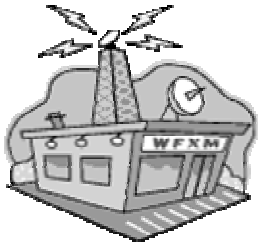
DIGITAL FM STEREO TRANSMITTER KIT



Ramsey Electronics Model No. FM30

A new and improved version of our popular stereo transmitter kits, the FM30 is an ideal upgrade for improved performance and ease of use! With a low-noise design and a metal case, the FM30 suffers from much less interference for a better S/N ratio. The FM30 also has full digital front panel control of output power, volume, balance, stereo/mono, and frequency!

- **Synthesized 87.9MHz to 108.1MHz for no frequency drift! Direct digital input of frequency, no jumpers or DIP switches!**
- **Designed for extruded, rugged metal case, all lines have RF chokes, and fully regulated for the cleanest sounding low noise performance yet!**
- **BNC style RF output for easy, reliable connections.**
- **Fully digitally controlled transmit power for custom coverage capabilities!**
- **Digital volume and balance controls for easy audio level adjustments.**
- **Runs from 13.8-16VDC, includes 15V DC adapter.**
- **Quality of signal indicator lets you know when you have a good signal or over-modulated signal. Lets you know when to turn it up, or down!**
- **Great for schools, health clubs, yard casting, drive-in movie theaters, haunted rides, amusement parks, churches, etc!**

PARTIAL LIST OF AVAILABLE KITS:

RAMSEY TRANSMITTER KITS

- **FM10A, FM25B, FM30, FM Stereo Transmitters**
- **FM100B, FM35 Professional FM Stereo Transmitters**
- **AM1, AM25 AM Broadcast Band Transmitters**

RAMSEY RECEIVER KITS

- **FR1 FM Broadcast Receiver**
- **AR1 Aircraft Band Receiver**
- **SR2 Shortwave Receiver**
- **AA7 Active Antenna**
- **SC1 Shortwave Converter**

RAMSEY HOBBY KITS

- **SG7 Personal Speed Radar**
- **SS70C Speech Scrambler/Descrambler**
- **TT1 Telephone Recorder**
- **SP1 Speakerphone**
- **MD3 Microwave Motion Detector**
- **PH14 Peak hold Meter**
- **LC1 Inductance-Capacitance Meter**

RAMSEY AMATEUR RADIO KITS

- **HR Series HF All Mode Receivers**
- **DDF1 Doppler Direction Finder Kit**
- **QRP Series HF CW Transmitters**
- **CW7 CW Keyer**
- **QRP Power Amplifiers**

RAMSEY MINI-KITS

Many other kits are available for hobby, school, scouts and just plain FUN. New kits are always under development. Write or call for our free Ramsey catalog.

FM30 Digital FM Stereo Transmitter Kit
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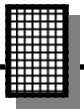

KIT ASSEMBLY
AND INSTRUCTION MANUAL FOR

DIGITAL FM STEREO TRANSMITTER KIT

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INTRODUCTION

The Ramsey FM30 is a true SYNTHESIZED STEREO FM broadcast transmitter, which any person may build and use in accordance with the rules of their nation's telecommunications authority. For U.S. residents, that authority is the Federal Communications Commission (FCC). The FM30's low-power broadcasting capability and other practical uses can be fun and interesting for people of all ages, but the FM30 is not a toy. We will refer to the FCC regulations frequently in this manual and provide you with some information necessary to enjoy the FM30's capabilities in accordance with the law.

Typical uses for the FM30 include the following:

- Extension of home stereo system and computer audio - without wires.
- Listening aid for auditoriums, churches.
- Student-operated school radio station.
- College dorm favorite music broadcast service.
- Drive-ins, haunted hayrides, amusement parks, etc.
- Short-range, two-channel experiments and demonstrations.

We think you will be very pleased with the transmitting range, low noise, audio quality, frequency stability and stereo channel separation of this build-it-yourself synthesized FM stereo transmitter. If you follow our assembly directions carefully and use your FM30 in accordance with applicable FCC rules, a whole new world of sharing music, news and views with friends and neighbors awaits you.

Since the sharing of music and information is vital to the culture of our 21st century global community, we realized that our FM30 low-power Synthesized FM Stereo Transmitter Kit was certain to attract worldwide interest among hobbyists, students and "pioneers." While the use of the FM30 may need to be limited to "wireless stereo extensions" in some USA households (to comply with FCC Rules, Part 15), we have seen it serve very well as a serious, though simple, broadcast station for remote villages throughout the world where low cost AM-FM receivers are available to people of all economic levels. After you're done building your kit, sitting back and listening to your handiwork, consider this: many other small transmitters like the FM30 are faithfully relaying news and information to listeners in remote areas around the world. The FM30 is most definitely not a toy!

FM35 CIRCUIT DESCRIPTION

We will begin by talking about the new and improved power supply section of the FM30. First off take a look at L1, C8, and C7. Does that look like anything familiar? That is a low-pass filter designed to remove any RF from leaving the power jack from the FM30, but more importantly from it entering back in! RF can easily get into power regulators and other components and cause them to “flake out” as we call it. The leads to hum and excessive noise in some cases, and can be very hard to remedy without these filters.

D1 is designed to protect you in the unlikely event that power is connected in reverse polarity. The diode is placed in-line with the power. Since a diode can only conduct in one direction, it prevents a reversed power supply from damaging your new FM30! We figured the addition of a 5 cent part was worth the peace of mind. C5 is another part used to reduce RF interference.

C13 is used to “smooth” any ripple there may be on the input to VR1, a 12VDC low dropout regulator. You may ask “what does low dropout mean?” No it doesn’t mean the regulator was made by a bunch of kids from a privileged school, it means that it can regulate lower voltages than it’s non-low dropout versions can. In this case to regulate to 12V, VR1 only needs about 0.8V across it, this means it can regulate 12.8V and up!

C9 is used in conjunction with VR1 for good regulation of the +12V. The +12V is then fed to VR2, a standard 5V regulator. This simply steps the +12V down to +5V for our logic and audio circuits. At this point our voltages are very well regulated for lowest noise! C10 works with VR2 for good regulation.

Now on to the audio input and control circuitry!

Audio is introduced into the FM30 at J8 (left) and J10 (right). For now we will only talk about the left channel, as the right channel is a duplicate of the left. Immediately after J8, you will notice L2 and C28. These parts are to prevent EMI produced from transmitting from getting into your FM30 and messing up the audio quality, similar to what we talked about in the power supply above. After this filter the audio goes into U4:A, a simple rail to rail opamp. R46, U2:A, and R43 set the gain of the opamp.

You may wonder, where the heck is U2:A? I don’t see any pots in my kit! Well, U2:A is a digitally controlled pot. Inside of the IC are a bunch of transistors switching in an out resistor arrays to make a digitally controlled variable resistance. In turn, this variable resistance controls the gain of U4:A, thus U2:A is the volume and balance control! We just happened to draw the IC like a pot in the schematic software to make more sense.

After this gain stage, the audio moves on to U5:B, another opamp

surrounded by a bunch of resistors and capacitors. This arrangement of parts is a low pass filter. This filter is designed to help reduce high-frequency audio signals from mixing with the stereo pilot signal and producing mixing products of various frequencies. Ok, perhaps that is too much to bite off. In layman's terms, this low pass filter prevents high frequency audio signals like symbols and chimes from getting garbled up during the creation of a stereo signal before transmission, so it increases the audio quality of the final transmitted signal.

This signal is then piped off to U3, the BH1415F stereo modulator IC. We wont get into that quite yet, because we have another circuit of importance before this that you will find to be very helpful to you during day to day use! Take a look at D9, D10, and R39. These are peak detectors that sample both the left and right channels and combine them together, which is presented on pin 3 of U5:A. The levels that these diodes detect are then compared against the constant voltage level seen on pin2 of U5:A. Right now R33 and R38 are not used, but are there in case the threshold needs to be changed in future revisions. Your product uses the 2.5V bias reference because it happened to be the correct value to detect audio peaks. Notice I used the term compare; U5:A is set up to be a comparator since it has no negative feedback.

Once the voltage on pin 3 surpasses that on pin 2 (our reference), the state of the output pin 1 of U5:A goes high (5V). If the voltage on pin 3 goes below that on pin 2, the output goes low (0V). The comparator is set up with these specific diodes and voltage reference so that audio peaks surpassing a very specific level flip the comparator state back and forth. This change of state is then sent to the microcontroller U1, and the program in there counts how many times this happens in an interval of time and then computes a quality of signal value for you. In our case, the comparator is designed to detect peaks over +/-75kHz of deviation, which is the standard bandwidth used by radio stations. If you run the volume up too high on the FM30, the comparator reference level is surpassed often, the micro counts this, and an indicator on the display will show a poor quality of signal indication.

Speaking of the reference voltage, all of the analog circuitry needs to be biased up at 1/2 of the supply voltage so that your audio signal has the greatest possible dynamic range. We would like the analog signals to be able to go all the way from 0V to 5V, and in order to do this with minimal distortion we need 2.5V. This bias voltage is generated with a simple resistor divider consisting of R22 and R24, and then noise filtered with C42 and C43. This voltage is then “amplified” with U5:D which is set at a gain of 1 and then distributed to the rest of the analog circuitry.

