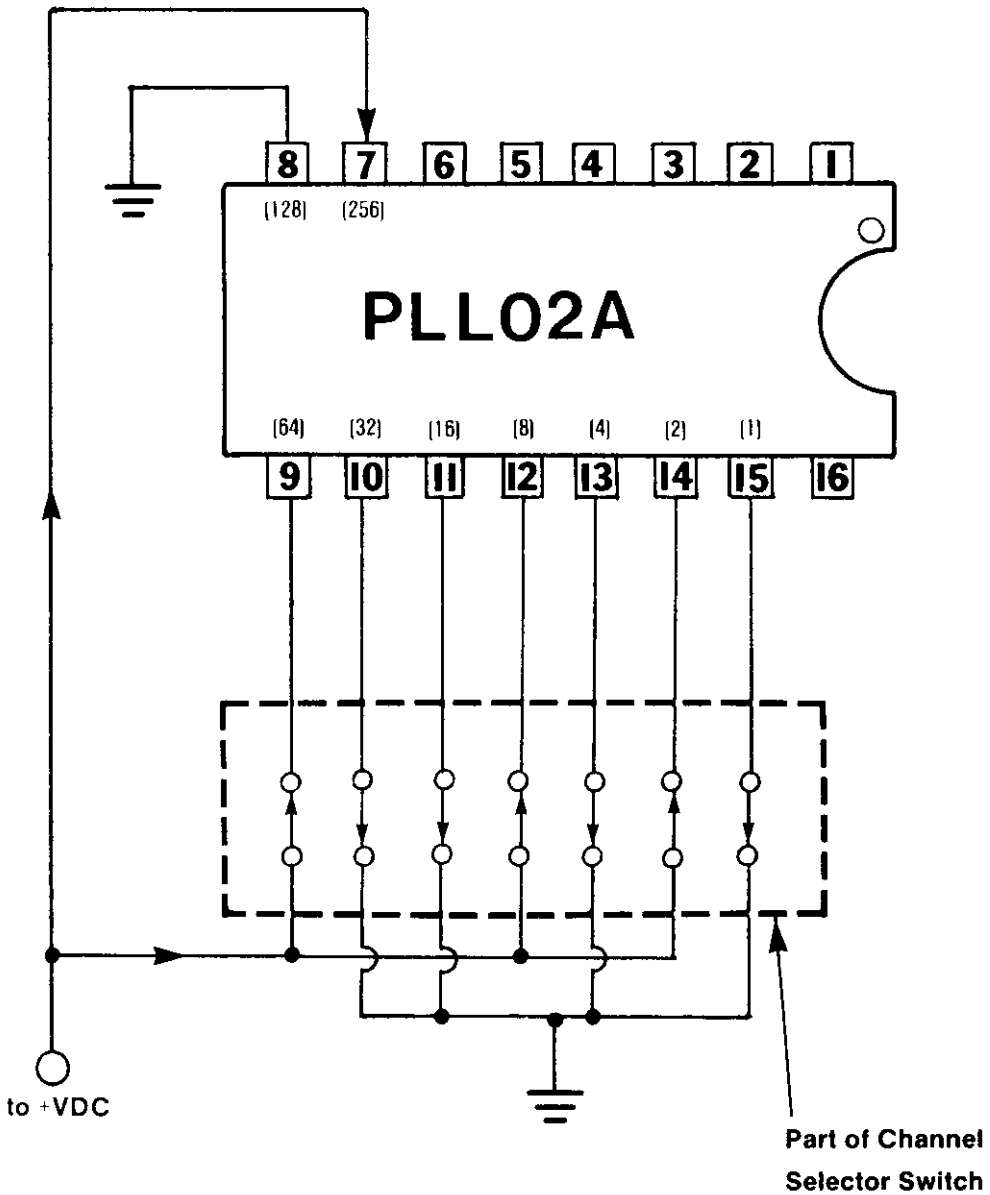
÷ N = 330: 256's bit + 64's bit + 8's bit + 2's bit = 330

POWERS OF 2	1	2	4	8	16	32	64	128	256
PLL PROGRAM PIN NUMBER	15	14	13	12	11	10	9	8	7
TRUTH STATE, CHANNEL 1	0	1	0	1	0	0	1	0	1

"1" = +4—8 VDC; "0" = 0 VDC or Ground.

Notice from Chart 1 and Figure 11 that the logic states of pins 7 and 8 never change at all for any of the 40 channels. Instead they are permanently hard-wired to the chassis such that Pin 7 is always connected to +DC voltage ("1") and Pin 8 is always grounded ("0").

FIGURE 11. HOW THE BINARY N-CODE IS GENERATED



÷ N = 256 bit + 64 bit + 8 bit + 2 bit = 330 for Channel 1

You'll discover that many service manuals won't even indicate these pin states in their Truth Charts because they never change *when programming 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 circuit diagram. Compare the total programming pins available to the total number used in a 40-channel rig; you'll find an obvious modification source!

The 18-Channel Australian CB service was recently expanded legally to match the standard 40-Channel FCC American service. Since many Australian rigs are simply U.S. rigs with a different (limited) Channel Selector switch, they can be easily modified to cover the extra channels. For example, Australian Channel 1 is 27.015 MHz, which is U.S. Channel 5. The N-Code here is 325. The N-Code for Australian Ch. 18 (27.225 MHz) is 304. Therefore by reprogramming N-Codes of an 18 channel Australian rig for numbers greater than 325 or less than 304, the rig can be expanded.

This particular chip, the PLL02A, has a total of 9 binary programming pins, which are pins 7 - 15. It therefore has what's called a "9-bit" binary programmer. Some quick math will tell you that this chip actually has a potential channel capability 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.

VCO CIRCUIT

Refer back to Figure 10 on Page 34. This VCO runs in the 17 MHz range, going from 17.18 MHz on Channel 1 to 17.62 MHz on Channel 40. The VCO is controlled by an error voltage it receives from the Phase Detector, which is always looking for a match between the Reference Divider and Programmable Divider outputs. The Reference Divider is very accurately controlled by a 10.240 MHz crystal oscillator whose signal is divided down digitally by 1,024 to produce the 10 KHz channel spacings. If the Programmable Divider should also happen to produce an exact 10 KHz output, the result would be perfect; there'd be no correction from the Phase Detector, 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. If it should see, for example, a signal of exactly 3.30 MHz appearing at its input, the resulting output would be 10 KHz. (3.30 MHz ÷ 330 = 10 KHz.) If we can somehow produce 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 some existing circuitry. If some 10.240 MHz energy from the Reference Divider is taken off and passed through a tuned doubler stage, the result will be 2 x 10.240 MHz = 20.480 MHz. Here's where that very important loop mixing principle enters: By mixing the 20.480 MHz signal with the 17.18 MHz Channel 1 VCO signal, sum and difference frequencies are produced. The sum frequency is 20.480 MHz + 17.18 MHz = 37.660 MHz. The difference frequency is 20.480 MHz — 17.18 MHz = 3.30 MHz which is precisely what's needed to lock the loop on Channel 1. And the 37.660 MHz signal isn't wasted either; it's used as the high-side injection signal to produce the first receiver IF when mixed with the incoming 26.965 MHz Channel 1 signal. (37.660 MHz — 26.965 MHz = 10.695 MHz first IF).

PHASE DETECTOR CORRECTION

What happens if the mixing product entering the Programmable Divider isn't exactly 3.30 MHz? Think about it. Since the N-Code is 330, any signal other than precisely 3.30 MHz will produce a slightly different output to the Phase Detector. For example, if a signal of only 3.10 MHz enters the Programmable Divider, the resulting output would be 3.10 MHz ÷ 330 = 9.39393 KHz. The Phase Detector will now sense this error and try to correct it by sending a DC voltage to the VCO. This correction voltage will drive the VCO up or down slightly in frequency, constantly being compared in the Phase Detector, until an exact match occurs once again. Although this appears to be a trial-and-error process, the whole thing happens in the time it takes you to switch from Channel 1 to Channel 2!

RECEIVER IFs

This completes the basic loop; everything else is icing on the cake.

We've just seen how the Channel 1 PLL mixer signal of 37.660 MHz provides the receiver's first IF injection signal. Now notice from Figure 10 that even a third use can be made for the 10.240 MHz Reference Oscillator. By mixing it with the 10.695 MHz first IF, the result is 10.695 MHz — 10.240 MHz = 455 KHz, the second IF. (The sum product is ignored.) Pretty smart these engineers! Almost all AM or FM CBs use this dual-conversion receiver process, and it's commonly used in car radios, scanners, FM stereos, etc. where a lot of the circuit hardware already existed.

TRANSMITTER SECTION

For the transmitter of this example, the on-channel frequency is produced very simply by mixing a separate 10.695 MHz crystal oscillator with the 37.660 MHz Channel 1 PLL mixer output. The difference is 37.660 MHz — 10.695 MHz = 26.965 MHz, which is then passed through tuned circuits and the normal transmitter RF amplifier chain.

You can use the preceeding explanation as the basis for any PLL circuit you find. We've already figured out some of the most common ones for you and their block diagrams appear in Section III.

TRUTH CHARTS & PROGRAMMING METHODS IN DETAIL

The Truth Chart is the most important first step in determining how a modification can be made, or even *if* it can be made, so we'll look at it in greater detail now.

The example just explained 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, whether it's AM or AM/SSB, etc. The AM 2-crystal loop had N-Codes going from 330 down to 286, because those were the dividers needed for proper loop mixing. An earlier PLL02A scheme used a 3-crystal synthesizer with N-Codes going from 224 *up* to 268. And for the ever-popular PLL02A SSB chassis (American or European versions), the N-Codes are 255 down to 211.

Notice that these N-Codes may go up or down with increasing channel

number; this depends purely on the VCO's design. In Section III you can compare all the PLL02A block diagrams to see where and why these differences occur.

Meanwhile let's return to a portion of Chart 1 to study some of its other features. Chart 3 shows only the channel number, channel frequency, and N-Codes from the original chart. Observe the progression of N-Codes from Channel 1 to Channel 40. Notice anything unusual? *The N-Codes are not all consecutive and skip a few numbers any time there is no legal CB frequency.* For example, Channel 3 is 26.985 MHz, and Channel 4 is 27.005 MHz. What happened to 26.995 MHz? It's not a legally assigned channel. This is known to CB people as an "A" channel, in this case Channel 3A. There are also skips at channels 7, 11, 15, and 19. In addition the American FCC Channels 23, 24, and 25 are assigned out of order. Therefore all N-Codes as well as VCO and mixer frequencies are also out of order in the chart. Many European countries having only 22 channels simply adopted the American scheme exactly for the first 22 channels. Australia uses 18 channels whose numbers didn't correspond to American/EEC numbers but many of the actual frequencies are the same. And Britain originally used 40 consecutive channels having no skips at all. Remember this fact whenever you're checking a PLL Truth Chart; otherwise you might think your math is wrong when it isn't!

BCD PROGRAMMING

Another common programming method is called "BCD", which means "Binary-Coded Decimal". Think of it as a cross between the binary (Base 2) and human Decimal (Base 10) number systems. Chart 4 shows part of a BCD channel program used in the very popular uPD858 SSB rigs. (Eg, Cobra 138/139XLR, Realistic TRC457/458, President "Adams", etc.) This chassis is an older PLL circuit requiring a Down Mixer into the Programmable Divider. If you check the block diagram for this chip in Section III, you'll see that the downmix frequencies are .910 MHz to 1.35 MHz. Therefore the N-Codes are 91 to 135 for standard 10 KHz spacings. Note that the N-Code between channels 3 and 4 skips in exactly the same way as in the PLL02A circuit, since Channel 3A is not a legal CB channel. What's the big difference? Above each PLL program pin number is now something called "BCD POWERS" rather than the previous "POWERS OF 2".

CHART 3

N-Code Variations For Channel Assignments

Channel No	Channel freq. (MHz)	"N" digital codes
1	26.965	330
2	26.975	329
3	26.985	328
4	27.005	326
5	27.015	325
6	27.025	324
7	27.035	323
8	27.055	321
9	27.065	320
10	27.075	319
11	27.085	318
12	27.105	316
13	27.115	315
14	27.125	314
15	27.135	313
16	27.155	311
17	27.165	310
18	27.175	309
19	27.185	308
20	27.205	306
21	27.215	305
22	27.225	304
23	27.255	301
24	27.235	303
25	27.245	302
26	27.265	300
27	27.275	299
28	27.285	298
29	27.295	297
30	27.305	296
31	27.315	295
32	27.325	294
33	27.335	293
34	27.345	292
35	27.355	291
36	27.365	290
37	27.375	289
38	27.385	288
39	27.395	287
40	27.405	286

CHART 4

BCD Programming of uPD858 Chip Described in Text

			Ones				Tens				Hundreds	
		BCD POWERS	1	2	4	8	10	20	40	80	100	200
	÷ N	PLL PROGRAM PIN NUMBER	13	14	15	16	17	18	19	20	21	22
Ch. 1	91		1	0	0	0	1	0	0	1	0	0
Ch. 2	92		0	1	0	0	1	0	0	1	0	0
Ch. 3	93		1	1	0	0	1	0	0	1	0	0
Ch. 4	95		1	0	1	0	1	0	0	1	0	0
⋮	⋮											
Ch. 40	135		1	0	1	0	1	1	0	0	1	0

NOTE: Pin 22 permanently grounded to chassis ("0") for all 40 channels.

In this system, the pins have been assigned such that each successive group of pins has a weight or significance *10 times greater* than the preceeding group. Within each decimal group, weights still double in the usual binary progression, except that the highest possible number in any group can't exceed 9 or its decimal multiple, such as 90, 900, etc. (Assuming there were that many pins on the chip.) Each decimal group can only have a maximum of 4 bits; in this chip, there are only 10 rather than 12 programming pins so the Hundreds Group can only add up to a maximum of (1 + 2) x 100 = 300. Figure the total binary value in each group, multiply it by 1, 10, or 100 as appropriate, and add the groups together: Ones Group + Tens Group + Hundreds Group, etc.

Since each group has a value, the sum of the *groups* produces the N-Code. For Channel 1, we therefore get 1 + (10 + 80) = 91. Try the math yourself for the other pins. Notice also that pin 22 is permanently grounded, since its weight is "200" and we never need an N-Code bigger than 135. (100 + 30 + 5 = 135). By using all 10 programming pins (pins 13 to 22) there's a potential channel capacity of 9 + 90 + 300 = 399 channels if N-Codes could be programmed from 1 to 399. This fact has been put to much use in frequency modifications! Once again, the 858 chip has this excess capability for possible use in other synthesizer circuits besides CBs.

Before you get too excited about all the potential channels hidden inside some PLL chips, I must point out that most rigs can't possibly cover as wide a range as these chips without a lot of retuning. Modern rigs are capable of about 1.2 MHz to 1.8 MHz total bandwidth, which means 120 to 180 10 KHz AM/FM CB channels.

The BCD method was originally used in about 15% of the older generation circuits. The reason was because certain support hardware such as BCD switches, keyboard controllers, and 7-segment LED displays required BCD inputs. The current generation almost always uses BCD inputs. Some examples are the LC7120, LC7130/31, LC7135, LC7136/37, uPD2814, uPD2816, and uPD2824. These chips also only have 6 programming pins.

PRESETTABLE DIVIDERS

An interesting variation of the programming expansion scheme is used in the new Cobra 148GTL-DX, which is a very popular rig sold only in Europe and the U.K. In order to get 120 channels, they start off with the same very flexible chip, the MC145106, as used in the typical PLL02A chassis. Only this time, the N-Codes *can be preset* to a new set of 40 channels each time you change the L,M,H band switch. This is done by using two special digital counter chips, the MC14008s, wired such that each band selection also changes the set of N-Codes. The net result is that a single Loop Mixer crystal (15.00 MHz) can be used to provide 120 channels. In previous 80 or 120 channel schemes, additional loop mixing crystals are switched in while maintaining *a single set* of N-Codes all the time.

The reason for doing this is purely economic: The Cobra 148GTL-DX can offer 120 AM/FM/SSB channels, and a dual-conversion AM receiver, for a total of only 3 crystals in the whole radio. Compare this to the typical 120-channel Cybernet (Ham Int'l, Colt, Major, etc.) or the 120-channel Uniden Superstar 360, which require 5 and 6 crystals respectively. The cost of a crystal to the manufacturer is about $3 each, while the cost of two MC14008s is about $1 total. Since there is roughly a 5:1 mark-up from manufacturer's cost to actual retail price of a rig, this means a savings *to you* of $30 to $45 on the total retail price!

The idea of presettable dividers is also found in several other PLL chips. The most common example is the MB8719. While the chip at first appears to have 7 binary programming pins, closer study shows that Pin 10 is actually used to preset *different* N-Codes for use with different loop mixer crystals in the American rig versions. (11.1125 MHz vs. 11.3258 MHz crystal in an otherwise identical chassis.) In the newest Uniden European rigs (Eg, Stalker ST9F-DX, Superstar 360FM) the MB8719 or MC145106 chip is used along with the MC14008 presettable dividers to provide 80 or 120 channels. In the Stalker, they even provide an additional Loop Mixer oscillator on its own small PC board which can be switched in to give the 40 U.K. channels as well. (15.4825 MHz for the first 80 "FCC" channels, and 15.55625 MHz for the 40 U.K.

channels.) Of course the N-Codes are different for each band and the Band Selector switches both the crystals *and* the proper IC programming at the same time.

MULTIMODE PROGRAMMING

There's one chip that deserves special mention, even though it's not being used much anymore: the uPD861. NEC really outsmarted themselves with this one!

The 861 has some special control pins so that the designer can choose either binary *or* BCD programming. There are 8 binary programming lines, which means a possible 2^8—1 or 255 channels when used in the binary mode. In the BCD mode, a special "ROM" Code Converter is connected to allow only the legal 40 channels. Thus the 861 could be used in other synthesizer applications. In Section III you'll find the exact specs; note that simply changing the voltages on a couple of control pins will allow you to convert a rig which when used in the BCD/ROM mode is non-modifiable. You can then program it directly in binary with switches.

A few chips such as the uPD2810, uPD2814, and uPD2816 allow multiple choices of N-Code sets such that several possible downmixer circuits can be used. This feature is intended only for design flexibility; it won't help you in your modification attempts. (Actually the feature was intended to make the chip usable in both AM/FM and SSB circuits, but to date only the AM/FM design has been found in CB rigs.)

CONTROLLING PROGRAM PINS

You know that to control a program pin, a voltage or ground must be connected to that pin. Most chips have resistors built into the chip structure which are connected internally to the main +DC supply or ground pins of the chip. These resistors are called "pull-up" and "pull-down" as they automatically force the logic state to a "1" or "0" respectively, unless controlled externally. The external control takes the form of the Channel Selector switch if the pin is needed, or a direct connection to the rig's circuit board ground or +DC if not needed for only a 40-channel set of N-Codes. When you need to control a pin for modifications, cut the circuit board trace leading to that pin and bridge the cut with a small (¼ watt) resistor of about 1K to 4.7K ohms. This will isolate that pin until it's ready to be switched by you. In addition it can help protect the chip from possible damage due to static electricity; a pin should never be left "floating" and should always be connected to something externally.

Returning to our first example, the PLL02A has internal pull-down resistors, which means that each program pin is always in the "0" state until +DC is applied externally. So if your modification calls for control of say, Pin 7, cut the foil trace going to Pin 7 and bridge it with a resistor. Figure 12 shows the principle of external pin control; it's commonly used with the PLL02A, MB8719, and uPD858 chips. You can also use this idea to get the automatic Ch. 9/19 recall feature in the LC7131, LC7135, or LC7136/37 chassis if the rig doesn't already have it installed.

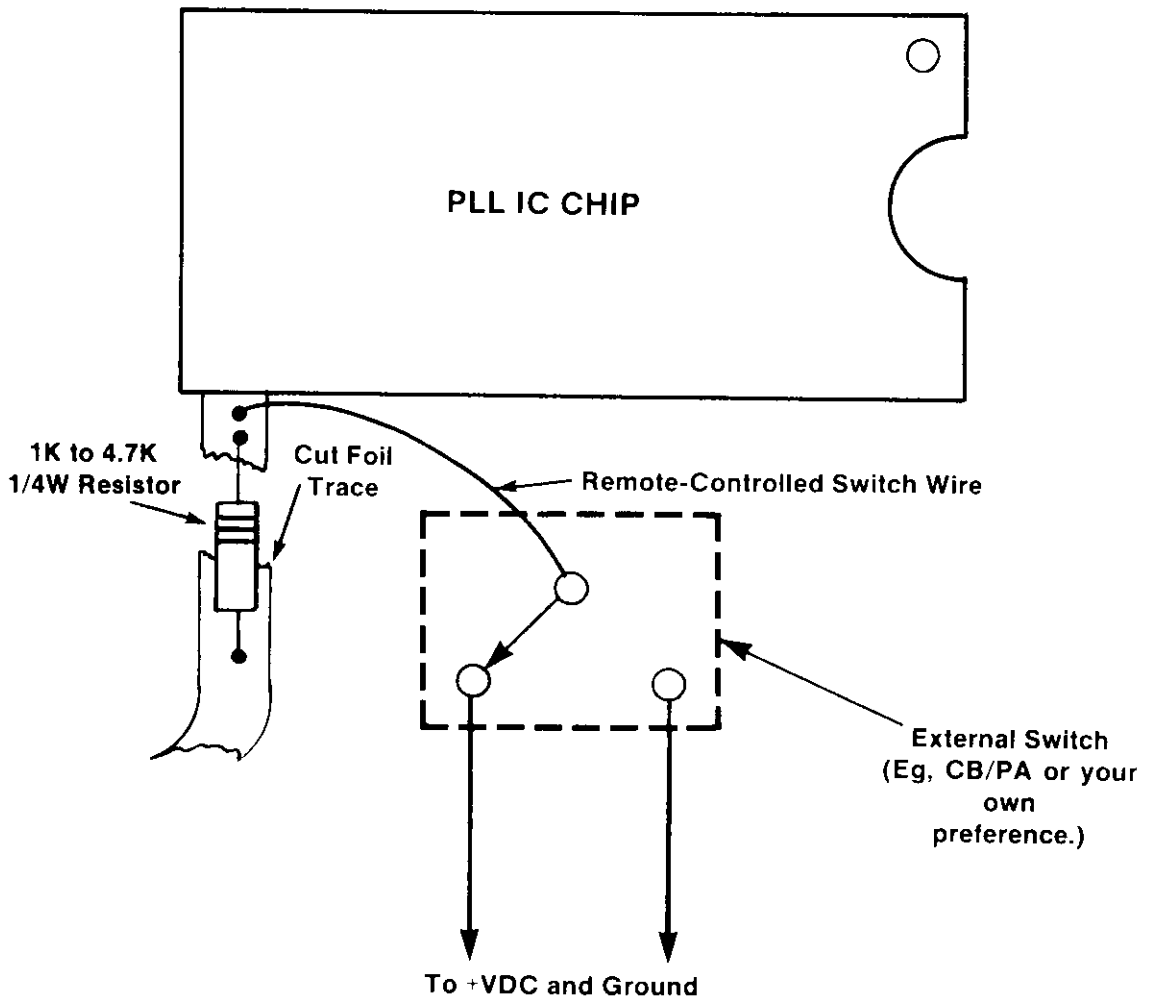
ROM PROGRAM CODE CONVERTERS

The reason the newest chips use BCD programming is purely a legal one: By using BCD combined with a sneaky additional circuit inside the chip called "ROM", any illegal frequency modifications by changing programming voltages are now impossible. The current FCC rules require that the PLL chip can only contain a total of 6 programming pins. So even by using the straight binary system, this alone limits possible channels to 2^6—1, or 63 total channels. (1 + 2 + 4 + 8 + 16 + 32 = 63.) By combining BCD and ROM, even this number is reduced to exactly 40, 22, or 18 as the case may be for various countries.

To date, the British government has given their "CB 27/81" approval stamp to a few rigs using the simple binary chips (Eg, DNT 2740 and M4OFM) but most legal U.K. rigs are using the LC7136/37 Cybernet chassis or the TC9119 Uniden chassis. In the U.S., the only rigs still being sold with modifiable PLLs are the SSB rigs using the PLL02A or MB8719 chips, because the manufacturers have never changed their particular model number from the time it was given the original FCC approval. If they ever changed their model numbers, they'd have to go through the entire re-approval process and end up with the newer PLL circuits. For this reason, rigs like the Cobra 148/2000GTL will probably be sold forever because as soon as a non-modifiable model appears, sales will drop drastically when the word gets out. It's no accident that some models are so popular! Be aware of this and if you're in the market for a good rig, see if the model is listed in Section III under the "good" PLL chips.

Since governments finally got wise to all the bootleg CB frequencies being used, ROM was the answer. A "ROM Code Converter" inside a PLL chip is the key to preventing modifications. The term "ROM" means "Read Only Memory" and is commonly used in digital computer systems. Inside the chip, safely out of reach by you, is a ROM Code

FIGURE 12. USING EXTERNAL PULL-UP OR PULL-DOWN RESISTOR TO CONTROL A CHIP'S PIN FUNCTION



Converter. The required N-Codes for only the legally-authorized number of channels were permanently written into the IC chip during manufacture.

The programming pins that connect the chip to the outside world at the Channel Selector switch are used only to command the ROM to release its stored N-Code information to the Programmable Divider circuit. In other words, there's now a "middleman" to interfere with your modification plans, and he's untouchable! The Channel Selector instructs the ROM, the ROM releases the correct N-Code, and the Programmable Divider then performs its usual division of the input signal. In addition, by using BCD it's a very simple matter to say to the chip (in BCD language), "Give me Channel 6". The BCD code adding up to the number "6" is then applied to the correct pins by the standard use of voltages and grounds. This code is among those the ROM will recognize, and the correct N-Code divisor is set up in the Programmable Divider. If you should try to force an illegal program code with other voltages and grounds, the chip either ignores you completely, kills the transmitter, or in some cases calls up Channel 9 or 19 instead. Also, the chip uses a T/R shift with *different* ROM N-Code sets for each mode to provide the 455 KHz IF offset for AM or FM dual-conversion use. A nasty trick!

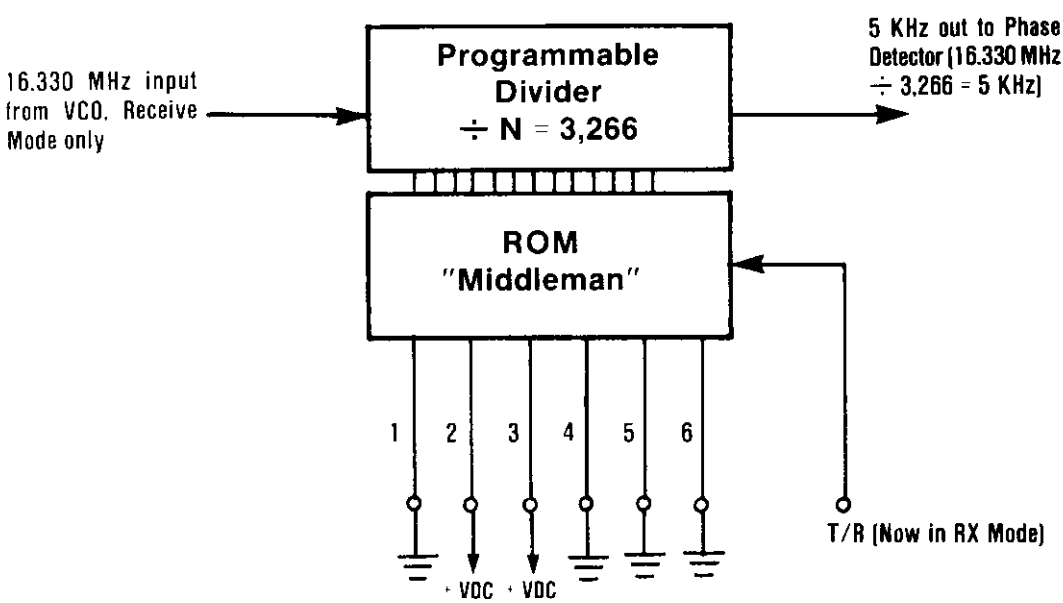
Chart 5 is a section of a ROM Truth Chart showing how this idea works. This is a typical example of a 6-bit BCD programming method. It's obvious however that every single channel is generated by calling out its number *directly* in BCD. This is received by the ROM, which then converts the program code to whatever the *real* N-Code happens to be.

Below Chart 5 is a drawing showing the equivalent circuit for Channel 6 in such a chip. This particular chip can directly divide a VCO signal in the 16 MHz range. I already know from the service manual that the input to the Programmable Divider from the VCO for Channel 6 (RX mode) is 16.330 MHz. The BCD equivalent of "6" is presented to the ROM input, which then converts it to the real N-Code. Since this chip uses 5 KHz steps from the Reference Divider and Programmable Divider, some simple math will tell you that the real N-Code for Channel 6 is 3,266. (16.330 MHz ÷ 3,266 = 5 KHz). You can't fill in the "A" channels, go below Channel 1 or above Channel 40, and even the FCC/EEC skips are already pre-programmed into the ROM. Examples of ROM chips are the LC7120, LC7130/31, LC7135, LC7136/37, PLL03A, PLL08A, TC9106, TC9109, TC9119, uPD2814, uPD2816, and uPD2824. (NOTE: A new U.S. chip has just appeared, the MB8733.)

CHART 5

Combining BCD with ROM for illegal channel prevention

	BCD POWERS		20	10	8	4	2	1
	BCD CODE		Pin 6	Pin 5	Pin 4	Pin 3	Pin 2	Pin 1
Ch. 6	0,6		0	0	0	1	1	0
Ch. 7	0,7		0	0	0	1	1	1
Ch. 7A		No N-code possible						
Ch. 8	0,8		0	0	1	0	0	0
⋮	⋮	⋮						
Ch. 23	2,3		1	0	0	0	1	1
Ch. 24	2,4		1	0	0	1	0	0
Ch. 25	2,5		1	0	0	1	0	1
Ch. 26	2,6		1	0	0	1	1	0



BCD Channel Code = "6" from above Chart

OTHER ROM VARIATIONS

There are several newer Toshiba chips (TC9106, TC9109, TC9119) that first appear to use very odd-looking program codes in their Truth Charts. You won't be able to figure out any kind of binary or BCD progression when studying the sequence of "1s" and "0s". That's because these chips contain *two* sets of ROM, and are designed to work with standard rotary or LED Channel Selector switches. The code you see in the Truth Chart actually does two different things:

1. Signals the second ROM set to release its stored N-Codes into the Programmable Divider. It does this only when a legal program code is presented to the first ROM set.

