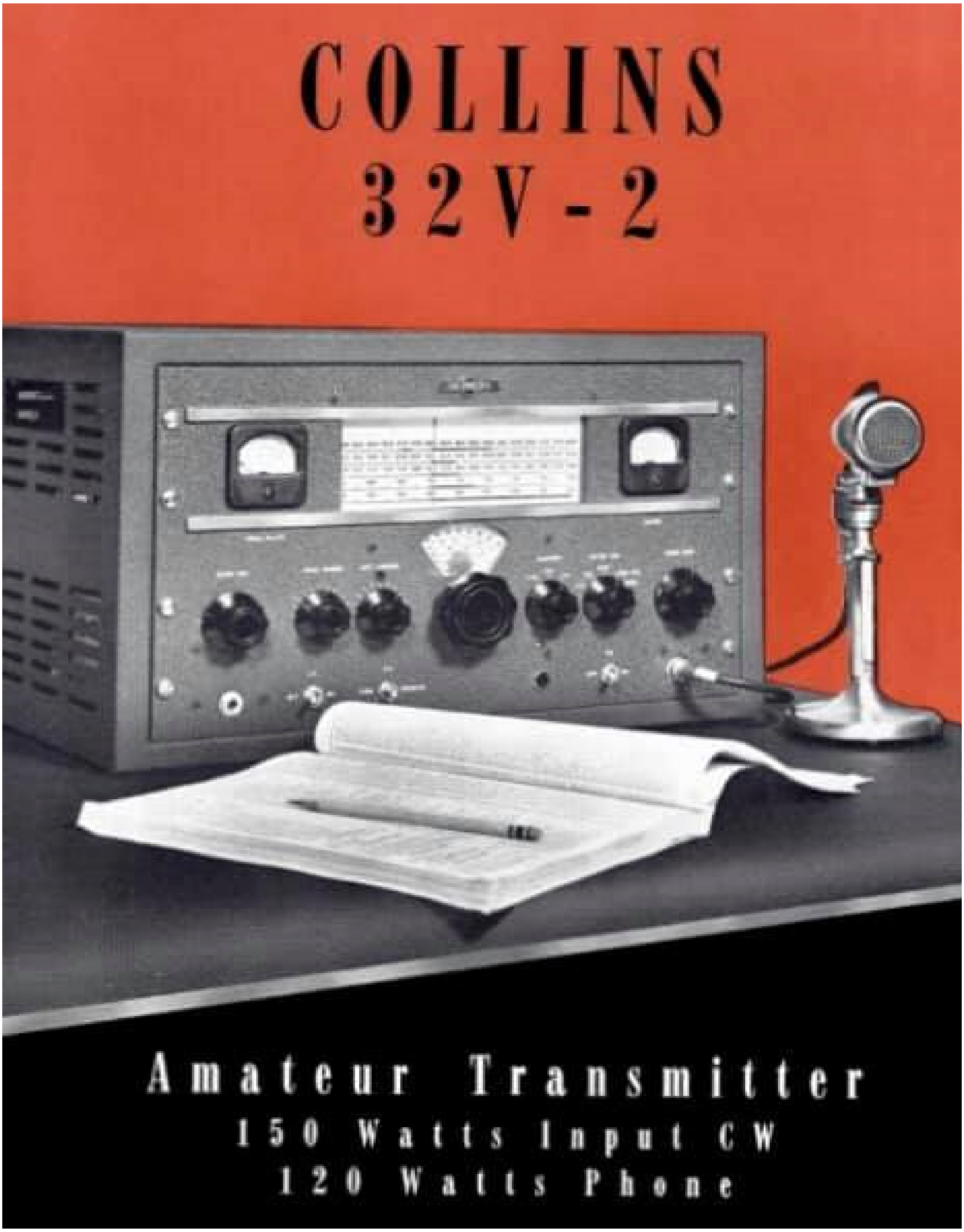
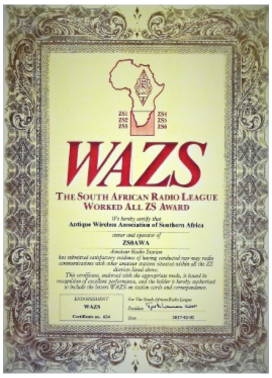
Newsletter
The Antique Wireless Association of Southern Africa
18th Anniversary

180 July 2021





ZS1 ZS2 ZS3 ZS4 ZS5 ZS6

WAZS

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WORKED ALL ZS AWARD

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Antique Wireless Association of Southern Africa
owner and operator of
ZS0AWA
Amateur Radio Station

ENDORSEMENT
WAZS
Certificate no.