This leads us to the next important part of the circuit, the microcontroller. This section is essentially the “brains” of the show. The microcontroller does several things all of the time; it checks for button presses, it counts the quality

of signal information, it measures RF power, and it updates the display. The microcontroller also does important tasks like converting the frequency value to text on the display that you can read, and signals that the stereo modulator IC needs to go to that frequency. It also sends the proper signals to the level control IC U7, which is just a digital to analog converter, U4, the digital pot, and DS1, the LCD display. In all there is a lot going on inside of the microcontroller, and be glad you don't have to do things with a bunch of dip switches any more.

Now here comes the fun part, the stereo modulator IC, U3. This IC is a great little part, and contains a lot of circuitry that helps us get on the air with minimal fuss, and great sound. This IC not only contains a stereo multiplexer, but also a phase locked loop (PLL), audio filters, and equalizations.

The audio filter portion of the part adds a little more low-pass filtering to the audio to increase quality more than what our external low pass filter does on its own. The equalization portion enhances the high frequencies for the radio standard of 75uS in the US. 75uS is just a term used for a high-pass filter to enhance the high frequency audio before transmission to help reduce noise upon reception.

The PLL is the portion of the IC which locks your chosen transmission frequency to the crystal reference X1. The PLL portion also contains an oscillator circuit which works in conjunction with the external parts of D5 and the STUB (that weird trace on the back of the board). D5 is called a varactor diode, and is a special variety of diode that is connected backwards. As a reverse DC voltage is applied across the diode, its capacitance varies. The higher the voltage, the less the capacitance. This is due to depletion layers of the diode junction, but we wont get into details here. This variable capacitor in conjunction with the stub, which is actually an inductor (coil) is the basis of our voltage controlled oscillator! As the voltage increases across D5, the frequency of oscillation increases.

The stub is just acting like a coil in this circuit, and because it is part of the circuit board layout, it has a very predictable value. This prevents us from having to tune anything in this section like our old products. Just turn the unit on, and you are good to go! The best part of the stub is it's low sensitivity to microphonics. Microphonics is a term used for mechanical vibrations that are picked up in a VCO circuit by vibrating components changing in value because of mechanical shock. The sub value is very hard to alter from mechanical shock, and therefore quite immune to vibration.

So what actually tunes the VCO you may ask? Good question. A PLL uses a phase comparator to compare the crystal frequency with the oscillator frequency combined with some internal dividers which are programmable. If the frequency is too low, U3's PLL tells pin 7 to turn up the voltage. This signal

on pin 7 needs to be filtered and amplified for good control, and that is provided by Q2 and Q3, along with R18, R17, C34, R20, C38, R21, and C33. All of these parts together act like a low pass filter to slow the tuning time enough for our multiplex signal to still be transmitted, but the tuning signals to not be transmitted. The parts in this section are carefully chosen for best operation in audio performance, but have the drawback of being really slow to tune from one end of the dial to the other. To speed it up would mean to loose some of the low frequency response of our audio signal. In the case of the FM30, we have made the PLL very slow to pass low frequency audio very well for best quality. You will just have to be patient when you turn the unit on before you can begin transmitting. Since most of these transmitters are left running all the time on the same frequency, we knew this wouldn't be a problem for most of you.

Now there are some other tricks going on in the PLL and the VCO circuit which you may wonder about. What is the purpose of Q4? Well, because we are tuning a broad range of frequencies in the FM30, the VCO's tuning sensitivity vs. frequency can change quite a lot. Without this part a properly adjusted +/-75kHz FM stereo signal at 108.1MHz may be +/-250kHz by the time you get down to 88.1MHz! This is unacceptable, because it would be very hard to know when you were over-modulating without test equipment. This would also render the quality of signal detector useless that we have on the audio inputs. Q4 corrects the tuning sensitivity by acting like a variable pot based on the tuning voltage. As the tuning voltage goes down, Q4 is turned on more and more, which in turn allows less and less of the multiplex signal that is injected into the VCO from pin 5 of U3 to reach the VCO. It is a great little compensation circuit which keeps our signal within +/-10kHz of error across the band!

Now that we have our locked frequency and our multiplexed signal added to it we want to get the level up to where we can transmit it! The level directly out of U3 on pin 11 is small, just enough to cover a room, so we need to boost it a little. U8 is a high-gain amplifier which will get up the level for us so the FM30 has a little more "oomph". However we don't want too much "oomph" where we don't need it, so before the final amp we have D8, which is another special variety of diode called a pin diode. This diode has a neat way of working like a variable RF resistor. As you put more and more current through it, more and more RF will pass through it too. To vary the current through D8, we have U7, which is a digital to analog converter. This will generate from 0-5 volts in 256 steps, and in doing so, will drive D8 with 256 steps of current control, which gives us the ability to control output level quite a bit. L5 and C62 prevent RF from getting back into the gain control of U7 and messing it up.

The higher level RF out of U8 is then sent through a low pass RF filter to reduce harmonics, and finally to the output jack where you would connect an antenna. L6 is simply to provide a DC path to ground in case of any static

electricity or low frequency interference.

Whew, a lot to absorb here! Surprising how much great info can be gleaned from a kit, isn't it? We covered a lot of aspects of electronics here in one simple project, digital, power, RF, and analog. If you want more information on these subjects, there are a lot of great electronics books and websites out there, and here are some keywords to search for: COMPARATOR, VARACTOR DIODE, PIN DIODE, LOW PASS FILTER, DIGITAL POT, DAC (Digital to Analog Converter), JFET (Q4), MULTIPLEX.

Have fun and happy learning! Now on to the kit building...

-Ramsey Staff.

RAMSEY Learn-As-You-Build KIT ASSEMBLY

There aren't that many solder connections on the BL2 printed circuit board, but you should still practice good soldering techniques.

- Use a 25-watt soldering pencil with a clean, sharp tip, preferably a temperature regulated iron, but a standard 25W will do.
- Use only rosin-core solder intended for electronics use.
- Use bright lighting; a magnifying lamp or bench-style magnifier may be helpful.
- Do your work in stages, taking breaks to check your work. Carefully
- brush away wire cuttings so they don't lodge between solder connections.

We have a two-fold "strategy" for the order of the following kit assembly steps. First, we install parts in physical relationship to each other, so there's minimal chance of inserting wires into wrong holes. Second, whenever possible, we install in an order that fits our "Learn-As-You Build" Kit building philosophy. This entails describing the circuit that you are building instead of just blindly installing components. We hope that this will not only make assembly of our kits easier, but help you to understand the circuit you're constructing.

For each part, our word "Install" always means these steps:

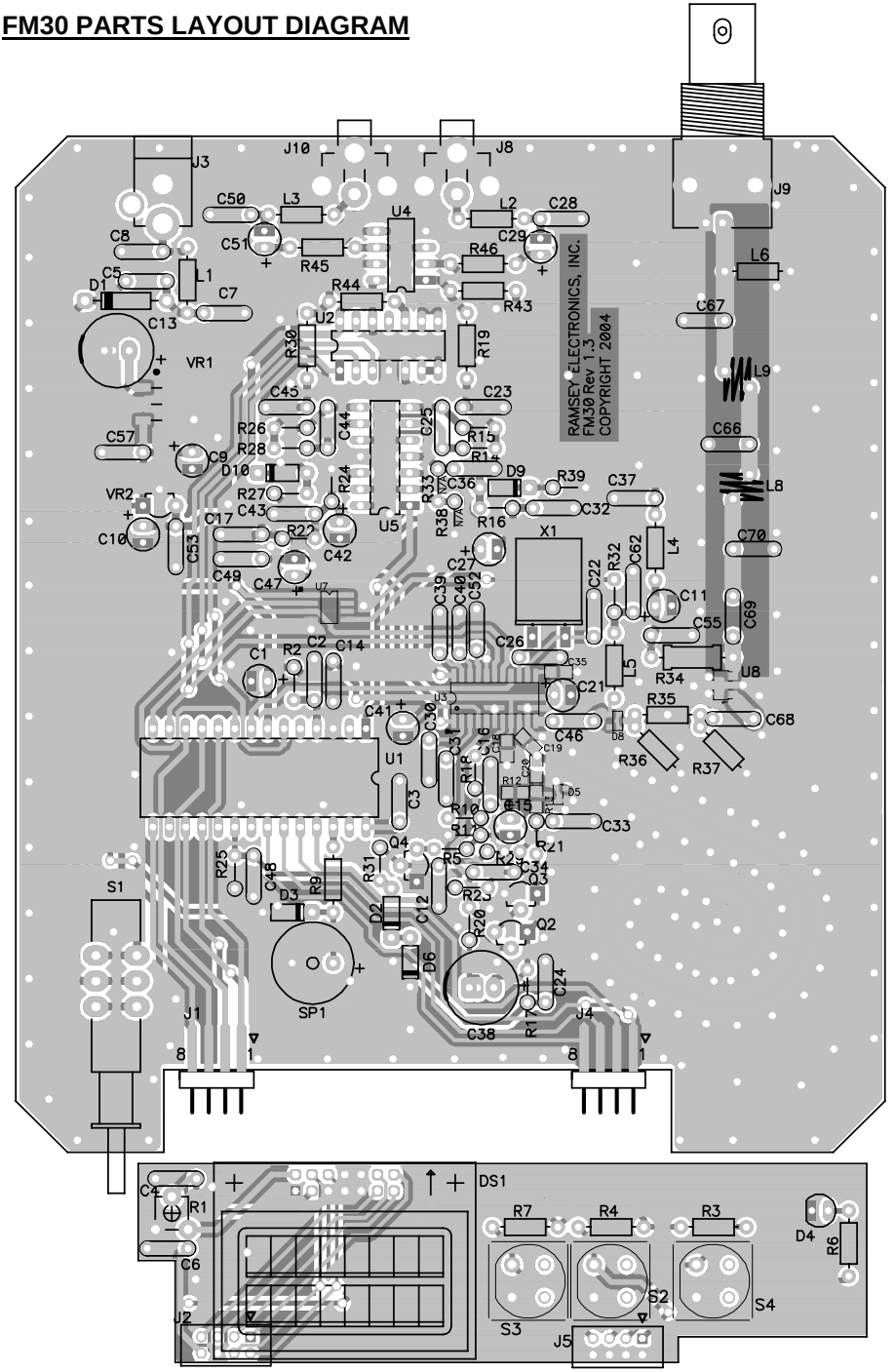
1. Pick the correct part value to start with.