2. Applies the correct set of +DC voltages and grounds to light up all the proper segments of the 2-digit, 7-segment LED channel numbers. This is another bit of digital magic that we won't get into here!

These chips use 8 programming pins to control the LED channel display, where the BCD chips only need 6 pins. You can think of the first ROM set as nothing more than a converter which translates an 8-bit rotary switch code into a language that can be understood by the channel display *and* the second ROM set. Figure 13 shows the general idea. The chips by the way are nearly impossible to modify by any easy method.

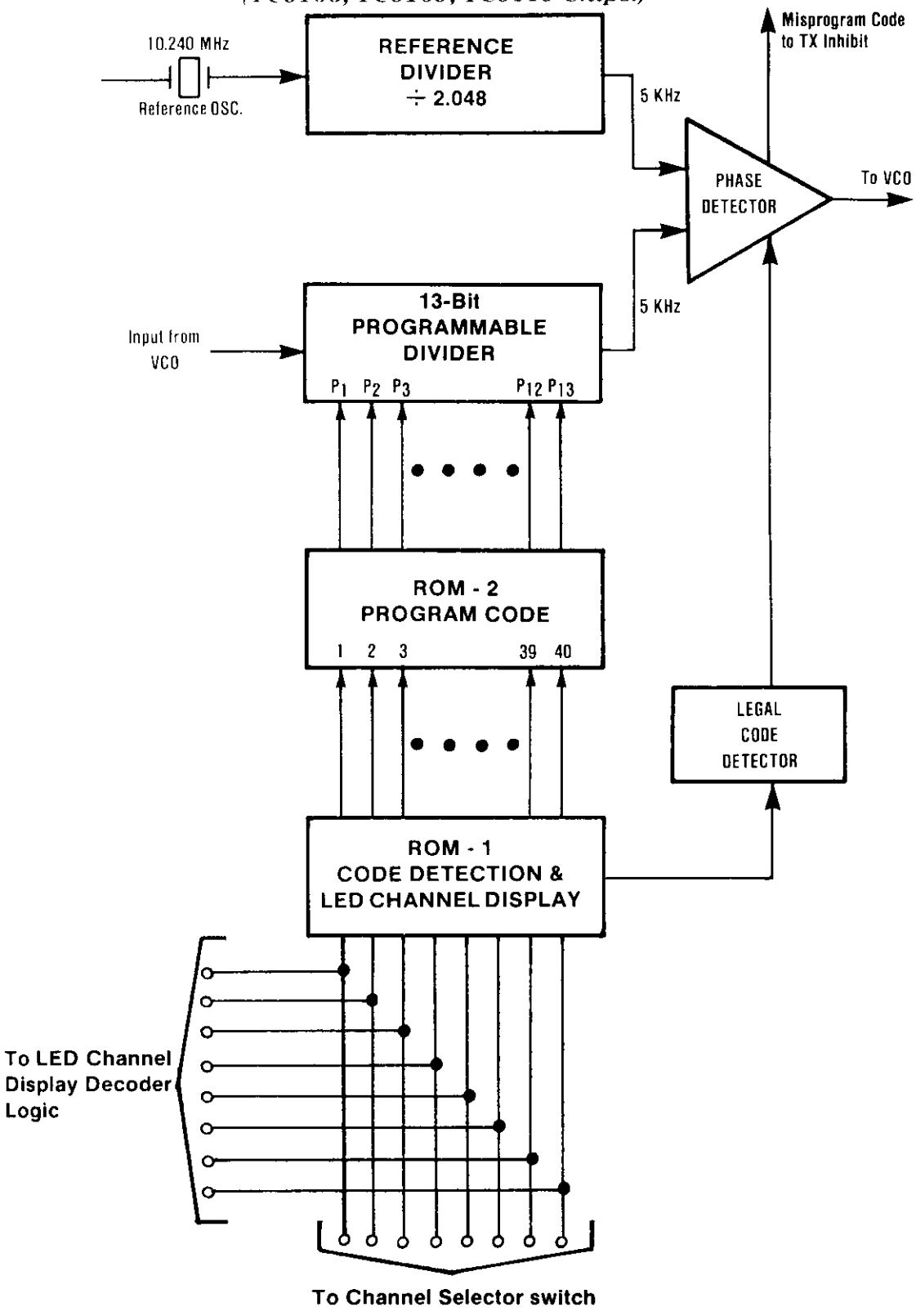
About the only good thing to be said in defense of all these newer ROM chips is that they've helped to keep radio prices affordable by greatly simplifying the PLL circuits. And they're more reliable because there are fewer parts to go bad. Compare all the block diagrams in Section III and you'll get some appreciation of just how far the PLL has evolved.

LOOP MIXER MODIFICATIONS

Now let's look at 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 that contains a downmix signal. A few chips such as the PLL02A, MB8719, and uPD858 can be modified by

FIGURE 13. HOW A DOUBLE-ROM IS USED FOR PROGRAM CODE DETECTION & LED DISPLAY

(TC9106, TC9109, TC9119 Chips.)



either the programming pin change or the downmix change methods. No wonder rigs using these chips are so popular even today!

Changing the mixer crystal is commonly done in CB-to-Ham 10 Meter conversions. Since the rig will never be used on the lower frequency CB band, it can be permanently retuned up in the higher Ham band. However most of you are probably expanding the CB band to add another 40 or 80 channels. The very popular European rigs from Ham International, Major, and Superstar are basically an American PLL chassis with the extra mixer crystals already installed.

Never forget there's always a trade-off for any modification involving a large desired bandwidth. You can't stray too far from the rig's design limits without retuning the entire radio. Modern solid-state rigs can generally cover about 120 to 180 channels without much work, and sometimes even more when certain broadbanding tricks are used by a qualified technician. One major problem that results from broadbanding is that receiver selectivity and "bleedover" rejection suffer. It's no accident that American CB rigs which are designed for only 40 channels have much better Adjacent-Channel Rejection specs than their European counterparts which allow 80 or 120 AM/FM channels. The difference is typically 60 dB for American vs. only 40 dB for European rigs; the American rigs thus have 100 times better rejection. (20 dB difference = power factor of 100.) The new line of high-frequency CHANNEL GUARD crystal filters available from CB CITY INTERNATIONAL can add razor-sharp selectivity and bleedover rejection for the popular 7.8 MHz, 10.695 MHz, and 11.275 MHz SSB rigs. Write for details.

CB-TO-HAM CONVERSION PROBLEMS

When permanently planning a CB-to-10 Meter change, the PLL's Lock Detector may need to be disabled before you can retune the rig. Substituting a new loop mixer crystal that throws the rig 2 MHz or more from its original design limits may place the VCO outside of its normal lock-up or capture range. You can easily defeat any Lock Detector by either cutting the foil trace to that PLL pin or lifting one end of the switching diode normally connected to it. Just unsolder one diode end from the PC board until the VCO is retuned to its new range; then put it back.

SAMPLE MODIFICATION

Once again I'm using the PLL02A chassis, this time the SSB version. Refer to its Block Diagram in Section III as we proceed.

The VCO for this chassis runs in the 17 MHz range, and is mixed with a 20 MHz signal to produce the downmix signal into the Programmable Divider. This downmix signal is 2.55 MHz on Channel 1, down to 2.11 MHz on Channel 40. The 20 MHz mixing signal can be generated in two different ways, and you'll find both methods used. Either a crystal in the 10 MHz range is doubled, or a crystal in the 20 MHz range is used directly. The American 40-channel version uses a 10.0525 MHz loop mixer crystal oscillator. You can add complete new 40-channel segments by switching in new crystals according to the formula:

$$\text{New Crystal} = 10.0525\ \text{MHz} \pm (N \times .1125),$$

where N is the number of 40-channel segments above or below the "legal" 40 channels where you want to begin.

As an example, using a crystal of 10.165 MHz (10.0525 MHz + .1125 MHz) will give you a 40-channel band segment starting at 27.415 MHz in the Channel 1 position. If you do this, you will still have the same skips in the "A" positions and Channel 23-25 positions. In some European versions of this chassis, a small PC board containing the 10 MHz or 20 MHz crystals is installed; a front panel switch is already there to choose among the Low, Medium, and High (L,M,H) bands. The same idea is used in the Superstar 360, which is a European version of the basic American MB8719 chassis. It contains an extra PC board with additional 11 Mhz tripler crystals that are switched in from the front panel.

In this type of modification, there will always be the exact same skips at the "A" positions and Channel 23-25 positions as there are for the normal 40 FCC channels. That's because the Truth Chart and programming N-Codes are still the same; they are already pre-determined by the Channel Selector switch. In other words, the N-Codes are identical. If N = 255 for Channel 1 with the 10.0525 MHz crystal, it will still be 255 with any other loop mixing crystal. The new loop crystal simply drives the VCO higher or lower as required to maintain the identical downmix input to the Programmable Divider.

CRYSTAL SWITCHING METHODS

Figure 14 shows three ways to switch in extra mixing crystals. For diode or transistor switching, the actual switch can be a little-used switch already on the rig, such as the CB/PA. Otherwise you can drill a small hole in the side or rear of the metal frame and install a miniature SPDT toggle switch. For the CD4066 IC switch, you can drill a frame hole for a miniature rotary switch. The important point is that the crystals and electronic parts themselves must be physically very close to the existing crystal; long wire leads are out! There's enough capacitance in 6" of switch wire to pull the oscillator off frequency or kill it completely. With the new crystal and its associated parts right by the original crystal, it's perfectly safe to use long wires to the switch itself. Any of these three switching circuits can be built on a small piece of perf board or PC board and mounted near the original oscillator circuit.

EXTERNAL CRYSTAL OSCILLATORS

As PLLs developed more on-chip functions, the process of loop mixing was simplified. Instead of needing a separate transistor oscillator, the chips began providing a suitable mixing signal directly off one of their pins. This signal is typically 5.12 MHz, which is half the Reference Oscillator frequency. (10.240 MHz ÷ 2 = 5.12 MHz.) Since the most common VCO frequencies are in the 16-17 MHz or 34-37 MHz ranges, it's an easy matter to multiply the 5.12 MHz signal up by the proper amount to mix with the VCO and produce a downmix signal into the Programmable Divider.

The most common circuit uses a 16 MHz VCO and triples the 5.12 MHz up to 15.360 MHz. (5.12 MHz x 3 = 15.360 MHz.) This is usually done by passing the 5.12 MHz chip output through a tuned coil and then mixing it with the VCO. In addition most chips having this feature also have the T/R shift feature needed to produce the 455 KHz IF difference for the receiver. To make matters even worse, they also use ROM! Examples are the LC7120, TC9102, uPD2814, and uPD2816.

Since the 15.360 MHz signal never changes between Transmit and Receive modes, all you need is to replace this signal with a slightly different one to get a new 40-channel band segment, To do this, you must build a very simple crystal oscillator circuit with the proper new crystal. Figure 15 shows the general idea for both the AM/SSB rigs

FIGURE 14. CRYSTAL SWITCHING METHODS

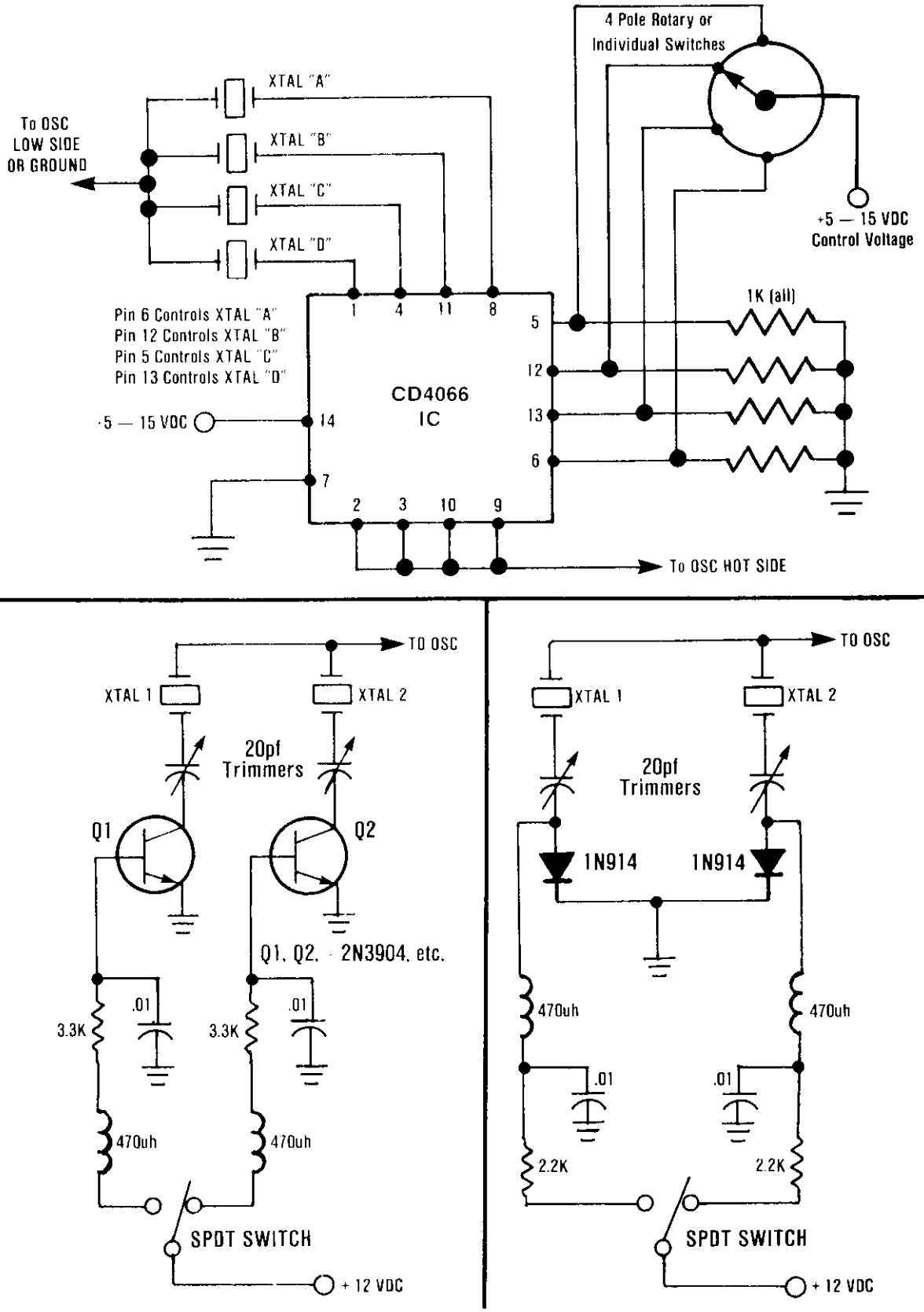
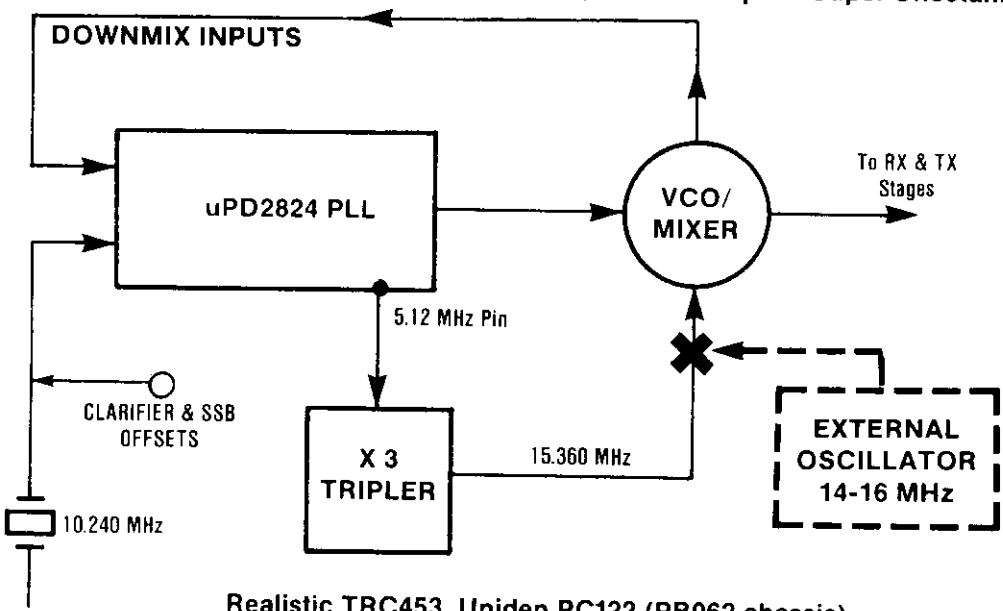


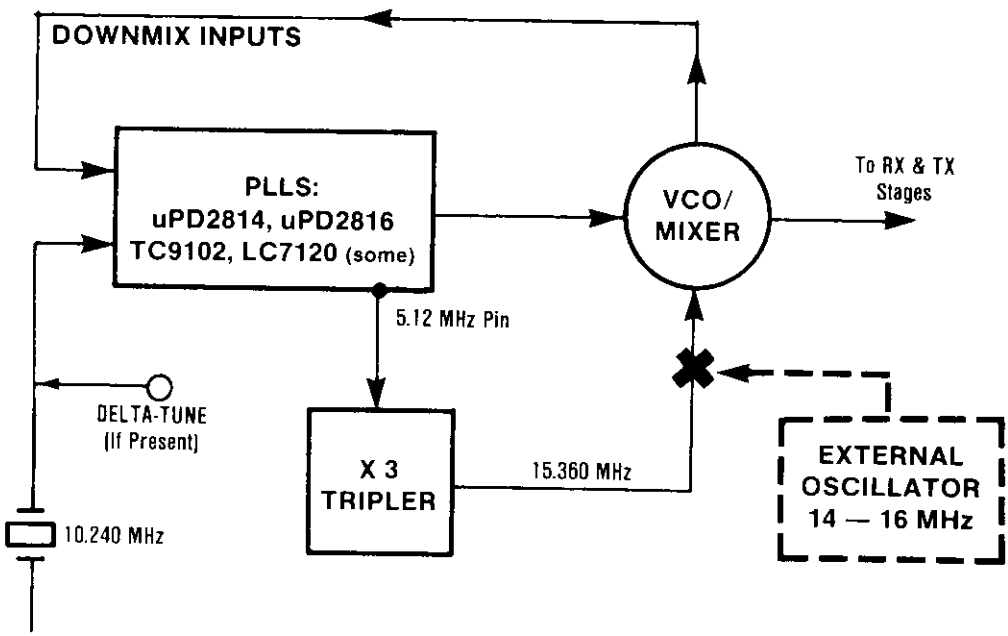
FIGURE 15. ADDING EXTERNAL LOOP OSCILLATOR SIGNAL

SSB: Cobra 146GTL, Midland 6001 (new), 7001 (new), President AR-144, AX-144, Realistic TRC451, Sears 663.3810, Uniden PC244, Pearce-Simpson Super Cheetah.



Realistic TRC453, Uniden PC122 (PB062 chassis). Uniden PRO-640E (PB105 chassis).

AM: See list under each PLL in Section III



Points marked "X" are usually a small disc capacitor. You can lift one end from PC board and switch between standard and modified 40-channel sets.

with the uPD2824 chip and the uPD2816 chip used in the more common AM or AM/FM rigs. Inject the new signal at the points marked "X". NOTE: You can't use a crystal oscillator exactly as shown for the SSB circuits, because both the Clarifier and the mode offsets are generated from the 10.240 MHz crystal. These would be disconnected and would no longer work. Our **EXPANDER 160** includes special jumpers which allow the correct modification in these chassis types.

The new signal will be in the 14-16 MHz range. To calculate the new crystal, the formula is

$$\text{New Crystal} = 15.360\ \text{MHz} \pm (N \times .450),$$

where N is once again the number of 40-channel band segments above or below the "legal" 40 channels. (The standard CB band is 450 KHz wide.)

For example, a new crystal of 15.810 MHz (15.360 MHz + .450 MHz) will give you a higher 40-channel band starting at 27.415 MHz in the Channel 1 position. This is exactly how it's done in the European versions of the common American LC7120 PLL chassis sold by Midland, Colt, Commtron, and others. Again, there will be the usual skips because the Channel Selector was designed that way, and these chips also use ROM.

For 10-Meter Novice ham conversions, a new crystal might be 16.455 MHz, which gives you 28.060 MHz (Ch.1) to 28.500 MHz (Ch.40).

Now you're probably wondering, "Well great, but where do I get a new signal to replace the 15.360 MHz that comes from the PLL?" The answer of course is that you must build one, but it's very easy. Figure 16 shows a proven crystal oscillator circuit that you can build on a small piece of perf board or PC board and place close to the original injection point. You can even combine this oscillator with one of the crystal switching methods shown earlier on the same piece of board. This could then be remotely switched from the front panel again, giving you 80 or 120 channels total. (For the lazy, you can order our **EXPANDER 160** which is a combination oscillator & switch, or our **EXPANDER 240** which is just a 6-position crystal switch. Write for details.

CRYSTAL SOURCES

For those of you having trouble locating a special-cut crystal, the following companies are very good if you have no other local source:

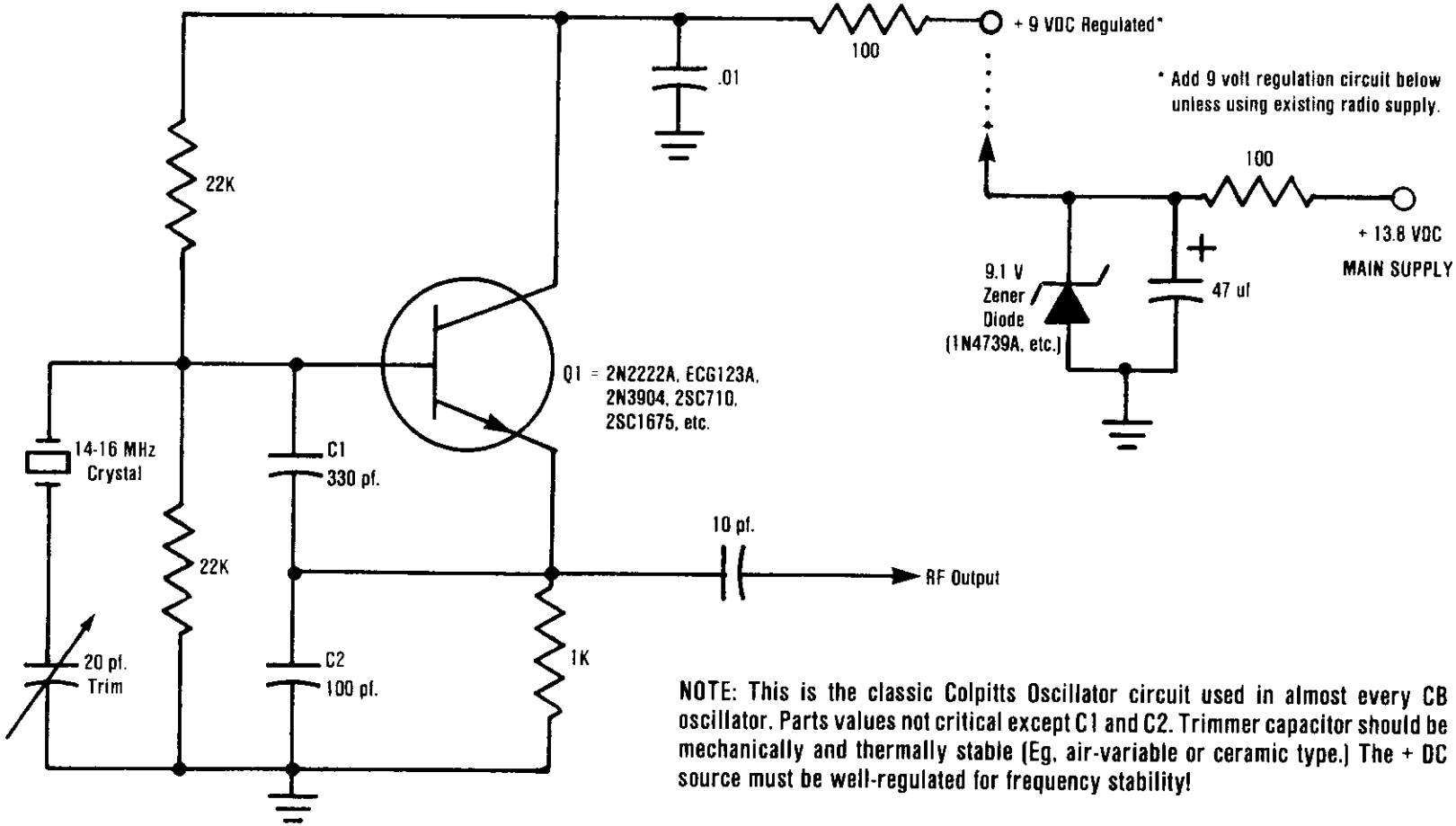
CRYSTEK Corp.
P.O. Box 06135
Ft. Myers, FL 33906 U.S.A.
(800) 237-3061

OR

JAN Crystals
P.O. Box 06017
Ft. Myers FL 33906 U.S.A.
(800) 237-3063

I've dealt with both these companies and they're both good. The cost is about $6 these days plus shipping. Be very specific when ordering. You

FIGURE 16. AN ACTUAL CRYSTAL OSCILLATOR YOU CAN BUILD FOR NEW LOOP MIXING SIGNAL



NOTE: This is the classic Colpitts Oscillator circuit used in almost every CB oscillator. Parts values not critical except C1 and C2. Trimmer capacitor should be mechanically and thermally stable (Eg, air-variable or ceramic type.) The + DC source must be well-regulated for frequency stability!

must state the exact frequency desired, holder type, accuracy, and load capacitance. Holder types are normally HC18/U for solder leads and HC25/U for plug-ins. Accuracy should be at least .005% or better. Load capacitance is typically 32 pF which is fine for AM-only rigs; however for SSB rigs you should get the 20 pF crystals because they require less external capacitance to trim and when part of the Clarifier circuit they will slide much further.

THE REFERENCE OSCILLATOR CRYSTAL

So much for the modifiable ROM chips. It's important to emphasize now that you can *never* modify any AM/FM PLL circuit using the single 10.240 MHz design by changing this crystal. Many people wrongly believe it can be done, but it can't. Too many internal chip functions depend upon this exact frequency. For example, the 455 KHz T/R shift is the direct result of digitally dividing down this signal. If the signal were changed by changing the crystal, the T/R shift would change because the output from the Reference Divider would also change. This of course would change the VCO and mixer frequencies, there would be no 455 KHz receiver IF injection and therefore no operating receiver. The guys who designed these things are way ahead of you! (This does not apply to the LC7131 SSB chassis on Page 71.)

THE IMPOSSIBLE CHIPS

As if to pour salt into your wounds, governments and engineers have now created a generation of PLL ICs that are almost totally foolproof. In addition to using a single 10.240 MHz crystal, T/R shift, and ROM, there is no loop mixing either. The Programmable Dividers are now so fast that they can *directly* divide down a VCO frequency as high as 20 MHz. Since there's nothing to be mixed, you can't change the ingredients! These chips use a VCO running in the 16-17 MHz range and include:

LC7130, LC7131, MB8733, TC9106, TC9109 (40-channel U.S.)
LC7135 (22-channel EEC)
LC7136, LC7137, TC9119 (40-channel U.K.)
LC7132 (40-channel U.S. and U.K.)
SM5123A, SM5124A (40-channel U.S.)
C5121 (40-channel U.S.)

The best way around this problem, if you can't get one of the older rigs, is to buy a rig having SSB in addition to AM or AM/FM. The SSB circuits either use a loop mixer or don't use the T/R shift, at least not yet. They're a bit more expensive but that's part of the price you must pay if you ever expect to go "upstairs".

Another possible solution is to use an EPROM modification board. These allow you to customize the channel programming to your needs, and will work in many of the newer ROM PLL circuits. You can program out the skips, include 5 KHz spacing, or even program in a 100 KHz T/R shift for 10-Meter repeater use. Our new publication, **THE CB EPROM DATA BOOK** by Martin T. Pickering, explains not only how to make these boards, but also includes schematics and PC artwork for the most popular SSB chassis types. Highly recommended! Furthermore we'll be offering these conversion boards soon. You can get full details by writing to us and enclosing a stamped SAE:

CB CITY INTERNATIONAL
P.O. Box 31500
Phoenix, Arizona 85046 U.S.A.

THE BASIC MODIFICATION RULE IS:
The simpler the PLL circuit appears to be, the harder it will be to modify. There are fewer and fewer places where you can jump in with your own program codes or loop mixing signals.

Good luck and Happy DXing!

SECTION III

PLL CHIP SPECIFICATIONS

This section contains specific information for almost every PLL chip ever used in CB radios. A few very old devices were omitted; your chances of ever seeing them are nil. However I have included some other obsolete chips because there are still radios out there using them that may need repair or modification if encountered. It will become obvious by the amount of space devoted to each chip which ones have survived with the greatest popularity.

First we'll illustrate the actual internal workings of the IC chip itself. All the various sub-circuits of modern PLLs are shown in block diagram form, followed by a detailed definition of pin function terminology. Any time you're referring to a specific chip, you'll understand at a glance which pin is which. And if you should happen to get the actual data sheets from the manufacturer, you'll be equipped to figure out his particular terminology and circuitry.

