

**A PRACTICAL GUIDE FOR USING THE HP3586A/B/C SELECTIVE  
LEVEL METER©**

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## 1. INTRODUCTION

This document is intended for those having a HP3586 without the operator's manual or are having trouble understanding the operator's manual and want to learn how to use this versatile instrument. It should also be of use to those considering purchasing one of these instruments. This document is not intended as a complete operating manual but should help you understand what it does and how to use it. This document is written in a tutorial manner with many simple examples of typical measurements. If you want a copy of the HP operator's or service manuals, I highly recommend obtaining copies from Manuals Plus at 801-936-7000 where I obtained a professional quality copy of the operator's manual at a reasonable price.

The HP 3586 family of Selective Level Meters was designed for the measurement of low power or voltage levels on telephone lines carrying multiplexed single side band radio frequency signals along with lower frequency audio signals. It's designed to test and troubleshoot parameters commonly found on these lines. This instrument is a very sensitive, selective and accurately calibrated receiver that's also capable of outputting a very low distortion signal of 0dbm at exactly the frequency it's tuned to.

A while back I obtained a HP3586B that had been surplused from GTE from a couple of friends. They had found a number of these for a reasonable price at a surplus electronic warehouse, they obtained all they could and refurbished them, and then passed them on at their cost. Most had bad or leaking internal batteries, which they removed. They also installed the more common BNC female input connectors in place of the less common telephone connectors. Like all of these instruments on the surplus market mine came without operating or service documentation. But I figured out how to use it to measure frequency, use as an outboard VFO to drive my BC-610 AM transmitter, and as a receiver to search the radio bands for interesting signals. I felt this was a very large and heavy, 60lb, instrument to do what some cheap Radio Shack rice boxes could do and would take less room on my workbench. Also its internal receiver seemed to have rather poor audio quality. However, after obtaining and studying a copy of the operator's manual and becoming more familiar with my HP3586B, a light went on in my head. I realized it's a very versatile and useful instrument and I wasn't even using 10% of its capability.

Please, first read this document sequentially to best learn about your HP3586 since each chapter will build on the experience you gain in previous chapters. We'll start off describing the instrument so you'll know how it works, what it can measure, then learn how to control and set it up by discussing it's front panel along with its inputs and outputs, and finally learn how to use it for conducting useful measurements using hands on type examples.

Feel free pass on copies of this document to others that may find it useful. I'll publish revised versions as I learn more about my HP3586 and discover new applications. I recommend you print out this document and the schematics in Appendix C, place it in a binder and add any additional notes you may wish just after the Appendix. Please don't revise the document, just send me any suggested changes or additions at n6py@arrl.net and I'll include them in future versions. Otherwise there will be different versions in circulation with no revision control causing mass confusion for those attempting to use it. I'm also releasing it in the Adobe PDF format to discourage uncontrolled changes and for easy Internet downloading so I don't have to get into the book printing and binding business. I copyrighted this document to further control it and keep it's use free of charge by using the © symbol on the document's title.

This document is dedicated to all those amateur radio operators that enjoy working on electronic circuits, measure the performance of radios, repairing their radios, measuring audio through HF radio signals, or restoring amateur or military radios that are keeping the hobby of amateur radio alive, well and interesting. So read on and I hope you enjoy learning about the wonderful world of the HP3586.

## 2. DESCRIPTION OF THE HP3586

**2.1 General** – For those not familiar with selective level meters they can best be visualized as a receiver having very high selectivity with a detector system capable of accurately measuring low power signal levels from +20dbm down to –100dbm and frequency over a wide range from 200Hz to 32MHz and. It also will output a signal of 0dbm, one milliwatt, at exactly the same frequency that the instrument is tuned to, which is usually the center frequency of the selected receiver band pass filter. It's also a SSB receiver to aid in tuning the signal to be measured. Because of these features a selective level meter is extremely valuable for measuring and the analysis of audio up through RF signals, it's a whole lab of instruments in one package. Because of this it can be used to measure the performance of electronic radio and RF circuits, measure the strength and frequency of radio signals along with driving other electronic devices using it's one milliwatt low distortion output signal as a low power signal generator.

The HP3586 family of selective level meters was designed to measure signal levels and frequency in selected portions of its total frequency spectrum on multiplex telephone transmission lines. These frequency slices can be operator set by selection of filters from 20 Hz up to 3100 Hz in bandwidth that are front panel selectable. All versions will have 20 and 400 Hz filters. The A and B versions have one additional 1740 or 2000 Hz filter depending on model. Those with 003 option will have a 3100Hz filter and a noise weighting WTD filter that can be switched in series with the 3100Hz filter to reduce low and high audio frequency noise. The C version only has the 3100Hz filter without a WTD noise filter and no filter options.

There are three versions of this family of instruments. The A and B versions have modes and features making it easier to measure SSB channels on phone lines. The C version is more basic and doesn't have the SSB channel features of the A and B versions. However all three will work equally well for most of the RF and audio measurement described in this document.

In its measuring modes except wideband the instrument will display and output a 0 dbm signal to a rear panel connector at the center frequency its filter from an internal tracking oscillator. This signal's frequency can be set using the front panel keyboard or tuning knob. It also has a counter system that can be commanded to read and display the frequency of the strongest steady signal within its filter's pass band. It can then be commanded to store this frequency in its frequency register changing its center frequency to the register's frequency and outputting this new frequency to its rear panel Fo connector. This feature is very useful for measuring the frequency of a carrier and then synchronizing the frequency of another device to that frequency. The instrument also contains a SSB detector system that is used to receive and tune SSB signals or other signals into the instruments pass band.

In the following chapters I'll describe how to setup your HP3586 to do useful measurements of frequency, power, voltage, network analysis, distortion analysis, and use it on the air as an accurate signal strength meter along with using it as a VFO to control an AM transmitter. In the interest of keeping things simple, instrument features and modes that I feel are not useful for RF or audio measurements will not be discussed in this document.

**2.2 Instrument Capabilities** - Since the HP3586 measures the total power of all signals in its filter's pass band, its always best to use the narrowest possible filter when measuring narrow band signals to reduce noise errors. Power measurements are usually displayed in db's referenced to one milliwatt, dbm units, but can also be referenced to a pico watt, which I haven't found useful. It can also measure the voltage of a signal in db's referenced to .775 volts on all versions and 1 volt on the C version. These units may seem cumbersome since most of us prefer dealing with linear measurements in watts and volts, but it's better suited for measuring over very large ranges and is a standard method for those working with telecommunications systems. If you are not familiar with this system of measurement or a little hazy on understanding it, please take a look at Appendix A for a better understanding. You can easily convert to watts or volts from the HP3586 panel readings by using the following formulas and a hand held calculator:

Power dbm = 10 log (Power in watts/.001) or Power watts = .001 [ anti log ( power dbm/10) ]

Voltage dbv = 20 log (Voltage volts/Vr) or Voltage volts = Vr [anti log (Voltage volts/20)]

Vr = .775 volts for the A and B models: Vr = 1 volts or .775 volts can be selected on the C model.

For optimum accuracy the instrument takes measurements over a small part of its total -120dbm to +20dbm measuring range by using a range selectable detector circuit. The selectable ranges are, 100db and 10db and have resolutions of .1db and .01db respectively. The readings are accurate over the whole 10db range but are only accurate over the upper 80db of the 100db range. The location of a range within the instruments total measuring range is operator or automatically selected for best level measurement accuracy. This is done by using an IF amplifier circuit whose gain is accurately changed. The IF amp is located just before the detector and changes its gain to select the upper limit for the range of values the detector is measuring. Specifying an upper limit for a range using the entry command actually selects the gain of the IF amplifier. Automatic limit selection is done using a circuit similar to the AGC circuit in a radio receiver.

One important point to remember is that the upper limit for the 100db range can not be set below -45dbm because -80db below this setting starts to equal the instrument's noise floor of around -120dbm. When the detector is set to the 10db range the upper limit can be set much lower to -120dbm. The SSB demodulator receives its signal from the IF strip in parallel with the level detector and will only be able to demodulate signals above -55dbm. When the instrument is in the 100db range the gain of the IF strip is too low to read radio signals below this level. Therefore, when using the SSB detector for audio tuning of received radio signals we should almost always have the instrument in the 10db range since these radio signals are usually below -55dbm. In chapter 4 we'll show how to work around this problem when receiving SSB signals.

For those of us working on electronic circuits or taking radio signal measurements this instrument is a valuable tool that can be used to measure RF or audio noise, the frequency of a received carrier, find and measure spurious transmitter signals, provide a signal and detector system for circuit analysis, and as a VFO to control the carrier of a transmitter. It will work as a SSB receiver over its whole frequency range to tune on the air signals for measurement. It receives and accurately measures signals down to -100dbm, which is much lower than the noise on most ham bands.

One disadvantage when receiving SSB signals is that the HP3586 will not output the actual carrier frequency of a SSB signal to its rear panel Fo output when using the SSB detector. It only outputs the center frequency of the selected band pass. In this document I will describe how to work around this problem when controlling AM transmitters.

**2.3 Instrument Accuracy** - The instrument uses 100db or 10db changeable ranges for maximum accuracy as described above. The 100db range is only accurate over its upper 80db portion and has a resolution of .1db. In the automatic range limit control mode the 100db range will have its upper limit automatically changed to always stay within the accurate upper 80db part of this range. The narrower range of 10db has a resolution of .01db. The instrument's level measuring frequency range is 200Hz to 32MHz with a frequency resolution of .1Hz and accuracy of + or - .000001 of its reading during the first year after calibration. The 004 optional crystal frequency reference was offered for greater frequency display accuracy, see Chapter 16, section 16.8 if your instrument doesn't have this option.

The instrument is intended for accurate measurements only in the range of -100dbm up to +20dbm. Using the 50 or 75 ohm input from 200Hz to 32MHz and for signal levels between +20dbm and -80dbm, between -80db and -100db its accuracy is +/- .75dbm. From 200Hz to 200KHz and from +20dbm to -80dbm its level accuracy drops to +/- .40dbm, and from -80dbm to -100dbm it's +/- .95dbm. Below 100dbm it's accuracy isn't rated and level measurements below -100dbm should not be trusted even though the instrument will appear to read down to its noise floor of around -120dbm. By using

comparative measurement between different devices or conditions its accuracy can approach the 100db or 10db ranges precision of .1db or .01db, we'll talk about that in Chapter 16.

To maintain accuracy the HP3586 does a 3 second duration automatic calibration, auto cal, when it's first turned on, every two minutes during operation, if its frequency is changed more than 1MHz, and when a new measuring range width is selected. If any problems arise during calibration or during its operation the display will output error codes, which are described in Append B. For special reasons such as SSB audio tuning discussed in this document, the auto cal feature can be turned off at any time after its initial power up.

**2.4 The 004 Option** – When I purchased my HP3586B I assumed it didn't have the 004 enhanced frequency accuracy option but I noticed a 004 installed sticker on its back panel. Also there was an oven output connector installed on its back panel but no jumper from this connector to the external reference connector just to its right. I then removed the instrument's top cover by loosening a screw in the back of the cover and sliding the cover off. To my delight I found a wire from the oven connector to a module labeled A16 installed to the RH rear of the instrument's motherboard, which was the 004 option module with the 10 MHz crystal standard in a oven.

When I connected a jumper between these two connectors the oven light on my front panel came on for about 10 minutes and then went off. After the oven light went out indicating the crystal oven was up to temperature, checked WWV on 10 MHz using the counter procedure in section 5.3 of chapter 5 and found my instrument was within .7 cycles of 10 MHz when using the counter on WWV's 10 MHz carrier. Without the jumper installed between the connectors, it was off by over 9 cycles so activating the 004 option made a great difference in the frequency accuracy of my instrument.

If the oven connector is installed on the back panel of your instrument but isn't connected to the EXT REF connector to its right, look inside your instrument and maybe you will be lucky and have this valuable option. If your instrument has the A16 module installed, you must connect a jumper cable with two BNC male connectors to activate the option.

**2.5 Level Measuring Modes** – The HP3586 family of instruments has the following modes for measuring signal levels:

SELECTIVE	See Chapters 4, 5, 6, 7 and 9
CARRIER	See Chapter 8
NOISE/DEMODULATION	See Chapter 10
WIDEBAND	See Chapter 11
IMPULSE	See Chapter 12
NETWORK ANALYSIS	See Chapter 14
tone	Not Applicable
JITTER	Not Applicable

I have found the first six measurement modes useful for radio and audio measurements. The other modes are not normally useful because they are designed specifically for telephone measurements or require other not normally available specialized equipment.

All measurement modes discussed in this document apply to the A and B versions where the noise/demodulation, impulse and carrier modes are not available on the HP3586C general purpose version. However, I'll show how to make noise/demodulation measurements with the selective mode using the C version.

### 3. SIGNAL CONNECTIONS

**3.1 General** - In this section I'll describe how to connect a HP3586 for measuring frequency and power level in the selective modes. In the following chapters I'll also describe any differences for other measurement modes.