For The South African Radio League
President
Date

Inside this issue:

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- Acting VicePresident—John ZS1WJ
- Technical Advisor—Rad ZS6RAD
- Secretary/PRO—Andy ZS6ADY
- KZN—Don ZS5DR
- WC—John ZS1WJ
- Historian—Oliver ZS6OG

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Reflections:

Once again, in the blink of an eye, the winter solstice has come and gone and we are on our way back to warm summer months.

Well it may take a while still to get there, but, before you know it, it will be December and we will all be thinking of what we are going to surprise ourselves with for a nice present.

In the meantime we have all been fighting diminishing bands, which according to predictions were supposed to be going in the opposite direction by now, but somehow seem to have got lost along the way.

Those more knowledgeable than many of us are still trying to decide whether cycle 25 has actually started or are these just a few false hiccups planted along the way to confuse us even more than we have been.

I swear I am starting to have withdrawal symptoms because it has been so long since having a few decent QSO's. I sit longingly looking at my rigs on the shelf and wonder when will we get the opportunity to use some of the frequencies.

Suddenly a CW station bursts in to life on 7020 and I dive for the key to reply. Before we can even get to exchanging RST reports, the band has started to fade and by the end of it, the station is gone again. A whole 3 min is what we had.

I must say one thing though. If I did not have my radio on, I would never have heard that station, and would never have had the chance to have that quick QSO. It helps to satisfy the need for some RF.

Sometimes I have wondered if I should not just disconnect the antenna where it goes out the shack and just bounce some RF off the walls. I don't think the rig would like it very much though.

I have never sent so many WhatsApp's to radio friends in all my life.

But yet we are assured, once again by those who know more than us, that there will be an improvement. Some say conditions will be better than we have known, others say it may not be great, but it will be there.

I have never been a sun worshipper, but I could quite easily change my mind should this great change come and the bands be opened up.

Until then, hang in there my radio friends. Do not become despondent and give up all rights to transmit. It may be all that we have left to hang on to one of these days, the way things are being pulled out from under us at the moment.

I hope this subtle attempt at humour has not upset too many of you and I assure you that no valves were destroyed in the making of this article. We need them all for the Streeter Challenge.

Best 73

DE Andy ZS6ADY

Wikipedia

Sunspots:

The earliest record of sunspots is found in the Chinese *I Ching*, completed before 800 BC. The text describes that a *dou* and *mei* were observed in the sun, where both words refer to a small obscuration. The earliest record of a deliberate sunspot observation also comes from China, and dates to 364 BC, based on comments by the astronomer Gan De (甘德) in a star catalogue. By 28 BC, Chinese astronomers were regularly recording sunspot observations in official imperial records.

The first clear mention of a sunspot in Western literature is dated around 300 BC, by the ancient Greek scholar Theophrastus, student of Plato and Aristotle and successor to the latter.

The first drawings of sunspots were made by an English monk named John of Worcester in December 1128.
Sunspots were first observed telescopically in late 1610 by English astronomer Thomas Hariot and Frisian astronomers Johannes and David Fabricius, who published a description in June 1611. After Johannes Fabricius' early death at the age of 29, the book remained obscure and was eclipsed by the independent discoveries of and publications about sunspots by Christoph Scheiner and Galileo Galilei, few months later.

In the early 19th Century, William Herschel was one of the first to equate sunspots with the abundance of heating and cooling it was capable of causing on Earth. He believed that the "great shallows (sunspots' penumbrae) ridges (bright, elevated extended features resembling faculae) nodules (bright, elevated, yet smaller features resembling luculi) and corrugations (less luminous, rough, mottled, dark features) instead of small indentations (depressed, extended dark features) on the sun would let in large amounts of heat into Earth. On the other hand, "pores, small indentations -central regions of dark, depressed spots - and the nodules' and ridges' absence," meant less heat touching Earth. During his recognition of solar behavior and hypothesized solar structure, he inadvertently picked up the relative absence altogether of spots on the Sun from July, 1795 to January, 1800. He was perhaps the very first to construct a past record or observed or missing sunspots and found that, in England at least, the absence of sunspots coincided with high wheat prices. Herschel read his paper before the Royal Society. He was completely misinterpreted and heartily ridiculed before that body.