There are special pages showing the internal ÷ N numbers for the most common ROM chips. I've included this to help you better understand how the newer "state-of-the-art" devices function in the overall PLL circuit. For example, knowing the N-Code for a specific channel and mode, and the divisor of the Reference Divider, you can calculate the VCO frequencies for that channel. This may be very useful for repair work because few manufacturers these days bother to provide anything but the most crude, unreadable schematic diagrams!

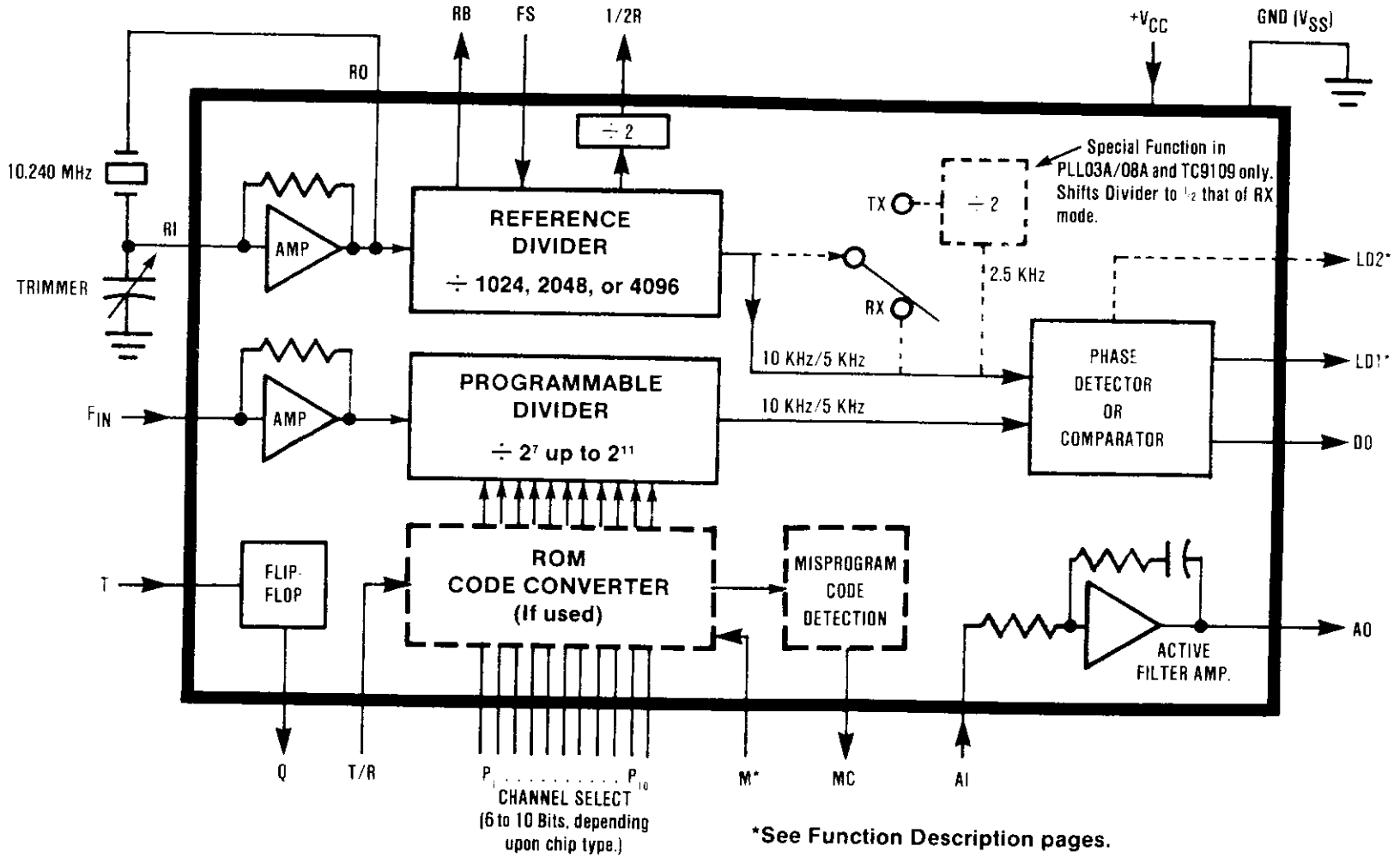
Chassis block diagrams for the most numerous and popular PLL circuits are shown next, in alphabetical order by chip manufacturers' letter prefix. Signal mixing and flow direction, programming, and VCO/IF frequencies are included, as well as general SSB offsets, Clarifiers, and FM connection points. These serve to teach you in the most direct way how to isolate a problem or modification area of the PLL circuit. Remember that these diagrams are purposely very oversimplified; I've assumed you read the text of Sections I & II first! When used along with a service manual, schematic, or SAMS Fotofacts, any of these circuits can be understood.

Finally, each specific chip is described in great detail, again in alphabetical order by letter prefix. Often the device is made by several manufacturers, which may be a great help in finding a replacement for repair. Most pin functions were determined either from manufacturers' spec sheets or a careful study and cross-reference of known chassis. (I have thousands of rig diagrams in my files!)

In a few cases of very old chips, no data sheets were ever available, so pin functions were determined by studying the schematics. Therefore a few functions may not be defined exactly but all the most popular, current PLL chips are well-documented. Also included is a list of every rig model known to use the chip at press time. In some cases they are further identified by reference to one of the block mixing diagrams. If your rig isn't listed, chances are that it's identical to one that is; there are hardly any new chassis being produced these days, even in the U.K. The only differences are the "manufacturer's" model number and some cosmetic changes in the cabinet. For the better-known Uniden and Cybernet chassis, actual PC board numbers are included when known. PC board numbers may vary slightly from those shown since there are minor changes in production runs.

INSIDE THE MYSTERIOUS PLL CHIP

On the following pages the exact pin functions of each major PLL IC chip will be discussed. To simplify your understanding, this sketch represents all the possible functions that a chip might have; you'll never find all these in one chip! Refer to the Pin Function descriptions on the next two pages for definitions of terms.



*See Function Description pages.

EXPLANATION OF PIN FUNCTION TERMS

V_{CC} or V_{DD} This is the +DC supply voltage which actually provides the operating power to the chip, and is generally in the range of 4-8 volts.

GND or V_{SS} This is the DC power ground connection for the above.
NOTE: A chip may be found to have one or more of its functional pins tied to either of the above sources. This may be done to enable a specific function by connecting that function to a "1" or "0", or to prevent an unused function pin from "floating" unconnected to prevent a possible change in its logic state.

RI Reference Oscillator input. This is where the (usually) 10.240 MHz crystal is connected. Crystal pins sometimes called "X" by the manufacturer.

RO Reference Oscillator output. In most chips the crystal is simply connected across RI and RO because the chip has a built-in oscillator circuit which only requires some external capacitors. However some chips such as the PLL02A don't have the built-in oscillator; thus there is no RO pin and an active transistor oscillator is required externally which connects to RI.

1/2R A built-in $\div$ 2 circuit which provides an output of half the 10.240 MHz Reference Oscillator frequency, or 5.12 MHz. If used, it normally connects to a tripler circuit to provide a 15.360 MHz signal (5.12 MHz x 3) which can be used for loop mixing with the 16 MHz VCO. This mixing provides a low-frequency signal input or downmix to the Programmable Divider.

RB Buffered output of the 10.240 MHz Reference Oscillator. This signal if present can be used for mixing with the 10.695 MHz receiver first IF or mixing with the 16 MHz VCO during TX mode to provide the 455 KHz second IF (RX) or the direct on-channel TX frequency.

F_{IN} Input to the Programmable Divider which is coming from the output of the VCO. Sometimes called "PI" (Programmable Input) or "DI" (Divider Input) by some manufacturers. This is the actual downmix signal or direct VCO signal in the faster chips which will be compared to the Reference Divider's output in the Phase Detector. It is the change in this signal's frequency which forces the Phase Detector and VCO to correct until the loop locks.

DO Phase Detector output. Sometimes called "PO" or "PD_{OUT}" (Phase Output) or "EO" (Error Output) by some manufacturers. This is the output which results from comparing RI and F_{IN}. If the two inputs don't match exactly, this circuit sends a DC correction output to the Loop Filter/VCO until the loop corrects itself and locks up.

LD Lock Detector. Sometimes called "LM" (Lock Monitor) by some manufacturers. This is a second output of the Phase Detector which is used to kill the transmitter (and sometimes the receiver) if the loop is not locked and operating correctly. Some chips have more than one Lock Detector pin and thus you'll sometimes see "LD1" and "LD2" on the specs. When two Lock Detectors are used, their normal outputs are usually opposite logic states; i.e., one LD is normally "1" and the other is normally "0". This is a convenient design feature which allows the manufacturer some flexibility because he can have a choice of inhibiting circuits; some work with LOW outputs, some work with HIGH outputs. Some rigs use both LD pins in their circuits.

MC Misprogram Code Detector. The same idea as the Lock Detector, this is found in the newer ROM chips. If you try to force an illegal program code on the chip, this pin is activated and will kill the transmitter, receiver, or in some cases, call up Ch.9 or Ch.19 instead.

T/R Transmit/Receive switch. As explained in Section I, this is used to provide the 455 KHz offset for the receiver's second IF stage in dual-conversion AM or FM rigs. Pressing the mike button changes this pin's logic state to its opposite state from the RX Mode. This shifts the ROM controlling the Programmable Divider, and in some chips also shifts

the output of the Reference Divider from standard 5 KHz steps to 2.5 KHz steps. The T/R shift is the reason you'll see two different sets of N-Codes and VCO frequencies in a rig's service manual or SAMS Fotofacts.

NOTE: Some manufacturers' chip spec sheets show a bar ($\overline{\ }$) above some pin functions, such as LM, T/R, etc. This bar is a digital logic symbol which indicates what state ("1" or "0") that pin is in when activated. For example, the $\overline{T/R}$ with the bar notation means that the pin is normally HIGH ("1") in the Receive Mode and normally LOW ("0") in the Transmit Mode. $\overline{LM}$ means the Lock Monitor is "active LOW"; i.e., it is normally HIGH but goes LOW if the loop is unlocked.

FS — Frequency Select. This is a feature of some chips which allows them to synthesize frequencies in either 10 KHz CB steps, or 5 KHz steps. Remember, some older chips such as the PLL02A were intended for other uses besides CB, such as VHF marine radios, aircraft radios, etc., where 5 KHz channel spacing is common. In addition, this feature often makes it easier to synthesize SSB frequencies as well as AM/FM although the feature hasn't been used much for this. Depending upon whether the chip has an internal pull-up or pull-down resistor here, it is generally connected to produce 10 KHz CB spacings in the older chips. The newer chips having a T/R shift must use the 5 KHz spacing when the T/R pin is also used. IMPORTANT: You can't use this function to get 5 KHz channel spacings, because the Programmable divider must also change to match the spacing.

AI,AO — Active Loop Filter Amplifier input and output. This circuit if present is used to smooth out the digital waveform coming from the Phase Detector, before it's applied to the VCO. (See text.) This filter is found in the newer CB-only chips. The older chips (Eg, PLL02A) require external passive filters using capacitors and resistors. In many rigs you'll find that these pins are connected either directly or through a resistor so that they are placed in series between the Phase Detector output pin and the VCO input.

FIL — Active filter. We're using this designation in certain very old chips when the exact spec sheets are not available but it's known from studying the chip's wiring in the rig that the pins are in fact part of a loop filter.

T & Q — This is a wave-shaping circuit found in a few NEC chips (uPD2810, uPD2814, uPD2816, and uPD2824). It adds design flexibility but is often not even connected. This circuit consists of an input amplifier and a "flip-flop", and its purpose is to change a sine-wave input (T) to a square-wave output (Q) which is more compatible with digital electronic circuits.

P_0...P_{10} — Program Select pins from Channel Selector switch. (Sometimes called "D" for "Data" rather than "P" for "Program".) These pins control the actual channel selection, as explained in Section II. They may control selection through straight binary coding, BCD, or ROM. The sub-numbers indicate the weight or significance of each pin. For example if there were 8 programming pins, P_1 to P_8, P_1 would be in the "least significant bit" and P_8 would be the "most significant bit". The higher the sub-number, the greater the weight of that pin.

NC — No Connection. An unused pin. May actually be disconnected inside the chip, or simply not used for that particular rig's PLL circuit.

* — Special remarks when necessary.

THE INTERNAL ÷ N-CODES OF THE NEWER ROM CHIPS

Shown here are partial charts for the latest ROM PLL chips which will give you an idea of what is actually going on inside the Reference and Programmable Dividers. It won't help you a bit as far as modifications, but it will help your overall understanding of the chips and their functions within the rig. Refer also to the chassis mixing diagrams for these chips shown later in this section.

LC7130/31, TC9106 (U.S.)
LC7135 (EEC)

	RX	TX
Ch. 1	3254	3345
Ch. 2	3256	3347
.	.	.
.	.	.
.	.	.
Ch. 22	3306	3397
.	.	.
.	.	.
.	.	.
Ch. 40	3342	3433

NOTES:
1. 91-count upshift on TX provides 455 KHz offset for receiver IF mixing.
2. Reference & Programmable Dividers use 5 KHz steps.

Example of VCO Determination, Ch. 1:
3,254 x 5 KHz = 16.270 MHz (RX Mode)
3,345 x 5 KHz = 16.725 MHz (TX Mode)

TC9109 (U.S.)
Uniden Chassis

	RX	TX
Ch. 1	3254	5393
Ch. 2	3256	5395
.	.	.
.	.	.
.	.	.
Ch. 40	3342	5481

NOTES:
1. Special ÷ 2 circuit in TX mode changes Reference Divider output to 2.5 KHz steps. The 2,139 count upshift produces a a 13 MHz VCO which is then doubled for the direct on-channel TX frequency.

Example of VCO Determination, Ch. 1:
3,254 x 5 KHz = 16.270 MHz (RX Mode)
5,393 x 2.5 KHz = 13.4825 MHz (TX Mode)
(13.4825 MHz x 2 = 26.965 MHz.)

LC7136, LC7137 (U.K.)
Cybernet Chassis

	RX	TX
Ch. 1	3381	2760
Ch. 2	3383	2761
.	.	.
.	.	.
.	.	.
Ch. 40	3459	2799

NOTES:
1. Reference & Programmable Dividers use 5 KHz steps.
2. TX VCO frequency is doubled to provide direct on-channel frequency.

Example of VCO Determination, Ch. 1:
3,381 x 5 KHz = 16.905 MHz (RX Mode)
2,760 x 5 KHz = 13.800 MHz (TX Mode)
(13.800 MHz x 2 = 27.600 MHz + 1.25 KHz tuned offset = 27.60125 MHz.)

TC9119 (U.K.)
Uniden Chassis

	RX	TX
Ch. 1	3381	3472
Ch. 2	3383	3474
.	.	.
.	.	.
.	.	.
Ch. 40	3459	3550

NOTES:
1. Identical operating principal to U.S. TC9106 and LC7130/31. Only difference is the N-Codes themselves.
2. Reference & Programmable Dividers use 5 KHz steps.
3. 91-count upshift on TX provides 455 KHz offset for receiver IF mixing.

Example of VCO Determination, Ch. 1:
3,381 x 5 KHz = 16.905 MHz (RX Mode)
3,472 x 5 KHz = 17.360 MHz (TX Mode)
+ 1.25 KHz tuned offsets

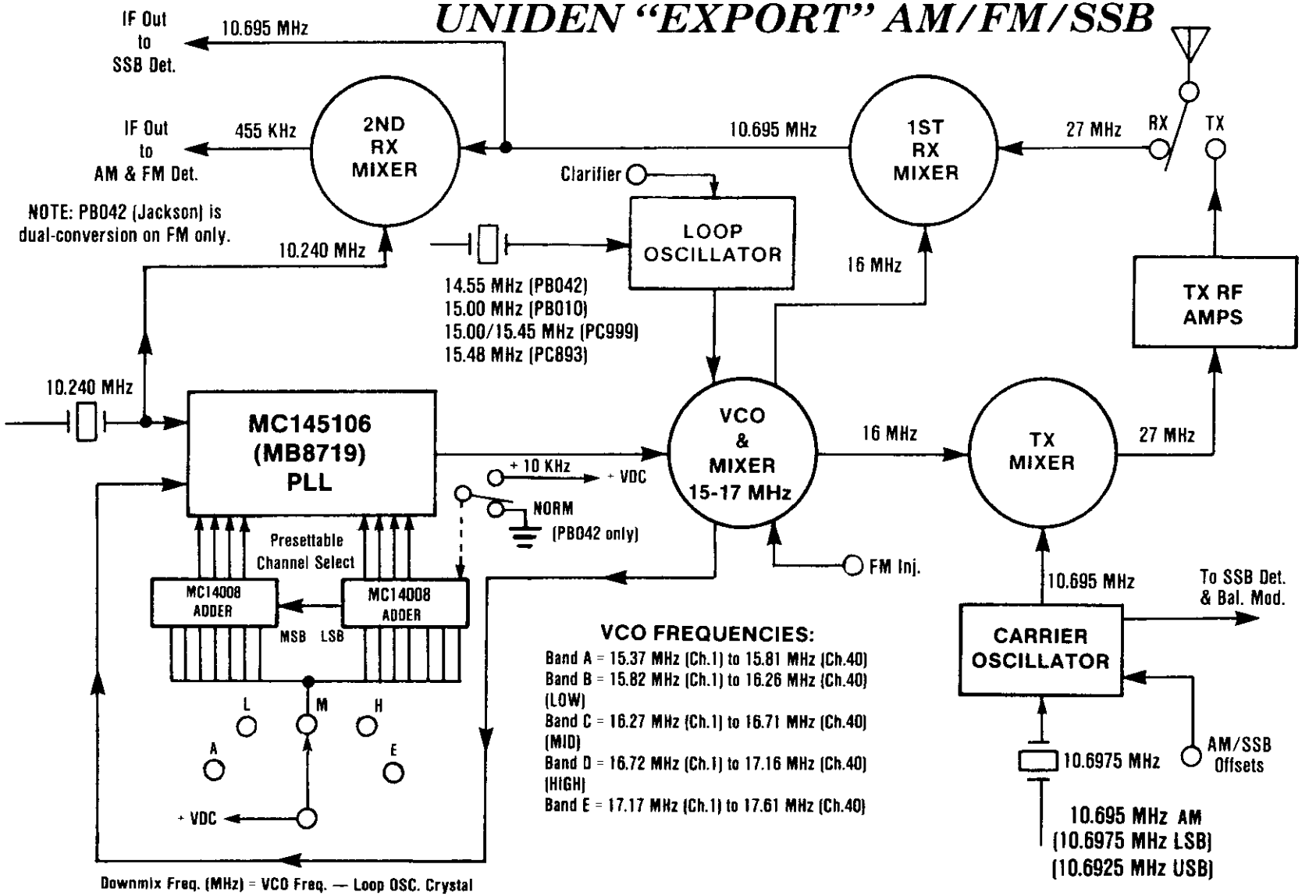
PLL03A (U.S. - AM)
PLL08A (EEC - FM)

	RX	TX
Ch. 1	1206	1297
Ch. 2	1208	1299
.	.	.
.	.	.
.	.	.
Ch. 22	1258	1349
.	.	.
.	.	.
Ch. 40	1294	1385

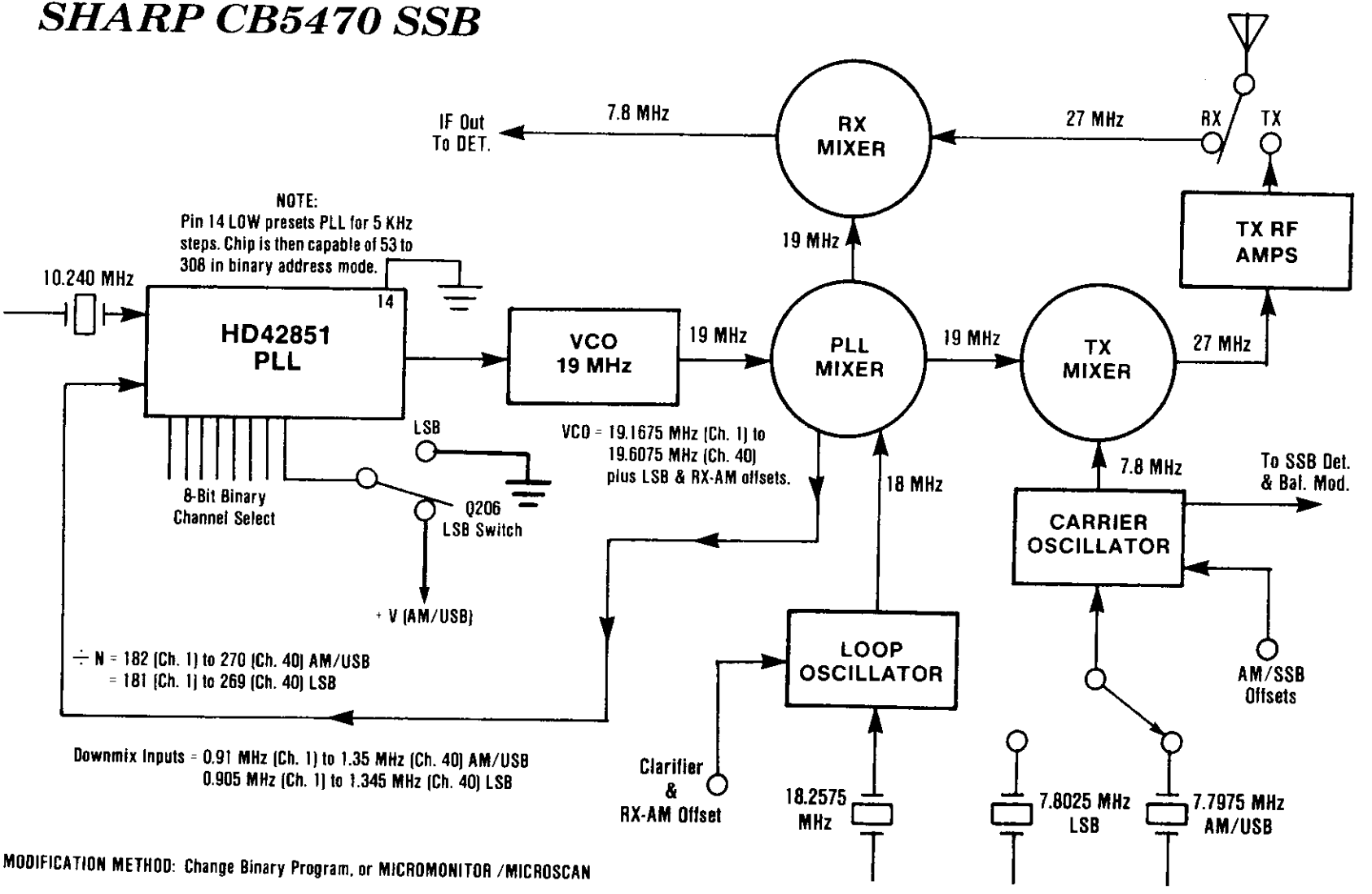
NOTES:
1. Special ÷ 2 circuit in TX mode changes Reference Divider output to 2.5 KHz steps.
2. 91-count upshift on TX provides 455 KHz offset for receiver IF mixing when VCO frequency is doubled.
3. Since chips cannot divide VCO directly, they are down-mixed with the 10.240 MHz Reference Oscillator signal, producing 6 MHz outputs (RX Mode) and 3 MHz outputs (TX Mode) into dividers. Standard 16 MHz VCO is used.
4. PLL08A contains only the first 22 FCC channels for EEC use; otherwise both chips are identical.

Example of VCO Determination, Ch. 1:
1,206 x 5 KHz + 10.240 MHz = 16.270 MHz (RX Mode)
1,297 x 2.5 KHz + 10.240 MHz = 13.4825 MHz (TX Mode)
(13.4825 MHz x 2 = 26.965 MHz. Thus VCO is doubled in exactly the same way as the TC9109 or LC7136/37 to produce the direct on-channel TX frequency.)

UNIDEN "EXPORT" AM/FM/SSB



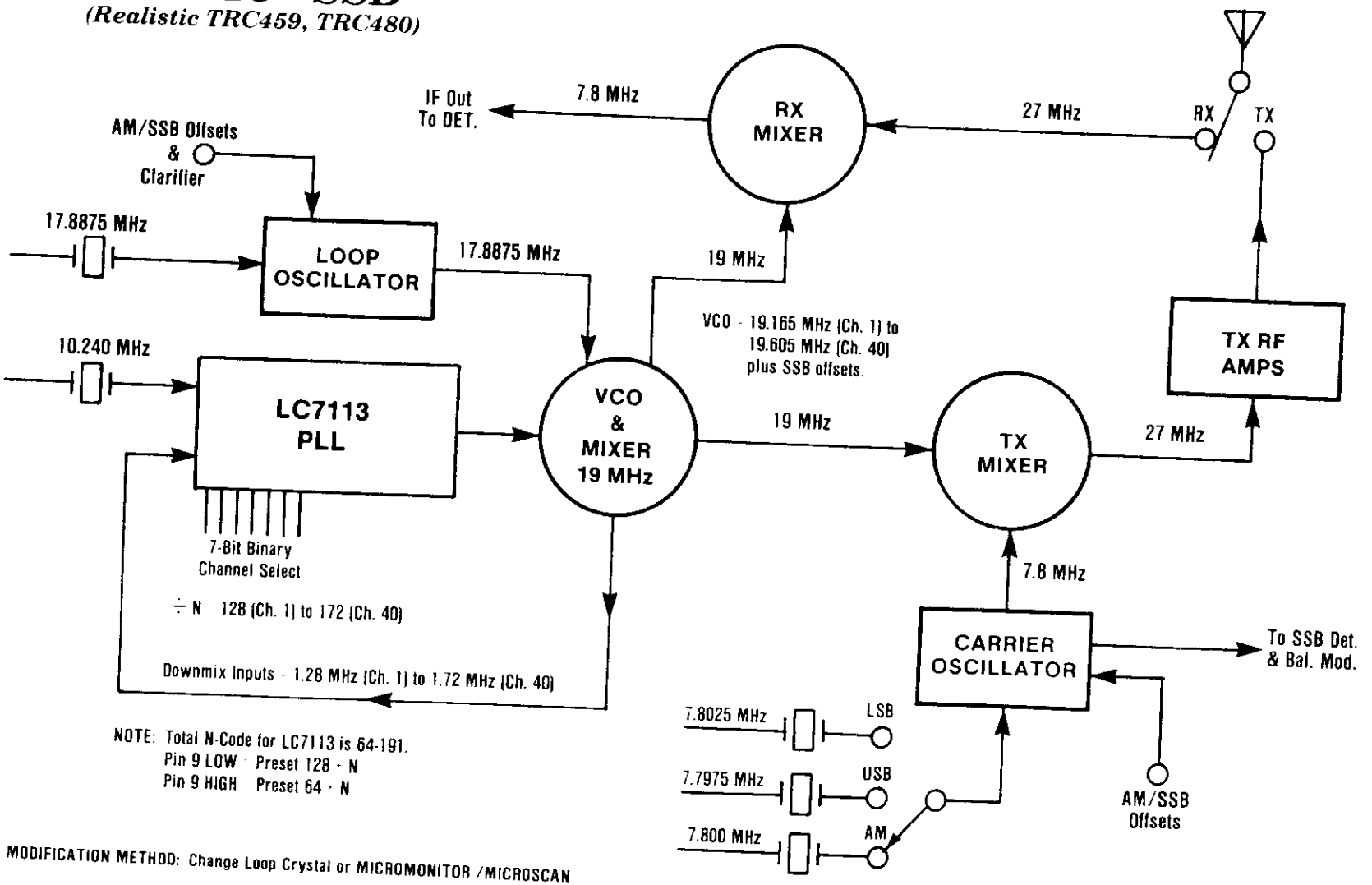
SHARP CB5470 SSB



MODIFICATION METHOD: Change Binary Program, or MICROMONITOR /MICROSCAN

LC7113 - SSB

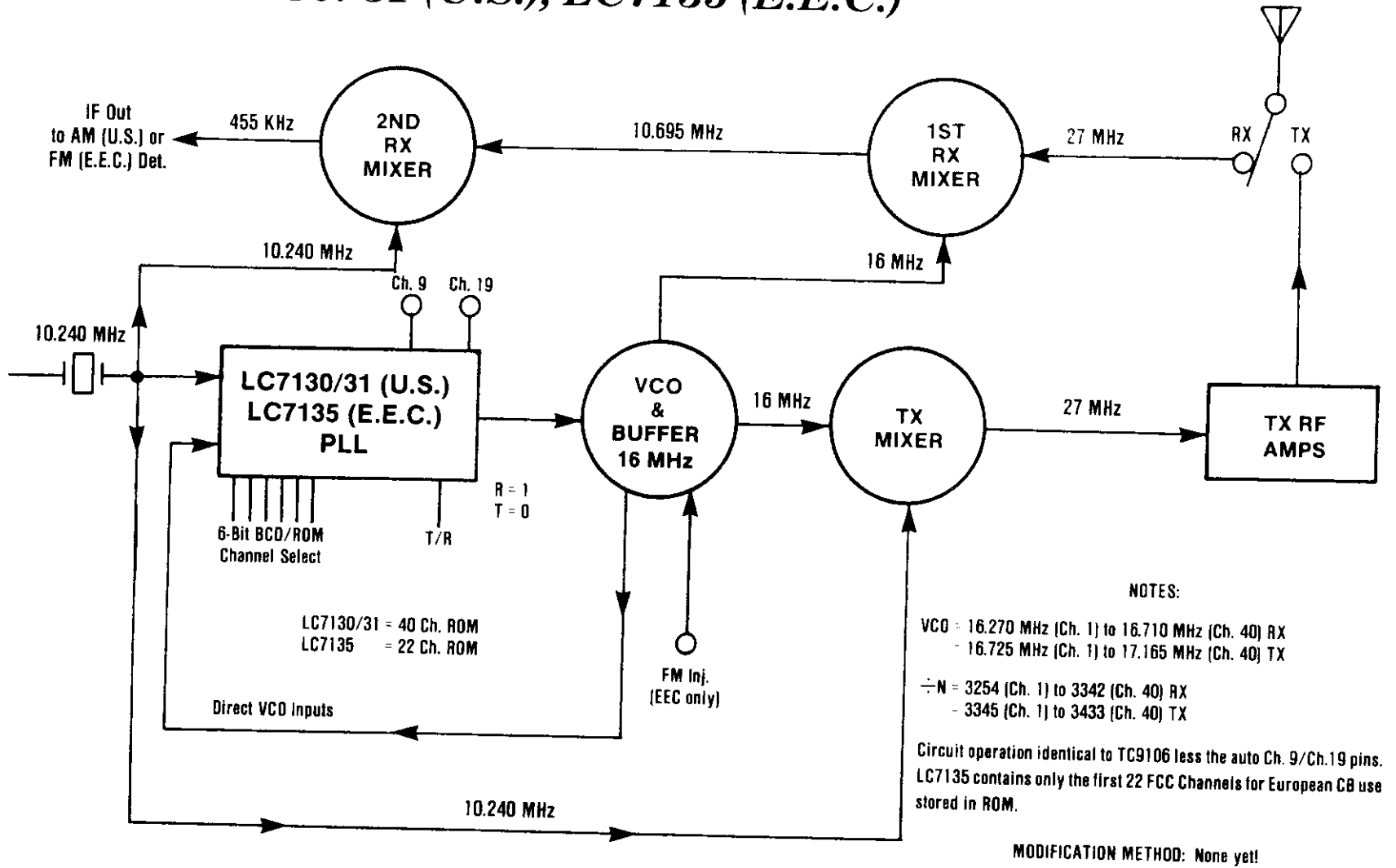
(Realistic TRC459, TRC480)



NOTE: Total N-Code for LC7113 is 64-191.
Pin 9 LOW Preset 128 - N
Pin 9 HIGH Preset 64 - N

MODIFICATION METHOD: Change Loop Crystal or MICROMONITOR /MICROSCAN

LC7130/31 (U.S.), LC7135 (E.E.C.)