2. Insert it into the correct PC board location.

3. Orient it correctly, follow the PC board drawing and the written directions for all parts - especially when there's a right way and a wrong way to solder it in. (Diode bands, electrolytic capacitor polarity, transistor shapes, dotted or notched ends of IC's, and so forth.)

4. Solder all connections unless directed otherwise. Use enough heat and solder flow for clean, shiny, completed connections.

FM30 PARTS LAYOUT DIAGRAM



FM30 PARTS LIST

SEMICONDUCTORS

- ☐ 1 LM940CS-12 12VDC low dropout regulator (VR1)
- ☐ 1 1N4000 series power diode (can be any number from 1N4002 to 1N4007 (Black body, grey stripe, marked 1N4002) (D1)
- ☐ 1 1N4148 Small signal switching diodes. (Marked 4148) (D3)
- ☐ 3 SD101 Shottkey switching diodes (orange body, black stripe, marked 101A) (D9,10,11)
- ☐ 2 2N3904 NPN transistors (marked 3904) (Q2,3)
- ☐ 1 J177 P-Channel JFET in a TO-92 (marked J177) (Q4)
- ☐ 1 78L05 5V regulator in a TO-92 package (marked LM78L05) (VR2)
- ☐ 1 LMC6482AIN Dual rail to rail opamp. (U4)
- ☐ 1 LMC6484AIN Quad rail to rail opamp. (U5)
- ☐ 1 28-pin microcontroller IC with sticker (U1)
- ☐ 1 MCP42010-I/P A dual 10k digital pot (U2)
- ☐ 1 Small green LED (D4)

RESISTORS

- ☐ 1 4.7 ohm resistor (yellow-violet-gold) (R35)
- ☐ 2 100 ohm resistors (brown-black-brown) (R43,44)
- ☐ 1 120 ohm 1/2 watt resistor (brown-red-brown) (R34)
- ☐ 1 180 ohm resistor (brown-grey-brown) (R20)
- ☐ 2 270 ohm resistor (red-violet-brown) (R6,9)
- ☐ 4 1k ohm resistors (brown-black-red) (R10,16,27,36,37)
- ☐ 2 2.2k ohm resistors (red-red-red) (R22,24)
- ☐ 2 3.3k ohm resistor (orange-orange-red) (R21,31)
- ☐ 1 4.7k ohm resistor (yellow-violet-red) (R17)
- ☐ 6 10k ohm resistors (brown-black-orange) (R2,3,4,7,32,39)\
- ☐ 2 16k ohm resistors (brown-blue-orange)(R45,46)
- ☐ 1 20k ohm resistor (red-black-orange) (R18)
- ☐ 2 27k ohm resistors (red-violet-orange) (R14,28)
- ☐ 1 33k ohm resistor (orange-orange-orange) (R29)
- ☐ 4 47k ohm resistors (yellow-violet-orange) (R23,25,)
- ☐ 4 56k ohm resistors (green-blue-orange) (R15,19,26,30)
- ☐ 1 10k ohm trim pot for display contrast. (Orange top, marked 103) (R1)

CAPACITORS

- ☐ 5 1nF or 0.001uF ceramic disc capacitors (marked 102) (C5,33,46,68,69)
- ☐ 9 10nF or 0.01uF ceramic disc capacitors (marked 103) (C3,4,7,8,12,32,49,53,55)
- ☐ 10 0.1uF ceramic disc capacitors (marked 104) (C6,14,17,24,36,37,43,48,57,62)
- ☐ 1 10pF ceramic disc capacitor (marked 10) (C2)
- ☐ 2 33pF ceramic disc capacitors (marked 33) (C22,26)

☐ 1 47nF or 0.047uF ceramic disc capacitor (marked 473) (C34)
☐ 2 47pF ceramic disc capacitors (marked 47) (C67,70)
☐ 1 75pF ceramic disc capacitor (marked 75) (C66)
☐ 5 100pF ceramic disc capacitors (marked 101) (C16,25,28,44,50)
☐ 2 150pF ceramic disc capacitors (marked 151) (C31,40)
☐ 2 560pF ceramic disc capacitors (marked 561) (C23,45)
☐ 2 3300pF ceramic disc capacitors (marked 332) (C30,39)
☐ 3 100uF electrolytic capacitors (C13,38, R5[no kidding!])
☐ 12 10uF electrolytic capacitors (C1,9,10,11,15,21,27,29,41,42,47,51)

MISCELLANEOUS
☐ 1 28 pin socket (for U1)
☐ 1 PCB Mounted BNC connector (J9)
☐ 1 2x8 line LCD display (DS1)
☐ 1 14-pin dual row connector (for DS1)
☐ 1 DPDT Power switch (S1)
☐ 6 2.2uH inductors (green body, red-red-gold-silver) (L1,2,3,4,5,6)
☐ 2 4 turn air core inductors (L8,9)
☐ 1 2.1mm center post positive power jack (J3)
☐ 2 RCA audio jacks (J8,J10)
☐ 2 8-pin dual row connectors (J2,5)
☐ 1 Mini speaker (SP1)
☐ 3 Momentary buttons (S2,3,4)
☐ 1 7.6MHz Crystal (Marked 7.600) (X1)
☐ 1 Switch cap
☐ Case Top & Bottom, screws for case
☐ Front and rear panels
☐ 1 15VDC power supply
☐ 1 Whip antenna

SURFACE MOUNT PARTS, PREINSTALLED
☐ 1 BBY40 Varactor diode. SOT23 package (marked S2) (D5)
☐ 1 1SV172 Pin Diode. SOT package. (Strange B and E marking) (D8)
☐ 2 0.1uF ceramic surface mount capacitors (C18,35)
☐ 2 470pF ceramic surface mount capacitors (C19,20)
☐ 1 BH1415F Stereo Modulator IC (U3)
☐ 2 10K ohm surface mount resistors (marked 103) (R12,13)
☐ 1 TC1320EOA Digital to analog converter (U7)
☐ 1 GAL5 DC-8GHz monolithic RF amplifier (U8) Marked o5

FM30 PC BOARD ASSEMBLY STEPS

The FM30 is one of our larger, more complicated kits, however, if you follow the steps closely you will find that it will go together smoothly. We will start with the larger main PC board. We'll have a working kit in no time!

❒ 1. The first thing you'll have to do is to separate the front panel PC board from the main PC board. Simply grasp the two boards and carefully snap them apart.

❒ 2. Once you have the boards apart you'll notice that there are little tabs left where the boards used to be connected. You'll want to trim these down so that the board fits into the case correctly. Take your sidecutters and nip off the excess board material, then take some sandpaper or borrow your wife's emery board to sand down what's left. But don't tell your wife that we told you to borrow the emery board!!

❒ 3. Now we'll install a surface mount part but don't worry, it's not a difficult one. We've placed all the tough ones on the board for you and left you the regulator VR1, LM940CS-12 12VDC low dropout regulator. The first thing to do is to tin the large pad that the body of the regulator will sit on. Tinning means to melt a small amount of solder on that pad. Next, place the part on the large pad so that the legs line up with their individual, smaller pads. Once you're sure everything is aligned properly, solder the three leads of the part. With those soldered, you're going to solder the large metal tab on the part to the pad you tinned earlier. Hold your iron down on the large metal tab on the regulator while pressing it onto the tinned pad until you see the solder flow. That should hold things in place and should also provide a heatsink for the part.

❒ 4. Install U5, the LMC6484AIN quad rail to rail opamp. We're starting with the ICs so that you can use the PC board to keep the part flat until you solder it. Follow the dot or notch on the chip and match it to the silkscreen marking or Parts Layout Diagram for proper placement. Make sure that all the pins are through the board and none are bent under or sticking out, then slightly bend two corner pins to keep the IC from falling out when you flip the board over. Check to be sure that the part is flat to the PC board, then solder all 14 pins.

❒ 5. Install U2, an MCP42010-I/P dual 10K digital pot. Follow the notched end for correct placement and make sure you solder all the pins.

❒ 6. Install U4, the LM6482 dual rail to rail opamp, following the same procedure as the last two ICs.