A crystal alternative (Part 1)
On my bench – Renato Bordin May 2021

Every now and then I want to fire up a transmitter or test a transmitter on the bench, I'm talking about CW/AM sets like the HT-40, Trio TX-88A and many others that use an external crystal as the master oscillator. Every time the AWA has a valve QSO party I'm transmitting high up in the 40m band, a place no ham frequents hence no QSO. I have a limited supply of suitable crystals, one or two that are high up in the 40m band not suitable for CW and one crystal suitable for CW in the 80m band, but not quite right for AM transmissions considering the 80m band plan. Over the years my eyes have become finely tuned crystal locating instruments that can spot suitable pieces hidden deep down a box in the back of a bakkie at a boot sale. I have a home brew crystal tester in my arsenal of test gear that is close to my bench and has seen much use. Every time I find a suitable crystal, it's lazy and won't oscillate. There must be many crystal hoarders in South Africa that hang onto their prized treasures because one can never find suitable crystals unless one starts looking at importing at considerable cost. I know that crystals can be substituted with a VFO but I find this solution fiddly to setup and quite frustrating to connect everything together. I'm told that one can even connect a signal generator to the transmitter, dial up a frequency and away you go! First prize is to plug a FT-243 or even a HC-18 crystal into the radio and tune up. And if 3615 is busy then try a 3620. Nice and easy but not to be without crystals.

In true AWA spirit I believe we need to homebrew a solution and we have a few options. The simplest would be an LC oscillator with enough stability and possibly powered from the filament 6.3V supply if no purpose built VFO is available? Perhaps a PLL type oscillator that is a lot more complex to build and get working but of course the benefit would be far greater stability than the LC oscillator and finally the DDS oscillator. No doubt that this technology has taken our hobby by storm with many DDS type VFO's and oscillators readily available in kit form or fully assembled and tested. The advantage is low component count, low power requirements and small footprint. The problem? I've never done this and I don't see much info on the internet regarding DDS implementation to boatanchors so let's begin.

I'm no expert on DDS (Direct digital synthesis) and would suggest browsing the internet to find a suitable explanation of how a DDS oscillator works. I can tell you that it's an oscillator on a chip minus the traditional LC components like the capacitor and inductor that are familiar to us. Instead we need a small controlling device that will instruct the DDS oscillator what to do.
Right now I can see a few of you reaching for your phones about to call Andy and have him fire my ass. Please hang in there, the controlling device is very similar to a drill sergeant on the parade ground.

The DDS oscillator or programmable waveform generator is capable of producing a sine wave at a user defined frequency. The device I will be using for the boatanchor compatibility test is the AD9833. This chip or "spider" as John ZS1WJ calls them uses a 25MHz crystal oscillator as the master clock generator providing the eventual user defined output frequency. The AD9833 is capable of generating a sine wave from 0 to 12.5Mhz in 0.1Hz increments perfect for our 80 and 40m band transmitters. This 10 legged spider only needs the 25Mhz crystal oscillator, which is conveniently included on all DDS modules I have seen and a few external components to get going but it does need to be told what to do. Must be a male spider?
The control mechanism of the spider is an SPI data stream, this Serial Peripheral Interface sends configuration data to the spider in a serial fashion that must be sent from some other device. In our case we going to get our DDS spider married to another spider and hopefully they will live happily ever after without any serious bodily damage and provide us with a nice stable 3615Khz transmission.

There are many options available to configure the AD9833 DDS, the most popular being the Arduino microcontroller. These programmable boards are readily available and very cheap with loads of downloadable libraries and code to get our DDS spider working. Some of these fully documented projects have rotary encoders, LCD displays and other bits that make up a very useful VFO. In our case I'm going to use the Microchip PIC16F818, this entry level 8 bit micro controller by Microchip is featured in my junk box inventory and I happen to have all the tools needed to kick start it. This micro has a number of configurable pins available, of which we need 3 for the SPI interface. I will be adding a dipswitch to our crystal alternative so Andy can select which portion of the band his crystal must work on or change band. 7020 when Andy is in a CW mood or switch to 3615 when he wants to chat on AM. Yes, that's correct, one crystal for multiple frequencies and bands (I hope) The project brief here is to find an alternative to the crystal and not develop another VFO. We want a small footprint device that can plug into our transmitter powered by either the transmitter or external power source. Since I have a few general purpose I/O pins available on the micro we will add a dip switch to select DDS output frequency. Block diagram of Fig1 shows all hardware components.