NOTES:

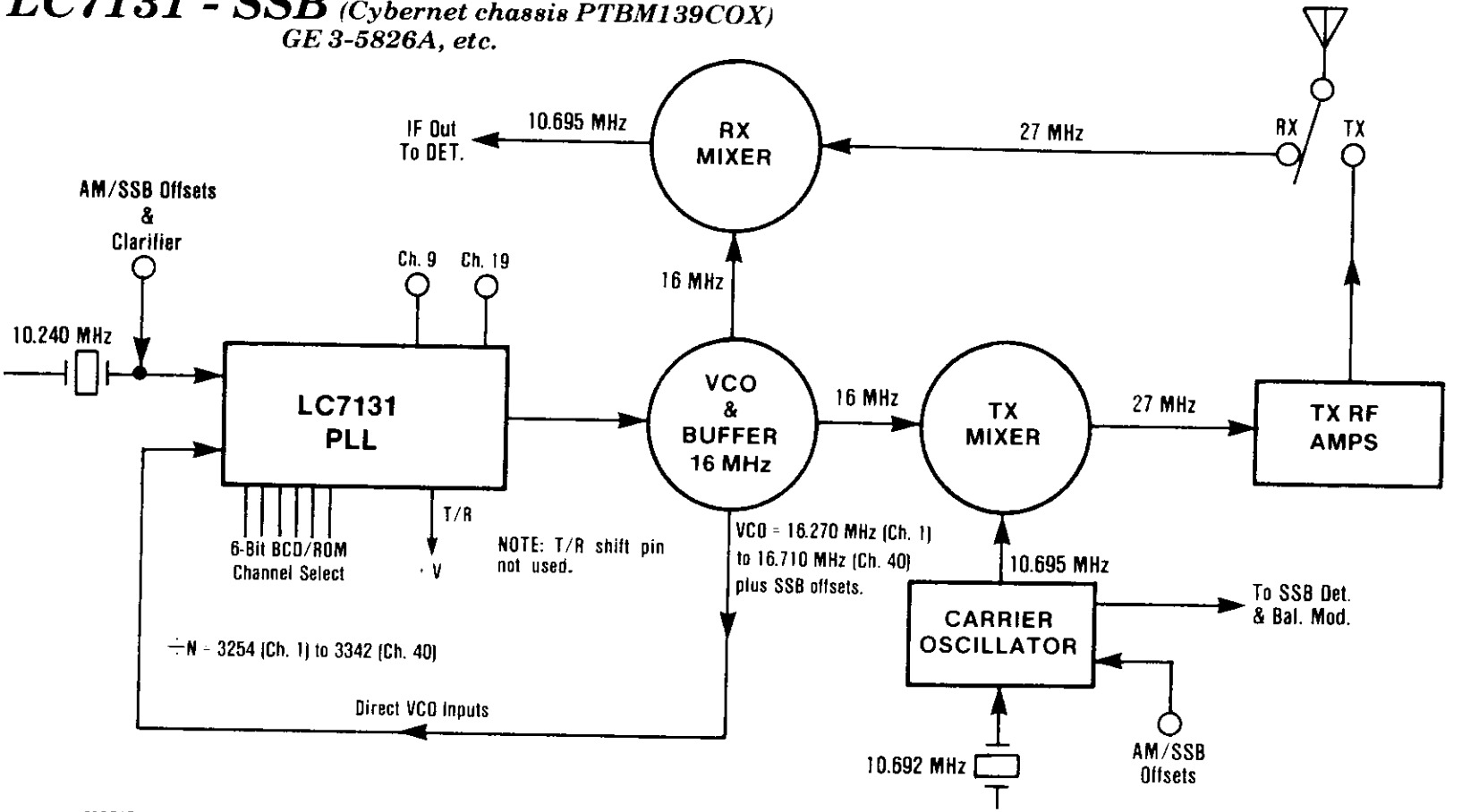
VCO - 16.270 MHz (Ch. 1) to 16.710 MHz (Ch. 40) RX
- 16.725 MHz (Ch. 1) to 17.165 MHz (Ch. 40) TX

÷N = 3254 (Ch. 1) to 3342 (Ch. 40) RX
- 3345 (Ch. 1) to 3433 (Ch. 40) TX

Circuit operation identical to TC9106 less the auto Ch. 9/Ch.19 pins. LC7135 contains only the first 22 FCC Channels for European CB use stored in ROM.

MODIFICATION METHOD: None yet!

LC7131 - SSB *(Cybernet chassis PTBM139COX)*
GE 3-5826A, etc.



MODIFICATION METHOD 1: Cut trace connecting T/R pin (Pin 20) to +V. Use control switching such as that shown on Page 47 between +V & Ground. In +V position, channels are normal. In Ground position, you will get a 40-channel band which is 455 KHz high and ending in the "0" numbers such as 27.420 to 27.860. Strap Clarifier to slide enough to regain correct frequencies.

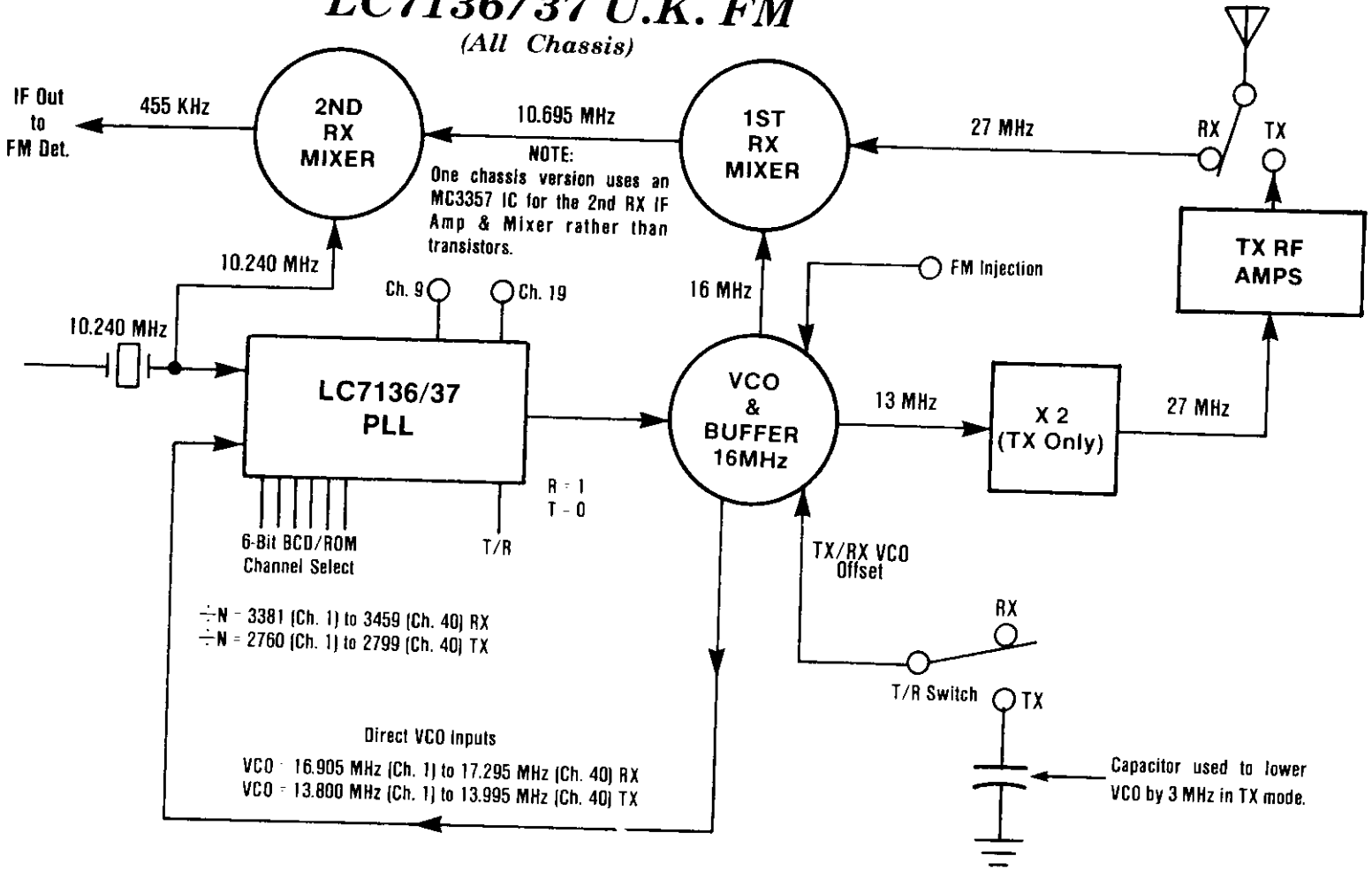
MODIFICATION METHOD 2: Change the 10.240 MHz crystal. Examples of range are:

9.9568 MHz = 26.515 MHz to 26.955 MHz
10.5232 MHz = 27.415 MHz to 27.855 MHz Crystal formula = 10.24 $\pm$ (N x .2832 MHz)
10.8064 MHz = 27.865 MHz to 28.305 MHz.

NOTE: Frequencies will not track exactly across all 40 channels; use Clarifier as required.

LC7136/37 U.K. FM

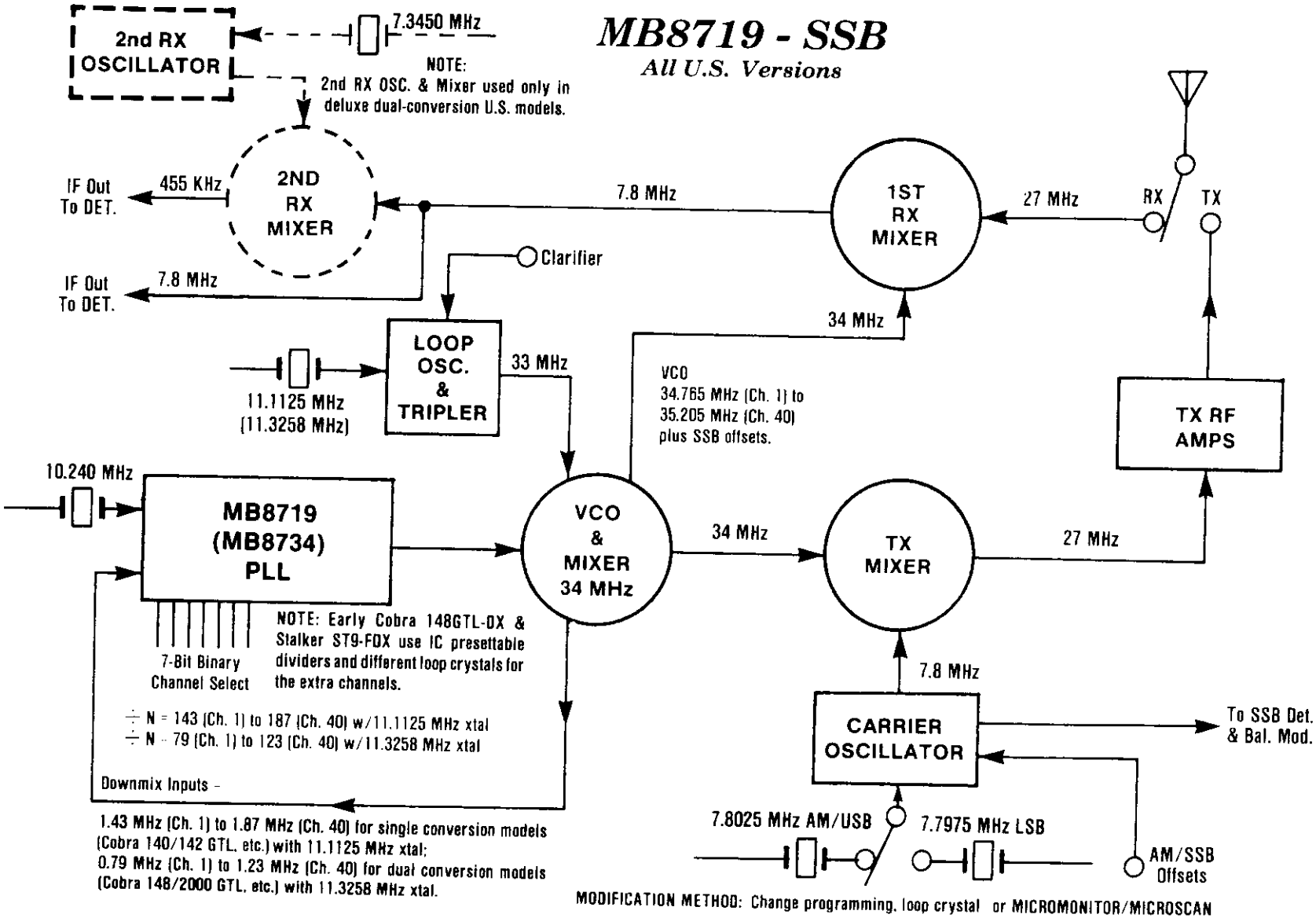
(All Chassis)



MODIFICATION METHODS: None yet!

MB8719 - SSB

All U.S. Versions

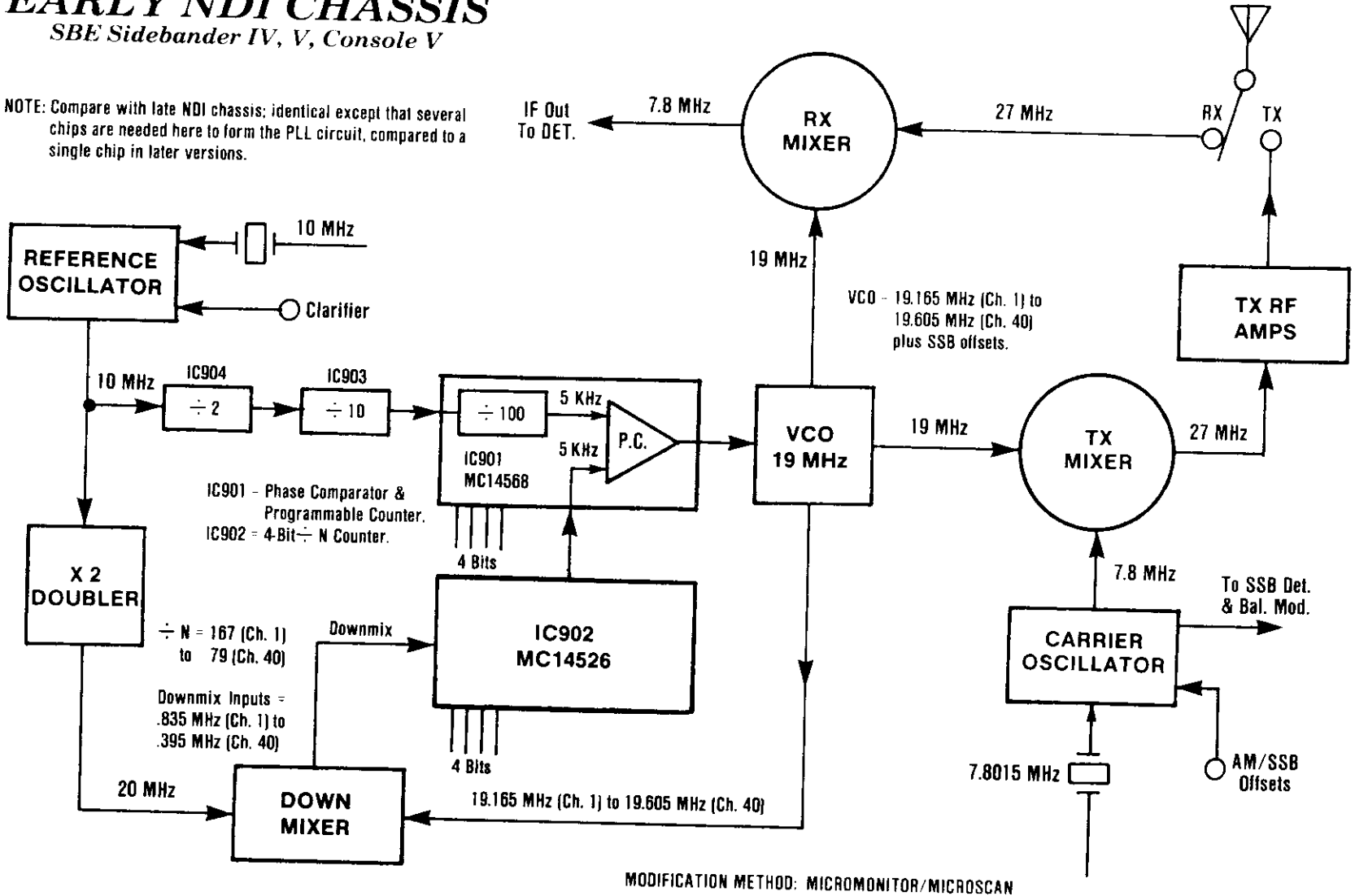


MODIFICATION METHOD: Change programming, loop crystal or MICROMONITOR/MICROSCAN

EARLY NDI CHASSIS

SBE Sidebander IV, V, Console V

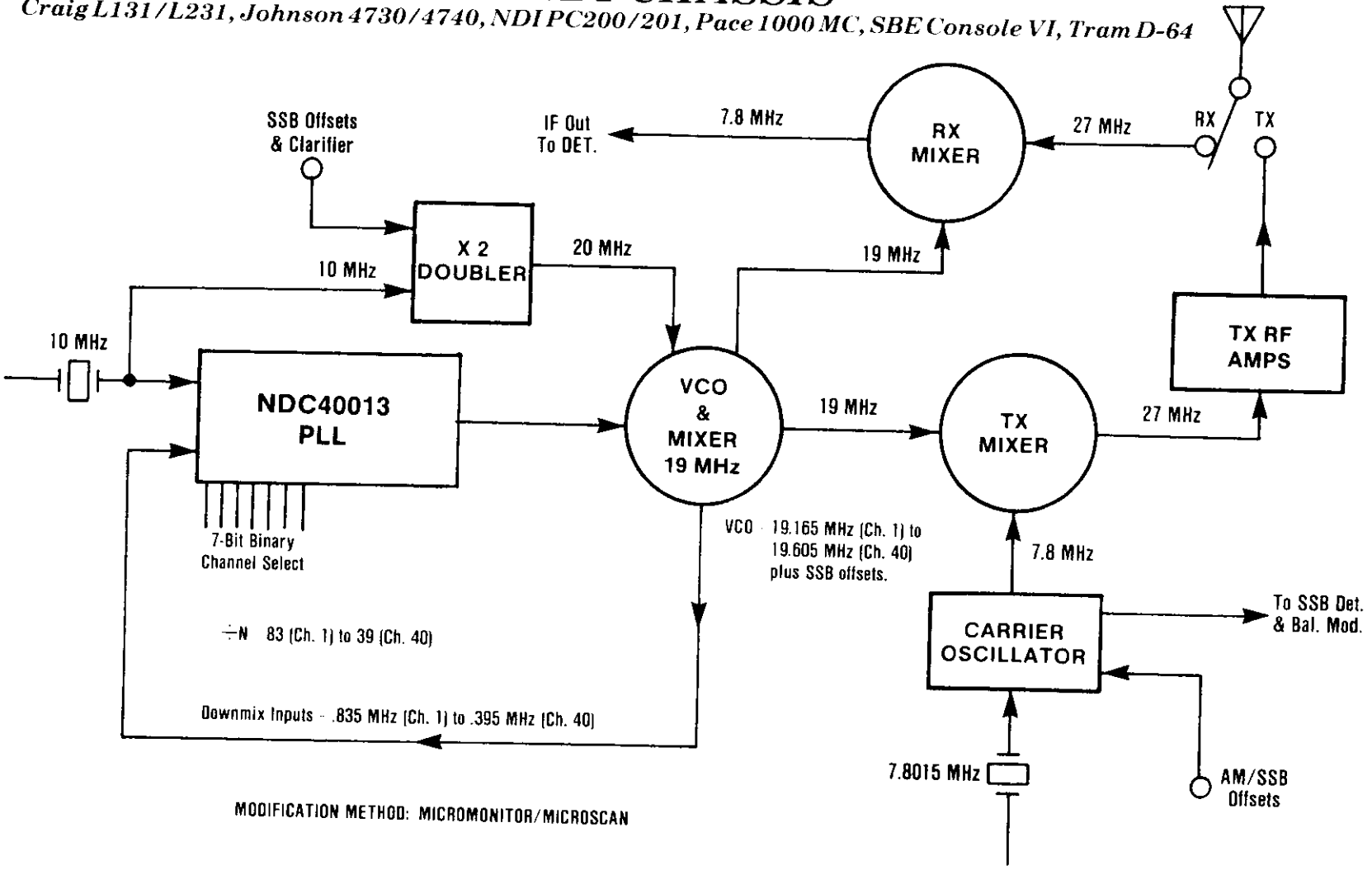
NOTE: Compare with late NDI chassis; identical except that several chips are needed here to form the PLL circuit, compared to a single chip in later versions.



MODIFICATION METHOD: MICROMONITOR/MICROSCAN

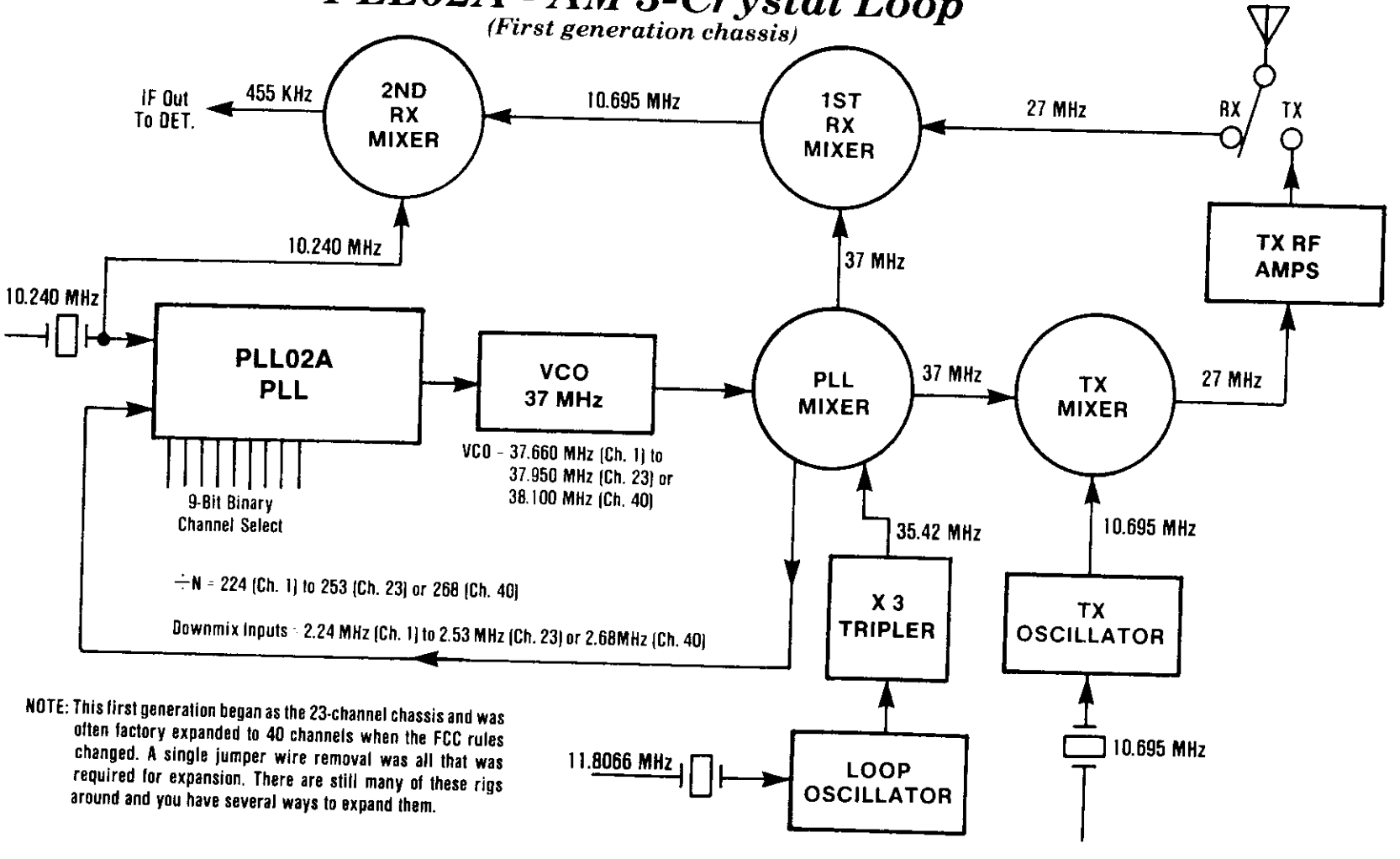
LATE NDI CHASSIS

Craig L131/L231, Johnson 4730/4740, NDI PC200/201, Pace 1000 MC, SBE Console VI, Tram D-64



PLL02A - AM 3-Crystal Loop

(First generation chassis)

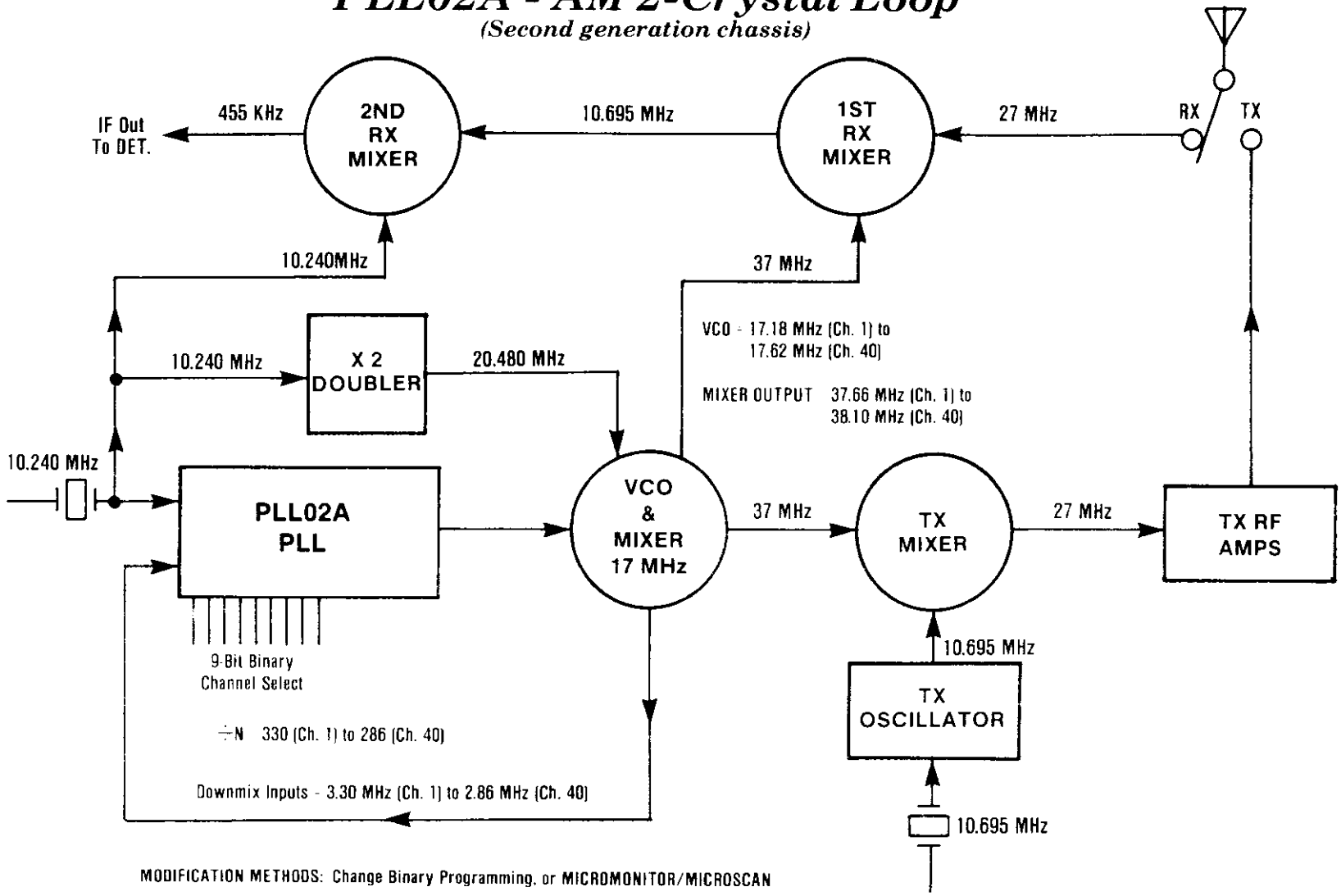


NOTE: This first generation began as the 23-channel chassis and was often factory expanded to 40 channels when the FCC rules changed. A single jumper wire removal was all that was required for expansion. There are still many of these rigs around and you have several ways to expand them.