**3.2 Signal Input and Termination – Never put more than +27dbm or .5 watts total power into the input 50 or 75 ohm connector of a HP3586 when using the internal termination. Never put more than an AC + DC total of +42 volts into an unterminated connector.**

To get a signal into a HP3586 you have the choice of many different input connectors and impedances. However the only input I've found useful is the 75 or 50 ohm unbalanced input. All other inputs, including the 600 ohm one, are not useful over the complete frequency range of the HP3586 and terminate in impedances usually used for telephone circuits but not for RF circuits. The 75 or 50 ohm input is usable over the instruments complete frequency range. Those with a HP3586C are fortunate that it has a 50 ohms input. A or B versions only have a 75 ohm input. Most of the surplus instruments have telephone type input connectors but many of us have converted ours to a more standard BNC connector for radio use. The A and B version make all their power calculations based on 75 ohms even if the input is unterminated or has an external 50 ohm termination resistor. However you can enter an offset to compensate for this difference, more on this in section 6.2 of Chapter 6.

When making on the air measurements to a 50 ohm unterminated antenna line, use the 50 ohm termination option on a C version or use a 50 ohm terminating resistor on the A and B versions and use the 10K 50pf unterminated 75 ohm input. When measuring antenna signals in parallel with a receiver having a terminated 50 ohm input, just simply hook a short 50 ohm feed line to the receiver's antenna terminal in parallel with the receivers antenna input and use the unterminated input option on all models of the HP-3586.

When making measurements on RF circuits you can terminate the input with 50 or 75 ohms termination, but on many circuits you may want to use the higher 10K 50pf unterminated input. Unfortunately this is not very high for some tuned circuits and the 50pf may detune the circuit causing measurement errors. HP did at one time offer accessory probes to isolate these circuits however they are not easy to obtain today so consider a link coupling if only measuring frequency. For accurate level measurements you may want to consider building a FET source follower or tube cathode follower one to one isolation amplifier to isolate these circuits from the instrument's input. I've shown two suggested circuits for this in Appendix C.

**3.3 Tracking Oscillator's Output Signal** - This output signal can drive a transmitter or other device, connect a BNC male connector with a 75 ohm line from the driven device's input to the Fo output connector located on the back panel. This outputs power is 0dbm or .27 volts RMS, which may not drive many older tube type transmitters. It will drive my Viking 2 on 160 through 40 meters but not above these bands and also is too low in power to drive my BC-610 through its crystal socket. I've constructed a small solid state broad band amplifier to drive the BC-610 and my Viking 2 that boosts the output to at least 10 volts RMS for more drive and better isolation, its schematic is shown in Appendix C. This amplifier is in a RF sealed box and mounted to the back panel of my HP3586. It's powered by the transmitter and has its B+ cut off during receive to kill any back wave in my receiver.

Other output signals are available on the instrument's back panel but are not useful to most of us doing Audio and RF measurements along with being for other specialized equipment, like HP computers and jitter measuring devices, so won't be discussed in this document.

## 4. FRONT PANEL DESCRIPTION AND INITIAL SET UP

**4.1 General** - Before turning on your HP3586 be sure it's configured for the right input power, usually 115VAC. Also be sure the filter on its back panel is clean, if not remove it and clean with only soap and water. The filter should be cleaned after every 720 hours of operation.

In the following sections and chapter you'll see capital letters in brackets like [AUTO]. These identify buttons used to control the instrument or enter data. The front panel of a HP3586 is broken into groups or sub panels, which we'll refer to in this chapter to aid in locating individual displays and controls.

Additionally, on the front panel you will see some buttons with a second label below the button or two labels on the button like buttons near the keyboard, these are dual function buttons. Ones with two labels on the button will select the proper function automatically by the button that is previously pushed, like if you push [FREQ] the instrument knows MHz, KHz, or Hz apply instead of the other labels like -db or -db. The ones with labels below and above the button are shifted button. On the same panel you will see an unlabeled colored shift button with a light on it. When it's light is on, the lower label of the dual-purpose adjacent buttons will apply. Also buttons with lights will have their function on when their light is on.

Plug your HP3586 into AC power and the STANDBY annunciator should light, next turn on your HP3586 by pressing [POWER]. It will first perform an auto calibration for about 5 seconds. If a ERR or CE with a number is displayed on the LH front panel read out there has been an error during calibration, refer to Appendix A for a listing of errors and suggested corrective action. The [AUTO CAL] button light should be on but you can turn off auto cal at any time by pressing this button, but for now leave it on. After the initial power up and auto cal the instrument should default to the low distortion-measuring mode with a range setting of 10db auto. During the following sections we will describe the front panel controls. Since the instrument will default to the selective low distortion level measuring mode when first it's powered up you may not need to perform all the described button pushing commands but just confirm that the instrument is set up as described.

During the following sections of this chapter, have your HP3586 available in front of you to find the described controls and LED displays.

**4.2 Measurement/Entry Group** - On the upper LH is the measurement/entry sub panel, which is used for displaying the power or voltage measurements and their units on a LED display. The measuring range and range full scale range value is set using it's buttons. Set the range by pressing [10db] and the full scale range limit by pressing [AUTO] for the automatic mode. The analog meter reads the relative level of signals within the selected 100db or 10db range. With the 100db and auto settings this meter will work as a relative signal strength meter to aid in frequency tuning. Press [dbm] to have the display read in dbm units. A dbm annunciator should now light to indicate the units are shown in dbm. The [OFFSET] button is used to subtract values placed in an offset register that will be subtracted from level values computed by the instrument to correct or normalize displayed level values. We will discuss this feature later, for now leave it off. Other buttons we'll discuss later during some of the examples.

**4.3 Frequency/Entry Group** - On the upper RH side of the front panel is the frequency/entry sub panel. This panel will usually display the frequency that the instrument is tuned to. It will display during frequency entry frequencies being entered by the instrument's keyboard in KHz or Hz. This frequency will be the center RF frequency of the selected band pass filter except when in the SSB channel measurement modes. On all models this panel can select a LSB or USB, side band channel for measurement using the two channel buttons with a funny symbol I can't show with Word. The left button is for LSB while the one on the right is for USB. A counter button is provided to start the frequency measurement counter system. Only the A and B versions have the SSB entry frequency selection buttons. The carrier button should be on when in one of the SSB channel modes and tuning a SSB signal. This changes the display to read SSB carrier frequency instead of filter center RF frequency. Even when their lights are on, the tone



and carrier buttons are only active in the SSB channel modes. The tone button is only useful for phone line analysis and won't be used or discussed in this document.

**4.4 Status Group** - This small status sub panel on the top far right indicates if the instrument is receiving or sending data to a remote computer and whether it's under local or remote control. If the remote annunciator is on, press [LOCAL]. For our use it should always be in local front panel control mode.

**4.5 Measurement Mode Group** - On the lower LH side is the measurement mode sub panel that's used for selection of how level a measurement will be made by the instrument. All versions have the selective mode buttons, but only the A and B versions have the specialized SSB channel modes for performing many SSB channel measurements. The only useful SSB modes I have found a use for are noise/demod, carrier, and impulse modes. With the shift key light off, press the selective [LO DIST] key to select the maximum dynamic measurement range for the instrument.

**4.6 Termination Group** – **Never put more than +27dbm or .5 watts total power into the input 50 ohm or 75 ohm connector of a HP3586 when using the internal termination. Never put more than +42 volts total AC + DC into an unterminated connector.**

The termination sub panel is also located on the lower LH of the control panel. This panel is used to select the input termination for an input signal. The 50 or 75 ohm unbalanced input on the LH side of the panel is the only ones useful for radio work and used in the examples of this document. The others use non-standard RF circuit impedances and are for telephone applications. See Chapter 3 for a complete description on how to connect to the unbalanced low impedance input.

For the measurements we'll be doing in the following chapter, press the [100K 50pf] button on an A or B versions. On the C version press the [50 ohm] button and the unlabeled shift key to the right of the 75 ohm key to remove its 50 ohm load. If you're not connected in parallel with a terminated load like a radio receiver, and need a termination such as when being directly connected to an antenna feed line, turn off the shift key's light on the C version to provide a load. For unterminated 50 ohm loads using the A or B version you will need to provide an external 50 ohm termination. In Appendix C is a schematic for a termination box with a blocking capacitor that I use with my HP3586B.

**4.7 Entry Group** - On the lower center of the front panel is located the entry sub panel. This sub panel is used for entry of frequencies, data offsets, frequency tuning steps, full scale measurement values, and transferring frequency and offset values to their respective registers by using its keyboard buttons.

One very important key is the measurement continue key, [MEAS CONT]. During many data entries that use one of the LED displays this key's red light will turn on or flash indicating the instrument's measurement process has been interrupted. Anytime you see this button's light and want to return to the measurement mode press this key to continue measuring. You can also press it to cancel a mistaken partially keyboard entry.

Another useful feature of the HP3586 is its ability to store its configuration settings for future use in making similar future measurements. To do this you can press [STORE] on the entry sub panel followed by any number from 1 to 9 on the keyboard. This will store the present configuration of the instrument in the memory location of the number pressed for future recall and to save setup time. To recall the configuration press [RECALL] followed by the register number to rapidly configure the instrument to a previously stored configuration. To return to the default power up configuration, press [RECALL] then enter 0. These configurations will be stored after the front panel power button is off and the instrument is in standby as long as AC power is connected to the instrument or its internal battery is charged. Unfortunately many surplus HP3586's have dead batteries or their batteries removed and will lose their stored configurations when disconnected from AC power.

If you press [OFFSET] on this sub panel you'll first see the offset in the measurement level offset register. If the number you want to enter is close to the present one in the data offset register, you can change the existing number up or down using the arrow keys, [↑] or [↓] and then press one of the db buttons and followed by [MEAS CONT].

**4.8 Frequency/Tune Group** - On the lower right side of the front panel is the frequency/tune sub panel. This sub panel contains a knob, which is useful in fine-tuning the instrument's frequency, especially to SSB signals. Different automatic tuning steps are selected for the selected filters using the [AUTO] button. Entry panel pre-programmed steps can be selected by pressing the frequency step button. The actual step size is entered on the entry sub panel for the [FREQ STEP] button. Pressing the off button can lock off the frequency tune function.

**4.9 Bandwidth Group** - On the lower right is the bandwidth sub panel, which is used to select the instrument's bandwidth that a power or voltage measurements are to be taken over. All models have 20Hz and 400Hz filters. The A and B versions will have one additional filter of 1740Hz, 2000Hz or 3100Hz. A and B versions may also have the optional WTD audio noise filter which is selected by a fourth button to be in series with the wide third filter. For now select the widest filter your HP3586 has.

**4.10 Audio Group** - On the lower far right is the audio sub panel. This panel contains a small speaker and headphone jack along with a volume control knob for output of audio from the SSB detector. Since we won't be using the audio output during our first measurements turn the volume knob full CCW to turn off the sound.

**4.11 Improving SSB Reception** - This method that is not in the HP operator's manual gets around the problem of these signals being very distorted in the instrument's speaker due to the fact the automatic range level selection is acting as a AGC system for the SSB demodulator but because of its slow action there is heavy distortion on the onset of audio signals such as words. I first set the instrument in the 10db and auto range selection mode, press [10db] then [AUTO] on the frequency/entry sub panel if they aren't on. Next press [AUTO] on the measurement/entry panel and tune the speaker's audio for best possible audio. Then enter a frequency step of one Hz by pressing [FREQ STEP] on the entry panel and enter 1 followed by [Hz] and [MEAS CONT]. Now press [FREQ STEP] on the frequency/entry sub panel and again tune for best audio.

Now to improve the speaker audio by preventing over loading the SSB demodulator, lock the instrument into manual IF gain control by pressing [ENTRY] on the frequency/ entry sub panel. This will stop the IF amps AGC action and fix the gain of the IF strip to that of the last automatic setting. This should partially reduce distortion but to further reduce it, press [FULL SCALE] on the entry sub panel and use the [↑] key to move the range full scale setting shown on the level display up until the modulation peaks on the analog meter are near 1/3 scale and turn up the speaker's volume if necessary. If you go too far and loose the audio, then press [↓] to increase the IF's gain but I've found 1/3 scale on the analog meter gives best audio. You can experiment and find the best IF gain setting by entering smaller and larger limits using these keys just like you would using a manual RF or IF gain control knob on your receiver. If you get UL or OL on the level measurement display, don't worry if your just tuning or listening to SSB, this only indicates level measurements are inaccurate. Also to not have your SSB signal interrupted during tuning or monitoring, turn off auto cal. However when doing level measurements, always have auto cal back on and press [AUTO] on the measurement/entry sub panel when your doing signal level measurements.

**4.12 Back Panel Oscillator Output** – On the HP3586's back panel is located a female BNC connector labeled Fo that supplies an output of 0 dbm, 75 ohm from the internal tracking oscillator. Its frequency will always equal to the frequency of the selected filter's center band pass frequency. This output is disabled in the wideband measuring mode.

## 5. SETTING AND MEASURING FREQUENCY

**5.1 General** - Now we're ready to have some fun doing examples of how to use your HP3586. This chapter we'll show how to use the HP3586 as a VFO by adjusting its frequency and outputting this frequency for controlling an outboard device like an AM transmitter. We'll also command the instrument to measure the frequency of a received AM carrier then lock its output to the carrier's for zero beating to another transmitter's carrier along with checking your HP3586's frequency calibration. These examples can be used in all the selective measurement. For now stay in the low distortion selective mode.