❒ 7. Install the socket for U1, the 28 pin microcontroller IC. Install the socket the same way you installed the ICs in the above steps, making

sure the part is flush to the PC board before soldering and placing the notched end as shown on the Parts Layout Diagram and PC board silkscreen.

❒ 8. You can now place the microcontroller in the socket you just installed. Be sure the notched end is placed correctly and press the chip into the socket, then check for bent under or bent out pins.

Now we'll start installing the rest of the components starting at the corner of the board near J3. Place the board so that you can read the writing on it right-side up.

❒ 9. Install C8, 10nF or 0.01uF ceramic disc capacitor (marked 103). Disc caps have no polarity and can be installed in either direction. We'll always let you know when you have to be particular about how to install a component.

❒ 10. Install C5, 1nF or 0.001uF ceramic disc capacitor (marked 102).

❒ 11. Install D1, a 1N4000 series diode (1N4002—1N4007). Note the stripe or band on one end of the part and the stripe marked on the PC board silkscreen and Parts Layout Diagram. This diode must be placed correctly to function properly. Line the part up with the mark on the board and solder it in place.

❒ 12. Install L1, 2.2uH inductor (green body, red-red-gold-silver).

❒ 13. Install C7, 10nF or 0.01uF ceramic disc capacitor (marked 103).

❒ 14. Install C50, 100pF ceramic disc capacitor (marked 101).

❒ 15. Install L3, 2.2uH inductor (green body, red-red-gold-silver).

❒ 16. Install R45, 16k ohm resistor (brown-blue-orange).

❒ 17. Install C51, 10uF electrolytic capacitor. Electrolytic caps have a polarity and must be installed correctly in order to work . . . and in some cases in order not to blow up when power is applied! You'll note that the legs of the part are different lengths and there is a stripe or band down one side of the capacitor that corresponds to the shorter of the two leads. This is the negative side of the cap. The silkscreen and Parts Layout Diagram will show where the positive lead is to be placed by a "+" sign on the board. Orient the part with the longer lead in the "+" hole and solder the part in.

❒ 18. Install R44, 100 ohms (brown-black-brown).

❒ 19. Install R30, 56k ohms (green-blue-orange).

❒ 20. Install C13, 100uF electrolytic capacitor. Remember to orient the longer positive lead with the '+' sign on the board before soldering.

- ❒ 21. Install C44, 100pF (marked 101).
- ❒ 22. Install R24, 2.2k ohms (red-red-red). This resistor is installed in standup fashion; simply place one lead of the part into the hole marked with a circle then bend the other lead over to fit in the other hole for R24. Solder as usual.
- ❒ 23. Install C45, 560pF disc capacitor (marked 561).
- ❒ 24. Install R26, 56k ohm resistor (green-blue-orange).
- ❒ 25. Install R28, 27k ohms (red-violet-orange).
- ❒ 26. Install D10, SD101 Shottkey diode (marked SD101A). Follow the band on the PC board and the band on the diode for orientation.
- ❒ 27. Install R27, 1k ohm resistor (brown-black-red).
- ❒ 28. Install C43, 0.1uF ceramic disc capacitor (marked 104).
- ❒ 29. Install C42, 10uF electrolytic capacitor. Remember to watch the polarity when installing.
- ❒ 30. Install R22, 2.2k ohms (red-red-red).
- ❒ 31. Install C47, 10uF electrolytic. Do I have to remind you about the polarity again? No, I didn't think so.
- ❒ 32. Install C17, 0.1uF ceramic disc capacitor (marked 104).
- ❒ 33. Install C49, 10nF or 0.01uF ceramic disc capacitor (marked 103).
- ❒ 34. Install C57, 0.1uF ceramic disc capacitor (marked 104).
- ❒ 35. Install C9, 10uF electrolytic cap. Remember polarity!
- ❒ 36. Install VR2, 78L05 (marked LM78L05). Bend the center lead out and place the flat side as shown on the silkscreen. Solder all three leads.
- ❒ 37. Install C53, 10nF or 0.01uF ceramic disc capacitor (marked 103).
- ❒ 38. Install C10, 10uF electrolytic cap. Check placement before soldering.
- ❒ 39. Install C1, 10uF electrolytic capacitors, below and to the right of C10. It's another electrolytic but you're an old pro at these by now so I won't remind you to be sure to line up the longer lead with the hole marked "+".
- ❒ 40. Install R2, 10k ohm resistor (brown-black-orange).
- ❒ 41. Install C2, the only 10pF capacitor (marked 10).
- ❒ 42. Install C14, 0.1uF ceramic disc capacitor (marked 104).

Well, we've made some good progress so far and your board is starting to have a few parts on it. Take a break if you need to and we'll start again in the area right below J8, assuming you're orienting the board so that you can read the silkscreen and it isn't upside down. I'll go warm up my forgotten coffee and be right back.

Ok, break's over. Let's keep going.

- ❒ 43. Install L2, 2.2uH inductor (green body with red-red-gold-silver bands).
- ❒ 44. Install C28, 100pF ceramic disc capacitor (marked 101).
- ❒ 45. Install C29, yet another 10uF electrolytic cap. Orientation!
- ❒ 46. Install R46, 16k ohm resistor (brown-blue-orange).
- ❒ 47. Install R43, 100 ohms (brown-black-brown).
- ❒ 48. Install R19, 56k ohms (green-blue-orange).
- ❒ 49. Install C25, 100pF ceramic disc capacitor (marked 101).
- ❒ 50. Install C23, 560pF disc capacitor (marked 561).
- ❒ 51. Install R15, the last 56k ohm resistor (green-blue-orange).
- ❒ 52. Install R14, 27k ohm resistor (red-violet-orange).
- ❒ 53. No part is installed in the R33 position; this part was left in place in case we need it in the future.
- ❒ 54. As with R33 above, install nothing in the space set aside for R38.
- ❒ 55. Install C36, 0.1uF ceramic disc capacitor (marked 104).
- ❒ 56. Install D9, another SD101 Shottkey diode (marked SD101A). Again, follow the silkscreen and banded end of the part for correct placement.
- ❒ 57. Install R16, 1k ohm resistor (brown-black-red).
- ❒ 58. Install C27, a 10uF electrolytic capacitor. Remember that the long lead should be placed in the hole marked with the "+" sign.
- ❒ 59. Install C32, 10nF or 0.01uF ceramic disc capacitor (marked 103).
- ❒ 60. Install R39, 10k ohm resistor (brown-black-orange).
- ❒ 61. Install C37, 0.1uF ceramic disc capacitor (marked 104).
- ❒ 62. Install C39, 3300pF ceramic disc capacitor (marked 332).
- ❒ 63. Install C40, 150pF ceramic disc capacitor (marked 151).

- ❒ 64. Note the silkscreen position for C52. This part is not installed; leave the space for C52 empty.
- ❒ 65. Install C26, 33pF ceramic disc capacitor (marked 33).
- ❒ 66. Install C22, the other 33pF ceramic disc capacitor.
- ❒ 67. Install X1, the 7.6MHz crystal (marked 7.600). Place the leads in the holes then bend the part over so that it fits in the silkscreen outline. Solder both leads.
- ❒ 68. Install R32, 10k ohms (brown-black-orange).
- ❒ 69. Install C62, 0.1uF ceramic disc capacitor (marked 104).
- ❒ 70. Install L4, 2.2uH inductor (green body with red-red-gold-silver bands).
- ❒ 71. Install C11, 10uF electrolytic capacitor. Again, be careful to follow the silkscreen when installing.
- ❒ 72. Install L5, 2.2uH inductor (green body with red-red-gold-silver bands).
- ❒ 73. Install C55, 10nF or 0.01uF ceramic disc capacitor (marked 103).
- ❒ 74. Let's move toward the back of the board, near J9, and install L6, 2.2uH inductor (green body with red-red-gold-silver bands).
- ❒ 75. Install C67, 47pF ceramic disc capacitor (marked 47).
- ❒ 76. Install L9, 4 turn air coil.
- ❒ 77. Install C66, 75pF ceramic disc capacitor (marked 75).
- ❒ 78. Install L8, the other 4 turn air coil.
- ❒ 79. Install C70, 47pF ceramic disc capacitor (marked 47).

The caps and coils you just installed are the output filter for the kit.

- ❒ 80. Install C69, 1nF or 0.001uF ceramic disc capacitor (marked 102).
- ❒ 81. Install R34, 120 ohm 1/2 watt resistor (brown-red-brown). This part is easy to recognize because it's larger than the other resistors.
- ❒ 82. Install C21, 10uF electrolytic cap. Yes, watch your polarity.
- ❒ 83. Install C46, 1nF or 0.001uF ceramic disc capacitor (marked 102).
- ❒ 84. Install R35, 4.7 ohms (yellow-violet-gold).
- ❒ 85. Install C68, 1nF or 0.001uF ceramic disc capacitor (marked 102).