MODIFICATION METHODS: Change Binary Programming, 11MHz crystal, or MICROMONITOR/MICROSCAN

PLL02A - AM 2-Crystal Loop

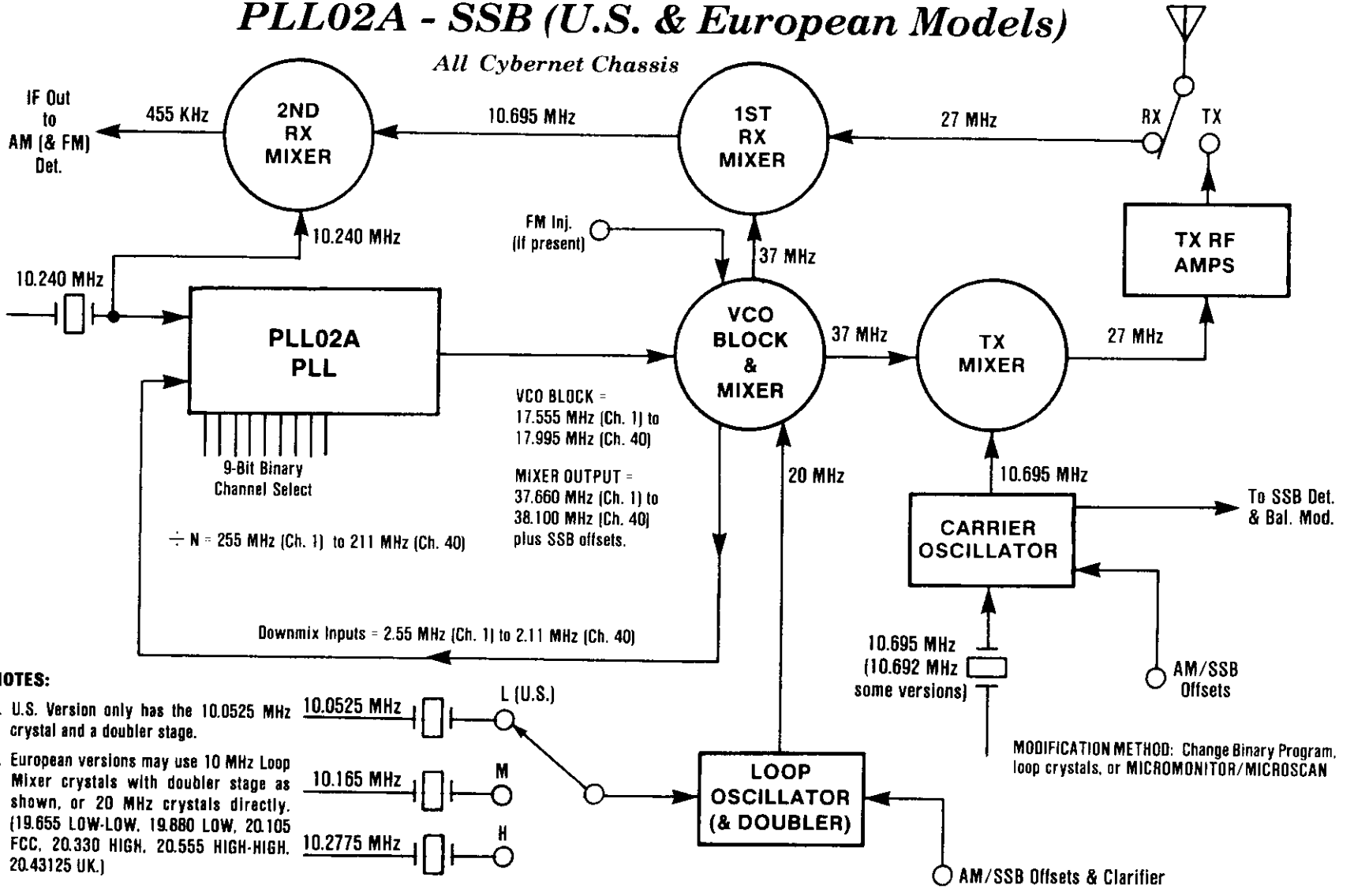
(Second generation chassis)



MODIFICATION METHODS: Change Binary Programming, or MICROMONITOR/MICROSCAN

PLL02A - SSB (U.S. & European Models)

All Cybernet Chassis

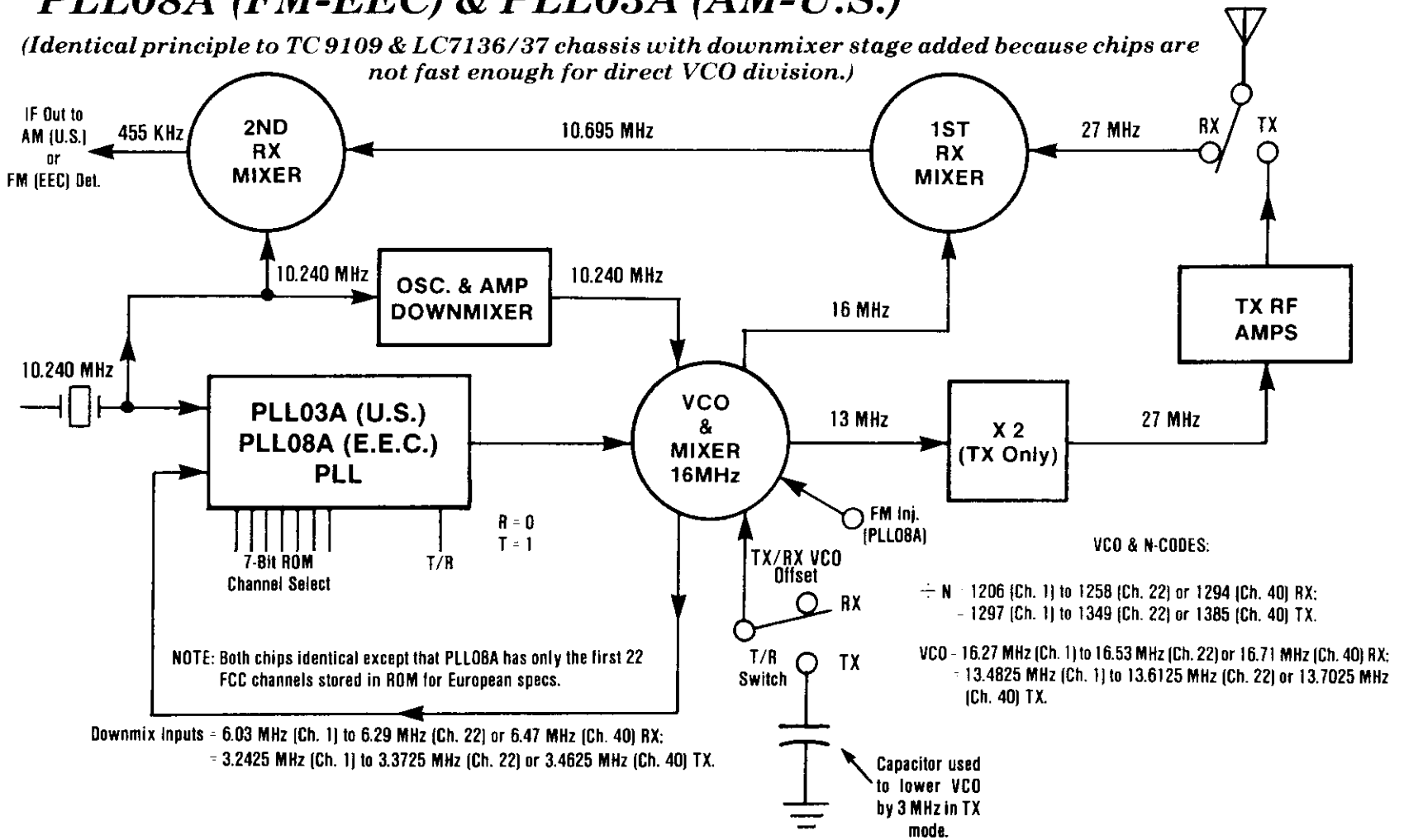


NOTES:

1. U.S. Version only has the 10.0525 MHz crystal and a doubler stage.
2. European versions may use 10 MHz Loop Mixer crystals with doubler stage as shown, or 20 MHz crystals directly. (19.655 LOW-LOW, 19.880 LOW, 20.105 FCC, 20.330 HIGH, 20.555 HIGH-HIGH, 20.43125 UK.)

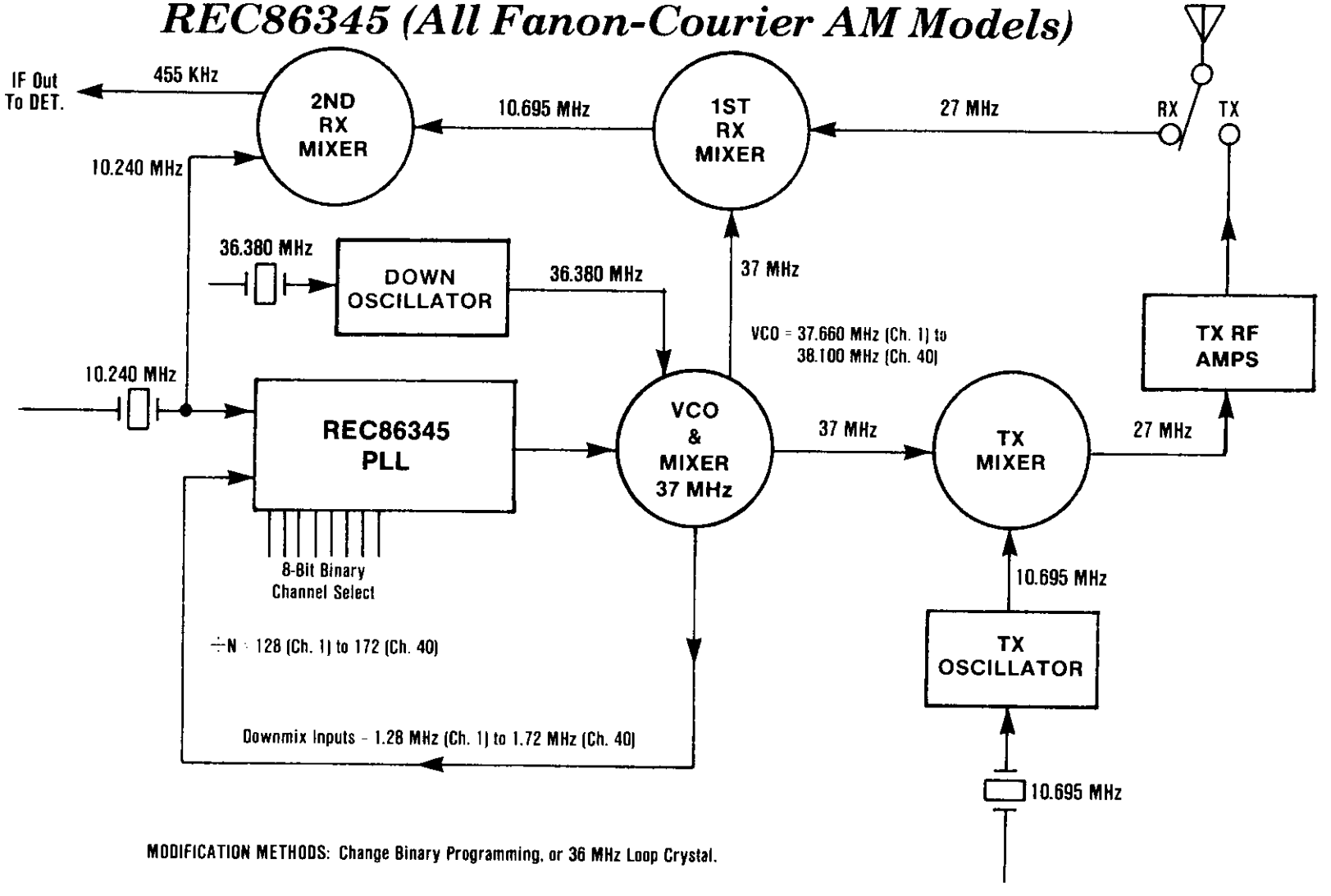
PLL08A (FM-EEC) & PLL03A (AM-U.S.)

(Identical principle to TC 9109 & LC7136/37 chassis with downmixer stage added because chips are not fast enough for direct VCO division.)



MODIFICATION METHOD: Disconnect the 10.240 MHz signal where it enters the Mixer, replacing it with an external oscillator signal of your own. Not worth the trouble!

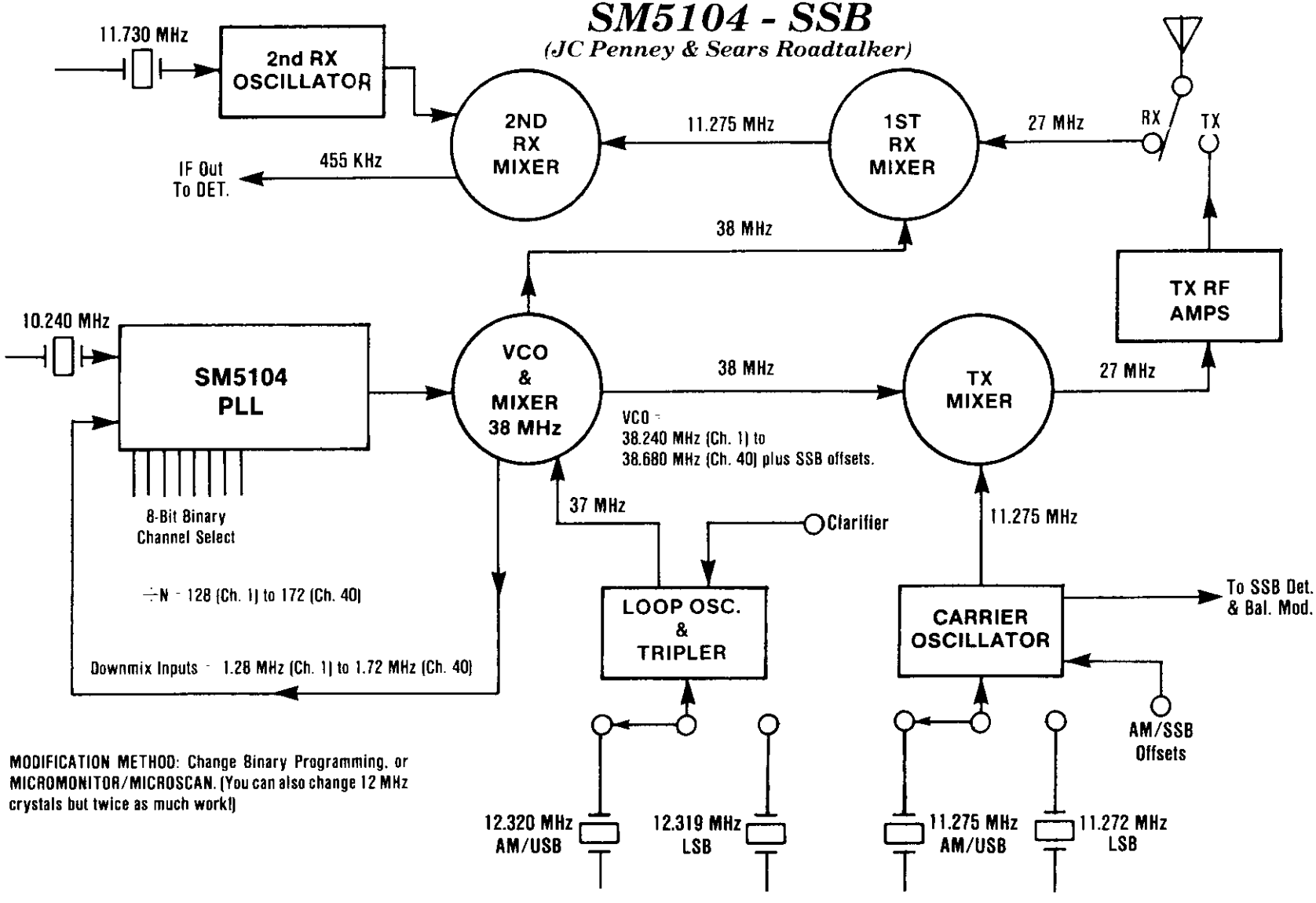
REC86345 (All Fanon-Courier AM Models)



MODIFICATION METHODS: Change Binary Programming, or 36 MHz Loop Crystal.

SM5104 - SSB

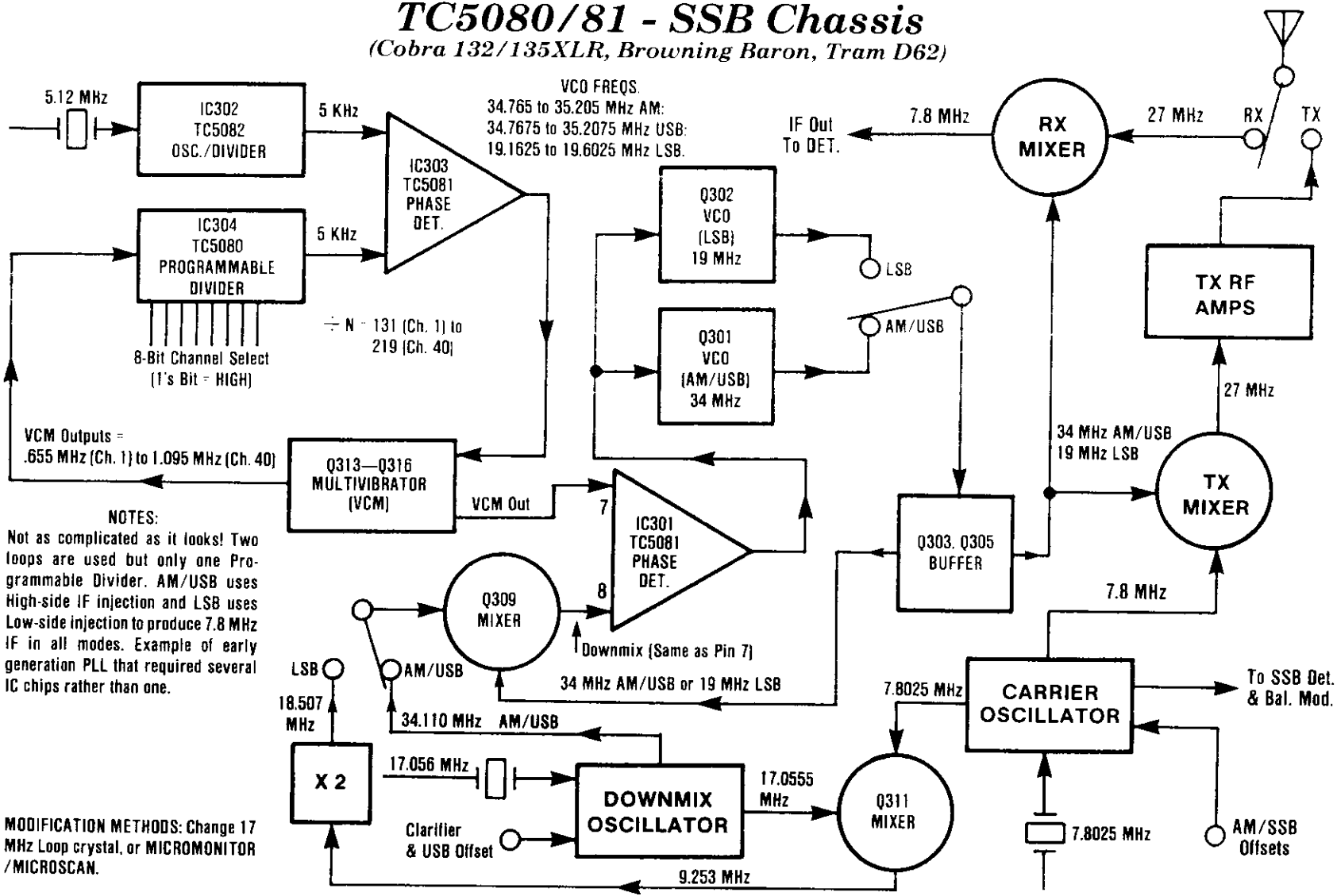
(JC Penney & Sears Roadtalker)



MODIFICATION METHOD: Change Binary Programming, or MICROMONITOR/MICROSCAN. (You can also change 12 MHz crystals but twice as much work!)

TC5080/81 - SSB Chassis

(Cobra 132/135XLR, Browning Baron, Tram D62)

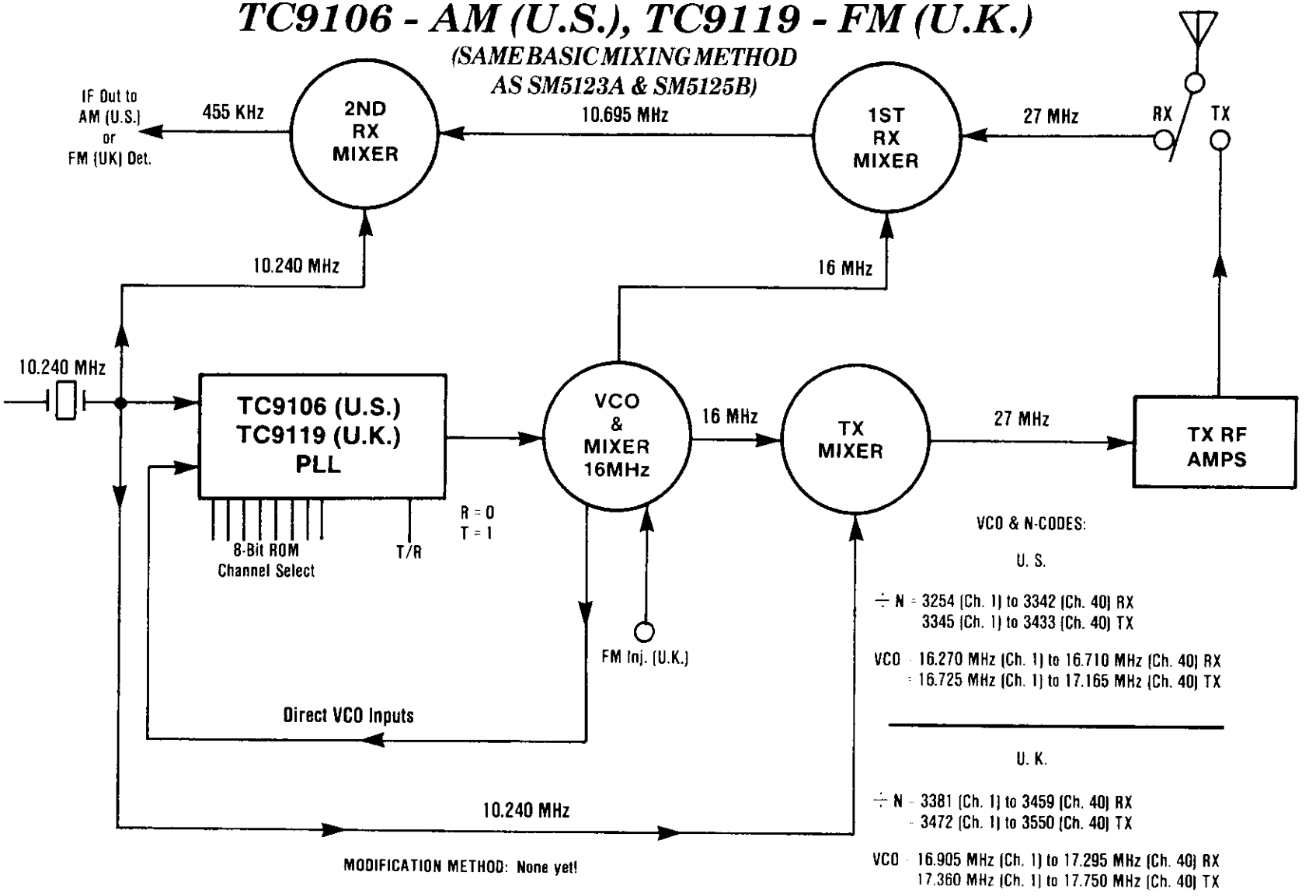


NOTES:
Not as complicated as it looks! Two loops are used but only one Programmable Divider. AM/USB uses High-side IF injection and LSB uses Low-side injection to produce 7.8 MHz IF in all modes. Example of early generation PLL that required several IC chips rather than one.

MODIFICATION METHODS: Change 17 MHz Loop crystal, or MICROMONITOR /MICROSCAN.

TC9106 - AM (U.S.), TC9119 - FM (U.K.)

(SAME BASIC MIXING METHOD AS SM5123A & SM5125B)



VCO & N-CODES:

U. S.

÷ N = 3254 (Ch. 1) to 3342 (Ch. 40) RX
3345 (Ch. 1) to 3433 (Ch. 40) TX

VCO = 16.270 MHz (Ch. 1) to 16.710 MHz (Ch. 40) RX
16.725 MHz (Ch. 1) to 17.165 MHz (Ch. 40) TX

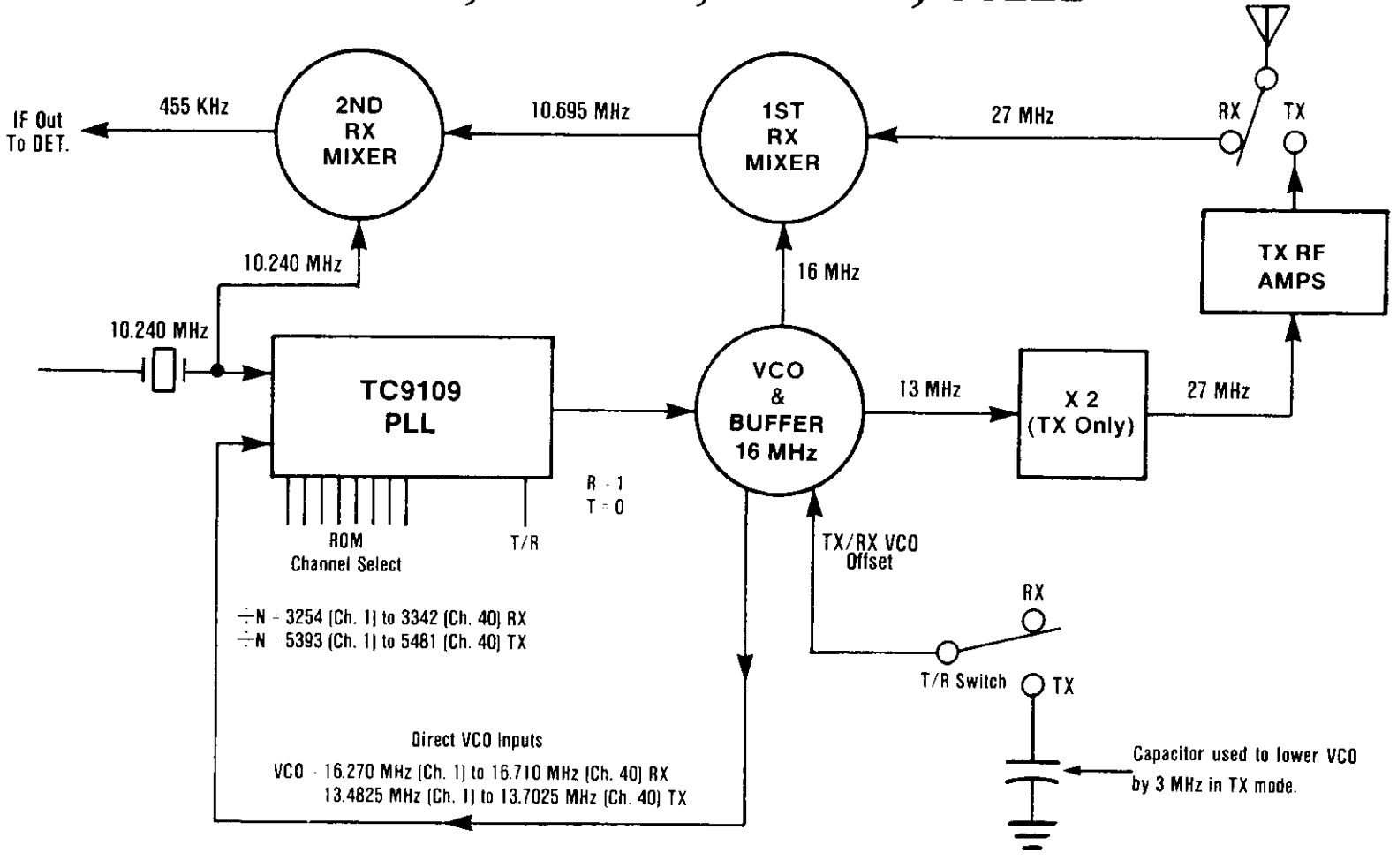
U. K.