**5.2 Setting Frequency** - The easiest way to set the frequency of the instrument is to enter the desired frequency using the entry keyboard. On the entry keyboard first press [FREQ], enter a number for the desired frequency on the keyboard. Then press one of the dual function [Hz], [KHz] or [MHz] buttons for the units the frequency is in. The frequency display will now read the frequency you have just entered and a CENTER annunciator on the display will light indicating this is the frequency the center of its selected filter. It will also output this frequency to the back panel Fo connector at a 0dbm, 75 ohm level. Now the HP3586 can be used as an outboard VFO for controlling other devices through its Fo connector. In Appendix C is the schematic of an amplifier I use to drive my AM transmitters from this output.

To make small frequency adjustments you can use the frequency tune knob. But first you have to set up the resolution of this control. First go to the entry panel and press [FREQ STEP] and enter on the keyboard the step resolution you want, I usually use 10Hz or for fine tuning of carriers so let's enter 10, then press the [Hz] button for the units of the step you selected followed by the [MEAS CONT] button to return the instruments to its measuring mode. Now go to the frequency tune knob and press the [FREQ STEP] button. As you turn the knob you will see the frequency display change in 10Hz increments. Since the instruments frequency register is being changed the tracking oscillator output at Fo is also changing with the displayed frequency. For faster tuning you can press the [AUTO] button, which selects frequency steps depending on what bandwidth filter you selected. Knob tuning is a handy feature I use for zero beating the instrument's Fo output to a carrier being receiving on my 75A4 receiver. I turn on the exciter stage in my transmitter then using the HP3586's frequency tune knob to adjust the HP3586's frequency to zero beat with the received carrier while listening to my 75A4.

**5.3 Automatically Determining a Station's Frequency** – Be sure the 75 or 50 ohm connector is connected in parallel with your receivers antenna input as described in the previous section. To use this feature the instrument must be receiving a steady signal that's stronger than any other signals in its filter's pass band.

To automatically tune the HP-3586 to exactly the frequency of a received carrier, tune the carrier into the pass band of the instrument's selected filter. I usually use the instrument's widest filter, which we already selected in the previous chapter when setting up the instrument. Turn up the volume knob on the audio panel on the lower RH side of the front panel to hear signals being received and be sure either USB or LSB is selected using the buttons below the frequency display. Press the [AUTO] button for the frequency input knob and tune it into the filter's pass band. Tune the tone for zero beat on one side of the filter's band pass and you should be able to confirm the carrier is the one you want to tune to by listening to the audio from the carrier's side band. Be sure you're in the 10db measurement range and auto full scale for a good speaker output.

After confirming the stations identity, tune the carrier back into the band pass indicated by a strong carrier tone and press [COUNTER] under the frequency display to turn on the frequency counter. The display frequency will now automatically lock onto the received carrier's frequency. Next press [CNTR→FREQ] on the keyboard entry panel to store the counter frequency in the frequency register then [COUNTER] to turn off the counter followed by [MEAS CONT] and return the display and instrument's frequency to the new contents of the frequency register. The instrument's frequency is now the carrier's measured frequency and in the speaker you should now hear the received carrier's tone at around half the frequency of the filters band pass frequency indicating the carrier is now exactly in the center of the filter's pass band.

If there is other strong signals in the filter's band pass and the instrument has trouble locking on to the received carrier, select a narrower filter and repeat the above procedure.

Unfortunately the HP3586 can't be easily used as a receiver when controlling a transmitter, see section 16.11 of Chapter 16 for a possible method. It only has a SSB product detector and only displays the center RF frequency that its filter is tuned to, so after locking onto a carrier, you will have to turn the volume control knob full CCW to kill the carrier's tone in the speaker. Then use your outboard receiver to copy the other station.

**5.4 Checking Your Instrument's Frequency Calibration** – HP recommends that the instrument be calibrated each year. Unfortunately most of us don't have access to a calibration lab and can't afford to pay a lab to do this for us. But we can check its frequency calibration using one of the frequency standard WWV stations. Select a wide filter to make it easy to tune in one of the WWV stations, press [3100Hz] or the button for your widest filter. With the same setup as the previous section tune your instrument to one of the following frequencies, 2.500MHz, 5.000MHz, or 10.000MHz. Be sure to have an antenna connected to your instrument's unplaced input.

Turn up the audio volume on the audio sub panel to find a frequency where WWV is well above the noise. You should hear a strong tone from its carrier in the filter's pass band. You can also confirm you are tuned to WWV by tuning the tone for zero beat using the frequency tuning knob and listen for the announcer to identify the station as WWV in its AM side band. Be careful since WWV will send tones at times that you could lock onto by mistake, it's better to tune when their tone is off. Now retune the carrier to the filters center and switch to your 400Hz filter being sure the WWV carrier is within the filters pass band.

Now press [COUNTER] on the frequency/entry sub panel and read what your HP3586 says the WWV carrier frequency is. The difference from exactly one of the above frequencies you first tuned to is the frequency error in your HP3586 since WWV stations have their frequency held to within a small fraction of a cycle. See section 16.8 of Chapter 16 for a suggested way of keeping your HP3586's frequency accurately calibrated. Also see section 2.4 of Chapter 2 to see if you have the 004 frequency standard option and if it's activated.

## 6. POWER LEVEL MEASUREMENTS USING THE SELECTIVE MODE

**6.1 General** - The most basic function of the HP3586 is to measure the power of signals on telephone lines using its selective measuring mode. This useful feature can also be used to do on the air measuring of radio signal strength or on the bench measuring output of electronic circuits such as oscillators and amplifiers.

For maximum accuracy the HP3586 has front panel selectable measuring ranges of 10db or 100db to look at only a portion of its total measuring range of +20dbm down to -100dbm. The 10db range will have a measurement resolution of .01db or better over its complete range. The 100db range will have a lower resolution of .1db over the upper 80db of its 100db range. When tuning a signal by looking at the strength of the signal on the analog meter it's best to be in the 100db auto range. However, you must only use the 10db range for audio tuning of signals whose strength is under -60dbm. For high precision measurements it's best to always select the 10db auto range.

By fixing the range by pressing [ENTRY] we can fix the range's location. I only use the [ENTRY] button mode when using audio in the 10db range to tune a signal that is rapidly changing like a SSB station or measuring rapidly varying signals, but more on that later when we tune a SSB station. For the following section stay in the low distortion, 10db auto modes.

**6.2 Setup for Performing Power Measurements** - Now let's go through a typical example of measuring the power output of a typical electronic circuit. Assume we have a small crystal oscillator tuned to 14.020 MHz followed by a 12db 50 ohm unterminated attenuator pad in a RF sealed enclosure. We want to know its output power since it will be used in a test circuit to measure receiver dynamic range. We first connect the circuit through a short 50 ohm coax line to the 50 or 75 ohm input on the termination sub panel. Since the circuit requires 50 ohm termination we must provide this at the HP3586. On a C version do this by pressing [50 ohm] with the shift button light off to select a 50 ohm terminated input. On an A or B versions things are more complicated. We must add a 50 ohm resistor at the output but only if the frequency is very low and the line to the instrument's connector is very short. It would be best to have the resistor in an adapter across the 75ohm input. This will now provide a 50 ohm terminated input for the oscillator circuit. In Appendix C I show the circuit I use to provide a 50 ohm termination for my HP3586B.

**6.2 Setting Input Termination Impedance** - Make sure the display is reading in dbm by confirming the dbm annunciator on the level display is on, if it isn't press [dbm] under units on the measurements/entry sub panel. We still have another little problem when using an A or B versions instrument with a 50 ohm input, it does all its power calculations based on the 75 ohm resistance it was designed for. But since the HP3586 measures power in dbm, we can add a offset to the level measurement to correct the data to power across a 50 ohm load. This offset can be calculated by:

$$\text{OFFSET} = 10 \log (R1/75) = -1.76\text{db} \quad R1 \text{ will equal } 50 \text{ for our } 50 \text{ ohm load termination resistor}$$

Enter the offset by pressing [OFFSET] on the entry panel, and then enter the value, 1.76, using the number keyboard, press [-db] for it's sign and units, and then press [MEAS CONT] to return to the measurement mode. Last activate the offset feature by pressing [OFFSET] on the measurement/entry panel. When we first pressed [OFFSET] on the entry sub panel the value in its offset register will be displayed and then when we enter our new offset it will overwrite the old offset to confirm our entry. Now our display readings will be in dbm referenced to a 50 ohm load as long as the light on the offset button is on. Also an O annunciator behind the dbm annunciator will turn on indicating the readings are offset by the value in the offset register.

**6.3 Performing Power Measurements** - Now tune the frequency of the HP3586 to that of the oscillator's output by any of the earlier described methods. Once we have found the oscillator's frequency by hearing it's beat tone in the SSB audio speaker, or seeing an upward deflection of the analog level meter

and a reading on the LED level display, we need to accurately set the filter center frequency. Press [COUNTER] just under the LED frequency display. Now set the instrument's frequency register to this frequency by pressing [CNTR→FREQ] followed by [MEAS CONT]. Last select the 20Hz filter to eliminate as much noise as possible from the level measurement.

To see the difference in precision for the different ranges, press [100db] under the range label on the measurement/entry sub panel. Now we may see a reading near what we expected, like -30.2dbm on the measure/entry LED display. Now we can proceed to get a more precise measurement of within .01dbm. Change back to the 10db range by pressing [10db] under the range label and the reading changes to -30.17. Now we can record the oscillator's output into our data book or make adjustments to it to get the power level in dbm we want.

If the reading was very low, say -90.12dbm, which is close to the instruments internal noise floor, try pressing [LO NOISE] on the measurement mode sub panel. If the level now drops to say -90.05dbm, use this low noise mode since the level using the low distortion was affected by the instrument's internal noise. If the reading increased, use the low distortion mode reading since this indicates there were other strong signals present maybe not in the filter's pass band but had caused intermodulation products to fall within the filter's pass band, more on this later in Chapter 16.

**6.4 Transforming Power From dbm to Watts** - Since our instrument only measures power in dbm, which is referenced to .001 watt, to get the power in actual watts we can use the following:

$$\text{Power in watts} = .001 \text{ anti log } (P \text{ dbm}/10) \quad \text{Where } P \text{ dbm is our display reading in dbm units.}$$

You can also make on the air power measurements in the same manner as above using the selective level modes. With carriers or steady signals pick the narrowest band filter to cover the complete signal, i.e. 20 Hz for carriers or single frequency signals. It's best to always use the low distortion selective measurement mode if there are other strong signals present. These are more likely to cause intermodulation products when using the low noise mode and will cause an inaccurate power reading. But you can test for this by watching the level reading and changing mode as described above in section 6.3.

**6.5 Averaging With Varying Signals** - With rapidly varying signals, the display reading will be changing rapidly over a large range. This will be the case with carriers subject to selective fading. The display readings will be more stable if averaging is used. Averaging will also increase the probability of a more accurate reading in the presence of rapid fading intermodulation products and noise so it is always best to have it on by pressing [AVE] on the measurement/entry panel when measuring radio signals. Also averaging should always be on when measuring greatly varying signals such as SSB signals.

**6.6 Saving the Instrument's Configuration** - For use in a future example let's now store the instrument's configuration. Press [STORE] followed by entering 1 in the entry sub panel.

## 7. VOLTAGE LEVEL MEASUREMENTS USING THE SELECTIVE MODE

**7.1 General** - The HP3586 can only output level measurements in db's referenced to a power like one milliwatt, one picowatt, or a voltage level like .775 volt on all models and a 1 volt input on the C version. But remember that every level reading is only in db referenced to a power or voltage level. If you're not familiar with this comparative nonlinear system of measurement, take a look at Appendix A for a better understanding. Now let's do a couple of examples of voltage measurements.

A very important consideration is that if we were going to do a voltage measurement of a very high impedance tuned circuit where the instrument's unterminated 10K 50pf input would load or detune, we need to insert a one to one probe or amplifier to isolate the HP-3586's input. In Appendix C I've shown the schematics of two circuits you may want to consider to isolate the circuit under test from you instrument.

**7.1 Performing the Measurement** - First let's use the first example of the padded output oscillator in the previous example. This is very easy to do by first recalling our configuration stored in the 1 location by pressing [RECALL], entering 1 on the keyboard. We first need to change the measurement units for voltage measurements, press [db.775V] on the measurement/entry sub panel. If the offset button's light is on, press this button to deactivate the offset calculation. Now our readings of the oscillator's output will be in units of db referenced to .775 volts. We can easily calculate the level in volts using a calculator and the following formula:

Level in volts =  $20 \text{ anti log } (V_r / .775)$  Where  $V_r$  is the display panel reading in db.775V units.

## 8. MEASURING CARRIER SIGNAL STRENGTH

**8.1 General** - In this chapter we'll do an example showing the use of the carrier mode in the A and B versions. This mode is not available in the C version but this example can be performed with a C version by using the low distortion selective mode by using the procedure described in chapter 7. If you saved the C models configuration in chapter 7, press [RECALL] followed by entering 1 on the entry sub panel keyboard.