- ❒ 86. Install R36, 1k ohms (brown-black-red).
- ❒ 87. Install R37, 1k ohms (brown-black-red).
- ❒ 88. Install C41, 10uF electrolytic. Remember that polarity is still important!
- ❒ 89. Install C3, 10nF or 0.01uF ceramic disc capacitor (marked 103).
- ❒ 90. Install C30, 3300pF (marked 332).
- ❒ 91. Install C31, 150pF (marked 151).
- ❒ 92. Install R18, 20k ohms (red-black-orange).
- ❒ 93. Install C16, 100pF capacitor (marked 101).
- ❒ 94. Install R25, 47k ohms (yellow-violet-orange).
- ❒ 95. Install C48, 0.1uF ceramic disc capacitor (marked 104).
- ❒ 96. Install D11, SD101 Shottkey diode (marked SD101A). Follow the band on the PC board and the band on the diode for orientation.
- ❒ 97. Install R9, 270 ohms (red-violet-brown).
- ❒ 98. Install D3, 1N4148 small signal switching diode. This part has a banded end that must be lined up with the band on the silkscreen and Parts Layout Diagram.
- ❒ 99. Install SP1, the mini speaker. You'll see a "+" sign on one side of the part and the same "+" sign on the board. Line these two up and solder the part.
- ❒ 100. Install R31, 3.3k ohms (orange-orange-red).
- ❒ 101. Install Q4, a J177 P-Channel JFET in a TO-92 package. Notice the flat side on the part and the flat side shown on the PC board. Line the part up with the flat side and bend the center lead out so that the part fits in the board correctly. Push it down but not to the point of stressing the leads, then solder all three leads in place.
- ❒ 102. Install a wire jumper in the spot designated for D2. Simply bend a scrap component lead into the shape of a staple and solder it where the board is marked for D2. Nope, there's no polarity with a piece of wire! This part was replaced by a jumper to improve the operation of your FM30.
- ❒ 103. Install another wire jumper in the D6 position. Just like D2 before, this part was removed and we need to put a jumper in its place.
- ❒ 104. Install R10, 1k ohms, (brown-black-red).

FM30 SCHEMATIC CENTERFOLD

❒ 105. You'll see a place on the board for R11. Install no part in this position.

❒ 106. Install R5, 100uF electrolytic cap. Yes, it's a little unconventional but it was a late parts change and we knew you could handle it. The shorter negative lead is placed in the hole facing Q4. Get it in place as well as you can and solder it in.

❒ 107. Install C12, 10nF or 0.01uF ceramic disc capacitor (marked 103).

❒ 108. Install C15, 10uF electrolytic. This one's a little weird because the "+" sign is inside the "C" of the silkscreen, but it's there so follow it for orientation.

❒ 109. Install R29, 33k ohms (orange-orange-orange).

❒ 110. Install C34, 47nF or 0.047uF ceramic disc capacitor (marked 473).

❒ 111. Install R23, 47k ohms, (yellow-violet-orange).

❒ 112. Install R20, 180 ohms (brown-grey-brown).

❒ 113. Install R21, 3.3k ohm resistor (orange-orange-red).

❒ 114. Install C33, 1nF or 0.001uF ceramic disc capacitor (marked 102).

❒ 115. Install Q3, 2N3904 NPN transistor. Follow the flat side on the part and the Layout Diagram for correct placement.

❒ 116. Next install Q2, another 2N3904 NPN transistor. Again, orient the part using the flat side of the transistor.

❒ 117. Install R17, 4.7k ohms (yellow-violet-red).

❒ 118. Install C24, 0.1uF ceramic disc capacitor (marked 104).

❒ 119. Install C38, 100uF electrolytic capacitor. Just as you did with all the others, follow the "+" sign on the board so you'll know how to install this part.

Now we'll place some of the larger parts, the jacks and switches, then we'll move on to the smaller front panel PC board.

❒ 120. Since we're in the area, install S1, the DPDT power switch. Make sure it is seated flat on the PC board before soldering.

❒ 121. Moving on to the back of the board, install J3, the 2.1mm center post positive power jack. Again, be sure the part is flat before soldering.

❒ 122. Install J10, one of the RCA jacks.

❒ 123. Install J8, the other RCA jack.

❒ 124. Install J9, the PCB mounted BNC connector.

Take a look over your PC board and check for unsoldered components or anything that looks less than perfect. You'll have to be sure everything is right before moving on to the small front panel board because once we're finished with that we'll be firing this kit up. You'll want to be confident that nothing will burn up or blow up once power is applied!

❒ F1. On the front panel PC board, install C4, 10nF or 0.01uF ceramic disc capacitor (marked 103).

❒ F2. Next we'll install R1, the 10k ohm trim pot (Orange top, marked 103). It only fits in the board one way, however, we're going to place it on the back side of the board, the side you've been soldering to so far. This is so that you can adjust the contrast without pulling the board out of the case. Simply place it into the holes for it on the backside of the board and be sure the part is flush to the PC board before soldering all three leads on the front of the board. It's a little unconventional but much more user friendly this way.

❒ F3. Install C6, 0.1uF ceramic disc capacitor (marked 104).

❒ F4. Install R7, 10k ohms (brown-black-orange)

❒ F5. Install R4, also a 10k resistor (brown-black-orange).

❒ F6. Install R3, yet another 10k ohm resistor (brown-black-orange).

❒ F7. Now we'll install S3, one of the momentary buttons. You'll see that the part has a flat side and the silkscreen shows you where to place that flat side on the board.

❒ F8. In the same way, install S2.

❒ F9. Install the last momentary switch, S4.

❒ F10. Install R6, 270 ohms (red-violet-brown).

❒ F11. Next we'll install J2 and J5, the two 8-pin dual row connectors. These will be used to attach the front panel PC board to the main board. They are placed from the back side of the board similar to how you placed R1. This is the side you've been soldering to that has no silkscreen on it. The shorter pins go through from the back of the board and are soldered on the front, leaving the longer pins to be connected to the main PC board in a later step. Be sure these parts are seated nice and flat before soldering.

❒ F12. The next part we'll install is the 2x8 line LCD display. First you'll need to snap off the two metal tabs on the front of the part to make it ready to

install. Grip one of the tabs with your needlenose pliers and bend it back and forth until it comes off. Do the same for the other tab.

❒ F13. Next take the 14 pin dual row connector and place the short side pins through the LCD display board from the back. The back is the side with the big IC on it and the front is the LCD side. Solder all 14 pins.

❒ F14. Once the pins have cooled, place the LCD board through the holes for the connector on the front panel. If you push the LCD board flat you'll see that the IC on the back of it is a good marker for height and flatness. You'll also see that J2 sits underneath the LCD board. With the board pushed flat against the IC, take a look at the tab on the LCD that's closest to J2. Yes, it might be a little *too* close! We're going to bend that tab just to be sure it doesn't short to J2. Simply bend it gently away from J2 so that when you solder the LCD board to the front panel board no part of that tab is touching any of the pins of J2. Be careful when bending it because it's holding the LCD on and you don't want to damage anything.

❒ F15. Now you're ready to solder the LCD board to the front panel board. Hold the LCD board flat on the IC on the back and solder one of the corner pins, then check flatness before soldering the opposite corner pin. Carefully solder the rest of the pins of the connector. Be careful handling the board when you're done; those pins stay hot for a little while!

❒ F16. Look over your connected boards and make sure all the solder joints look good, all parts are installed, the LCD is nice and flat and flush to the board using the IC as a guide for flatness. Our next task is to connect the main and front panel PC boards and once it's done you won't want to try and get them apart again, so check the boards over carefully now, before it's too late. The flatness of the LCD board is especially important for the kit to fit correctly into the case.

❒ F17. We'll make sure our boards are going to line up with the front panel and case before we solder everything together (and it's too late!). Take the front panel board, one of the bezels (plastic case parts), and the bottom base tray for your case. The front panel board sits inside the bezel and the bezel is attached to the base tray using one of the included screws. The front panel will only fit on one side of the bezel. Look at the two screw holes on the front panel and you'll see two screw holes to line them up with on the bezel. Before screwing the parts into the base tray you'll want to peel the protective plastic from the front panel. Screw the front panel into place on the base tray.

❒ F18. Now take the front panel board and slide it into its place on the main board. All the pins on J1 should line up with J2 and J4 should line up with J5.

❒ F19. Take the connected but not yet soldered boards and slide them into

the back of the base tray so that the buttons can protrude through the front panel you just attached. There are slots on either side of the base tray for the board to slide into. Once you have the main board slid into position (as far forward as it will comfortably go . . . see why you trimmed those breakaway tabs in that early step?) you can position the front panel board so that the buttons protrude nicely and everything is lined up.

- ❒ F20. When things are right where you want them take your soldering iron and tack one of the end pins on the connector that joins the two PC boards, either J1 or J4. Check placement again and then tack solder a pin on the other connector.

- ❒ F21. Pull the connected boards out of the case and finish soldering the J4/J5, J1/J2 connections, being careful to solder them all and not to bridge any. These are both the physical and electrical connections from the main to the front panel PC boards so make sure you have solid, reliable solder joints

- ❒ F22. With the boards soldered together and the main board in the correct position, place D4, the small green LED, into the front panel, but do not solder. The part has a flat side and so does the silkscreen for the part, but it's a little hard to see so you can also check placement by the longer lead. This longer lead is the positive side and should be placed in the hole opposite the flat side on the drawing, the side closest to R6. Then slide the circuit board assembly forward in the case bottom (until you can't push it forward any further) with the buttons properly protruding through the front panel. Now align the unsoldered D4 so that its yellow lens fits into the hole in the front panel. It is finally time to solder this little bugger in place. When you're done, nip off the excess lead length on the back of the board just as you did with all the other parts.