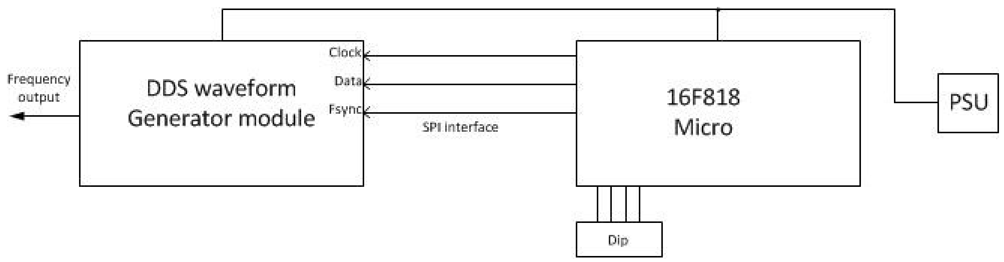


Fig 1

Back to our drill sergeant on the parade ground. The SPI clock line on the micro is very similar to our sergeant shouting “left right left right” commands to his marching troops. Regardless of how many troops drop out the command sequence the timing remains the same. If we were to send 11111111 binary data to our DDS spider, our sergeant would dictate the speed at which the data moves along. Equally, if the data was 10111011 the data would be sent out minus a few troops. The DDS spider sees the data coming in at the sergeant’s pace and can determine if the troop or data is there or not. A 1 or a 0 every time the clock pulses. This is the data our DDS spider needs to make Andy happy. The diagram below, Fig 2 should paint a good picture.
The data sent by the Micro controller under firmware control includes the following configuration data necessary for the AD9833 DDS device. Please see AN-1070 in references for detail.

Control register	hex 2100	Ready for data
Frequency register LSB	hex 7A69	LSB 3615Khz
Frequency register MSB	hex 40EC	MSB 3615Khz
Phase angle	hex C000	0deg
Reset and signal on the output pin	hex 2000	Output on