If you have the A or B version, press [CARRIER] on the measurement mode sub panel under SSB channels. The instrument will default to the 20Hz filter but to aid in tuning a carrier you can select a wider filter then return to the narrow filter for the actual level measurement.

Let's do an example of on the air measurement of the accuracy of our outboard receiver's signal strength meter that reads in S units of 6db per S unit up to S9, then db's over that level and is suppose to be calibrated for a 100uv antenna input to give a meter reading of S9.

**8.2 Normalizing the Measurement** – Now let's calculate a db.775V display offset to reference the display to 100uv or .0001 volts. This will make the display read 0db when the input signal is exactly 100uv, .0001 volts. Calculate the offset using the following formula.

$$\text{OFFSET} = 20 \log (V_r/.775) = -77.79\text{db} \quad \text{Where the new voltage reference } V_r = .0001 \text{ volts}$$

Enter the calculated offset into display offset register by pressing [OFFSET] on the entry sub panel, followed by entering the absolute offset number on the entry keyboard of 77.79, then pressing [-db] followed by [MEAS CONT]. Now activate the offset calculation by pressing [OFFSET] on the measurement/entry panel to turn the button's light on and the O annunciator behind the dbV.775 units.

**8.3 Measuring the Carrier's Signal Strength** – This is an example of a procedure to measure a signal's strength in db over or under a normal S9 level of a receiver's strength meter level calibrated for 100uv signal equal to a S9 reading.

Tune the HP3586 to exactly the carrier frequency of the 40 meter broadcast carrier on our outboard receiver using any of the previous frequency tuning methods. If you initially tuned the carrier using the SSB detector, set the measuring range for 10db and the range upper limit for automatic to be able to hear the signal. Because of possible carrier fading, be sure averaging is on; press [AVE] on the measurement/entry sub panel. Once you have the signal in the filters pass band lock onto it using the counter and transfer it to the frequency register using the methods previously described in chapter 6. Switch back to the 20Hz filter if you used a wider one for tuning the carrier and to the 100db measuring range for less noise error and more stable readings.

The HP3586 should now display db readings close to that of the receiver's S meter if the S meter is in its db range over S9 and if the reading on the instrument is positive indicating a reading over the 100uv S9 value. For -db and S meter readings below S9, just divide the absolute -db value by 6db and subtract that number from 9 to get the S unit value between 0 and 9. Don't be surprised if you receivers S meter reading is different than the measurement of the HP-3586

When doing this experiment I found it instructive and fun to also set the measuring range at 100db but set its upper limit for entry and then enter 0db as the limit. However, when I tried to set the limit at 0 it defaulted to +1dbm because of the resolution of this setting wouldn't allow exactly 0db. But I wanted the analog meter to be close in dbm and 1db won't make that much difference, it's close enough for government work. Now the meter was reading signal strength in dbm where the display was reading average db above S9 for signals on an AM net on 75 meters. It was interesting and instructive to see signals between S8 and 25db over S9 on the LED level display were running from -75dbm and up to -50dbm on the analog meter.



## 9. TUNING SSB SIGNALS USING THE SELECTIVE MODE

**9.1 General** - This Chapter will describe the only method of tuning SSB signals on the HP3586C. The next chapter will describe a much easier method used only in the A and B versions. Even if you have an A or B versions with the SSB channel tuning and measurement features, reading this section and understanding its example will give you a better understanding of how your HP3586 works.

**9.2 Common Problems When Using the HP3586 as a SSB Receiver** - All HP3586's contains a SSB demodulation system that allows it to demodulate USB and LSB signals. The demodulated audio signal is then output to an audio amplifier and front panel speaker for tuning SSB signals.

This demodulation system has three disadvantages making it not a very good system for normal reception of SSB signals. As an automatic volume control system it uses a IF gain control system which is designed to accurately measure signal levels but not optimum for a SSB receiver because of its slow response that results in a slow reduction of IF gain as the signal increases in strength causing poor audio. This results in unnatural sounding voice audio with distortion on the beginning of words. In section 4.11 of Chapter 4 we showed a way of greatly improving SSB audio quality by fixing the instrument's IF gain.

The second disadvantage is, when in the selective mode the instrument's displayed frequency for a properly tuned SSB signal will always be the center RF frequency of the filter's band pass. Those working with SSB signals on telephone lines identify the signal's frequency as the center frequency of its channel on the phone line. The conventional way for those of use working with radio signals is to identify the frequency of a SSB signal as the frequency of the SSB signal's carrier as if it were an AM signal causing confusion when using a HP3586 in the selective measurement mode.

A third disadvantage is that a properly aligned SSB transmitter does not transmit a carrier or a single strong steady tone much greater than its SSB signal, which is continually varying in strength. There is nothing in the pass band of a SSB radio signal for the HP3586's frequency counter system to lock onto for finding a channel frequency like it can with an AM signal having a strong carrier. This will always force us to determine the SSB radio signals frequency by tuning it for best audio using the SSB demodulator system just like we tune a SSB station on a radio receiver. When testing SSB telephone lines using the HP3586 the technician will usually put a test tone of known frequency into the SSB channel to aid in determining the channel's frequency. But with radio signals we don't usually have this luxury.

These disadvantages make the HP3586C, which was designed for telephone use, a little difficult for us to use however by using a little patience, a few simple calculations and an understanding of how it works, it's possible to use it for SSB radio work. The following examples will illustrate this.

**9.3 Tuning a SSB Signal** – Place your HP3586 into the low distortion mode or press [RECALL], then 1 to recall our preciously saved our low distortion mode configuration. Select the instrument's widest filter on the band pass sub panel. Press [USB] or [LSB] just under the frequency display to select the proper side band for the band you're on. Be sure you are still in the 10db auto measuring range to copy a SSB signal on your speaker. Also you should have the instrument's input connected in parallel with a SSB receiver. Tune in a SSB signal on the HP3586 using the procedure in section 4.11 of Chapter 4, which will help you tune a SSB signal for best audio. Congratulations, you have successfully tuned in a SSB station.

After you have the station tuned in the station press the [AUTO] button on the measurement/entry sub panel for accurate level measurements. On your receiver connected in parallel with the HP3586, tune it to the same SSB signal for best audio. Now take a look at the frequency your receiver is tuned to and compare it with the frequency on the HP3586 display. In this example I'm assuming your receiver has an accurate frequency display. The frequencies on the receiver and HP3586 displays will not be the same. What's causing this difference in the two readings?

The difference is caused by the different way telephone and radio people denote SSB channel frequency. When comparing a SSB radio frequency with a HP3586 frequency on LSB the HP3586 will have a fixed negative offset from the receiver's whose value depends on the filter that is selected in the HP3586. On USB the HP3586's frequency offset will be positive by the same filter offset. This is because the HP3586 in the selective modes defines a channel by its center frequency where SSB receivers and transmitters use the convention of defining the channel by the carrier frequency.

Filter offset values can be used to obtain the carrier frequency used by radio SSB transmitters and receiver by adding or subtracting it from the HP3586 display frequency readings. These carrier offset numbers are shown below for each of the HP3586 filters that can be used for SSB:

FILTER BAND WIDTH	CARRIER OFFSET
1740Hz	1350Hz
2000Hz	1500Hz
3100Hz	1850Hz

**9.4 Setting a AM Transmitter's Carrier to a SSB frequency** - To better understand this let's go through an example of zero beating an AM transmitter with a SSB signal. Assume I want to check into the Collins Collectors Association net on LSB at 3895kHz. The net control operator and most of the members are on LSB but welcome anyone to check in on AM as long as they have a stable signal and are zero beat with the net control operator so they can be copied on LSB by the net members. Tonight there is a QSO down a few KHz below the net so the net control has moved the net up an unknown number of Hz and it's hard to determine his exact frequency because I'm using my 75A4 receiver with an analog frequency dial. I can usually get to within 100Hz using it but even that will cause complaints by those on LSB, especially those that don't like AM. So I want to get as close as possible to their frequency with my BC-610F AM transmitter which is hooked to a HP3586.

I tune close to the SSB signal of the net control operator using a frequency keyboard entry then the method describer in section 4.11 of chapter 4. I next enter into my hand held calculator the frequency displayed on my HP3586, which is 3896KHz. Since I'm using my 3100Hz filter and on LSB, I use my calculator to add a carrier offset of 1850Hz to the HP3586C's frequency of 3896Kz to get the SSB stations carrier frequency of 3897.850KHz. I then enter the calculated SSB net's carrier frequency into my HP3586C using the following commands, press [FREQ], enter 3897.850 on the keyboard, press [KHz], and finally press [MEAS CONT] to place the new filter center RF frequency and internal tracking oscillator frequency into the HP3586's frequency register. I now turn down the volume of my HP3585's speaker since the SSB signal will be detuned by 1850Hz and use my 75A4 receiver to monitor the net. Now the filter center frequency and the frequency of the rear panel output to my transmitter is right on the SSB net's frequency so my AM transmitter's carrier frequency will be zero beat with the net control's frequency. Then most stations on the net will not even realize I'm using AM. This example should illustrate a way to work around the different methods of measuring SSB channel frequency used by telephone and radio technicians using the HP3586C.

**9.4 Frequency Shift During Auto Cal** - When transmitting AM to a SSB station using a HP-3586 with the instrument's auto cal function is on, the instrument's output frequency will change about 100Hz up and down in frequency during the 3 second auto cal cycle. For this reason I find it best to press [AUTO CAL] to turn off auto cal during AM transmissions. I usually leave auto cal off after the instrument has warmed up for a half hour when transmitting to SSB stations just after I have set my carrier frequency. Auto cal is only necessary after a large change in frequency and during level measurements.

## 10. TUNING A SSB SIGNAL USING THE NOISE/DEMODULATION MODE

**10.1 General** – The A and B versions of the HP-3586 have SSB channel modes that speed the setup of the instrument for reception and measuring of SSB signals. Unfortunately the C version doesn't have these modes but can still be configured to tune SSB signals using the method I described previously in Chapter 9. The noise/demodulation mode was designed for measuring noise and copying SSB signals on telephone channels. The demodulation feature is very useful for tuning SSB radio signals but I haven't found much use for the noise feature.

The noise/demodulation mode is basically the same as the low distortion selective mode except it automatically selects the instrument's widest band pass filter and sets its frequency display to show the SSB signal's carrier RF frequency or the RF frequency of a tone used to find a SSB channel on a phone line. This last feature is useless for our radio type measurements. But the carrier frequency display mode is very useful since this is the usual way of defining radio SSB signals.

**10.2 Instrument Setup** - Configure your HP3586 by pressing [NOISE/DEMOD] on the measurement mode sub panel to configure the instrument for demodulation of SSB signals. Press one of the channel select buttons [LSB] or [USB] located under the frequency display to match the sideband used on the band you're tuned to.

**10.3 Determining a SSB Station's Frequency** – I'm going to use the same CCA net example of chapter 9. First press [CARRIER] on the frequency/entry sub panel if it's light isn't on to read the SSB carrier frequency of the SSB station. You should now see the CARRIER annunciator on the frequency display on. Then confirm the net is on the air and it's approximate frequency using my 75A4. I next tune a frequency close to the net control operator using my HP3586 by setting it for proper side band and using the entry keyboard. Then fine tune using the frequency control knob on the HP3586 and the procedure described section 4.11 of Chapter 4. Since the Fo oscillator output is always tuned to my filter's center frequency it will still not be the same as the frequency on my LED frequency since I'm in the carrier tuning mode for the SSB channel measuring modes. But after tuning for best audio in the noise/demodulation mode I can easily change modes to move the center of my filter's band pass by changing modes. Just go to the measurement/mode sub panel, press [LO DIST]. Notice the display frequency doesn't change but the CARRIER annunciator goes out and the CENTER one goes on. Now I have moved my Fo output frequency right onto the net control's carrier frequency. I now will turn down the volume of the HP3586 speaker and use my 75A4 receiver to copy the net and proceed to check into the net.

**10.4 Measuring the Strength of a SSB Station** – After tuning in a SSB station for best audio in the auto 10db mode, while in the entry range limit setting mode press [100db] under the analog meter to use the 100db range for more for stable and reliable radio signal level measurements. To slow down the display variations and better represent the received station's average power, turn on averaging or be sure the [AVE] button's light is on below the measurement display. Choose the units you want the measurements in, you can choose dbm or use an offset and db.77V to make the readings more like that of a S meter and referenced to 100uv as previously explained in section 9.4 of Chapter 9. If we now look at the instrument's level measurement display while receiving a SSB station we should see it deflecting upward every time its operator talks. If you get an OL or UL on the level display, increase or decrease the 100db range's upper limit setting to get into an accurate measuring range.

With some A and B versions there is an additional WTD noise filter in series with the 3100Hz filter usually used for SSB on telephone lines. You may want to switch to the widest filter without WTD for more accurate level measurements. However, it really doesn't make a great difference because it's very hard to do precise level measurements on a varying SSB radio signal. If you are doing comparative measurements, just make sure you use the same filter for all measurements.