That's about it! Give the board one last good checkout before we apply power in the next section. You don't want to find out too late that an electrolytic capacitor, diode, or IC was installed backwards, or that you have a damaging solder bridge somewhere. Use the Parts Layout Diagram to help you determine which connections are correct and which are suspect if you have any doubts at all. Ok, let's fire this baby up and see what it will do!

FM30 SETUP:

It's time to set up and test your FM30, then get on the air. You'll need the case, power supply, whip antenna, a small screwdriver or diddle stick, and a line level audio source such as a CD player or computer sound card. Here we go!

FM30 operation is about as simple as it gets. The [SETUP] button cycles through the various screens, and the [UP]/[DOWN] button adjusts the value on the particular screen.

First of all, adjust the contrast pot, R1, by turning the orange top to the right (clockwise as you're looking at it) until it's about halfway to its stopping point. If you don't do this first you'll turn the kit on and hear the beep but see nothing on the display, at which point panic usually sets in along with the assumption that you've made a construction error. Let's skip all that and do a first adjustment now, then you can set the pot to your individual contrast tastes later.

Next, slide the kit into the case. It's best to have the kit in the case and know that there are no stray leads or other objects shorting out traces on the back of the board when testing (and when operating the kit!).

Connect the included power supply. Also connect your whip antenna. You shouldn't operate the FM30 without some kind of antenna; a transmitter should always transmit into a load of some kind and not into an open, even if it is operating at a relatively low power output.

Turn the kit on. You should hear a beep and see "FM-30, Rev 1.2" on the display, then in a few seconds the screen will change to a default display. The default display shows the current set power, frequency, clipping detector status, and the VCO voltage while still attempting to lock. Readjust your contrast now if you need to.

Pressing the [SETUP] button once brings us to the frequency display. Here, using the UP/DOWN buttons, we can select our frequency of operation. Note the voltage display which indicates the current VCO voltage. This helps us diagnose any problems if something goes wrong. If the voltage stays low (<0.5V) or high (>9.9V) no matter what frequency we choose, then the FM30 may not be locked.

Set your desired test frequency now. You should choose an open or "dead" spot on the FM dial as a starting point if you're not yet sure what frequency you can transmit on without interfering with anyone. Check the FCC information section of this manual for more details on legal part 15 broadcasting. Use the UP/DOWN buttons to select your frequency.

Pressing the SETUP again gets us to the mode display. Here you can toggle Stereo and Mono modes.

Another press of the SETUP button brings us to the volume display. Connect your line level source to the FM30. Your source can be a CD player line out, a computer sound card line output, or any other audio source you desire as long

as it is line level. Anything other than line level audio will sound distorted and cost you time troubleshooting a non-existent problem. NEVER connect the FM30 audio inputs to speaker outputs of a high power stereo system; such a connection will destroy the IC chip. Trust us when we say that a true line level audio source will give you the best results with your FM30.

The default volume setting is roughly ½ of full, which is a gain of 1. The means that 500mV peak audio coming into the FM30 is 100% modulation, typically, depending on frequency. The volume display also includes the clipping detector status and you should adjust the volume until the indicator toggles from '-' to 'g' occasionally, roughly a 50/50 timing between the two, with an occasional 'c' mixed in. If the character is always at '-', the modulation is too low, and if 'C' ever shows up (capitol) it means you are overmodulating. It's best to set your level up or down until you see the lower case 'c', which means that you're on the edge of clipping. If you see the lowercase 'c' it means that you're distorting a bit so if you want to avoid that completely, make sure you set the level so that you only see the 'g'. Of course you can simply adjust the volume until it sounds right to you.

The order of characters is approximately on average:
'-' <= +/-60kHz
'g' >+/-60kHz and <+/-75kHz
'c' >+/-75kHz and <+/-90kHz
'C' >+/-90kHz

Remember from the circuit description that the indicator doesn't specify the exact level, but the frequency with which the audio signal surpasses approximately 60kHz of deviation. The indicator is based on music signals, not test tones.

Again pressing the setup button will get us to the balance setting. The balance simply attenuates one side or the other depending on the adjustment. Set in the center there is no attenuation. Use the [UP]/[DOWN] buttons to swing the balance to the left or the right. The best way to adjust this is to listen on a receiver with headphones, and then adjust the balance until lead vocals sound like they are in the center of your eyeballs.

The last setup display is the power setting. This is a relative display simply showing you the drive through the level adjustment pin diode. However the power adjustment is not incremental like the display. For example, ½ of the bar is not necessarily ½ of the power. If you want exact power settings you'll need to use a piece of test equipment such as our sensitive PM50 to adjust it, but that is not strictly necessary. The best thing to do is to set up your unit and antenna as you intend to use it normally. Then, using a portable radio, go to the furthest distance you intend to receive the transmission from the FM30

(front living room, garage, deck) and have someone else turn up the power until you receive the signal clearly. Stop adjustment right at this point; this is as far as you will need to go! You may be surprised by how little power you really need. If you have to run it at full power you may need to play with the antenna a bit because that may indicate that you don't have a good match.

The last setup screen allows you to save all of your changes. Pressing the [UP] button will save them to the internal FLASH memory; [DOWN] will continue to use the current settings, but will not save them to FLASH in case you need to make some more changes. Cycling through all of the displays again will get you back to this screen to save all of your changes.

USING THE FM30 WITHIN THE HOME

Typical use for the FM30 would be to connect it to a personal computer within a large home so that whatever MP3 or other audio files are playing can also be tuned-in on portable FM radios in other rooms, the garage or out in the yard. The provided whip antenna should cover a typical home's boundaries quite well. An external antenna can be used for a larger coverage area if desired. Use the RF adjustment control to fine tune the RF output level to just reach the area you intend to cover.

The audio connection consists of using shielded audio cables to connect the line or speaker level output to the audio inputs of the FM30. Consult the literature that came with your stereo equipment.

Even if you intend use of the FM30 for your own home and family, it is still your responsibility, in accordance with Part 15 of the FCC Rules, to ensure that this operation does not cause interference to your neighbors.

EXPERIMENTAL "BROADCASTING" PROJECTS

To use the FM30 successfully as a "broadcasting" service for interested listeners in a school or immediate neighborhood, most of your effort will be concentrated on smoothly "managing" or mixing the audio signals fed into the transmitter input. Operation of the transmitter itself consists simply of the following:

1. Correct construction and adjustment.
2. Carefully checking for an open frequency between 88-108 MHz in accordance with FCC Rules, Part 15.
3. Setting up a suitable antenna.
4. Connecting the audio source to the input jacks.
5. Turning on the transmitter while you intend to be "on the air" and turning it off when you are finished.

The more home-built your complete setup, the more it is in conformity with the spirit of FCC Part 15 regulations.

You can greatly add to the versatility and professionalism of your transmitting station by adding an audio mixer and/or processor. Mixers allow you to smoothly 'blend' from one audio source to another just like the commercial stations do. Our STC1, Stereo Transmitter Companion provides audio processing in one easy package. The STC1 allows you to 'sweeten' the audio for more impact and punch. Plus, it has brick-wall low pass filtering on the stereo inputs to prevent that bothersome 'swishing' and squealing sound that is often found when using lower quality CD players as the audio source! Check out our free catalog for all the details.

ANTENNA IDEAS

A simple, yet very effective, antenna for the FM30 consists of a "dipole", set up either horizontally or vertically, and connected to the transmitter output jack

through a few feet of coaxial cable (either RG-58, RG-59 or miniature RG-174, available at Radio Shack and other sources). Correct dipole lengths for major sections of the 88-108 MHz band are:

88 MHz, each side: 2.7 feet; 5.4 feet total
98 MHz, each side: 2.4 feet; 4.8 feet total
108 MHz, each side: 2.2 feet; 4.4 feet total

You can see that there's not a great difference in antenna length from 88 to 107 MHz. Some antenna designers have the view that an "approximate" dipole such as 2.5 ft. on a side will do fine, while others believe it is worth the effort to calculate the length for your exact frequency, using the simple formula of Length (of one side, in feet) = 234/Frequency in MHz.

If the dipole is installed vertically, the end connected to the center conductor of the coax should be the upper (higher) end. If young children will be around the set-up, a flexible wire antenna is preferable, rather than rigid tubing.

A "ground plane" antenna can be quite effective. A ground plane consists of one vertical element, the same length as one side of a dipole, connected to the center conductor of the coax. Four "radials" are connected to the shielded side of the coax at a 90 to 135 degree angle to the vertical element. The dipole formula is also used to calculate the length of the radial; since radials should be slightly longer than the main element, use 240 rather than 234 in your calculations.

If you are equipped to make the field strength measurements required by Part 15 FCC rules, and if you think it would be best to aim or "focus" your signal in a narrower direction, you can consult an antenna handbook and design a suitable gain antenna. See Appendix A concerning FCC field strength limitations. An FM- VHF TV receiving antenna could be modified for such a purpose.

Ham radio books and magazines are filled with antenna principles and ideas which can be adapted to your application. Our TM100 Tru-match FM antenna is an ideal mate to your transmitter. It features proper impedance matching for optimum power transfer and range. See our catalog for details.