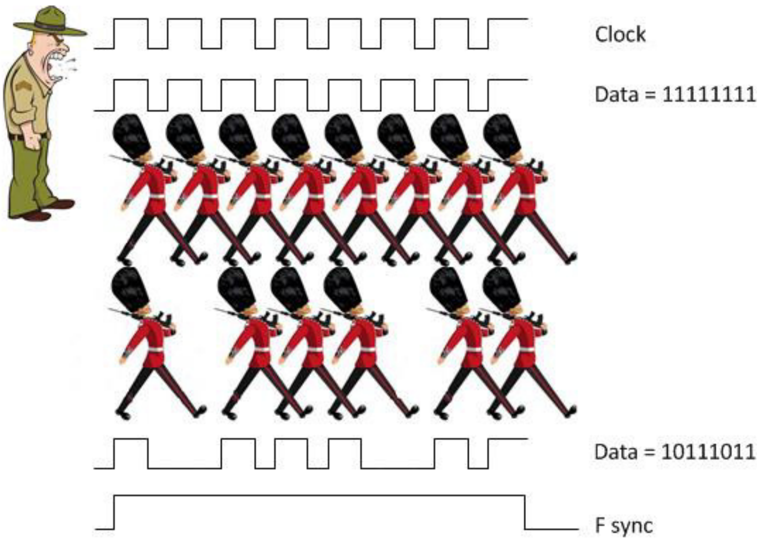


Fig 2

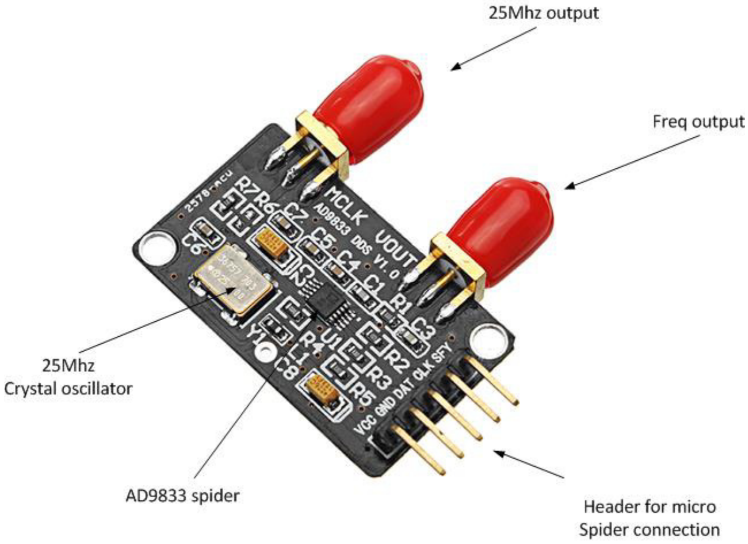


Fig 3

The DDS module I used, Fig 3 is very small but smaller modules are available minus the SMA connectors. The Fsync line simply lets the DDS oscillator know when configuration data is arriving. The CLK pin is the timing clock and the DAT pin is the data telling our DDS spider what frequency Andy has requested. Imagine trying to do this with a few pentodes? The DDS module I used for this project was purchased from a local on-line ordering web site that not only features the AD9833 but also has SMA connectors for the outputs, this just makes the development of this project a little easier but would prefer a loose component to build a final project or possibly use a board with minimal components.

Ok, now that we have the building blocks of our crystal emulator let us get a schematic going and fit all the pieces together before we discuss the micro configuration. Not much to see in Fig 4. I have omitted the DDS module since that may change. The PIC micro features a dip for frequency selection. This 4 way dip is used to select 1 of 16 frequencies of our choice in the 40 and 80m band. J1 and J2 are headers for DDS module connection. Power for now is 9 to 14Vdc on J1. Voltage divider resistors R1 and R2 will provide the micro analogue input RA0 with a voltage sense from incoming power that will be used to indicate a low battery state on Led. Values to be determined once we establish what power source we will use. If we use a 9V battery then R1 will be 4,7K and R2 2,2k for a divider output of 2,8V. The Led will then turn on and flash at about 2.6V. The dip switches are continuously read for any changes and update the DDS oscillator with the new frequency request, once again LED D1 will indicate that the dip status has changed. The PIC will run using its internal RC oscillator of around 4Mhz, this is more than adequate to provide the DDS spider with accurate SPI data on J2 and keeps components count low, no need for another crystal here! The 10k resistors are pull up’s since the AD9833 is active low and we will also read the dip as active low. On power up the micro will reset via the RC components on RA5. For the prototype board I opted to use the internal MCLR (reset) tied to VCC, this is part of Microchip's configuration fuses available on their products and set by the compiler.

Using a small micro for this type of project has many advantages since the firmware loaded in the device will make it work the way we want and we can change parameters whenever needed without any hardware modification or even redesign. Tomorrow Andy wants 3505Khz? No problem with a small change to the firmware and downloaded to our micro.