## 11. MEASURING AUDIO NOISE USING THE WIDEBAND MODE

**11.1 General** – All versions HP3586 can be used to measure total power input over their entire frequency range of 200Hz to 32MHz by placing them into the wideband measuring mode. This mode is useful for rapidly measuring a signal whose frequency isn't important or is determined by tuned circuits like in an IF stage as a digital wide band power or voltage meter. However, in this mode the instrument's noise floor is very much higher, around -70dbm, than in the other selective modes where it's around -120dbm. This could cause errors in measuring weak signals. In the following example we will illustrate how to use the wideband mode when measuring an audio line amplifier's internal noise.

In the wideband mode all the front panel frequency dependent displays and controls are deactivated. The instrument in the wideband mode is a broadband power or voltage measuring instrument with a frequency response of 200Hz to 32MHz.

**11.2 Wideband Amplifier Noise Measurement** – Assume we have an amplifier that we can input 200Hz to 10KHz audio signals from an audio device to and amplify this signal up to a 2.5 watts 75 ohm of audio output power. This amplifier has a 600 ohm input and a 75 ohm output impedances, a 20db gain, and it uses a socket mounted inexpensive audio IC chip that we can buy from different sources. We want to select the chip that has the lowest internally generated noise. We'll use our HP3586 to measure the noise performance of our amplifier with different chips in its wideband measurement mode.

First we terminate the input of our amplifier with a 600 ohm resistor and attach a scope to its output to be sure there is only internal noise generated by the amp from its output. Any of signals with a total power of over .5 watts will damage out HP3586 so we want to be sure there is nothing but low power white noise on the amps output. We now connect the AC coupled 75 ohm output to the termination sub panel 75 ohm connector. We next press [75 ohm] on the termination sub panel to provide a 75 ohm load for our amplifier. We next press [WIDE BAND] on the measurement mode sub panel. We also press [dbm] on the measurement/entry sub panel for units since we'll start by measuring the noise power in db relative to a milliwatt.

**11.3 Normalizing our Noise Data** - We now should see a low level reading in dbm units on the LED of the measurement entry sub panel. Let's say its -50.1dbm, which is about as low as our HP3586 can accurately measure in the wideband mode since the internal wideband noise floor on my HP3586B appears to be around 70dbm. Also the 100db measuring range is only available in the wideband mode so the resolution of our level data will only be .1db. We'll now let the instrument compare the IC's for us and also pick up a little more accuracy since we are down so low in power level that the HP3586 is starting to loose accuracy for absolute readings. Let's offset the HP3586 display to read in db's compared to our first standard chip.

To do this we could enter the -50.1dbm offset using the keyboard, but there is an easier way using one button to transfer the displayed offset directly into the offset register. Go to the entry keyboard and press [RDNG→OFFSET] to transfer the measurement display's level into the offset register. Now press [OFFSET] on the measurement/entry sub panel to activate the level offset feature. With our amplifier still powered and connected to our HP3586 we now see the LED display reading is 0db. We also should see O behind the dbm annunciator indicating the reading has been offset and is not in dbm but is now in db compared to the noise power from our amplifier with the IC chip we want to compare the others to.

**11.4 Taking the Data** – We now can proceed to plug in the other chips one at a time and record db readings for each. We see readings between +15db and -6db above and below our reference IC chip. It looks like the one that is -6db is the best choice for low noise.

## 12. MEASURING IMPULSE NOISE

**12.1 General** – During our wideband noise example we noticed some level changes indicating possible shot noise from some IC's, a common problem with many inexpensive consumer solid state IC chips. In this chapter we will use the impulse measuring mode to test the shot noise from these chips and illustrate the use of this measuring mode. Unfortunately, the HP3586C doesn't have this SSB channel mode and it can't be simulated by any other mode so we can't do this measurement with a C version instrument.

In this mode the instrument will output the number of pulses during a preset time that exceed a preset amplitude level.

**12.2 Setup** – Since the frequency display will be used for counting pluses in the impulse mode, enter the filter's center frequency before entering the impulse measurement mode. Press [FREQ] then enter 5.000 on the keyboard followed by pressing [KHZ]. Press [AUTO] on the measure/entry sub panel.

Press [SHIFT] on the measurement mode sub panel to select the impulse mode button. Press [IMPULSE] to place the instrument into the impulse measurement mode. Now press [OFFSET] on the measurement/entry sub panel to turn off the offset calculation if its button's light is on.

We'll arbitrarily decide to measure any noise pulse above -35dbm. Press [USB] or [LSB] to activate either one of the SSB channels, for this test either will work fine. Be sure the widest filter without WTD is selected and set its center frequency at 5KHz midway in our amplifier's audio pass band. Next set an interval measuring time of 5 minutes and 30 seconds and a minimum pulse threshold of -35dbm. On the entry keyboard press [TIME] and enter 5.30 on the keyboard followed by pressing [MIN]. Next press [THSHLD] followed by 35 on the keyboard, then press [-db] and [MEAS CONT].

**12.3 Taking Measurements** – Now install one of the IC's we want to test into our audio amplifier. Start the test by pressing [START] on the measurement mode sub panel. After our 5 minute 30 second time interval we should see the number of shot noise pulses that exceeded our maximum noise level of -35dbm on the RH side of the frequency display on the frequency/entry sub panel.

We can now compare the shot noise performance of our amplifier by the number of pulses over the time interval using different chips. This example is not especially the best way to measure shot noise in IC's but chosen only to illustrate how the HP3586's impulse measurement mode works and could be used.

## 13. MEASURING AUDIO HARMONIC DISTORTION

**13.1 General** – In this chapter we will show how to measure harmonics of a sinusoidal signal. This is an extremely valuable feature removing the necessity of having an audio distortion analyzer if you already have a HP3586. In a later chapter we'll demonstrate using the HP3586 to measure harmonic distortion at radio frequencies. This audio harmonic measurement example requires an external signal generator capable of outputting and controlling the level of a signal of very low harmonic distortion. From the following example you'll see, your HP3586 can be used as a very powerful 2<sup>nd</sup> and 3<sup>rd</sup> or higher order harmonic analysis tool.

As an example we will analyze the harmonic distortion of the 600 ohm input, 20db gain, 2.5 watt at 75 ohm output line amplifier that we used to test IC's for noise in chapters 11 and 12. In this example I'm going to skip a lot of the detail button pushing used to enter values and control our HP3586 since you should by now be familiar with this.

**13.2 Setup** – First we connect an audio signal generator capable of providing and controlling the level of a very low distortion 600 ohm signal at 1000Hz to the input of the audio line amplifier, like my HP205 audio signal generator. Since the amplifier has a 75 ohm output and needs a 75 ohm resistive termination we connect a 75 ohm 5 watt resistor to the amplifiers output and ground as a dummy load. We don't want to put a over .5 watts into our HP3585 and really only need to put around 1 mw into it. We add around a 4.7K ohm resistor between the amplifiers output and the instrument's 75 ohm input. We also turn on the 75 ohm termination in the instrument. This now provides close to a 75 ohm load for our amplifier and forms a power divider potentiometer network composed of the 5 watt 75 ohm load resistor, the 4.7K ohm series resistor and the instrument's 75 ohm internal termination resistor to present close to 1 mw to our instrument's input when the amplifier is outputting its full 2.5 watts.

If we have a HP3586 A or B we simply activate the carrier mode under the SSB channel modes for looking at a single signal through a 20Hz filter. We can also use the low distortion selective level mode on the C version and activate its 20Hz filter. You could use 10db measuring range but the 100db range would still give .1db of resolution, which is most likely more than needed. Place the display level in the dbm unit output and set the range upper limit in auto.

**13.3 Normalizing the HP3586 Display Level** – Tune both the HP3586 and signal generator to exactly 1000Hz. Turn up the signal generator's output until you see a signal of around -20dbm on the HP3586 measurement level display. Tune the signal generator to exactly 1000Hz by using the counter in the HP3586 and observing the frequency of the instrument's display and then turn off the counter to lock the instruments frequency.

Now measure the power across the 75 ohm load resistor using a calibrated scope or diode RMS rectifier probe and volt meter slowly increase the amps output power in the resistor by turning up the signal generator's output. If you see the power level on the HP3586 exceed 0dbm, increase the value of the 4.7K ohm series resistor to have as near as possible to a 0dbm reading with the amplifier putting out its rated 2.5 watts output power. We want to measure the amps harmonic distortion at it's maximum output power. If the instrument' input level is below 0dbm when the amplifier is at 2.5 watts, decrease the size of the resistor to get a display reading of within +/- 10db of 0dbm.

Now we can normalize the instrument's level display to only refer to levels below the amplifiers 1000Hz output of 2.5 watts to make comparative harmonic measurements. On the entry sub panel press [RDNG→OFFSET] followed by pressing [OFFSET] on the measurement entry sub panel to place the amps power reading into the offset register and activate the offset to display readings db's referenced to our amps fundamental frequency power input to our instrument. Now the display should read exactly 0db with the O annunciator on behind the dbm.

**13.4 Measuring Harmonic Levels** – With the amplifier still putting 2.5 watts at 1000Hz into the 75 ohm dummy load resistor, enter a frequency of 2000Hz using the HP3586's keyboard to change its measuring frequency to 2KHz. You should see a lower than 0dbm reading on the level display. If you have trouble finding it go to a wider filter and then back to the 20Hz filter after tuning it in. Let's say it's –24db but we are not really sure that maybe the signal generator's frequency has not shifted a few Hz. Because we are using only a 20Hz filter to reduce noise errors, we have to get right on the harmonic's frequency to get an accurate reading. Use the counter feature to lock the instrument to the harmonic. Say, the display now reads –20.06db, indicating the second harmonic is -20.06db, about 1/100 of the power of the fundamental frequency power, not bad about 1% of the fundamental's power.

We can now search out and record the third and fourth or higher harmonics by looking for them at 3KHz, 4KHz, etc. and using above procedure to tune and measure them. We can now try different amplifier power levels or different IC chips in our amplifier to investigate their effect on harmonic distortion.

If we weren't sure how clean our signal generator is we could even look at the generator's output with the level normalized to just the generator's output frequency signal. Then search for its harmonics using the same procedure.

## 14. PASSIVE AND ACTIVE NETWORK ANALYSIS

**14.1 General** – In this chapter we'll demonstrate the ability of the HP3586 to be used for network analysis. The HP3586 has the ability to accurately measure relative power and voltage levels over a wide range of frequency and also output a signal at the frequency it's tuned to. It can do the work of many instruments in one package.

We'll start by taking measurements on a passive band pass filter covering the 160 meter amateur radio band, 1.8MHz to 2MHz designed to reduce strong broadcast signals near the 160 meter band. To make it simple the filter will have a 50 ohm input and output impedance which we can easily match to a HP3586. The second example will be a low power 50 ohm 20db gain preamplifier to cover a wide bandwidth of 14MHz to 30MHz. Finally I'll suggest some applications using the instrument's tracking oscillator as a signal generator with its selective receiver as a detector for alignment of radio circuits.

As in the last chapter I'll assume you have studied the previous chapters and are familiar with the basic button pushing and operation of a HP3586.

**14.2 Setup** – Since the input and tracking oscillator output are both 75 ohms on our HP3586 I need to add some resistors to adjust the impedance for a 50 ohm device. The output impedance of the instrument's tracking generator is 75 ohms, so I can connect its Fo output to the input of my device but with an added 150 ohm resistor between the circuit's input and ground. This HP recommended method to provide the 50 ohm impedance for the device and not load the instrument's tracking generator. If I'm using a A or B version I add a 50 ohm load resistor to the device's output, or the 50 ohm load shown in Appendix C, connect it directly to the 75 ohm input of my HP3586 and turn off the internal 75 ohm termination. This will provide the required device termination and allow me to read device's output using the 10K 50pf input of the unbalanced input. HP also recommends this method of input termination. If we are using a C version we can simply use its 50 ohm terminated input and not add the external 50 ohm resistor.

Since we are going to make comparative before and after measurements we don't have to correct the power calculations from 75 to 50 ohms. We set our HP3586 for carrier or selective measuring mode, depending on instrument version we're using, and select the 20Hz filter, and automatic 10db range for maximum level precision.

**14.3 Normalizing our Level Measurements** – We now disconnect the device but leave the terminating resistors and simply connect a jumper wire between the terminating resistors to simulate a zero loss device. We now can read the output of our instrument's oscillator signal through the short circuit, which should be a little less than 0dbm since the oscillator's output is 0dbm. Say the display reads – 1.11dbm due to termination and other losses. We now can easily normalize our future level reading to the zero loss level using the same method of the previous chapter of putting the displayed dbm level into the offset register and turning on the offset function. Press [RDNG→OFFSET] on the entry panel followed by pressing [OFFSET] on the measurement/entry panel to store the displayed reading in the offset register and turn on the offset function.

**14.4 Measuring the Filter's Pass Band and Loss** – We now reinstall the filter and start to take measurements. At a frequency of 1900KHz in the center of the filter's pass band, say our display now reading is –2.42db. As we tune the instrument's frequency between 1820KHz and 1970KHz it stays close to this value. By recording relative levels vs. frequency we can plot the filter's frequency response along with its insertion loss in db relative to its input power.