ANTENNA ALTERNATIVES

If your situation involves a single large building or multi-level home where reception from the FM30 antenna may tend to be uneven because of walls and other VHF path obstacles, you might set up the FM30's output in a "carrier-current" configuration. If you know how, then do so - safely. If not, you can show your FM30 and this book to a licensed radio engineer and negotiate with that person for a safe installation which will feed your signal through interior wiring of your home or building. Do not attempt such an installation unless you know exactly what to do and not to do. Also, because such an installation is beyond the original purpose of this kit and the safety standards intended for all Ramsey kits, and because we have not tested the FM30 in such an installation, we cannot provide further details.

APPENDIX A: FCC RULES AND INFORMATION

The Rules of the FCC (Federal Communications Commission) and your kit built FM Stereo Transmitter.

An interim explanation of applicable FCC regulations supplied as a personal assistance to FM30 builders, by Dan F. Onley (K4ZRA)

It is the policy of Ramsey Electronics, Inc., that knowing and observing the lawful use of all kits is a first responsibility of our kit user/builders. We do not endorse any unlawful use of any of our kits, and we try to give you as much common sense help about normal and lawful use as we can. Further, it is the policy of Ramsey Electronics, Inc., to cooperate with all applicable federal regulations in the design and marketing of our electronics kit products. Finally, we urge all of our overseas customers to observe the regulations of their own national telecommunications authorities.

In all instances, compliance with FCC rules in the operation of what the FCC terms an "intentional radiator" is always the responsibility of the user of such an "intentional radiator".

To order your copy of FCC rules part 15, call the US Government, Superintendent of Documents, at 202-512-1800, or fax at 202-512-2250. To order the correct document, ask for “CFR Title 17: Parts 1 to 199.” The cost is $24.00. Master Card and Visa are accepted.

In the United States, this is how the FCC regards your transmitter kit

Licensed FM broadcast stations and their listeners have ALL the rights! Your use of a device such as the FM30 kit MAY have some limited privileges in locally-unused band space, but your non-licensed use of the FM30 has absolutely NO rights at all over the rights of licensed broadcast operators and the rights of their listeners to interference-free reception. If your operation of a device such as the FM30 interferes with ANYBODY'S use or enjoyment of an FCC licensed transmission of any kind, your only choice is to IMMEDIATELY terminate or change the operation of your low-power transmitting device so as to cause no more interference. That's it! No discussion, no exceptions.

Unlicensed operation of small transmitting devices is discussed in "Part 15" of the FCC Rules. These Rules are published in 100 "Parts," covering everything imaginable concerning the topic of "Telecommunications." The six books containing the FCC Rules are section 47 of the complete Code of Federal Regulations, which you are likely to find in the Reference section of your Public Library. If you have questions about the legal operation of your FM30 or any other kit or home-built device which emits RF energy, it is your responsibility to study the FCC regulations. It is best if YOU read (and consult with a lawyer if you are in doubt) the rules and do not bother the understaffed and busy FCC

employees with questions that are clearly answered in the rules.

Here are the primary "dos and don'ts" picked from the current FCC Rules, as of May, 1990. This is only a ***brief look*** at the rules and should not be construed to be the absolute complete legal interpretation! It is up to you to operate within the proper FCC rules and Ramsey Electronics, Inc. cannot be held responsible for any violation thereof.

1. In the past, no "two-way communications" use of the 88-108 MHz FM broadcast band was permitted. This prohibition does not appear in the current edition of Part 15. Previous editions of Part 15 discussed "wireless microphones" (such as Ramsey FM-1, FM-4, etc.), while the June 23, 1989, revision eliminates this discussion in favor of more detail regarding computer and TV peripherals and other modern electronic conveniences. However, it is not immediately clear that the 1989 revision of the FCC Rules Part 15 necessarily "cancels" previous regulations. Laws and rules tend to remain in force unless they are specifically repealed. Also, FCC Rule 15.37 discusses "Transitional Provisions for Compliance with the Rules," and states in item (c): "There are no restrictions on the operation or marketing of equipment complying with the regulations in effect prior to June 23, 1989."
2. It is the sole responsibility of the builder-user of any FM broadcast-band device to research and fully avoid any and all interference to licensed FM broadcast transmission and reception. This instruction manual gives you practical advice on how to do a good job of finding a clear frequency, if one is available.
3. For some frequency bands, the FCC sets 100 milliwatts (0.1 watt) as the maximum permitted power output for unlicensed, home-built transmitting devices, and that the combined length of your antenna and feedline (coaxial cable or other) must not exceed 10 feet. The technical standards for 88-108 MHz are very different, primarily concerned with band width and RF field strength.
4. FCC Rules do not differ for "stereo" or "monaural" transmissions.
5. Broadcasting on the grounds of a school (AM emissions only) is specifically permitted and encouraged between 525 and 1705 KHz under Part 15.221. Use our AM-1 AM radio broadcast kit for this use.
6. FCC Rule No. 15.239 specifically addresses operation in the 88-108 MHz FM broadcast band for which your FM30 transmitter kit is designed. However, this Rule does not, by itself, tell you everything you need to know about using a device of this kind. Therefore, we are noting a series of Part 15 regulations which should be observed:

- a. The "bandwidth" of your transmission is limited to 200 KHz, centered on the actual operating frequency. Since 200 KHz is enough spectrum

space for several different FM stations, this is a "generous" limitation designed to accommodate cruder FM devices. Properly built and adjusted, the FM30 kit operates well within this limit. In fact, its signal should sound no "wider" than any other FM station when listening on an ordinary FM radio.

- b. FCC Rule 15.215(a) says: "Unless otherwise stated, there are no restrictions as to the types of operations permitted under these sections." This general provision appears to leave you free to use your FM stereo transmitter in a manner similar to operations of an FM broadcasting station, or to use it for any other non-interfering, practical application.

- c. FCC Rule 15.5: General conditions of operation: "(b) Operation...is subject to the conditions that no harmful interference is caused and that interference must be accepted that may be caused by the operation of an authorized radio station, by another intentional or unintentional radiator, by industrial, scientific and medical equipment, or by an incidental radiator. (c) The operator of a radio frequency device shall be required to cease operating the device upon notification by a Commission representative that the device is causing harmful interference."

- d. The most specific FCC regulation of 88-108 MHz FM Broadcast band unlicensed operation is that the "field strength" of the signal must not exceed 250 microvolts/meter at a distance of 3 meters from the transmitter (FCC rule 15.239). If you have any concern about this emission limit, have your device checked by a technician with accurate measuring equipment. Remember that the "field strength" of a signal is determined as much by the antenna as by the RF output of the transmitter itself.

APPENDIX B: UNDERSTANDING LEGAL "FIELD STRENGTH"

The new FCC Part 15 Rules specify a maximum "Field Strength" of your transmitted signal. Since it is unlikely that you have the equipment to carry out accurate field strength measurements in microvolts, it is useful to understand at least the theory of field strength so that you can understand both what you can expect from such transmitters, and what limits the FCC intends.

Previous limits on non-licensed FM-broadcast band devices were defined as a maximum field strength of 40µV per meter measured at a distance of 15 meters. The June 1989 revised rule specifies a maximum of 250 µV per meter, but measured at 3 meters from your antenna. Both limitations are the same in practice. "250µV per meter" means that an accurate field-strength meter with a 1-meter antenna may indicate a maximum signal field strength of 250µV (In contrast, non-licensed operation from 26.96 to 27.28 MHz is limited to a field strength of 10,000 µV per meter at 3 meters).

In all cases, the field strength of a signal decreases in direct proportion to the distance away from the antenna. Power decreases by the square of distance: for every doubling in distance, the signal power is quartered, but the field strength voltage is only halved. Using this theory, we can construct a simple chart to show the maximum permitted performance of a non-licensed FM band transmitter. The theoretical figures assume a simple 1 meter receiving antenna in all cases and do not take into consideration that reception can be greatly enhanced with larger, multi-element antennas and preamplifiers. In the following chart, the field strength (theoretical minimum) gets even stronger as you move from the edge of these circular boundaries toward the antenna:

This "exercise in meters and microvolts" demonstrates that the FCC clearly intends to limit the theoretical range of non-licensed devices operating in this band. It also shows the potential for causing interference at a home down the street from you. But it also shows that you can legally put out quite a good signal over wider areas than you might have imagined.

For other kinds of radio services, the FCC restricts such factors as transmitter power or antenna height, which cannot really limit the possible "range" of a transmission under good conditions. By restricting the maximum field strength at a specific distance from your antenna, the FCC clearly plans for your signal to "die out" at a specific distance from your antenna, no matter what kind of transmitter power or extra-gain antenna you are using. On the other hand, the FCC standards do make it legal and possible for you to broadcast on a school campus, campground or local neighborhood, as long as you do not cause interference to broadcast reception.

“Why talk about acres"?

There are three reasons to translate our look at "field strength" into "acres".

1. The first one is easy: the numbers would get too cumbersome if we discussed your possible signal coverage in terms of square feet or square meters.
2. It's very easy to see that your signal can easily and legally serve a school campus or wilderness campground.
3. And, if we remember that typical urban single-family home sites run from 1/4 to 1/2 acre on the average, it should become extremely clear that your obligation to avoid interfering with broadcast reception can easily involve hundreds of homes, before adding apartments!