÷ N = 3381 (Ch. 1) to 3459 (Ch. 40) RX
3472 (Ch. 1) to 3550 (Ch. 40) TX

VCO = 16.905 MHz (Ch. 1) to 17.295 MHz (Ch. 40) RX
17.360 MHz (Ch. 1) to 17.750 MHz (Ch. 40) TX

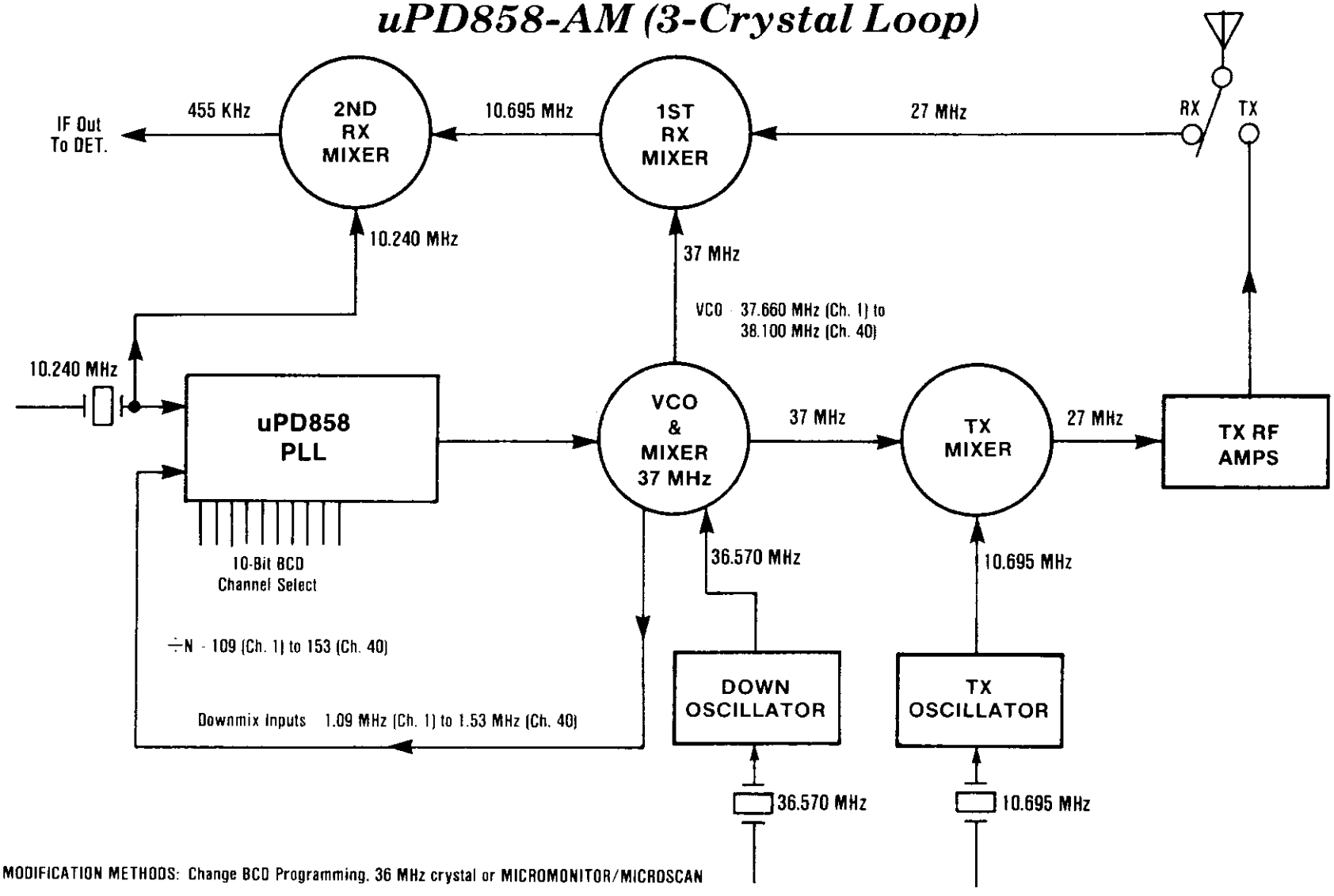
MODIFICATION METHOD: None yet!

TC9109, MB8733, LC7132, C5121



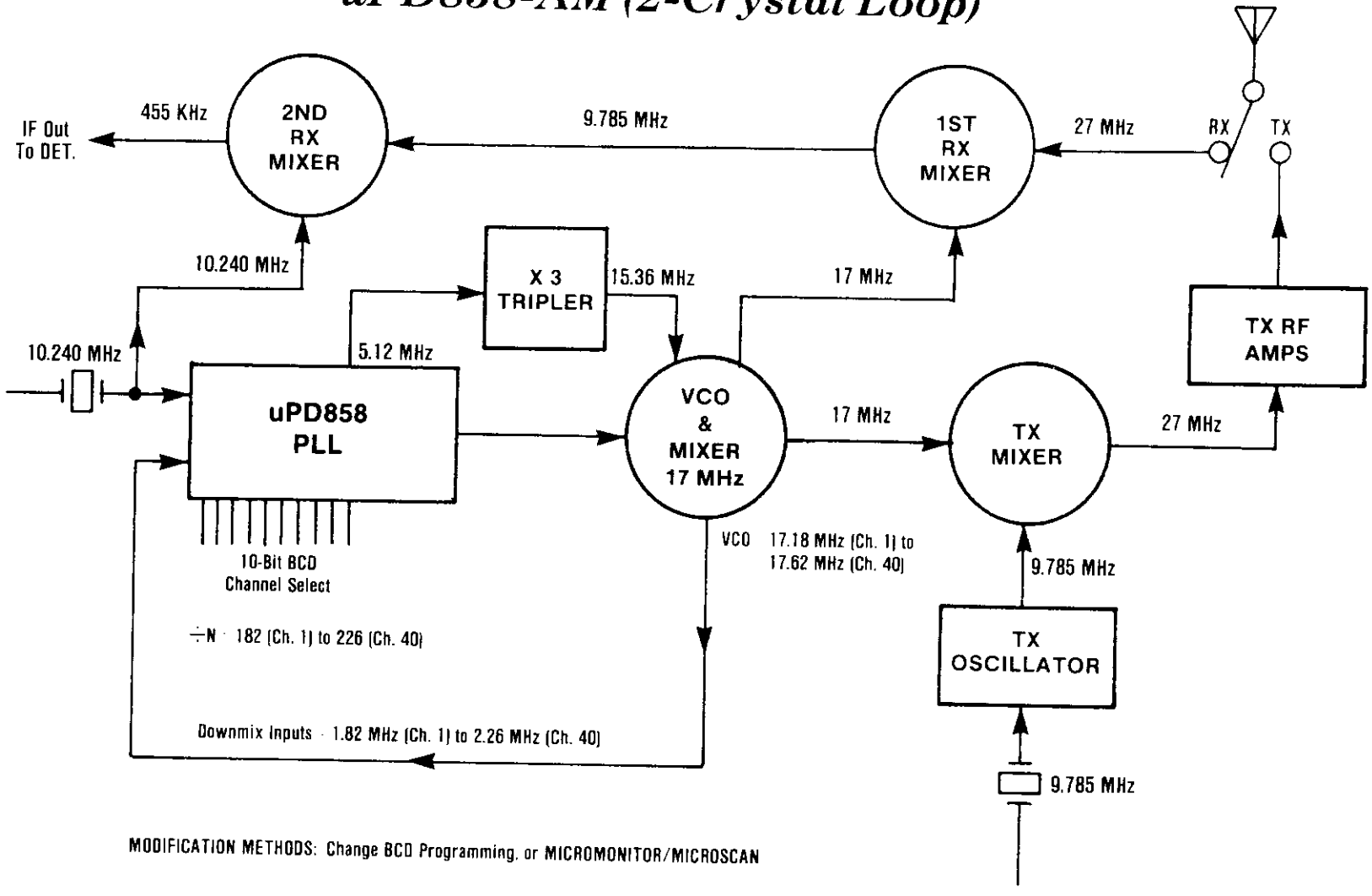
MODIFICATION METHOD: None yet!

uPD858-AM (3-Crystal Loop)



MODIFICATION METHODS: Change BCD Programming, 36 MHz crystal or MICROMONITOR/MICROSCAN

uPD858-AM (2-Crystal Loop)

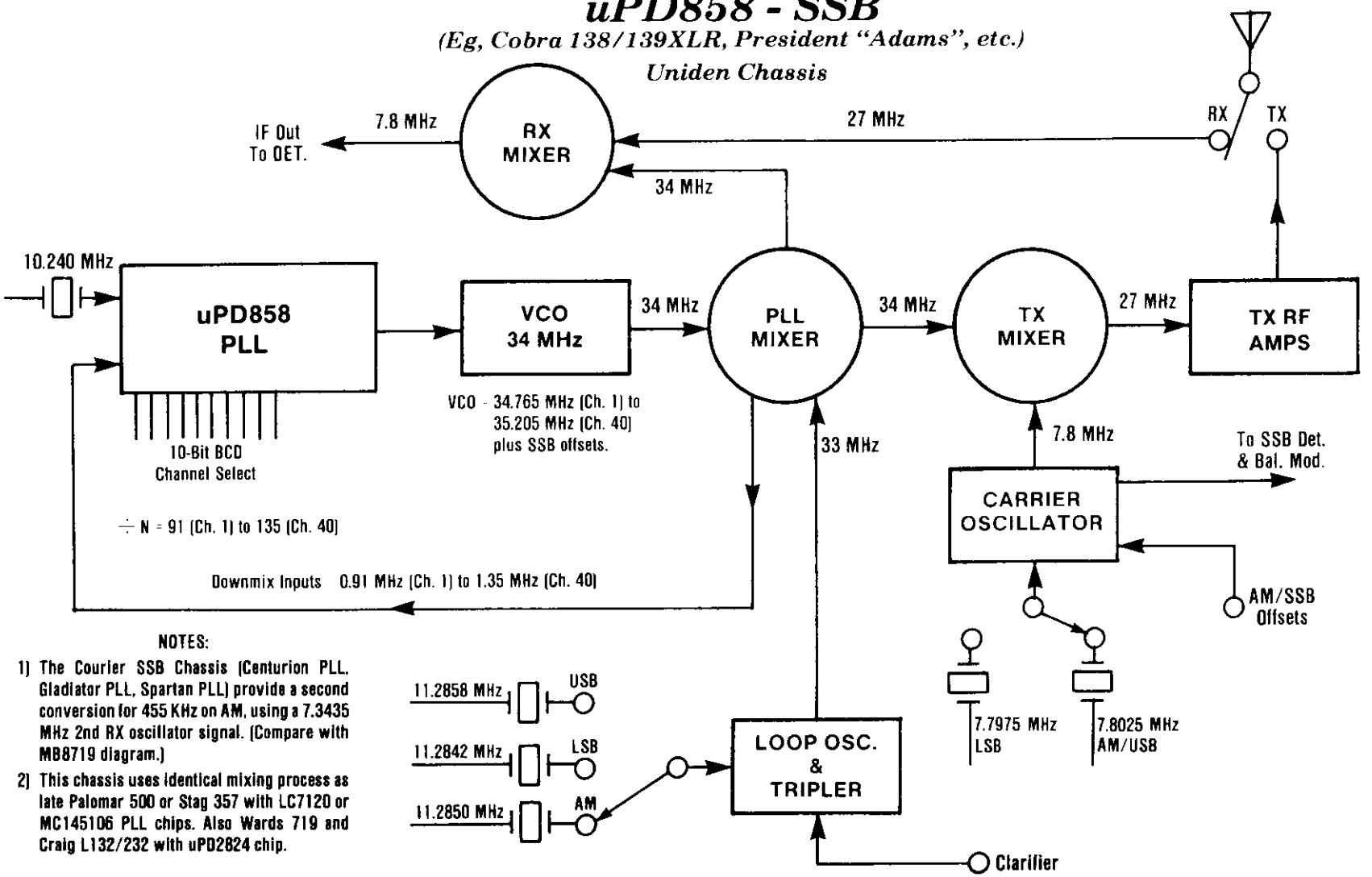


MODIFICATION METHODS: Change BCD Programming, or MICROMONITOR/MICROSCAN

uPD858 - SSB

(Eg, Cobra 138/139XLR, President "Adams", etc.)

Uniden Chassis

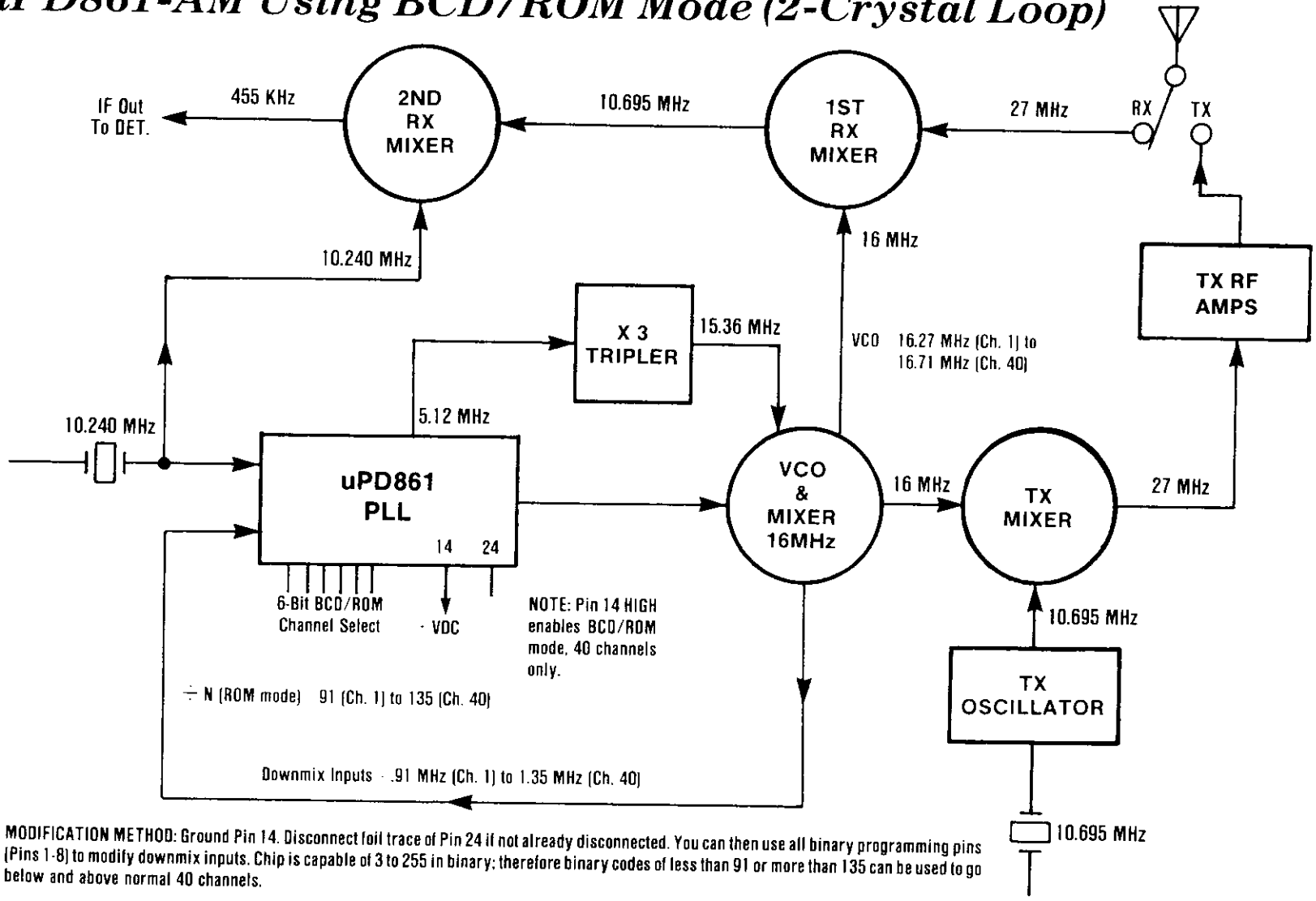


NOTES:

1) The Courier SSB Chassis (Centurion PLL, Gladiator PLL, Spartan PLL) provide a second conversion for 455 KHz on AM, using a 7.3435 MHz 2nd RX oscillator signal. (Compare with MB8719 diagram.)
2) This chassis uses identical mixing process as late Palomar 500 or Stag 357 with LC7120 or MC145106 PLL chips. Also Wards 719 and Craig L132/232 with uPD2824 chip.

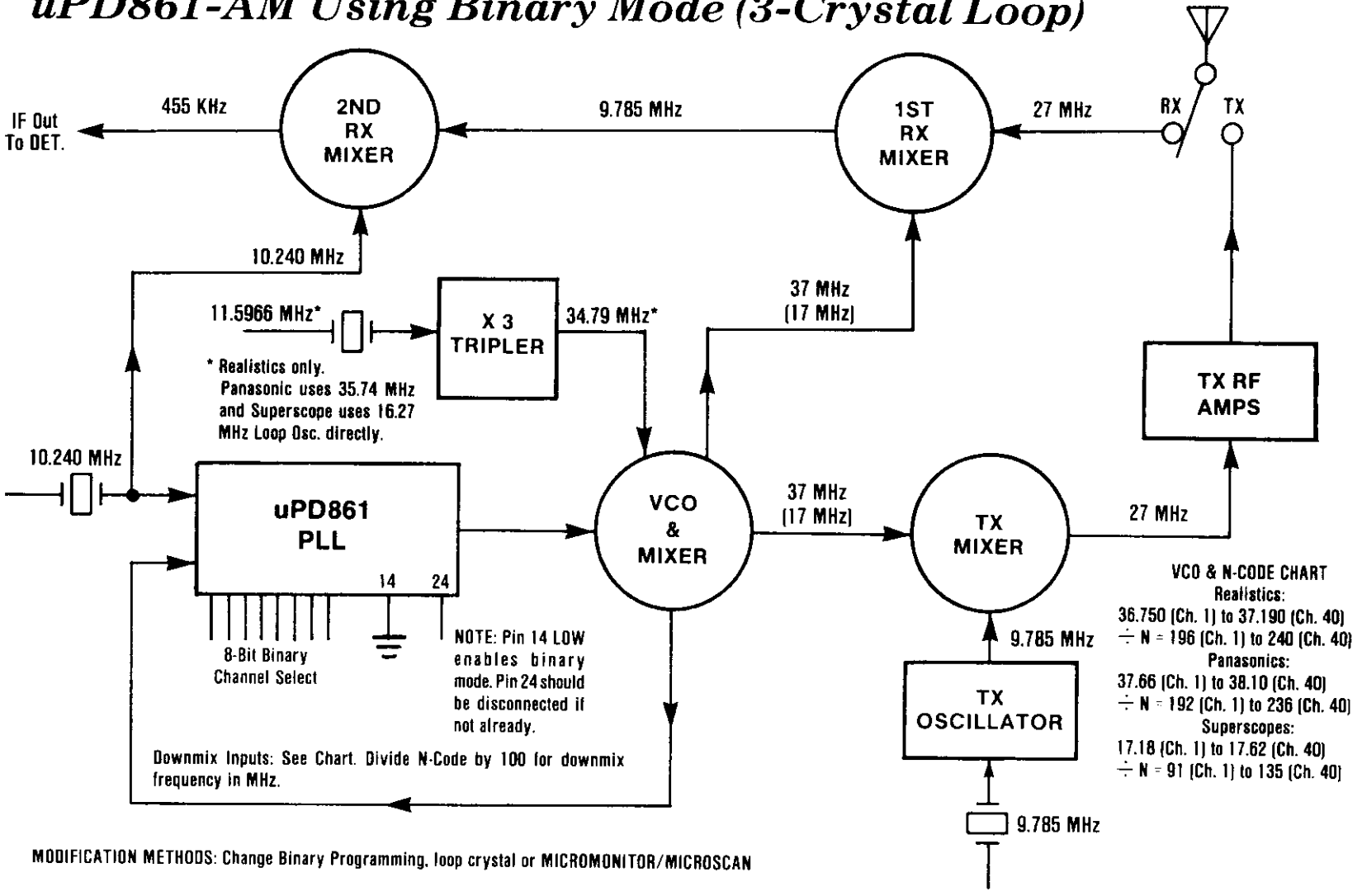
MODIFICATION METHOD: Change BCD program pins or MICROMONITOR/MICROSCAN

uPD861-AM Using BCD/ROM Mode (2-Crystal Loop)



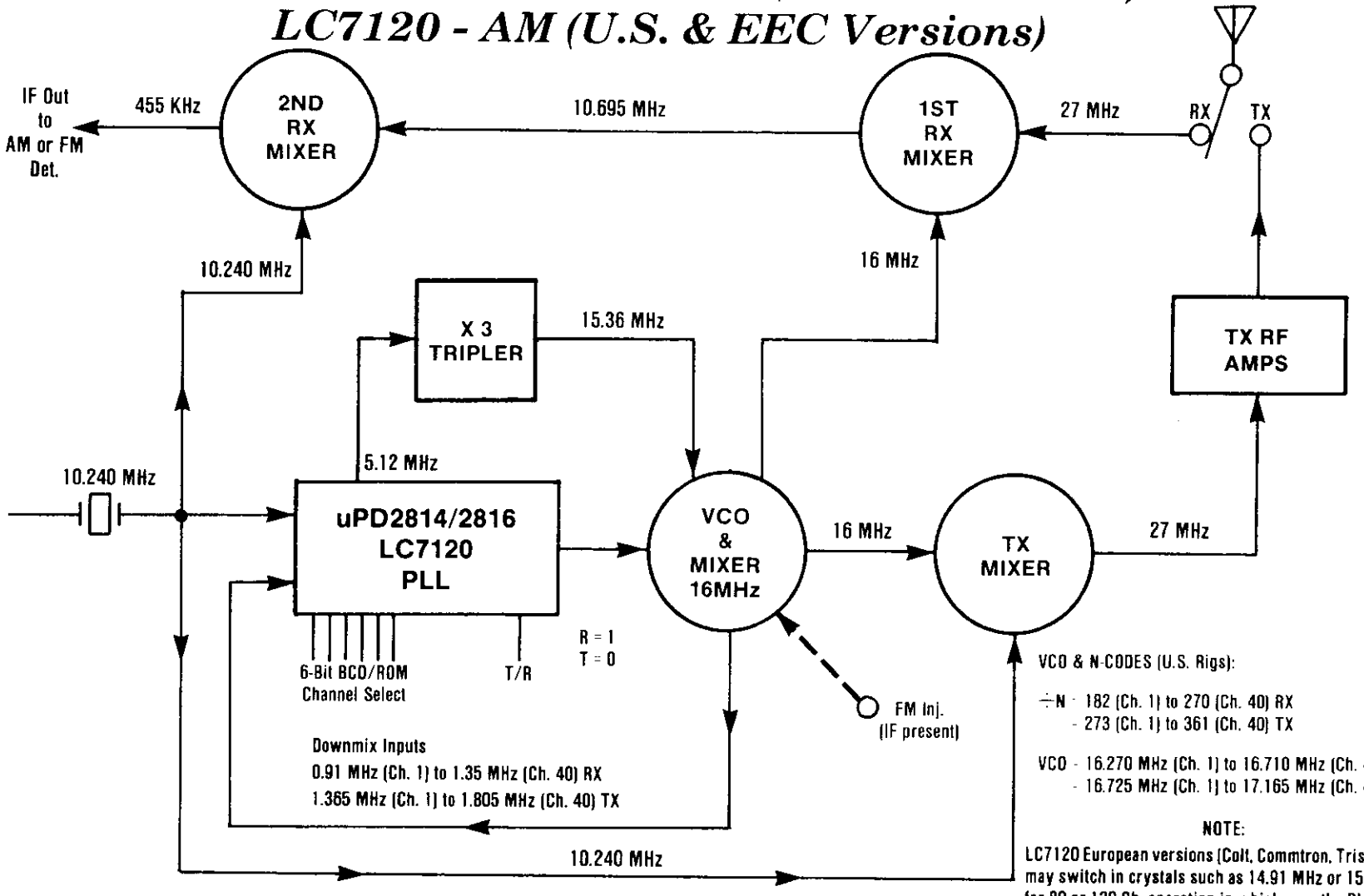
MODIFICATION METHOD: Ground Pin 14. Disconnect foil trace of Pin 24 if not already disconnected. You can then use all binary programming pins (Pins 1-8) to modify downmix inputs. Chip is capable of 3 to 255 in binary; therefore binary codes of less than 91 or more than 135 can be used to go below and above normal 40 channels.

uPD861-AM Using Binary Mode (3-Crystal Loop)



MODIFICATION METHODS: Change Binary Programming, loop crystal or MICROMONITOR/MICROSCAN

uPD2814 & uPD 2816 - AM (Uniden Chassis)
LC7120 - AM (U.S. & EEC Versions)



VCO & N-CODES (U.S. Rigs):

÷N - 182 (Ch. 1) to 270 (Ch. 40) RX
- 273 (Ch. 1) to 361 (Ch. 40) TX

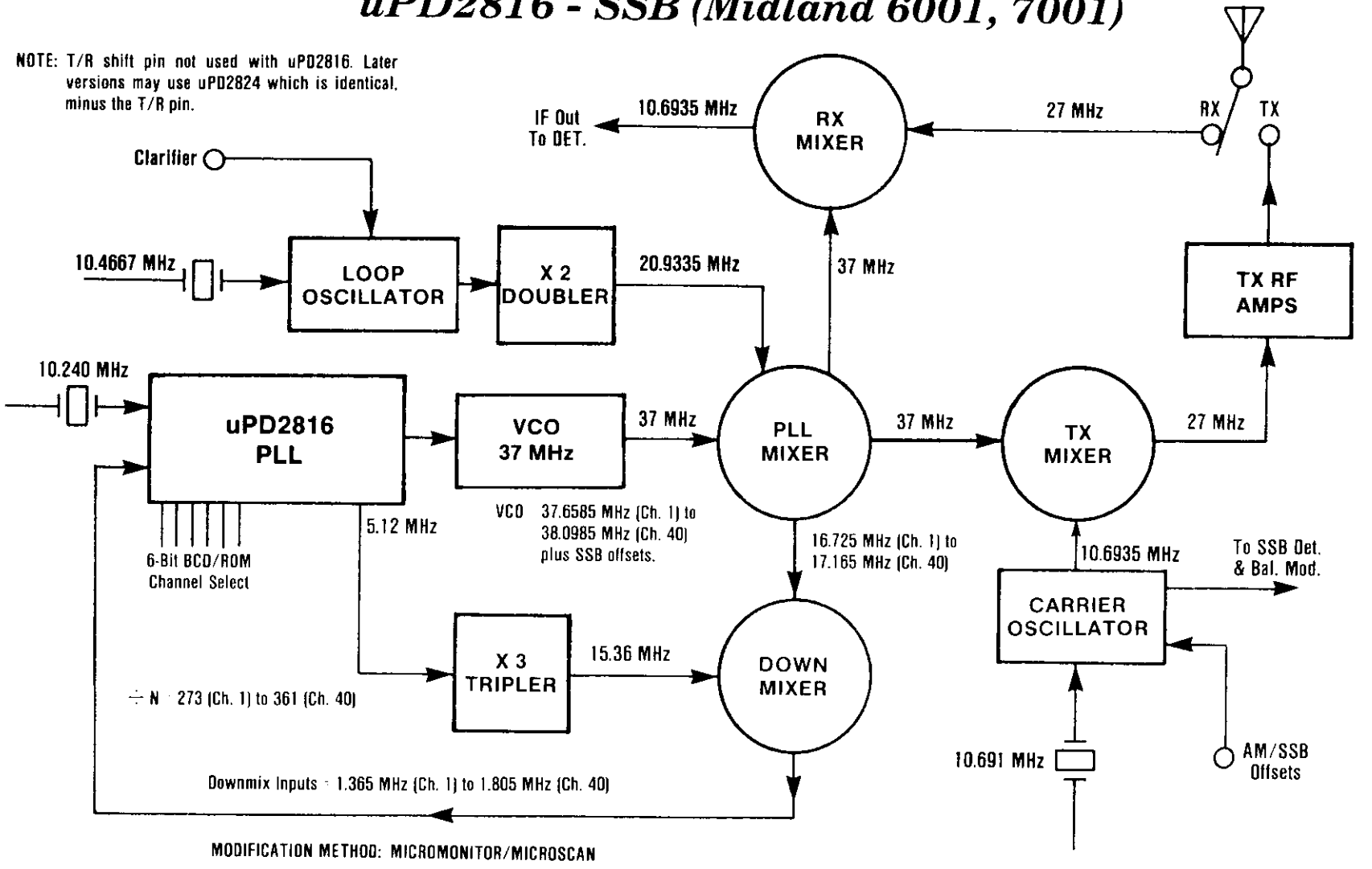
VCO - 16.270 MHz (Ch. 1) to 16.710 MHz (Ch. 40) RX
- 16.725 MHz (Ch. 1) to 17.165 MHz (Ch. 40) TX

NOTE:

LC7120 European versions (Colt, Commtron, Tristar, etc.) may switch in crystals such as 14.91 MHz or 15.81 MHz for 80 or 120 Ch. operation in which case the PLL's 5.12 MHz pin may not even be used. A 15.36 MHz crystal may replace this tripler signal.

MODIFICATION METHOD: External oscillator to replace the 15.360 MHz tripler signal.