**14.5 Measuring an Amplifier's Gain and Frequency Response** – We can now use a similar procedure to find the gain of our wide band amplifier. However, we had normalized our level display for near a 0 dbm standard, but since we think our amplifier should have a +20db gain we will be inputting power levels close to the maximum measuring capability of our HP3586. We should reduce the input



power to stay around an input power of 0 dbm to our HP3686 to stay well within its accurate measuring range of +20dbm to -100dbm.

The best way to do this and since we are dealing with low power, is to insert a 20db 50 ohm attenuator pad between the 150 ohm resistor and the amplifier's input. We remove the amplifier and insert the attenuator between the resistors in place of the amplifier. We now repeat the normalization procedure of section 14.3 at an instrument frequency of 14MHz to obtain a 0db reading with the offset enabled with only the attenuator and terminating resistors in the line.

Finally we reinstall the amplifier between the output of the 20db attenuator and with its output to the 50 ohm resistor. We leave the frequency of our HP3586 at 14MHz and power up our amplifier. We now see a reading of 20.13db on the instrument's level display indicating its gain. We now can tune the instrument's frequency between 14MHz and 30MHz and take gain readings of from 19.43db to 23.37db indicating a good flat response near 20db of gain over our required bandwidth.

This example illustrates the use of the HP3586 is an excellent tool for network analysis because of its internal stable tracking oscillator with the outboard attenuator being a signal generator and selective detector.

**14.6 Alignment and Analysis of Radio Circuits** - A HP3586 could also be used to aid in alignment, measuring gain or troubleshooting a receiver's RF amplifier or IF circuits. It can do this because it's a selective detector that can measure low power level signals between 200KHz and 32MHz along with having a tracking oscillator tuned exactly to the detector's frequency that can be used as an input to drive a circuit. Here I'll just suggest some ideas and considerations and leave the details to you.

If you use the HP3586's tracking oscillator to drive RF or IF circuits remember the oscillator is always at the detector's frequency so you can't go into a mixer stage and change frequency and then detect it at a different frequency. If you want to check the performance of a mixer, you'll have to use a separate oscillator. Also since the tracking oscillator is fixed at 1 mw output, 0dbm, you'll need some attenuator pads to control it's output level into very low power circuits. A fixed -60db pad with a -20db pad adjustable in 3db steps will work fine for reducing the Fo output for receiver inputs. I built one from film resistor using design information in the ARRL handbook. You can also look at the signal out of the attenuators to accurately know it's level using the HP3586's input and selective level measuring detector.

Since the HP3586's oscillator's output impedance is low, 75 ohms, and input impedance can be 50, 75, or 10K ohms it should be able to easily match it's impedances to low impedance solid state circuits. However when analyzing the high impedances usually found in tube amplifier circuits, you may need a method of isolating the instrument from the circuit. In measuring gain or aligning RF amplifier stages of a tube type receiver, feeding the signal from the HP3586 shouldn't be a problem since these radio's usually have a 50 antenna ohm input, but matching to the mixer end of the RF amplifier can be a problem. But you could use one of the isolation amplifier designs from Appendix C to do this at the grid of the mixer tube to not load and detune the mixer input circuit.

When introducing a IF signal into an IF strip and not to detuning the mixer output circuit, you can usually do this by introducing the tracking oscillator's low impedance signal at the grid of the mixer tube before the IF strip. This should work fine since the IF frequency signal should go through the mixer and the mixer tube will isolate the first IF circuit from the oscillator. This is the method usually recommended in receiver repair manuals for introducing a signal to align IF stages.

## 15. MEASURING A TRANSMITTER'S SPURIOUS EMISSIONS

**15.1 General** – One consideration when working on older or homebrew transmitters is maintaining low spurious emissions. These should be as low as possible, usually down–30db or more from the transmitter's carriers or maximum output level. The HP3586 has an excellent capability for searching for and measuring spurious emissions, as the following examples will show.

With plate modulated AM transmitters the spurious HF emissions are usually harmonics of its carrier frequency, sub-harmonics from signals leaking through from exciter's multiplier stages, and out of band emissions near its carrier frequency caused by non linearity or improper operation of its modulated stage.

With SSB transmitter there can be the harmonics of its tuned frequency, emissions at other frequencies used within the transmitter, along with the wide band emissions around its tuned frequency usually caused by improper modulation. In the following sections we will first show an example for a 100 watt AM transmitter than one for a 100 watt SSB transmitter.

Unfortunately, if we want to look at the harmonics up to the third harmonic, the maximum carrier frequency we could use is just over 10MHz since the instrument's frequency response is good only up to 32MHz.

**15.2 Setup** – We first put a resistor divider network on the input to a 50 ohm 100 watt dummy transmitter load in a manner similar to the one we used for our amplifier wide band noise measurements. One thing we want to be very careful of is the following:

**Never put more than +27dbm or .5 watts total power into the input 50 ohm or 75 ohm connector of a HP3586 when using the internal termination. Never put more than +42 volts total AC + DC into an unterminated connector.**

To attenuate the 70volts RMS 100 watt signal on the 50 ohm dummy load down to .27 volts, about 1 mw across the instrument's 75 ohm termination, we calculate that a series 26K ohm resistor between the dummy load and the 75 ohm terminated input of our HP3586 should accomplish this. Since we want to cover up to 30MHz of frequency, we put the dummy load as close as possible to the HP3586 and run a coax line to the AM or SSB transmitter's output.

Place the HP3586 into the selective low distortion or carrier measurement mode for this measurement and select units of dbm.

**15.2 AM Transmitter's Measurement Procedure** – We start by slowly tuning up our transmitter at 1/4 power, half voltage half plate current like most AM transmitters have the ability to do. Now watch the LED level meter on our HP3586 reading in dbm. It should be around –6dbm +/- 3db indicating about ¼ mw. If it isn't adjust the 26K resistor to get near to this instrument display level. Now we tune to full carrier power and should see around 0dbm, say +2.01 dbm, which is fine for our use. Now normalize this reading to 0db using the same offset procedure of our previous examples in section 14.3 of Chapter 14.

AM transmitters usually put out some harmonic and can put out sub harmonics depending on their exciter stage design. As we did in the audio amp harmonic measurements, look at twice three times the carrier frequency of the 2<sup>nd</sup> and 3<sup>rd</sup> harmonics, the 4<sup>th</sup> and higher ones are usually very much lower if the 2<sup>nd</sup> and 3<sup>rd</sup> are low. Use the same procedure of locking onto the harmonics using the counter as in Chapter 14. Say we find the 2<sup>nd</sup> is down –45db and the 3<sup>rd</sup> is down- 70db. This looks fine. Now tune to ½ and 1/3 or even ¼ of the carrier frequency and look for spurious signals. Don't be surprised if you find something leaking through from the transmitter's exciter stages, but it should be down at least –50db in a well designed AM transmitter.

Next change to the noise/demodulation mode under SSB channel on the measurement/mode sub panel. And be sure the [CARRIER] button is on below the frequency display and select USB. Now tune to your transmitter frequency, turn up the volume on the audio sub panel and listening to the audio using headphones and speak into the microphone hooked to your AM transmitter. You should hear your USB audio clearly. Adjust the transmitter's mike gain for how you usually set it by watching modulator current peaks or by the transmitter manual's instructions. Select the widest filter without WTD filtering on the HP3586. Turn on averaging by pressing [AVE] under the level display and set the measuring range to 100db entry mode with a upper limit of 0dbm to keep the instrument from changing range during measurements for more reliable and stable readings with the rapidly varying audio side band signal. Now speak into the mike and try to record the highest average level on the LED level display. If the measured signal is below -80dbm or you get a UL on the level display while transmitting, reduce the range limit to -20dbm to accurately measure signals down to -100dbm.

Now tune up in frequency exactly 5Khz above the carrier, and speak into the mike just as before. You should see any emissions at least 30db below the level you saw when measuring the carrier. If they exceed this level try turning down the mike gain to reduce them. If you can't reduce them, you have some work to do on your transmitter or audio system feeding it.

**15.3 SSB Transmitter Measurement Procedure** – Go back to the carrier mode. With a SSB transmitter, place it into the tune or AM mode and transmitter the highest level carrier the manufacturer recommends for CW or less than two seconds, this is also usually the peak SSB signal level. Use the mike push to talk button. Using a short carrier transmission at the fundamental frequency, normalize the HP3586's level display to the level of your carrier burst, using the method of section 14.3 of Chapter 14. You will have to work fast to do this to prevent damage to the transmitter.

Now tune to the harmonics in the carrier measuring mode as with the AM transmitter but only key the SSB transmitter in the CW mode for a full power carrier in short bursts and try to record the harmonic levels. Now to search for spurious non harmonic emissions which SSB transmitters can have at odd frequencies due to IF stage mixing, place the transmitter in the AM mode and tune the carrier power to that recommended by the manufacturer of the radio. Turn the AM carrier and tune the HP3586 up and down the band using your widest filter and a step of one KHz for the step tuning feature of the frequency tune knob to rapidly scan for spurs. If you find a spurious signal, lock onto it using the counter, switch to your 20Hz filter, turn off the transmitter and switch it to the CW mode, and then key the transmitter for a second as you did when looking for harmonics. During this second record how much down the spur is from the full power carrier using the instrument's level meter.

Now tune to the frequency of USB signal in the noise/demodulation mode and like with the AM transmitter. Also use averaging with the auto 100db measuring range and upper range limit set to 0dbm just like with the AM transmitter example for a more stable and readable audio sideband level reading. Speak into the mike while listening with headphones and properly adjust the mike gain. Note the level on the LED display with averaging on and in the widest instrument filter without WTD filtering. Now tune the HP3586 up exactly 5KHz and repeat the test of speaking into the mike. Now you should be able to reduce the instrument's level reading to 30db below what it read before on the transmitter's frequency using the transmitter's mike gain control. If the measured signal is below -80dbm or you get a UL on the level display while transmitting, reduce the range limit to -20dbm to accurately measure signals down to -100dbm.

Hopefully these examples will illustrate some ways of checking a transmitter for spurious emissions. Some rice box SSB transmitters can have spurs barely down -30db a long way from their tuned frequency. They depend on a tuned antenna system to further attenuate them. But there could be a problem if you use a multiband antenna that may not attenuate the spur.

## 16. SELECTION OF MEASUREMENT MODES AND OTHER CONSIDERATIONS

**16.1 General** – In this last chapter I'll discuss the advantages and disadvantages of the different measuring modes used in our examples and some other measurement accuracy considerations along with additional applications. Many measurements can be done in more than one of the measurement modes. Usually when in doubt select the low distortion selective measuring mode for best general purpose use. Some other measuring modes, like the carrier mode, actually set up the instrument similar to the low distortion selective mode but they optimize the other settings thereby saving him setup time.

**16.2 Low Distortion Selective** – This measurement mode will give the most accurate level measurement results for single signal measurements. However, if a signal is near the HP3586's front end and mixer's noise floor of between  $-116\text{db}$  with phone filters and  $-120\text{db}$  with the 20 or 400HZ filters, a level error can result. This is because the instrument's internally generated noise level adds to the signals level reading and may become a significant part of the total power in the instrument's pass band. If measurements are taken on weak signals on a band where there are very strong signals present but not in the selected filter's band pass, this mode will increase the instrument's dynamic range by 10db and reduce errors caused by spurious emissions generated within the instrument that may fall in the selected filter's pass band. This would be the case when taking signal measurements of a weak signal on a radio band, like 20 meters, when the band is very active with many strong signals. To test for this first try measuring in low distortion, then switch to low noise, if the signal level reading decreases use the low noise reading. If it increases use low distortion since spurious signals are present in the filter's pass band.

**16.3. Low Noise Selective** – This mode is the most accurate when measuring weak signal near the noise floor of the HP3586, i.e. signals less than  $-80\text{dbm}$ . This mode will lower the instrument's noise floor by 5db. Since the instrument measures total noise power over the selected filter's band pass, the white noise generated in the instrument will add to the signals power causing a higher reading than that of the actual signal. For signals above  $-80\text{dbm}$  this advantage is negligible and there is no advantage using this mode. Also to reduce noise, always use the narrowest band pass filter possible for level measurements.

However since the HP3586's front end is untuned and looks at all signals over it's nearly 32MHz band width, many signals besides the ones in its filter's band pass will be present in its front end amplifier and mixer. Harmonics of very strong signals can be generated in the HP3586's RF untuned front end and then mix causing spurious signals in the filter's band pass. This is reduced in the low distortion mode by increasing the instrument's dynamic range by 10db at the cost of 5db more noise, so it's a tradeoff which mode to use.

For signals over  $-80\text{dbm}$  always use the low distortion mode. For weaker signals in an electronic circuit being bench tested where the test signal is the only one present, the low noise mode should be used. For signals in the presence of suspected strong signals first start by using the low distortion mode. If the measured level is below  $-80\text{dbm}$ , try the test described in section 16.2. If the reading is lower in the low noise mode use this level reading, if it's higher you must use the level from the low distortion mode for best level accuracy since spurious signals are causing an error in the reading.