In fact, the most significant distance in the above chart is the 1.9 µV signal strength permissible at 1260 feet (about 1/4 mile), covering a circular area of about 114 acres. A quick glance at stereo FM receiver specifications shows typical sensitivity of 1.7 µV before considering high-gain antennas or preamplifiers. Your non-licensed signal can provide serious competition to a public

broadcast station fifty miles away, a station which someone in your neighborhood may have set up a special antenna to enjoy.

Calibrated "field strength meters" such as described in the ARRL Radio Amateur's Handbook can detect signals down to about 100 microvolts. To measure RF field strength below such a level, professional or laboratory equipment and sensitive receivers are required. A "sensitive" receiver responds to a signal of 1 or even .5 microvolts "delivered" to the receiver input by antenna. If the antenna is not good, the receiver cannot respond to the presence of fractions of a microvolt of RF energy.

SUMMARY

The present edition of Part 15 of the FCC rules does not provide detailed guidance on ALL aspects of using a low-power transmitter such as the FM30. The main point is that you may not cause any interference whatsoever to licensed broadcast services and that you must be willing to put up with any interference that you may experience.

In addition to operations not requiring authorization, you also have the option of writing a clear and polite letter to the FCC Engineer-in-Charge of your local district, describing your intended operation. Mention the operating frequency and planned hours of operation. This could be a good step to take if your project is in behalf of a school, Scout or community group.

If you become further fascinated with the service rendered by low-power broadcasting, other FCC regulations explain how to apply for a license or other authorization which may permit you to upgrade your FM30 or other equipment to accomplish any objective which the FCC sees to be in the public interest and not interfering with other authorized uses of the radio spectrum.

Lawful use suggestions

1. Build and adjust this kit strictly according to the published instructions.
2. Use the whip antenna supplied with the Ramsey case set, CFM.
3. Do not modify your kit in any way.
4. Check your intended operating frequency very carefully, as clearly explained in this instruction manual, to ensure you will not cause interference to reception of licensed broadcasting.
5. If you receive ANY complaint about your transmissions interfering with broadcast reception, stop or change your operation IMMEDIATELY.
6. If you are contacted by the FCC regarding use of this device, cooperate fully and promptly.
7. Do your own homework and research to understand and comply with present and future FCC rulings concerning devices of this kind.

8. Do not use made-up "station call signs" to identify your transmissions. Only the FCC has the authority to issue such call signs. Use some other way to identify your transmitting activity, such as "This is Stereo 90.5, Seabreeze School Student Music Radio," and so forth.
9. Identify the location and purpose of your transmissions from time to time. This is common courtesy toward other persons who may hear your signal. The FCC is toughest about clandestine transmission which cost time and money to track down.
10. Do not assume that the mere fact that you purchased this kit gives you any specific right to use it for any purpose beyond generating a low-level RF signal which is barely detectable beyond the perimeter of your personal dwelling space.

Finally, the FCC Rules call for the posting of printed notices on devices intended for non-licensed operation under Part 15 Rules. You will find such notices written up for the front or back of the instruction manual for nearly any computer or video accessory that you have seen in recent months. Consult the Part 15 Rules for the exact wording of such notices. Following is a text for such a notice which responds to FCC rule making intentions:

NOTICE:

The radio-frequency "intentional radiator" device which may be constructed from kit parts supplied by us is intended and designed by Ramsey Electronics, Inc. to conform to applicable provisions of Part 15 of FCC Rules. The individual kit-builder and all users of this device assume responsibility for lawful uses conforming to FCC Part 15 Rules. Operation is subject to the following two conditions:

1. This device may not cause harmful interference, and
2. This device must accept any interference received, including interference that may cause undesired operation.

Final comment

A well-informed person will see today's FCC Rules to be evolving and progressively less-restrictive. Even though today's technology is far more complex than what was possible at the time of the Communications Act of 1934, the FCC rules are becoming more relaxed, giving radio experimenters more and more opportunities to explore many frequency bands, using many communications modes, with no need for a formal license of any kind. A thorough study of Part 15 of the FCC Rules, which is completely beyond the purpose of this kit manual, will show you many legal uses of radio transmitting devices which do not require licensing, either amateur or commercial.

To provide more personal and club radio-learning opportunities, and to cut down on administrative costs, today's FCC permits far more non-licensed activity than at any time in previous history. On the other hand, today's FCC enforcement actions get bigger fines and real prison terms for scofflaws! From CB (now 3 bands of it, for varying applications) to easy entry-level Amateur Radio with long-term licensing, to numerous unlicensed Part 15 operations, the FCC is beginning to look out for the interest and good plans and intentions of private citizens and school-community groups as never before in radio communications history. Learn the rules...observe them...and have fun in radio!

If you enjoyed this Ramsey kit, there are plenty more to choose from in our catalog - write or call today!

CONCLUSION

We sincerely hope that you will enjoy the use of this Ramsey product. As always, we have tried to compose our manual in the easiest, most “user friendly” format that is possible. As our customers, we value your opinions, comments, and additions that you would like to see in future publications. Please submit comments or ideas to:

Ramsey Electronics Inc.
Attn. Hobby Kit Department
590 Fishers Station Drive
Victor, NY 14564

or email us at: techsupport@ramseymail.com

And once again, thanks from the folks at Ramsey!

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The Ramsey Kit Warranty

Please read carefully BEFORE calling or writing in about your kit. Most problems can be solved without contacting the factory.

Notice that this is not a "fine print" warranty. We want you to understand your rights and ours too! All Ramsey kits will work if assembled properly. The very fact that your kit includes this new manual is your assurance that a team of knowledgeable people have field-tested several "copies" of this kit straight from the Ramsey Inventory. If you need help, please read through your manual carefully, all information required to properly build and test your kit is contained within the pages! However, customer satisfaction is our goal, so in the event that you do have a problem, take note of the following.

1. DEFECTIVE PARTS: It's always easy to blame a part for a problem in your kit, Before you conclude that a part may be bad, thoroughly check your work. Today's semiconductors and passive components have reached incredibly high reliability levels, and its sad to say that our human construction skills have not! But on rare occasions a sour component can slip through. All our kit parts carry the Ramsey Electronics Warranty that they are free from defects for a full ninety (90) days from the date of purchase. Defective parts will be replaced promptly at our expense. If you suspect any part to be defective, please mail it to our factory for testing and replacement. Please send only the defective part (s), not the entire kit. The part(s) MUST be returned to us in suitable condition for testing. Please be aware that testing can usually determine if the part was truly defective or damaged by assembly or usage. Don't be afraid of telling us that you 'blew-it', we're all human and in most cases, replacement parts are very reasonably priced.

2. MISSING PARTS: Before assuming a part value is incorrect, check the parts listing carefully to see if it is a critical value such as a specific coil or IC, or whether a RANGE of values is suitable (such as "100 to 500 uF"). Often times, common sense will solve a mysterious missing part problem. If you're missing five 10K ohm resistors and received five extra 1K resistors, you can pretty much be assured that the '1K ohm' resistors are actually the 'missing' 10 K parts ("Hum-m-m, I guess the 'red' band really does look orange!") Ramsey Electronics project kits are packed with pride in the USA. If you believe we packed an incorrect part or omitted a part clearly indicated in your assembly manual as supplied with the basic kit by Ramsey, please write or call us with information on the part you need and proof of kit purchase.

3. FACTORY REPAIR OF ASSEMBLED KITS:
To qualify for Ramsey Electronics factory repair, kits MUST:
1. NOT be assembled with acid core solder or flux.
2. NOT be modified in any manner.
3. BE returned in fully-assembled form, not partially assembled.
4. BE accompanied by the proper repair fee. No repair will be undertaken until we have received the MINIMUM repair fee (1/2 hour labor) of $25.00, or authorization to charge it to your credit card account.
5. INCLUDE a description of the problem and legible return address. DO NOT send a separate letter; include all correspondence with the unit. Please do not include your own hardware such as non-Ramsey cabinets, knobs, cables, external battery packs and the like. Ramsey Electronics, Inc., reserves the right to refuse repair on ANY item in which we find excessive problems or damage due to construction methods. To assist customers in such situations, Ramsey Electronics, Inc., reserves the right to solve their needs on a case-by-case basis.
The repair is $50.00 per hour, regardless of the cost of the kit. Please understand that our technicians are not volunteers and that set-up, testing, diagnosis, repair and repacking and paperwork can take nearly an hour of paid employee time on even a simple kit. Of course, if we find that a part was defective in manufacture, there will be no charge to repair your kit (But please realize that our technicians know the difference between a defective part and parts burned out or damaged through improper use or assembly).

4. REFUNDS: You are given ten (10) days to examine our products. If you are not satisfied, you may return your unassembled kit with all the parts and instructions and proof of purchase to the factory for a full refund. The return package should be packed securely. Insurance is recommended. Please do not cause needless delays, read all information carefully.

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REQUIRED TOOLS

- Soldering Iron (WLC100)
- Thin Rosin Core Solder (RTS12)
- Needle Nose Pliers (PTS401)
- Small Diagonal Cutters (PTS400)

ADDITIONAL SUGGESTED ITEMS

- Helping Hands Holder for PC Board/Parts (HH3)
- Desoldering Braid (RTS08)

TOTAL SOLDER POINTS
540
ESTIMATED ASSEMBLY TIME
Beginner .....12 hrs
Intermediate .....6 hrs
Advanced .....4 hrs

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