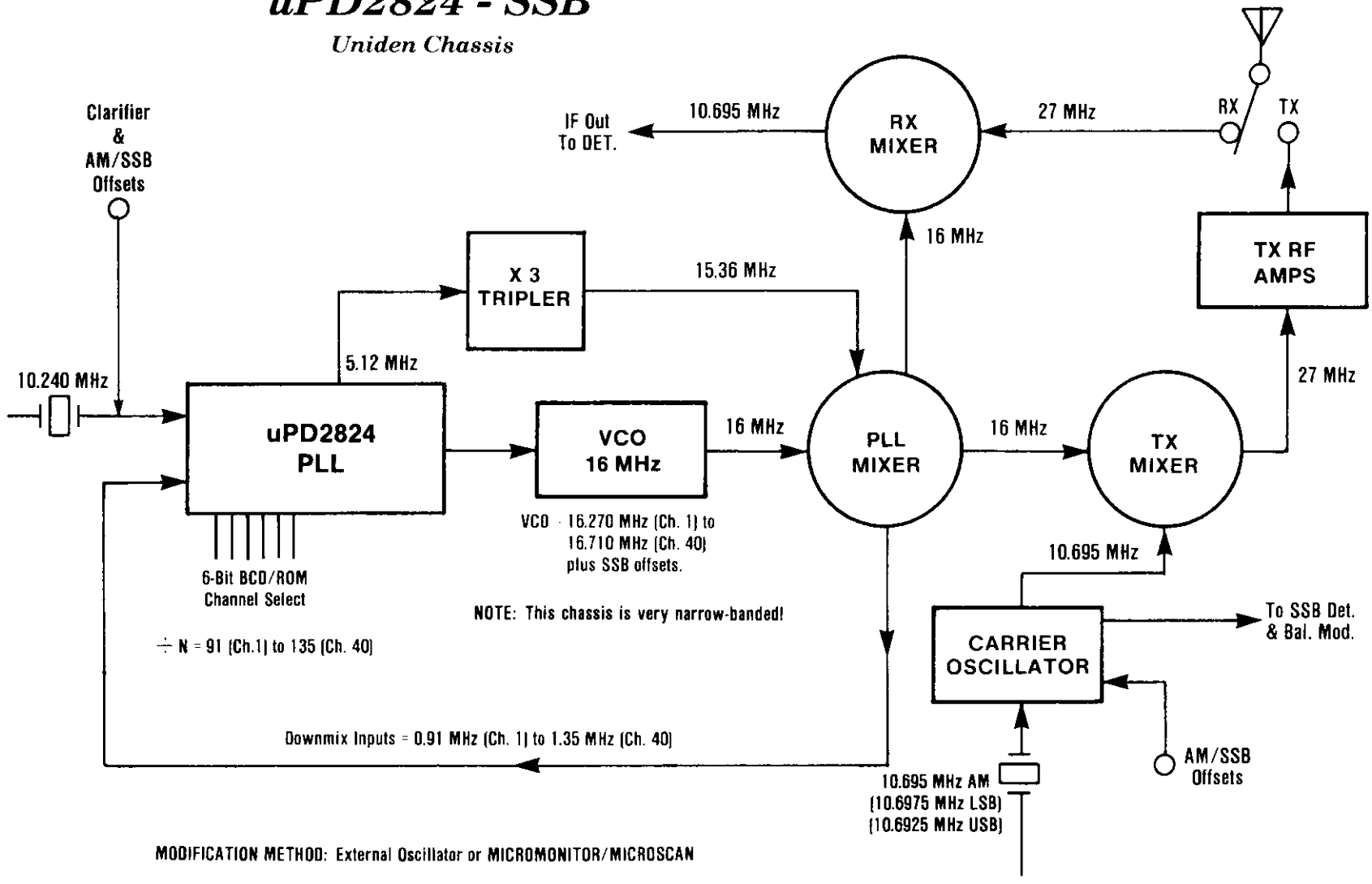
uPD2816 - SSB (Midland 6001, 7001)



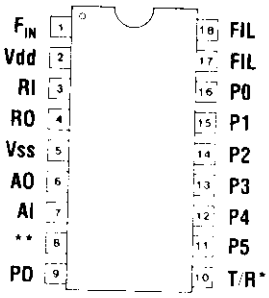
MODIFICATION METHOD: MICROMONITOR/MICROSCAN

uPD2824 - SSB

Uniden Chassis



CCI3001

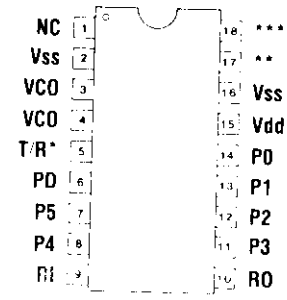


*R = 1, T = 0. Shifts down 455 KHz in Transmit mode.
**Control used to turn off one Mixer IC input between TX & RX.

MODELS
Pace 8093, 8193
Royce 582/651, 639/642
SBE LCMS-4
Sommerkamp TS310DX

Obsolete chip using binary inputs and internal ROM.

CCI3002



*R = 1, T = 0
**27 MHz out to TX Amps.
***17 MHz out to RX Mixer

MODELS
Kraco 2410
Pace 8003
Royce 607
SBE LCM-8P
Realistic TRC209-18

Obsolete chip using binary inputs. Unique in that it contains its own mixer for the VCO.

HD42851 (Hitachi)

MODELS
Sharp CB5470 SSB

PIN FUNCTIONS

1	=	P1	13	=	F_{IN}
2	=	P2	14	=	FS*
3	=	P3	15	=	PROG. DIV. OUT
4	=	P4	16	=	PD IN from REF. DIV.
5	=	P5	17	=	REF. DIV. OUT
6	=	P6	18	=	PD IN from PROG. DIV.
7	=	P7	19	=	AO
8	=	P8	20	=	AI
9	=	½R	21	=	PD OUT
10	=	RI	22	=	LD**
11	=	RO	23	=	V_{SS}
12	=	V_{DD}	24	=	MC (Usually unconnected.)

*1 = 10 KHz steps, 0 = 5 KHz steps
**1 = Locked, 0 = Unlocked

An interesting chip that's easy to mistake for the uPD861 as the pinout is almost identical. With Pin 14 LOW, N-Code is pure 8-bit binary with a range of N = 53-308. With Pin 14 HIGH, range is N = 3-191. If Pin 14 is HIGH and Pins 7 & 8 are LOW, programming is in BCD with standard N-Code of 91-135. Many internal functions brought out to IC pins for easier trouble-shooting. See block mixing diagram.

C5121

MODELS

Contact 40FM	Pace CB8001, CB8002
G.E. 3-5909A	Regency CB-1, CB-2
Midland 77-155	Unic RV-CB40TB

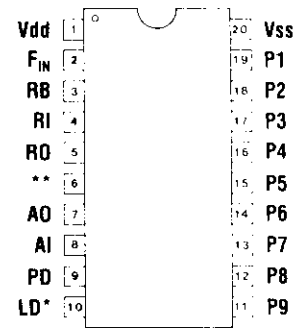
PIN FUNCTIONS

1	=	SEG-A	12	=	F_{IN}
2	=	SEG-B	13	=	V_{dd}
3	=	SEG-C	14	=	AO
4	=	SEG-D	15	=	AI
5	=	SEG-E	16	=	PD OUT
6	=	SEG-F	17	=	LD*
7	=	SEG-G	18	=	T/R**
8	=	V_{SS}	19	=	CH.9
9	=	RI	20	=	STEP***
10	=	RO	21	=	NC
11	=	V_{SS}	22	=	LED BAR/GRAPH MULTIPLEX OUT

*1 = Locked, 0 = Unlocked
**1 = TX, 0 = RX ***1 = STEP UP, 0 = STEP DN

The latest AM/FM type chip, identical in mixing to the TC9109 on Page 104. Note this one uses a single data bit to step up or down, eliminating the expensive BCD type Channel Selector switch. Like the SM5123A/SM5125B (Page 108), this contains the LED drivers within the chip. Not easily modified.

LC7110
(Sanyo)



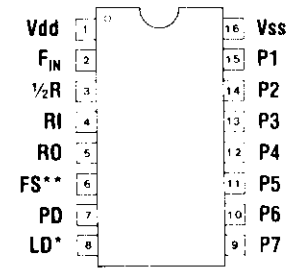
MODELS

G.E. 3-5804A, 5871B
Realistic TRC454, TRC470
Sanyo TA2000, TA4000, TA6000

An obsolete chip with internal ROM and binary inputs. As used in above models, ÷N = 150 (Ch. 1) to 194 (Ch. 40).

*1 = Locked, 0 = Unlocked
**Tied HIGH

LC7113
(Sanyo)



MODELS

Realistic TRC459/TRC480 SSB

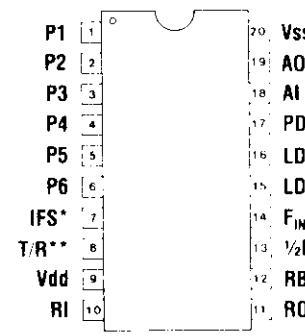
An obsolete chip used in a very expensive rig! Uses 7-bit binary programming with internal pull-down resistors. Pin 9 presets the counter as follows:
Pin 9 HIGH, 64 + N,
Pin 9 LOW, 128 + N

Since Pin 9 is grounded or automatically pulled down LOW in the Realistic, raising it HIGH allows a possible 64 channels below Ch. 1. However since in this rig N = 172 at Ch. 40 and the maximum N possible is 191, only an additional 19 high channels can be programmed. After that, you must replace the 17 MHz Loop Crystal.

*1 = Locked, 0 = Unlocked
**1 = ÷1024, 0 = ÷1152

See block mixing diagram.

LC7120
(Sanyo)



MODELS

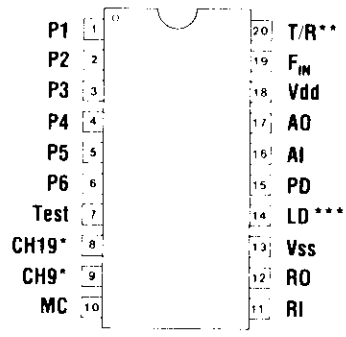
U.S.:
Colt 222, Midland 100M, 77-101B, 77-101C, 77-824C, Palomar SSB500 (late), SSB600, Realistic TRC462, Robyn SB540D, SBE 47CB (Stowaway)

Export:
Colt 510, Commtron VIII, Formac 240, HyStar 100, Jaws II, Midland 150M, Stag 357, Tristar 120, Vice-President FRANK

One of the later BCD/ROM chips now finding its way into European rigs. The programming, IFS, and T/R pins use internal pull-down resistors. Chip uses 5 KHz divider steps. LD1 is active LOW; LD2 is active HIGH. Several N-Code sets are possible depending upon AM or SSB use and choice of IF, very similar to uPD2810. Examples for AM circuits: For 10.695 MHz IF, N-Codes are 182 to 270 (RX) and 273 to 361 (TX); for 9.785 MHz IF, N-Codes are 364 to 452 (RX) and 273 to 361 (TX). Notice that the 455 KHz may shift up *or* down on TX relative to whether the IF is operating above or below the 10.24 MHz mixing signal. For SSB use, the T/R and ½R pins are not used; instead a separate crystal oscillator provides the loop mixing. For AM circuit, see the uPD2814/2816 block mixing diagram. NOTE: Most SSB chassis using this chip or the uPD858 (and some with MC145106 or uPD2824) have identical main chassis; the PLL chip is the only difference and all are designed for straight 91 to 135 N-Code division.

*1 = 10.695 MHz IF,
0 = 9.785 MHz IF
**R = 1, T = 0

LC7130/31 — U.S.
LC7135 — E.E.C.
LC7136/37 — U.K.
(Sanyo)



*Ch.9 & 19 called up when pins are HIGH
**R = 1, T = 0
***1 = Locked, 0 = Unlocked

MODELS

LC7130 OR LC7131:

Breaker 40FM, Cobra 19X, 19XS, 19+, 20+, 39LTD, 40+, 66LTD, 90LTD, Colt 210, Courier Classic IV, Galaxy IV, Galaxy V, Electrophone TX565, Fox CB340, CB911, G.E. 3-5805B, 5826A, K-40, Midland 102M, 103M, 151M, 202M, 2001, 3001, 4001, 76-300, 77-810, 77-911, Realistic TRC410, TRC414, TRC421A/422A, TRC428, RC472, SAM 2000, Uniden AX-11, PC77, Vice-President ROY

LC7136/LC7137:

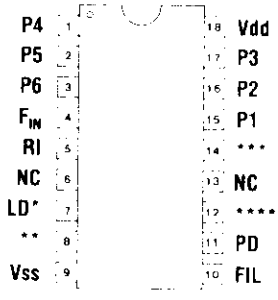
Academy 501, 502, Amstrad CB900, CB901, Barracuda GT868, HP940, Binatone 5-Star, Speedway, Cobra 21XFM, Colt 295, Commtron CB40F, Cybernet Beta 1000, 2000, 3000, Elftone ELCB6000, Fidelity CB300M, CB1000M, CB2000M, CB2001FM, Great GT858B, GT868B, Halcyon Cheetah, Condor, Harrier CBHQ, CBX, Harvard 400M, 402MPA, 420M, H401, Johnson XK2000, Lake 850, 950, Maxcom 4E, 6E, 16E, 20E, 21E, Midland 76-200, 2001, 2001T, 3001, 4001, Mustang CB1000, CB2000, CB3001, Nato 40FM, Oscar 1, Radiomobile 201, 202, Rotel RV220, RV230, RV240, Sapphire 2000X, Shogun, Sirtel Searcher, Steepletone SCB1FM, Transcom CBX2000, GBX4000, York JCP861, JCP863

No other U.K. models known at press time.

NOTES:
1. For LC7130, LD & MC are active HIGH; for LC7131/35/36/37, they are active LOW.
2. LC7131 & LC7137 can be interfaced to LC7181/LC7191 scanning system.
3. All chips use direct VCO division, ROM, 5 KHz steps, single 10.24 MHz crystal, and are impossible to modify.
4. LC7135 contains only the first 22 FCC channels in ROM for European spec.
5. Channel input codes are all BCD.
6. U.S. & U.K. differ only in ROM N-Codes.

See block mixing diagrams.

M58472P
(Mitsubishi)



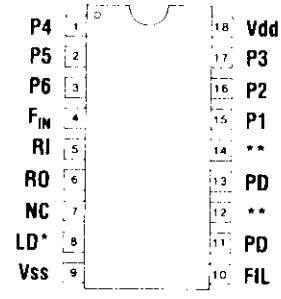
*1 = Unlocked, 0 = Locked
**Tied LOW
***1 presets 147 + N, 0 presets 102 + N
****Tied HIGH

MODELS

Channel Master CB6830, CB6832
G.E. 3-5800A, 5801A, 5810A, 5821A, 5871A
Teaberry Racer "T" (23 and 40 ch.), "T" Charlie

Obsolete chip with binary inputs. Reference Oscillator was 5.12 MHz. Used 5 KHz internal dividers. Easy modification by changing the loop mixing crystal.

M58473P
(Mitsubishi)



*1 = Unlocked, 0 = Locked
**1 = 147, 0 = 203 + N

MODELS

American Motors 32311847, 848, 849, 850
ITT 4400M
Kraco KCB-4005
Royce 1-632
Wards GEN-702A, 730A, 774A, 775A, 828A

Obsolete chip with binary inputs and Code Converter. Easy modification by changing the loop mixing crystal.

MB8719
MB8734
(Fujitsu)

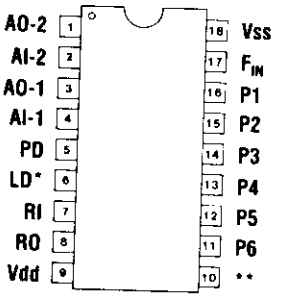
MODELS

U.S.:
Cobra 46/47XLR, 50/55XLR, Midland 63-445

Cobra 140/142GTL.
Courier Galaxy
Midland 79–900
President McKinley, Washington (new)
Realistic TRC450/490
Robyn SB505D (late)
SBE LCBS-8, LCMS-8
Teaberry Stalker IX, XV, XX
Tram D80/D300
(Single-conversion AM/SSB models)

Cobra 148/2000GTL
Uniden (President) new Grant, new Madison, Stalker XX export
Pearce-Simpson Bengal Mk II (Australian)
(Dual-conversion AM/SSB models)

Foreign:
Cobra 148GTL-DX (early; PC879)
Stalker 9-FDX, President McKinley (PC893)
President Grant (PC999)
All models shown in block mixing diagram.



*1 = Locked, 0 = Unlocked
**N-Code Select:
1 = 64 + N for use with 11.1125 MHz crystal,
0 = 128 + N for use with 11.3258 MHz crystal (This function not present in MB8734. U.S. models only.)

Pin 10 preset function normally pulls up HIGH

6-bit binary inputs
Pull-up resistors used

Used in the most popular Uniden chassis ever made. Still in current use worldwide, where it's been adopted to provide 80 or 120 channels and FM. All chassis very similar and FM/Loop Crystal PC boards often wired separately in the foreign models, or a pair of MC14008 binary adders is used to preset the chip's N-Codes, extending its range to cover 120 channels with one loop crystal. Easiest modification is by control of Pin 10, or by adding new loop crystals. (If MB8734 is used, it must be replaced by MB8719 first.)

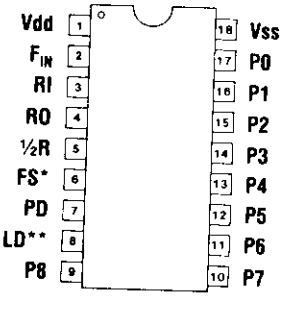
MC145106 (Motorola)
MM55106/116/126 (National)

MODELS

U.S.:
Browning Golden Eagle Mark IVA
DAK Mark V, Mark IX
Lake 600
Palomar SSB500 (late version; see uPD858 diagram.)
Regency CB501
Robyn 440
SBE Keycom
ARF-2001

Foreign:

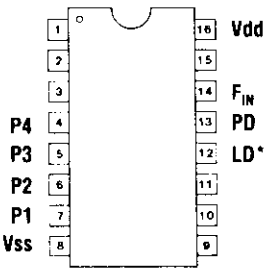
Cobra 148GTL-DX, Superstar 360FM (PB010; see block diagram.)
Excalibur base, Excalibur Samurai, Galaxy 2100, Galaxy II, Super Galaxy, President Franklin, Superstar 3600, 3900
President Jackson (PB042)
DNT M40FM, 2740FM (UK)
Stag 357, WKS1001 (similar to Palomar SSB500-late),
Vice-President FRANK, Colonel FR360, Pacific SSB800



*1 = 10 KHz steps, 0 = 5 KHz steps
**1 = Locked, 0 = Unlocked

The full pinout version of the Motorola series. Uses simple 9-bit binary programming with internal pull-down resistors on these pins. Foreign models often use two MC14008 binary adders to preset the program pins; this allows use of up to 120 channels with a standard 40-channel detent switch. Output of PD is negative-going; i.e., output is high level with low frequency input to Programmable Divider, and low level when input signal frequency is high.

MC14568 & MC14526 (Motorola)



SHOWN: MC14568
*1 = Locked, 0 = Unlocked

AM MODELS

Craig L101, L102
Lake 650
Royce 1-601
SBE 44CB (Malibu 40), 45CB (Trinidad III)

SSB MODELS

SBE 27CB/A (Sidebander IV)
39CB (Sidebander V)
40CB (Console V)

NOTE: This is early NDI Chassis. See block mixing diagram.

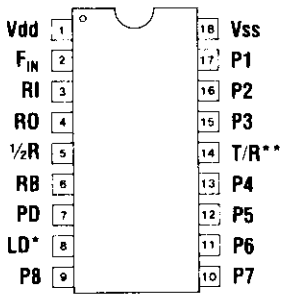
MC14568 is a Phase Comparator and Programmable Binary Counter; MC14526 is a 4-bit ÷ N Programmable Counter only. Both required to make up the 8-bit N-Codes. Weight of pins is:

MC14568
Pin 4 – 128 bit
Pin 5 – 64 bit
Pin 6 – 32 bit
Pin 7 – 16 bit

MC14526
Pin 2 – 8 bit
Pin 14 – 4 bit
Pin 11 – 2 bit
Pin 5 – 1 bit

An example of an early PLL device that required several discrete chips to form the loop. In the NDI chassis, these were replaced by a single NDC40013 chip. Compare both circuits in the block mixing diagrams.

MM55108 (National)



*1 = Locked, 0 = Unlocked
**R = 1, T = 0

U.S. MODELS

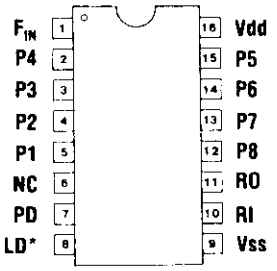
Lake 410

U.K. MODELS

Academy
Fidelity CB1000FM
Harvard 402MPA
Lake 850/950
Transcom GBX2000, GBX4000

An early National chip that never gained popularity in the U.S. Currently used in new U.K. FM rigs. Uses 455 KHz T/R shift, but program address is simple binary for modification use, with internal pull-down resistors on these pins. Negative-going PD output to VCO.

MSC42502P
(3001-201)



*1 = Locked,
0 = Unlocked

MODELS

General Motors (same as Johnson) GM4120, 4170, 4175

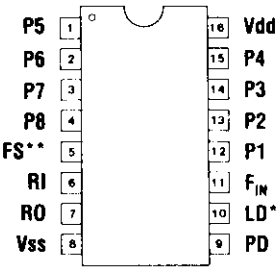
Johnson Messenger 191, 4120, 4125, 4135, 4140, 4145, 4230, 4250, Viking 200

Johnson Messenger 40, 50, 80, Viking 230, 260, 270, 430

Johnson Viking 4330, 4360

An early chip custom-made for the E.F. Johnson Company. Uses BCD inputs and internal pull-up resistors on the programming pins. The Reference Oscillator was always 5.12 MHz in this device. Several mixing schemes were used, and the above models are grouped by loop downmix frequencies into the chip. Modification by changing the BCD programming on the pins.

MSM5807
(OKI Semiconductor)



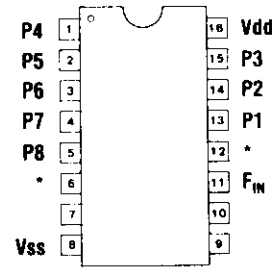
*1 = Unlocked, 0 = Locked
**1 = ÷512, 0 = ÷1024

MODELS

Alaron B-4900
Kraco KCB-4000
Palomar 49
Realistic TRC205
Tenna 10901, 10902, 11302

A very old obsolete chip. Programming is binary with internal pull-down resistors on the pins.

MSM5907
(OKI Semiconductor)



*Tied LOW

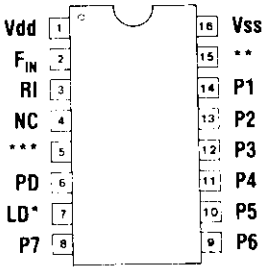
MODELS

Gemtronics GTX-4040, GTX-5000
Robyn T-240D
Shakespeare GBS-240
Teaberry Model "T"

A very early device, this is a Phase Comparator and Programmable Divider only. Used in conjunction with the MSL2301 Presettable Divider, in a manner very similar to the MC14568/MC14526 loop where several discrete devices were needed. Binary inputs are used.

The signal that drives the VCO comes from the MSL2301.

NDC40013
M58476
(Mitsubishi)



MODELS

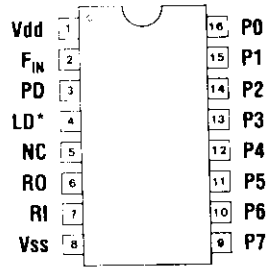
Craig L131/L231
Johnson Viking 4740, Messenger 4730
NDI PC200, PC201
Pace 1000MC
SBE Sidebander VI, Console VI
Tram D64

*1 = Locked, 0 = Unlocked
**Mode Select: 1 = AM/LSB, 0 = USB. Shifts Programmable Divider 1 bit (5 KHz) for SSB use.
***Tied HIGH

This chip uses binary inputs and was found in the late NDI chassis. Replaced the two discrete Motorola chips to create the exact same loop circuit.

Compare both circuits in the block mixing diagrams.

NIS7261A
(Suwa Seiko)



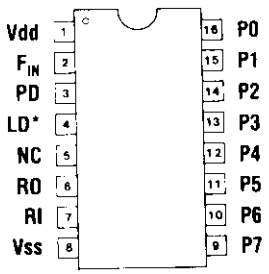
MODELS

Pearce-Simpson Jaguar 40B
Vector X, 770, 790

*1 = Locked, 0 = Unlocked

Both this chip and the NIS7264B shown below are identical except for the Reference Oscillator crystals. This one uses 10.24 MHz. Programming is binary. A very obsolete chip.

NIS7264B
(Suwa Seiko)



MODELS

Kraco KCB-4003, KCB-4088
Morse/Electrophonics 2001
Pace 8340
Surveyor 2630

*1 = Locked, 0 = Unlocked

Uses 11.52 MHz Reference Oscillator crystal. Programming is binary. A very obsolete chip.

PLL02A (NPC)
MC145109 (Motorola)
AN/MN6040 (Panasonic)
SM5109 (NPC)
TC9100P (Toshiba)
ECG1233 (Sylvania)

MODELS

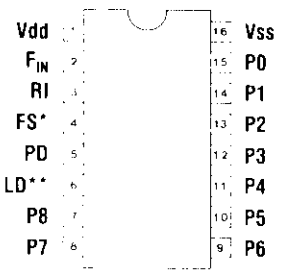
EARLY GENERATION AM, 3-CRYSTAL LOOP
(PCB: PTBM036/038A0X. See block mixing diagram.)

23 Channel:

Delco (GM) CBD-10, 1977/1978 series, G.E. 3-5810B, HyGain 681, 682, 2679, 2680, 2681, 2683, 2710X, 2716, 3084B, Kraco KCB2310B, 2320B, 2330B, Lafayette Com-Phone 23A, HB650, HB750, HB950, Micro 223A, Telsat 1050, Midland 13-830, 13-857B, 13-882C, 13-888B, 13-955, Pearce-Simpson Tiger Mk II, RCA 14T300, 14T301, Truetone MCC4434B-67, CYJ4732A-77

40 Channel:

HyGain 2679A, 2682, 2701, 2720, Pearce-Simpson Tiger 40A, Sears 60000



*1 = 10 KHz steps,
0 = 5 KHz steps

**1 = Locked, 0 = Unlocked

LATE GENERATION AM, 2-CRYSTAL LOOP, 40 CHANNEL
(PCB: PTBM049/051/057/092/095C0X. See block mixing diagram.)

Boman CB910, CB920, CB930, CBH990, Colt 290, 390, 800, SX33, Delco (GM) 1978 series, 120, Gemtronics GT44, GT55, GTX66, G.E. 3-5804D, 5811B, 5812A, 5813B, 5819A, Ham Int'l Puma, Viking, HyGain 2702, 2703, 3107, J.C. Penney 981-6204, 981-6218, JIL Citizen BPL524, Kraco KCB4010, 4020, 4030, 4045, 5001, 5003, Lafayette Comstat 525, HB640, HB740, HB940, LM100, LM300, Telsat 1140, Midland 76-858, 76-863, 76-886, 77-830, 77-838, 77-849, 77-857, 77-882, 77-888, 77-889, 77-899, 77-955, 77-963, Medallion 63-030, Mopar 4094176/77/78, Morse-Electrophonics 3005, Palomar 4100, Pearce-Simpson Lion 40, Super Lynx 18, Tiger 40, Ray Jefferson CB845, RCA 14T260, 14T270, 14T275, 14T303, 14T304, 14T305, Sears 60105, Truetone CYJ4832A-87, 4862A-87

FOREIGN MODELS OF ABOVE CHASSIS
(PCB: PTBM092/094/106A0X. May have the PTZZ033A0X FM bd. and/or Osc. unit bds.)

Colt 720, 870, Formac 88, 120, Ham International Puma, Viking, Major M540, Pearce-Simpson Superlynx 18

SSB CHASSIS (See block mixing diagram.)
Single PCB: PTBM048A0X, PTBM058C0X

AWA/Thorn 1503, Boman CB950, Cardon Iroquois 40, Colt 480, 485DX, 890, 1000, 1200 (Excalibur), Gemtronics GTX77, GE 3-5825A, HyGain 2705 (V), 2785, 3108 (VIII), J.C. Penney 981-6247, JIL Citizen MPL-5, SSB-M6, Lafayette Telsat SSB120, SSB140, Midland 78-976 79-892, Palomar 2900, Pearce-Simpson Super Panther, Super Bengal Mk I, RCA 14T302, Truetone CYJ4837A-87, Universe 5600

Double PCB: PTBM080/085C0X & PTRF004/005D0X)

DAK Mark X, G.E. 3-5825B, 3-5875A (Superbase), Midland 78-574, 78-999 79-891, SBE LCBS-4

FOREIGN "EXPORT" MODELS (May have FM, CW, Roger Beep, and up to 240 channels.)
Double PCB: PTBM059C0X & PTOS006A0X or PTSY016A0X

Ham International Concorde, Jumbo, Multimode II, HyGain V, Lafayette 1200FM, Major M360, M588

PCB: PTBM121D4X main bd.

Cobra GTL150, Colt 320DX, 320FM, 1200DX (Excalibur), Ham International Concorde II, Jumbo II, HyGain 2795DX, Intek 1200FM, Lafayette HB70AFS, Tristar 747

PCB: PTBM122D0X main bd.

Cobra 148GTL-B

PCB: PTBM125/131A4X main bd.

Colt 1600DX, 2000DX, HyGain 8795 (V), Lafayette 1800, Midland 7001 (export), Pacific 160, Superstar 2000, Tristar 777

PCB: PCMA001S main bd.

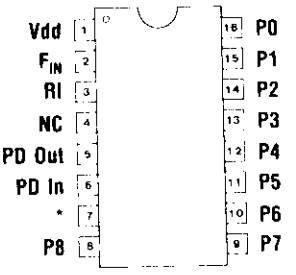
Argus 5000, Colt 2400, Cobra 148GTL-DX (fake), Falcon 2000, Lafayette 2400FM, Mongoose 2000, Nato 2000, Palomar 2400, 5000, Starfire DX, Superstar 2200, Thunder 2000, Tristar 797, 848

PCB: PTBM133A4X main bd.

Ham International Concorde III, Jumbo III, Multimode III

This is the big one, folks! The most popular chip ever made, still in worldwide use today. Chip is found in the Cybernet chassis. A member of the Motorola family, it uses straight binary programming with internal pull-down resistors and a negative-going PD output. Modification for additional channels is a simple matter of changing the programming or the loop mixing crystal(s) as discussed in Sections I & II. The chip is also widely used in the 18-Channel Australian rigs, where the only real difference is in the Channel Selector switch; i.e., replacing the switch with the 40-Channel version allows easy frequency expansion.