**16.4 Carrier** – This mode is very similar to the low distortion selective mode but sets range and filter for optimum accuracy for measuring single frequency signals like radio carriers. It is not available on the C version so use the low distortion mode in its place on this model. However, if a signal's level is  $-80\text{dbn}$  or lower, try low noise selective and see if the reading drops. If the level reading drops, use low noise for a more accurate level measurement being sure to use the 20Hz filter as discussed above in section 16.3.

**16.5 Noise/Demodulation** – This mode is intended for use with SSB channel noise measurements and tuning SSB or wide band signals on telephone lines. It's not available on the C version so the selective level modes can be used, but not as easily. This mode is much easier to use for tuning SSB signals because the frequency display will read the carrier frequency of the SSB signal instead of the RF frequency the

center of its filter's band pass like in the other modes if the [CARRIER] button under the frequency display has its light on. Its performance should be similar to the low distortion but it selects the instrument's widest filter.

It's important to realize when using this mode that the instrument's tracking oscillator's output signal is always at the RF frequency of the center of the instrument's filter band pass and offset from the display frequency. I haven't found a use for the tone frequency display feature, activated by the [TONE] button for RF work. It's designed for tuning on a tone in the band pass of a SSB channel on telephone lines.

Both [CARRIER] and [TONE] buttons do not affect tuning when the instrument is out of the SSB channel measuring modes, even when their button lights are on. When the instrument is in either of the selective modes and the CENTER frequency annunciator is on the display frequency is always the filter's center RF frequency. For level measurements of very weak SSB signals, try the low noise selective mode and look for signs of intermodulation, i.e. increased signal strength readings before recording any level measurements.

With the A and B versions this mode automatically selects the wide band pass filter. Signal level measurement errors can be introduced because of a WTD audio filter is also switched in which reduces audio levels below 400Hz and above 2000Hz. You may want to use the widest filter without the WDT noise filter if you have the 003 filter option in your instrument.

**16.6 Wideband** - Use only for broadband non-selective measurements like in our audio amplifier example. The frequency tuning and tracking oscillator features are disabled in this mode since they are not needed. It could be used for selective measurements of single signals in devices or electronic circuits, but its use will result in a much higher instrument noise floor of around -70dbm compared to -117dbm to -120dbm in the other modes.

**16.7 Impulse Noise** - Can be used for measuring the number of pre set level peaks over a preset time interval. This mode is not available on the C version. This mode is useful for measuring shot or impulse noise from amplifiers as shown in a Chapter 12. It also could be used for capturing peak power on widely varying signals like from SSB voice signals but for accurate measurements this may be difficult and very inaccurate when a SSB radio signal is subjected to fading.

**16.8 Enhanced Frequency Accuracy** - For one year after its calibration the HP3586 has excellent frequency accuracy. To further improve frequency accuracy HP sold the 004 option, which added an internal board with a 10MHz crystal in a temperature controlled oven for much higher accuracy and easier frequency calibration. Some surplus instruments have this option installed or the 004 board A16 module may be occasionally found on the used market. My instrument had this option installed but if yours

doesn't, I think a 10MHz standard could easily be built. Obtain an accurate 10MHz crystal from one of the common sources, California Crystal Labs or International Crystal, and build a solid state oscillator circuit in a small RF sealed box capable of outputting at least -10dbm, 1/10 miliwatt, at 10MHz. Mount it to the back of your HP3586 and connect its output to the EXT REF connector on the back of the HP3586. Provide a small padder cap in parallel with the crystal and a cap in series with the crystal so it will tune about +/- 200Hz around 10MHz for calibration. Then just calibrate the oscillator and instrument's frequency by simply tuning to the RF signal of one of the WWV stations at 5, 10 or 15MHz. Adjust the LED display frequency to the frequency of one of these stations and then place the instrument into the frequency counter mode. To calibrate it adjust the trimmer in parallel with the oscillator's crystal for a display reading of all zero's in the frequency display's least significant digits. Even though the crystal isn't in an oven, your instrument should stay calibrated within 10Hz when operating at room temperature between 50F and 80F for years just like the BFO crystals in a SSB receiver.

**16.9 Other Accuracy Considerations** –Always use averaging if a level measurement is rapidly changing its level like when measuring a radio carrier subjected to selective fading or SSB signals. This will give representative average readings over a two second periods and make it easier on your eyes by preventing racking of the display levels.

As discussed earlier, using the 10db measuring range will yield the greatest precision of .01db were the 100db range would have a lower precision of .1db. I have found on the air measurement of fading radio signals will loose accuracy with the 10db automatic level mode with averaging on caused by constant automatic measuring limit changes. The 100db range works much better for this and the .1db resolution is still much greater than needed for measuring rapidly varying radio signals.

Automatic selection of a range's upper limit will usually result in the most optimum selection for best level measuring accuracy. However when tuning varying signals or different signals on a band, especially when in the 10db range, using the entry manual limit setting option, the entry selection method will stop constant auto ranging and resulting reduction in audio quality when fine tuning SSB signals. This and its reason is fully discussed in Chapters 2 and 4, sections 2.2 and 4.11.

For maximum level measurement accuracy auto cal should always be on. However in some special cases like when using the instrument's tracking oscillator as a VFO to drive a transmitter, during the auto cal cycle there will be around a 100Hz frequency shift up and down in the frequency of the tracking oscillator. Then it's best to leave auto cal off during transmissions but be sure to turn it's on when changing frequency or making level measurements for maximum accuracy. Also turn off auto cal when tuning or monitoring the audio from a SSB signal since the SSB demodulation will be turned off during auto cal cycles.

**16.10 Using a HP3586 as a Signal Generator** – After studying Chapter 14 on network analysis, you should realize this instrument can be used as a audio or RF signal generator by using it's 75 ohm 1 miliwatt output from the Fo connector on it's back panel. When it's front panel is reading frequency with its CENTER annunciator on this frequency is always exactly that of the signal from the Fo connector. With a set of outboard 50 ohm attenuators and a 150ohm resistor in parallel with its Fo output, you can accurately adjust the output from nearly 0dbm down as low as the capability of your attenuators. The attenuators don't even have to be accurate since you can calibrate their output signal using your HP3586's level detector.

**16.11 Using a HP3586 to Receive and also Control a Transmitter** – Here is an interesting idea some of you may want to explore on how to use a HP3586A or B to operate transceive with an AM transmitter. You could use the HP3586 as a SSB or AM receiver when controlling an AM transmitter's carrier. Each time you transmitted you would have to be in the low distortion selective measuring mode with the speaker muted by turning down its volume. Then change to the noise/demodulation mode and turned up the speaker volume to receive the other station. This could be cumbersome having to remember to turn up or down the speaker and change mode each time you transmitted or received and if you forgot to change modes for transmitting while working a SSB station, get the other SSB station real mad at you. See section 10.3 of Chapter 10 and section 16.5 of this chapter to help understand how this would work.

You could also receive and tune the side band of an AM station the same way using the noise/demodulation mode, then use the low distortion mode only while sending to move the Fo output to the other AM stations carrier frequency. You could even use low distortion and the counter to first exactly determine the other AM station's carrier frequency and to transmit, and then use noise/demodulation only to receive

Possibly the instrument could be modified to do this automatically using a computer or other device and placing it into remote control. On HP3586's back panel is the HP-1B connector for remote computer control of the instrument that could possibly be used for this control function. To understand this connector's function you'll need a copy of the instrument's technical and service manual.

## APPENDIX A

### UNDERSTANDING THE DECIBEL RATIO MEASURING SYSTEM

The HP3586 will only outputs level measurement in the nonlinear logarithmic system of decibels. This system is widely used to express levels of power in electronic and acoustic measurements because it has the advantage of emphasizing only changes that are significant. In other words, if you had an instrument that measured length in inches but were measuring values around a mile in length and had a reference of 0db equal to a mile, a change of one inch would not look very important in db's. However if your reference was an inch and you entered a change of a mile, it would look very important in db's. This system tends to show the importance of significant changes but keeps you from getting concerned about insignificant changes. I hope the discussion below will shed some light on this useful measuring system.

The decibel system is simply a logarithmic ratio system that is used to scale a standard reference value to and then express a real world value such as feet, miles, volts, and watts. Just saying my meter reads a level of 20db doesn't mean anything in the real world. We have to know what it reads 20db compared to some real world reference or standard. Then when the decibel is transformed back to a linear ratio, that ratio can be multiplied by the reference to get a real value.

As an example, if we have a level of power in decibels of +6db referenced to one milliwatt, 1 mw or .0001 watt, usually shown as +6dbm, then to find out how many milliwatts this represents you first convert the ratio from decibels to a linear ratio which is 4. We'll show how to compute the linear ratio a little later. You then multiply the ratio by 1 mw to get 4 mw, which is what +6dbm represents. Now as another example, if we have -6dbm and want to convert it into power in milliwatts you use the same procedure to find the ratio but since it's a negative db number, you divide the ratio into the reference, i.e. -6dbm =  $1\text{mw}/4 = .25\text{ mw}$ . This system uses negative decibels to compute numbers less than 1. As another example, which will confuse you now but later you'll learn how it works, lets find the real value represented of 6db referenced to .775 volts, expressed as +6db.775V. This voltage reference is used by the HP3586 to express voltage levels. When we convert db's into volts the ratio formula changes so for +6db.775V in volts the linear ratio will be 2 and since it was in +db you multiply 2X .775volts to get 1.55 volts. Just read on and this should be clearer.

Now let's talk a little about how to convert back and forth between the linear ratio for power watts and potential in volts and logarithmic ratio in decibels. We'll start with the formula for power, which is:

$$\text{Power ratio in db} = 10 \log (P/PR)$$

Where P is the power in watts, milliwatts, horsepower, flea power etc. we want to convert to decibels and PR is the reference power we want to compare it to, both must always be in the same units. To indicate the reference is in milliwatts we use the notation for the units as dbm just like on the HP3586's display. If we were comparing to one watt we could use the unit dbw, which would let us know we are comparing to one watt.

The logarithmic system we use for decibels are to a base 10. If you aren't familiar with the logarithmic system, you may want to study a math book or the ARRL Handbook on the subject. In the old days we had to use tables in math books to compute logs and their anti logs but today many inexpensive calculator will do this for you. The log computation of the ratio converts it from a linear ratio to a logarithmic ratio. Multiplying by ten gives us more resolution to make the decibel system better express small changes.

Now to get back from db's to a real number for power we transpose the above formula to get the following:

$$P = PR \text{ anti log } (db/10)$$

As an example again let's say we have +6 dbm, we divide 6 by 10 to get .6 and using our calculator get the anti log as 3.98 on my HP 25 calculator, which is nearly 4, and multiply it by our reference of one mw and have 4 mw of power equal to +6dbm. If it were -6dbm the ratio would be negative, -.6, and the anti log would be .25, which is .25 mw since PR is in milliwatts.

To get a physical feel for ratios in db's compared to the linear number ratios they represent let's look at the following linear number ratios and their corresponding values in the logarithmic ratio of db's:

NUMBER RATIO	POWER DB RATIO
0	0db
2	3db
4	6db
6	8db
8	9db
10	10db
100	20db
1000	30db

In this table I rounded off the values to the nearest db. As you can see from this little table the logarithmic db ratio will increase more rapidly than the linear ratio at first then match it at 10 and 10db then increase much more slowly over ten. In the real world the log ratio is the way we experience many physical things like how we sense sound. We sense more in a logarithmic ratio than in the actual linear ratio. In other words a sound power increase of 4 times will sound 6 times louder where a sound power increase of 1000 will only sound 30 times louder, no wonder people go deaf at rock concerts. The db logarithmic system does a better job of showing the importance of measurement levels in the real world and that's why it's often used when dealing in levels over a very wide range in electronic measurements. Also notice that 0db is 1, and with positive db values we can't express numbers below one like fractions. But using negative db's does this for us, but more on this later.

To help understand what an instrument reading means, I get a feel for the linear magnitude of a decibel ratio the following easy way. For values under 10db we can memorize some key linear values to get a feel for the linear ratio values. For every db value of ten or over first ignore the first LSD, take the remaining significant digits and raise ten to the power of the number of digits, like in our table for 10db and raise ten to the first power which is 10, then for 20db raise 10 to the 2<sup>nd</sup> power which is 100 or if you had 60db raise 10 to the 6<sup>th</sup> power you have 1,000,000 or one million. 120db would be ten to the 12<sup>th</sup> power.

Now there is even an easier way, by adding zeros behind one. Take 30db, write down a 1 and put 3 zeros behind it and you get 1000. Or 120db write 1 and put 12 zeros behind it 1,000,000,000,000, boy that's sure a big number we can express with a much smaller one.

Next take the first LSD digit and multiply the MSD's value by its linear value to get the total ratio number. Take 23db, we first compute 100 for the MSD value, then using our table we find the LSD value for 3db is 2 and then multiply 2 X 100 to get 200. Or for 39db, take 1000 for the MSD value multiply it by the LSD of 9db, which is 8, to get the total take 1000 X 8 or 8000. As you can see by this simple calculation and knowing many of the db values between 0 and 10, you can make a quick estimate of the linear number ratio of a number in db's.