PLL01A (NPC)



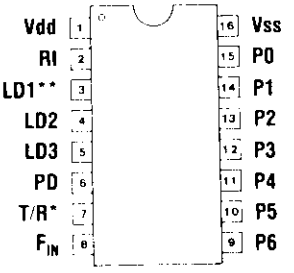
*Output of PROG. DIV. to PD

MODELS

HyGain 681, 682 (HyRange I & II)
Kraco KCB2310A, KCB2320A

An early predecessor to the PLL02A, before the chip technology got faster and more sophisticated. Programming is straight 8-bit binary. Reference Oscillator was 6.40 MHz due to slower speed of dividers. Used in a few old Cybernet chassis, such as PTBM027AOX, 029AOX.

PLL03A — U.S.
PLL08A — EEC
(NPC)



MODELS

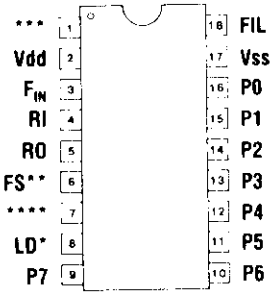
U.S.:
Delco (GM) 80BCB2, 90BCB1, 90BCB2, 90ECB1, 90BFTC1
G.E. 3-5813A, 5814A, 5817A, 5818A, 5819B, 5869A
JC Penney 981-6216
Midland 77-821, 77-859, 5001
SBE LCM-8

EEC:
Ham Int'l Hercules FM
HyCom CB2000, 3000, 4000
Major 3000
Multitech MS211
Midland 77-FM-005
(PCB:PTBM117AOX or similar)

*T = 1, R = 0
**Three LDs present. LD1 is active HIGH, LD2 is active LOW. LD3 not normally used.

First attempt to use ROM in this early generation chip. Loop downmix was still required due to slow divider speed. Binary inputs are converted by ROM to a divisor in the 1,200 range. Internal pull-down resistors on the program pins. The PLL08A has only the first 22 FCC channels stored in ROM for the European specs; otherwise both chips identical. See block mixing diagram.

REC86345



MODELS

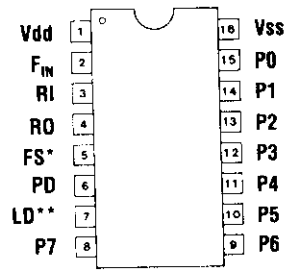
Courier Blazer 40D, Nightrider 40DR, Rangler 40D,
Renegade 40, Rogue 40
Fanon Fanfare 125F, 182F, 184DF, 185DF, 185PLL, 190DF,

Realistic TRC448

An early chip custom-made by Resdel, parent company of Fanon-Courier Corp. Uses simple 8-bit binary programming with internal pull-down resistors on the pins. See block mixing diagram for all the above models except the TRC448, which is SSB.

*1 = Locked, 0 = Unlocked
**0 = 10 KHz steps, 1 = 5 KHz steps
***AFC: Helps bring loop into lock. Is connected to VCO circuit.
****APC (Automatic Phase Control) switch. PD output feeds through this switch to VCO after lock-up.

SM5104 (NPC)
MC145104 (Motorola)
MM55104 (National)
MN6040A (Panasonic)
ECG1255 (Sylvania)



*1 = 10 KHz steps, 0 = 5 KHz steps
**1 = Locked, 0 = Unlocked

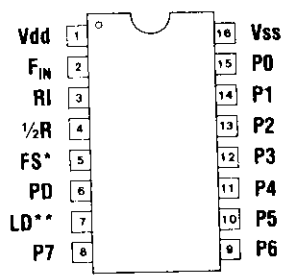
MODELS

AM:
Courier Caravelle 40D
Fanon Fanfare 880DF
Kris XL-45
Midland 77-825, 77-861
Motorola T4025A, CM540
Panasonic RJ3050, 3100, 3150
Pearce-Simpson Super Tiger 40A
Realistic TRC455
Robyn 007-140, DG-130D, GT-410D, LB-120, SX401, SX402D, WV-110
Utac TRX-4000, TRX-5000

SSB: (See block mixing diagram):
JC Penney 981-6241, 6246, 6248
Sears Roadtalker 934.3826, 3827, 3831

Another member of the Motorola family, almost identical to the PLL02A with one less binary bit but an on-chip oscillator for the 10.24 MHz input. Internal pull-down resistors on the program pins. Negative-going PD output to VCO. Easy modification by changing programming.

SM5107 (NPC)
MC145107 (Motorola)
MM55107 (National)



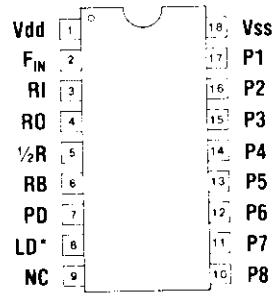
*1 = 10 KHz steps, 0 = 5 KHz steps
**1 = Locked, 0 = Unlocked

MODELS

Lafayette LM-200, Telsat 1240
Lake 650
Pace 8008, 8010A, 8015A, 8113, 8117, 8155
SBE 41CB (Aspen), 42CB (Cortez 40)
Sears 370.3805

Another member of the Motorola family but never a big one. Similar to the PLL02A, this one also requires an external Reference Oscillator circuit. It has only 8 bits of binary programming with internal pull-down resistors like the chip above, but this one also includes provision for the 5.12 MHz loop mixing output signal. Negative-going PD output to VCO.

SM5118
(NPC)



*1 = Locked, 0 = Unlocked

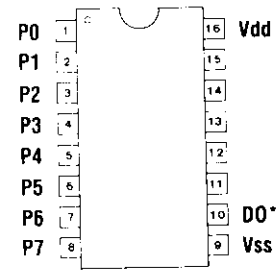
MODELS

AM/FM/IN-DASH AUTO RADIOS:
Automatic CBR-2175
Boman CBR-9940
Chrysler 4048076, 8077
Pearce-Simpson Leopard B
RCA 14T405, 14T410

STANDARD AM OR AM/SSB CB:
Pace CB185, 8046, 8047, 8092

Almost identical to the MM55108, minus the T/R pin. Programming is straight 8-bit binary.

TC5080P
(Toshiba)
Sub: ECG1207 (Sylvania)



*Divider Output to TC5081

MODELS

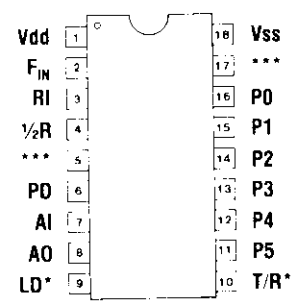
AM:
Browning Sabre, SST-2 (Same chassis for all of these except the Sharp.)
Cobra 32XLR, 86/87XLR
Kraco KCB4090, KCB4095
Sears 562.3820, 3822
Tram D42

Sharp CB750A, 800A, 2260, 2460 (All Sharp use same chassis)

SSB:
Browning Baron, Cobra 132/135XLR, Tram D62
(See block mixing diagram.)

This device is a simple binary Programmable Divider, used along with the TC5081 Phase Comparator and the TC5082 Reference Oscillator & Divider. Example of early PLL circuit that required several discrete chips to compose the loop, before LSI chips had evolved further.

TC9102
(Toshiba)



*1 = Locked, 0 = Unlocked
**T = 1, R = 0
***Tied LOW

MODELS

Midland 76-860, 77-861B

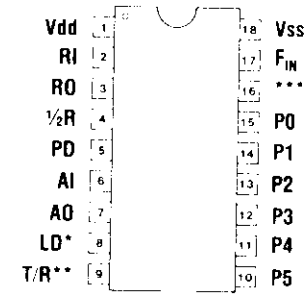
Sharp CB2170, 4370, 4470, 4670

Not a big one. Uses 5-bit binary channel programming with Programmable Divider preset to 91 + N in Receive mode and 182 + N in Transmit mode to produce 455 KHz T/R offset. Standard 16 MHz VCO. Requires an external 10.24 MHz transistor oscillator for the reference signal.

TC9103 (Toshiba)

MODELS

Medallion 63-540
Motorola CT95AOX
TRS Challenger 730, 1200
Wards GEN-680A, 696A, 716A



*1 = Locked, 0 = Unlocked
**T = 1, R = 0
***Tied LOW

Very similar to the TC9102, this chip also uses a 5-bit binary channel program with the Programmable Divider preset to 182 + N for Receive and 273 + N for Transmit to give the 455 KHz T/R offset. Internal division was 5 KHz. Unlike the TC9102, this chip contains its own oscillator, with only the 10.240 MHz external crystal required. Compare with TC9106, TC9109, and TC9119 which are basically identical but use a ROM Code Converter to prevent operator access to chip modifications.

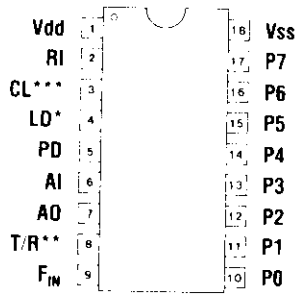
TC9106 (U.S.) TC9119 (U.K.) (Toshiba)

MODELS

TC9106:
Cobra 18/20LTD, 21/25GTL, 21/25LTD, 25LTD Classic
G.E. 3-5804B, 5804F, 5805, 5815A
Midland 77-824B, 200M
NDI PC101, PC102
President Andrew J, AR-7, AX-43, AR-44, AX-44, AR-711, AX-711
Realistic TRC425, TRC426, TRC427, TRC473, TRC474
Teaberry Stalker III
Uniden PC33, PC43, PC55, PC66, PRO540E

TC9119:
All Uniden chassis (Eg., PA-039)
Audioline 340, 341, 345, Tandy TRC2000, TRC2001, TRC2002, Uniace 100,200

No other legal U.K. rigs known at press time.



*1 = Locked, 0 = Unlocked
**T = 1, R = 0
***Tied to Ground by a capacitor, which determines the time constant for LD pin.

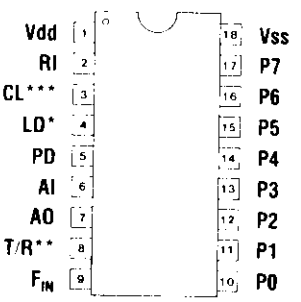
The beginning of the Impossible Chips! Uses double-ROM set which protects against illegal programming and also allows compatibility with 8-bit rotary LED Channel Selector. (See Figure 13, Section II.) Chips use direct division of a 16 MHz VCO, 5 KHz steps, and the only difference between them is the ROM N-Codes needed to divide down the different U.S./U.K. VCO frequencies.

See block mixing diagram.

TC9109 (Toshiba) MB8733 (Fujitsu)

MODELS

Cobra 19GTL, 19GTL AM/FM, 19LTD, 78X
Craig L103
G.E. 3-5804G, 5816, 5900A/C ("HELP")
President VEEP, AR-14, AX-14
Realistic TRC210, TRC411, TRC416, TRC429
SBE LCM5
Sears 663.3802, 38009
Teaberry Stalker IV, Stalker VIII
Uniden PC14

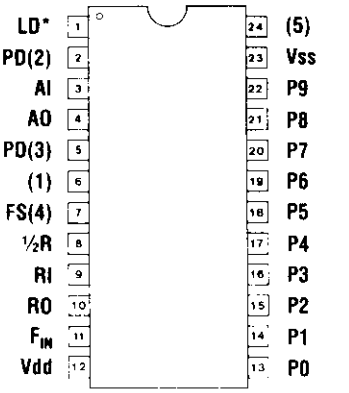


*1 = Locked, 0 = Unlocked
**R = 1, T = 0
***Tied to Ground by a capacitor, which determines the time constant for LD pin.

Very similar to above,the only difference is a special ÷ 2 circuit following the Reference Divider output inside the chip. The T/R count shifts up by 2,139 but is then divided in half, resulting in an output in the Transmit mode which can be easily doubled to provide the direct on-channel frequency.

See block mixing diagram.

uPD858 (NEC)
Sub: ECG1198 (Sylvania)



*0 = Locked, 1 = Unlocked
(1) Reference Divider Output
(2) Output
(3) Input
(4) 1 = 10 KHz steps,
0 = 5 KHz steps
(5) Programmable Divider Output

MODELS

AM, 2-CRYSTAL LOOP (See block mixing diagram):
Cobra 21X, 77X, Courier Rebel PLL, Rebel 40A, Fanon Fanfare 100F1, Midland 13-883B, 77-883, Realistic TRC452

AM, 3-CRYSTAL LOOP (See block mixing diagram):
Boman CBR-9600, Cobra 21XLR, 29/89XLR, President Dwight D (old), Honest Abe, John Q, Teddy R, Zachary T (old), Robyn AM500D, Teaberry T-Bear, T-Command, T-Dispatch, Titan-T

SSB (See block mixing diagram):

Cobra 138/13XLR, Palomar SSB500 (early), President Adams, Grant (old), Madison (old), Washington (old), Realistic TRC449, TRC457/458, Robyn SB51OD, SB520D, Stag 357, Teaberry Stalker 101, 102, 202, WKS1001

(single-conversion AM chassis)

Courier Gladiator PLL, Spartan PLL, Fanon Fanfare 350F, Midland 79-893

(single-conversion AM chassis)

Courier Centurion PLL, Centurion 40D

(dual-conversion AM chassis)

Used in one of the most popular Uniden chassis ever made. Easy to modify, and very broadbanded. Uses BCD programming with a potential of 399 channels. Program pins must be controlled externally with pull-down resistors such as illustrated in Figure 12 of Section II. More features in this chip than have ever been used! Many internal chip functions are brought out to pins which makes troubleshooting easier. No longer allowed to be used in new U.S. rigs, this chassis is now being widely used in Europe particularly by President, where they often add an extra 40 or 80 channels, and FM.

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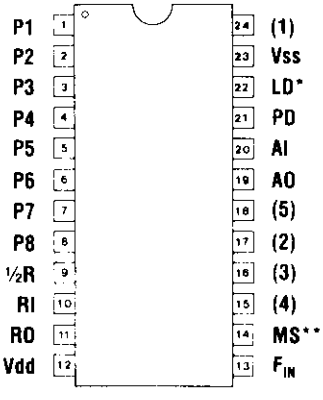
uPD861 (NEC)
Sub: ECG1254 (Sylvania)



*1 = Locked, 0 = Unlocked
** Mode Select: 1 = 40 Ch. BCD/ROM, 0 = 8-bit binary (N of 3 to 255) using pins 1–8.
(1) Inhibit. Goes HIGH in BCD/ROM mode for non-legal program. Disconnect if not already.
(2) Reference Divider output
(3) PD IN from REF. DIV.
(4) Programmable Divider output
(5) PD IN from PROG. DIV.

MODELS

AM, BINARY PROGRAM MODE (See block mixing diagram):
Panasonic RJ3250, RJ3450, RJ3600, RJ3660,
Realistic TRC424, TRC431, TRC456,
Superscope CB140, CB340, CB640, CB1040

AM, ROM/BCD MODE (See block mixing diagram):

Colt 350, Convoy CON-400, JC Penney 981-6203, 6221, 6225, 6237, 6255, Realistic TRC440, TRC461, TRC466/467, TRC468, SBE 49CB, (Tahoe 40), Sears 934.3806, 380807, 380817, 381107, 381207, TRS Challenger 460, 600

SSB

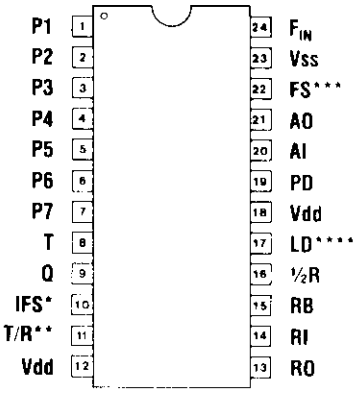
CDE Mark 26
Contact PSC301, Wagner 510 (Australian)
Pearce-Simpson Super Bengal Mk II (Australian)

Another very versatile chip, not seen much today. For rigs already in the Binary mode, it's a simple matter to expand. For the BCD/ROM rigs, simply ground Pin 14 and you can use all programming bits (Pins 1–8). Disconnect Pin 24. Many of the chip's internal functions are brought out to pins, which makes troubleshooting easier.

uPD2810 (NEC)

MODELS

Audiovox MDU-6000
TRS Challenger 850, 1400
Tristar 727



A very versatile chip no longer seen in the U.S. but showing up in European rigs. Uses 7-bit BCD/ROM programming with internal pull-down resistors on these and the IFS pins. T/R & FS pins use pull-up resistors. Several N-Code sets possible depending upon AM or SSB use and IF choice, very similar to LC7120. Examples for AM: With 10.695 MHz IF, N-Codes are 182 to 270 (RX) and 273 to 361 (TX); for 9.785 MHz IF, N-Codes are 364 to 452 (RX) and 273 to 361 (TX). Notice the 455 KHz may shift up *or* down on TX relative to whether the IF is above or below the 10.24 MHz reference signal. For SSB (TRS Challenger, Robyn SB540D with LC7120) T/R pin and ½R pins are not used; instead an actual crystal oscillator provides loop mixing.

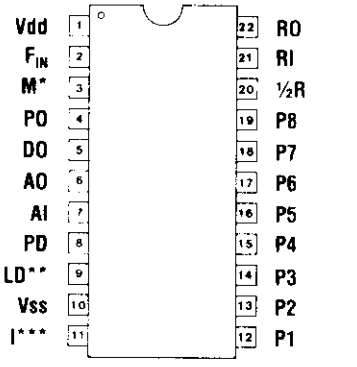
*IF Select: 1 = 10.695 MHz, 0 = 9.785 MHz
**R = 1, T = 0
***1 = 10 KHz steps, 0 = 5 KHz steps
****1 = Locked, 0 = Unlocked

---

uPD2812 (NEC)

MODELS

Audiovox MCB-5000
JIL 615 CB



Another versatile chip now extinct, this one allows a choice of binary (N = 3 to 255) or BCD/ROM (N = 182 to 226) programming, controlled by the level on Pin 3. Program pins use internal pull-up resistors.

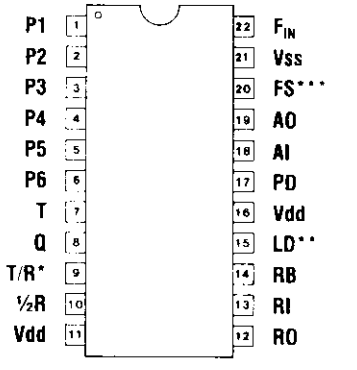
*Mode Select: 0 = Binary, 1 = 40-Channel BCD/ROM
**1 = Locked, 0 = Unlocked
***Inhibit. Goes LOW if illegal BCD code is present in the ROM mode.

---

uPD2814 (NEC) HD42853 (Hitachi) KM5624

MODELS

Cobra 66GTL
Craig L150
Midland 77-856
President AR-11, James K, Old Hickory
Realistic TRC420A, TRC421/422, TRC432, TRC441, TRC469
Uniden PC22



Another versatile chip similar to the uPD2810. Was originally intended for AM or SSB rigs but to date has only been used for AM. Uses 6-bit BCD/ROM programming with internal pull-down resistors. Pull-up resistors used on the T/R and FS pins. Thus for FS = 1 (10 KHz steps), N-Code is 91 to 135. For FS = 0, N-Code is 182 to 270 (RX) and 273 to 361 (TX) which is the standard AM chassis wiring. See block mixing diagram. NOTE: Australian rigs may use HD42856 which is identical but only has 18 channels stored in ROM.

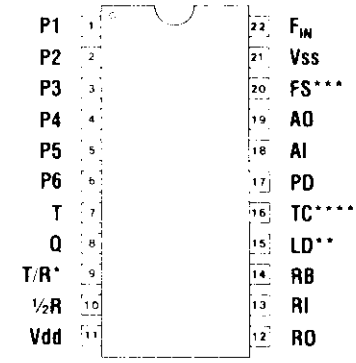
*R = 1, T = 0
**1 = Locked, 0 = Unlocked
***1 = 10 KHz steps, 0 = 5 KHz steps

uPD2816
(NEC)

MODELS

AM:
Cobra 29GTL, 29LTD, 29LTD Classic, 63GTL, 87/89/1000GTL
President Dwight D (new), Thomas J, Zachary T (new)
SBE LCB-8
Superstar 120
Teaberry Stalker V, XII
(See block mixing diagram.)

SSB:
Midland 6001, 7001 (early)
(See block mixing diagram.)



*R = 1, T = 0
**1 = Locked, 0 = Unlocked
***1 = 10 KHz steps, 0 = 5 KHz steps
****TC is a second unbuffered LD normally just tied HIGH.

Another versatile chip but quickly fading away in AM use for the more secure chips. Uses 6-bit BCD/ROM programming with internal pull-up resistors on the T/R, FS, and programming pins. With FS HIGH, divider uses 10 KHz steps with N-Codes of 91 to 135. With FS LOW, N-Codes are 182 to 270 when T/R is 1, and 273 to 361 when T/R is 0, yielding the standard 455 KHz AM IF offset. See block mixing diagram for AM rigs. For SSB use, T/R pin is not required.

NOTE: An interesting and simple modification for the SSB Midland is to switch the state of the T/R pin; this will give 40 channels beginning 455 KHz below normal Ch. 1.

---

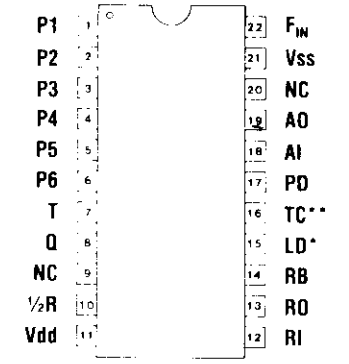
uPD2824
(NEC)

MODELS

Cobra 146GTL
Midland 6001, 7001 (late versions), 79-260
Pearce-Simpson Super Cheetah (Australian)
President AR-144, AX-144
Realistic TRC451
Sears 663.3810
Uniden PC244, PRO640E, PRO810E
(This is a current Uniden single-conversion SSB Chassis: PC833, PC965 or similar. See block mixing diagram.)

Realistic TRC453
Uniden PC122
(This is a current compact version of the above, PB062. Same PLL circuitry.)

Craig L132, L232
Wards GEN-719A
(This is an old Uniden SSB chassis, virtually identical in operation to the uPD858 chassis on Page 87 except for the chip; see block mixing diagram. The same 34 MHz VCO and individual loop mixing crystals for AM, LSB, and USB are also used here. The ROM N-Code is still the same, 91-135.



*1 = Locked, 0 = Unlocked
**TC is a second unbuffered LD normally just tied HIGH.

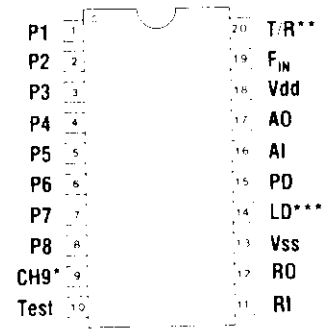
This is a cheap version of the above and is pin-for-pin identical except that it doesn't have the T/R pin. It was intended strictly for SSB synthesizers using either 1 or 2 crystals. To date, the single-crystal approach has been the only one used, as in the new Uniden chassis. In this application they use the tripled 5.12 MHz pin for loop mixing with a 16 MHz VCO, and a modification was discussed in Section II. The only N-Codes are 91 to 135.

LATE ADDITIONS

LC7132
(Sanyo)

MODELS

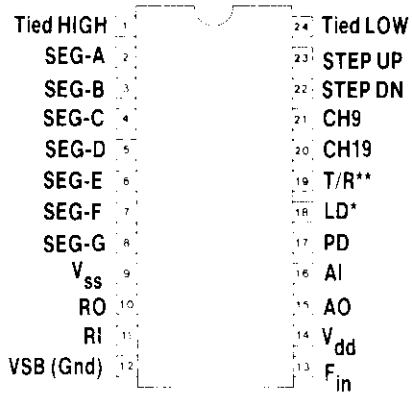
DNT 4000FM
Fox CB240, CB440
G.E. 3-5806, 3-5808, 3-5828A
Midland 77-104, 77-145, 77-145A, 77-149, 77-250, 77-805, 77-805A
Realistic TRC413, TRC415, TRC417, TRC418, TRC419, TRC423, TRC433



*Ch.9 called up when HIGH
**R = 1, T = 0
***1 = Locked, 0 = Unlocked

The newest American AM-only type chip, identical to the TC9109 and MB8733 (Page 84). ROM controlled with direct VCO division. Note it now uses 8 program lines rather than 6, with the Ch. 19 recall pin of the LC7130/31 series removed; only the Ch. 9 recall feature is retained. Again, not modifiable by normal methods. Found mainly in the Korean-made Maxon chassis types.

SM5123A
SM5125B

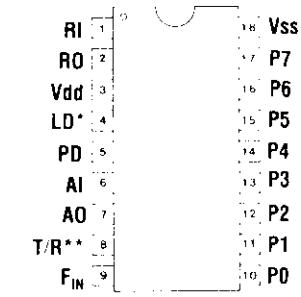


*1 = Locked, 0 = Unlocked
**R = 1, T = 0
Pins 20-23 active when LOW

Cobra 18 Plus, 21 Plus, 25 Plus, 29 Plus, 33 Plus

A new ROM chip which is identical in operation to the TC9106 on Page 83. The only real differences are the inclusion of Ch.9/Ch.19 pins (like the LC7131), 7 programming bits instead of 8, and UP/DOWN step pins. The step pins are required here because they've eliminated the expensive Channel Selector switch. Not easily modified.

SM5124A

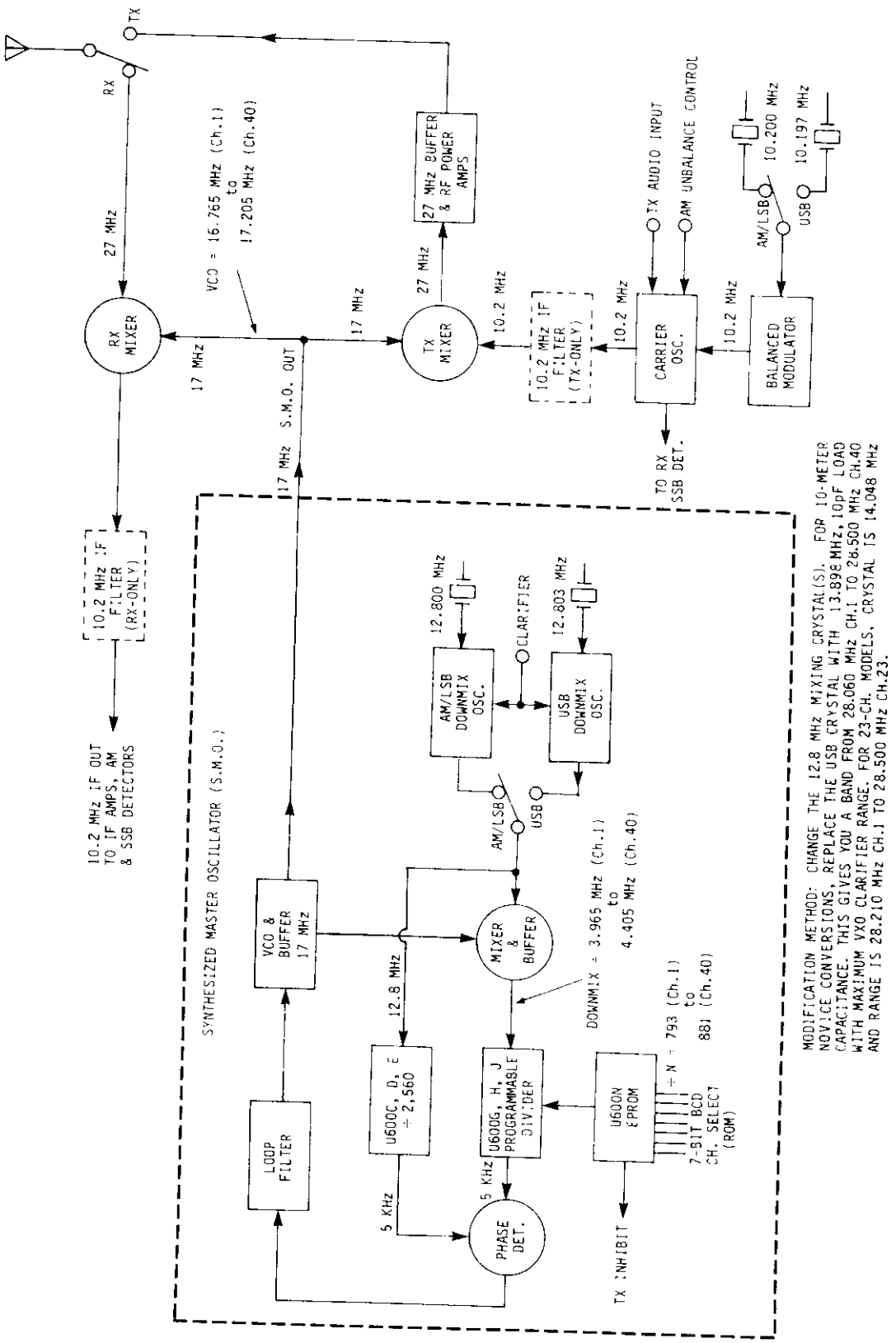


*1 = Locked, 0 = Unlocked
**T = 1, R = 0

Cobra 31 Plus
Uniden PRO330E, PRO510/520E, PRO710E

Another new ROM chip like the TC9106. The big difference is that this circuit shifts the VCO from 16 MHz on RX, directly to 27 MHz on TX by switching different inductances across the VCO coil. This saves the expense of one extra mixer stage. However, a 27 MHz VCO is extremely difficult to decouple on TX, resulting in possible spurious FM of the carrier. A very cheap design. Not easily modified either.

SIMPLIFIED PLL BLOCK DIAGRAM - CPI CP300, CP400, CP2000



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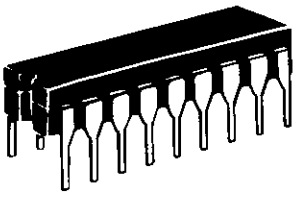

Author Lou Franklin (THE "SCREWDRIVER EXPERT'S" GUIDE) unravels more mysteries of CB Radio electronics — this time focusing on the Phase-Locked-Loop or PLL Frequency Synthesizer. This is the heart of every modern CB circuit, and one area which until now has given headaches to beginner and expert alike.

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