You can also compute -db ratios in a similar manner by remembering they express linear ratios less than 1. In other words -3db is 1/2 or .5, -10db is .1, and -30db is .001. The rule for estimating -db's is to take the MSD's as one less than the number of zeros to the right of the decimal point. -30db would be .001, two zeros, and -60db would be .000001, five zeros. For -db's that the LSD value is not zero, just divide the linear value of the LSD to the linear value of the MSD's. -26db would be .01 divided by 4 or .0025. As you can see it's also easy to estimate linear ratio values from -db's.



When working with voltage the formula is a little different from the power formula:

$$\text{Voltage ratio in dbv} = 20 \log (V/VR)$$

Where V = the level in volts and VR is the reference in volts. Our HP3586 uses .775 volts as a reference where:

$$\text{dbV}.775 = 20 \log (V/.775)$$

Where VR is now .775 volts and V is still in volts.

To convert from db to find V use:

$$V = VR \text{ anti log } (\text{dbv}/20)$$

As you can see by comparing the voltage with the power formulas, they are the same except the power constant of 10 is now 20 for the voltage formula, which is twice as large. The constant is twice as large for volts because voltage across a constant impedance, say 50 ohms, will increase as the square of the power. What's nice about this is we can work with level readings in db's referenced to watts and knowing the resistance the power is going into then compute volts by:

$$\text{For voltage } V = (P \text{ squared})R$$

Voltage is a little harder than power to estimate in our head because of the constant being 20 in it's formula. If you're smarter than me, for converting +db linear value in volts you can do it by squaring the MSD's linear value and multiplying by the square of the LSD linear value. For converting -db to volts take the MSD's linear number, which will be less than one, and square it, then divide by the square of the LSD's value. That's too hard for me to do in my head so I just work with converting to power ratios from db's or use my trusty HP25 to get linear voltage ratios from db's.

I hope this discussion has helped you in understand how to work with db's and not further confused you. For more on this subject, consult a math book or the ARRL Handbook for a further discussion of this subject.

## **APPENDIX B**

### **HP3586 ERROR CODES**

During initial power up and following auto cal cycles, the follow error codes could appear on one of the LED displays indicating a failure to calibrate and or an instrument failure. Some error codes could also indicate improper entries or operation of the instrument. Below is a list of these codes to help you in determining the problem and a solution:

The format for all non-calibration error messages is **Err N** or **E N.N**

- N = 1** The Full Scale level cannot be changed manually while the instrument is in Automatic Full Scale.
- N = 1.2** The 10db range cannot be used when the instrument is in the Wideband or Impulse measurement modes.
- N = 5** The instrument is in Remote and therefore will not respond to front panel controls. Or the Local control has been disabled by a local lockout message.
- N = 6.1** Accurate Impulse Measurements are unlikely. The threshold level is 56db or more below full scale.
- N = 6.2** The threshold level is more than 3db above the full scale. This is a nonsensical instrument configuration.
- N = 3.0** Instrument failure, at least one of the phase locked loops in unlocked.
- N = 4.1** Instrument failure, the impulse counter did not start during CAL.
- N = 4.2** Instrument failure, the impulse counter did not stop during CAL.
- N = 7** Instrument failure, the Analog to digital converter was unable to make a conversion within two seconds.

I haven't shown error codes 2.2, 2.3, and 2.9 since they are only for the jitter mode that's not used or discussed in this document because this mode takes additions instruments to use and understand its measurements.

Calibration Error messages are always instrument failures. For calibration errors the format is: **CE – N**

Where **N** is an alphanumeric character that indicates which step of the calibration sequence failed.

For instrument or calibration failures, try turning the instrument on and off, check your input connections control settings, and if this fails to clear the error code the instrument will need service. Copies of the service manual are available from Manuals Plus at 801-936-7000. If you aren't capable of repairing it yourself, try to find an instrument calibration lab, which could service your HP3586 or recommend where to get it repaired.

Hewlett Packard has withdrawn from the electronics instrumentation business so I don't think they would be much help in finding a repair source. If I identify any repair sources I'll list them in further revisions of this document.

## **APPENDIX C**

### **SCHEMATICS FOR USEFUL HP3586 ACCESSORIES**

Print these Adobe PDF files from the following files you received with this text file for the contents of this appendix and insert them behind this page:

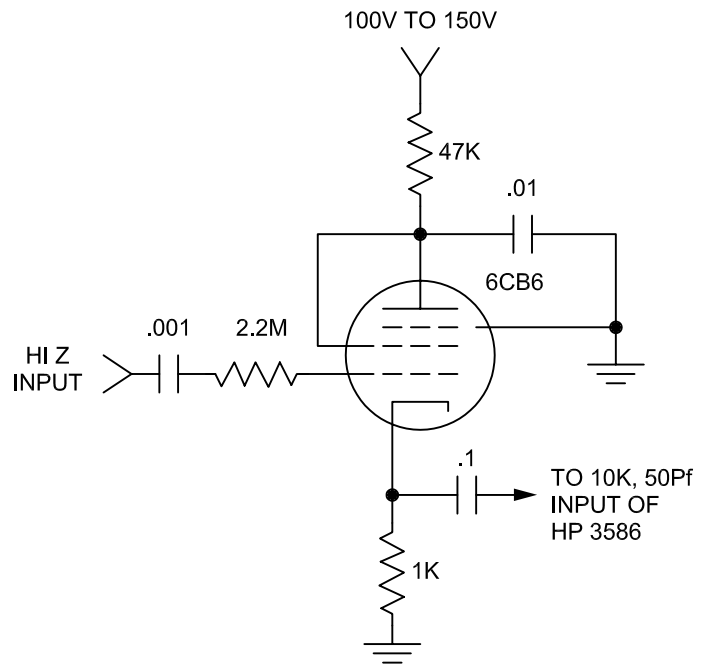
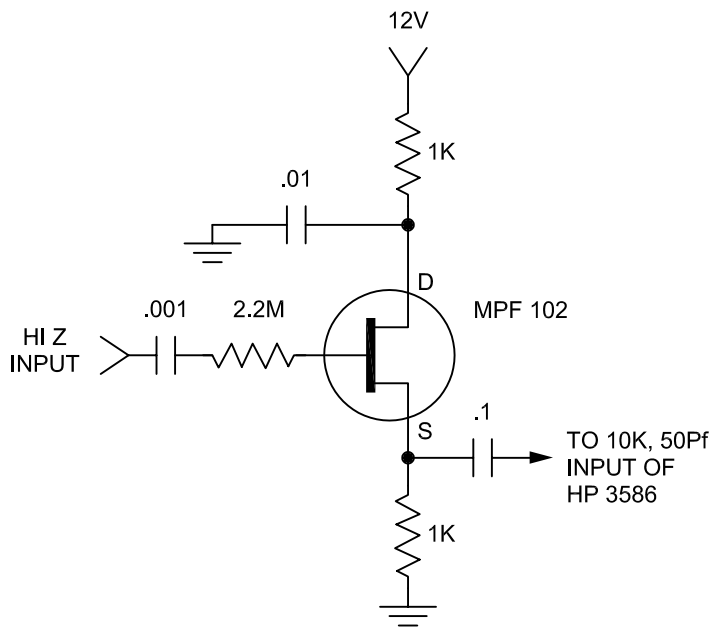
C1-C2.PDF

Fig C1– Hi Z ONE TO ONE ISOLATIONS AMPS  
Fig C2 – DC ISOLATED 50 OHM TERMINATION BOX

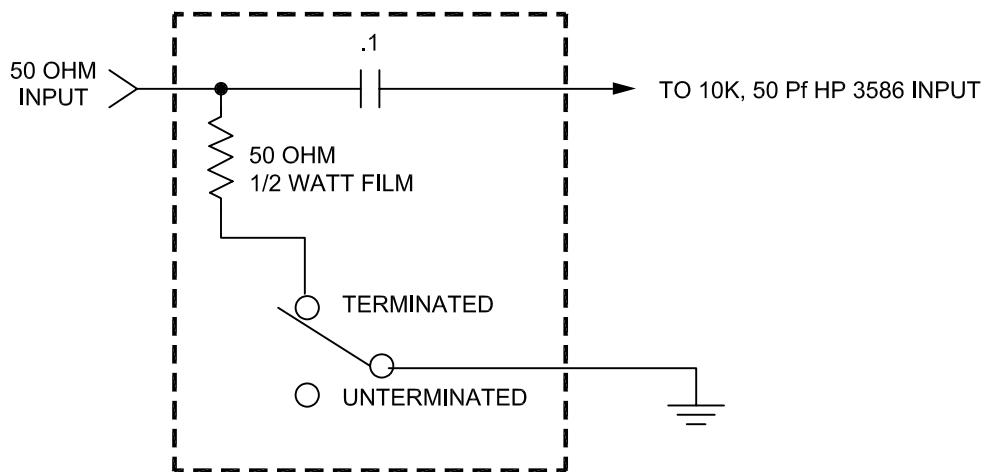
C3.PDF

Fig C3 – AMP FOR HP3586 Fo OUTPUT TO A BC-610 OR A VIKING 2

I would like to thank David Jennings, WJ6W, for the excellent job of drawing these figures in Auto Cad.

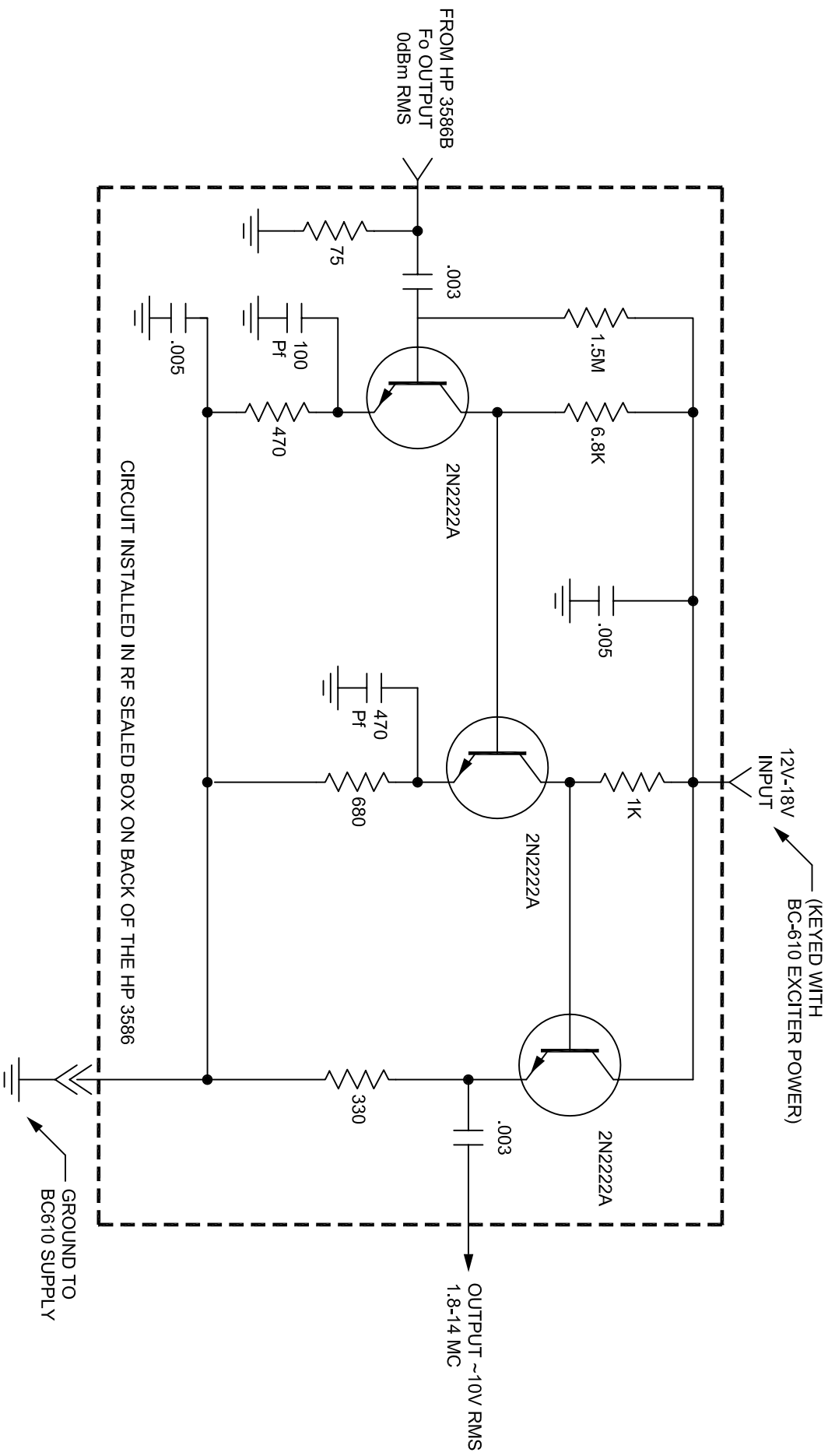


HI Z ONE TO ONE  
INPUT ISOLATION AMPS  
(FIG. C1)



IN BOX WITH MALE CONNECTOR  
HOLDING IT TO THE FRONT PANEL  
BNC FEMALE CONNECTOR.

DC ISOLATED 50 OHM  
TERMINATION BOX  
(FIG. C2)



AMP FOR HB368GB OUTPUT

TO BC-610

(FIG. C3)