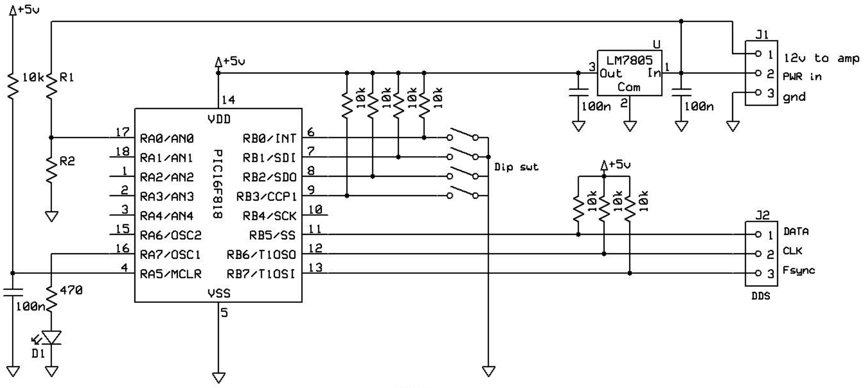


Fig 4

During the development, construction and testing of this project I used an HT-40 as the test transmitter but some smoke managed to escape, DDS module failed when I connected the output directly to the crystal input of the HT-40 switched to "crystal "– this is a mistake since the DDS oscillator must share a common ground with the transmitter and the black crystal socket is very close to B+ of the triode oscillator! Any mistake here can lead to failure. I cannot explain what went wrong but I felt that it may be prudent to understand the electrical properties of the front panel crystal socket during tune up and transmission before my second attempt. The AD9833 has no buffering or isolation on the output. The DDS output, which is derived directly from a digital to analogue convertor (DAC) is on the grid of the 6CX8 triode, this is on the red terminal. The black connector is grounded to chassis when in "VFO" mode. I felt it was very easy to make a mistake and possibly fry another DDS module so I decided to add a small broadband amplifier and transformer for isolation between the radio and the sensitive DDS oscillator output. The schematic in Fig 5 is used for DDS oscillator buffering, I added a small broadband transformer of about 2:1 ratio via a 100nF cap that managed 1Vrms into 50Ω using 12Vdc for the supply this on the 80m band. The AD9833 does not maintain output amplitude as frequency increases and in my prototype the output voltage halved when set to 40m band frequencies. Valve type oscillator/transmitters do not load the crystal of external VFO, certainly not as hard as 50Ω but more on this latter.

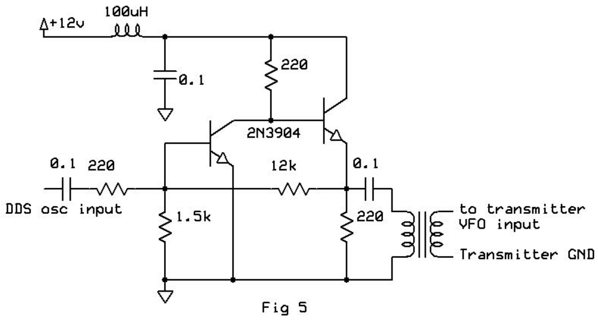


Fig 5

I must at this point add a few comments about the firmware written and loaded into the pic micro controller, as mentioned I used the 16F818 since it is re-programmable and has a number of I/O pins available to the user. The most important feature of the micro is the on-board SPI hardware, one simply writes the data required into memory and send to the SPI hardware, which serially sends the data including the clock pulse, F sync control is done manually by turning a pin on or off at the appropriate time. It is also possible to "bit bang" the SPI stream by using the assembler programming language and manually sending each individual data bit and clock pulse so an even smaller micro could be used for this application. I found that the AD9833 is tolerant of any serial data stream timing inaccuracies and performed very well using the internal pic's RC oscillator in both hardware SPI mode and software controlled bit bang data streaming mode. The program flow is quite simple, after configuring the ports, SPI and ADC hardware, I start by reading the dip switches, select the correct data to send, send data and go back to start, I also made the led flash during this cycle so I have confirmation that the micro is alive. It's that simple and no need to repower the oscillator every time the frequency is changed. For now I have omitted the low battery detect using the ADC since the buffer amp needs 12Vdc. The 4 way dip switch can address 16 frequencies within the range of the AD9833 and I chose the following – Dips 1234 all 0000 meaning switch 1 to 4 is off and 1 = on.

Dips 0000	Output off
Dips 1000	3510Khz
Dips 0100	3515Khz
Dips 1100	3520Khz
Dips 0010	3525Khz
Dips 1010	3610Khz
Dips 0110	3615Khz
Dips 1110	3620Khz
Dips 0001	3625Khz
Dips 1001	7015Khz
Dips 0101	7020Khz
Dips 1101	7025Khz
Dips 0011	7030Khz

Dips 1011	7130Khz
Dips 0111	7135Khz
Dips 1111	7140Khz

The AD9833 is quite capable of generating audio frequencies and by adding a second amplifier to buffer audio frequencies could be added to this project. IF alignment frequencies could also be added, 455KHz, 10.7Mhz etc. Someone with better programming skills could even build a wobbulator sweeping 400Khz to 500Khz. The uses are endless for the entry level AD9833 DDS. Other devices in the Analog Devices DDS range have far greater control such as the AD9850 which is better suited for RF applications. User can select the required frequency without a power cycle, select the dips and away you go, just don't do this while transmitting!

And there you have it. Fig 6 is the complete board featuring the micro, DDS module, buffer amplifier and 78L05 12V to 5V regulator. The project was built on a small piece of Vero board measuring 43X65mm. besides the 12V power cable. I made a crystal socket for direct radio connection using a non-working flea market find tin can. Crystal wired to the transformer. I found a DDS module that did not feature the SMA connector and is perfect for this project, all the other components were in my parts inventory. The 6 way header on the right side of the board is not featured in the Fig 4 schematic, this header is used to program the PIC and not required for normal use. I also added a second led to help me debug the code.

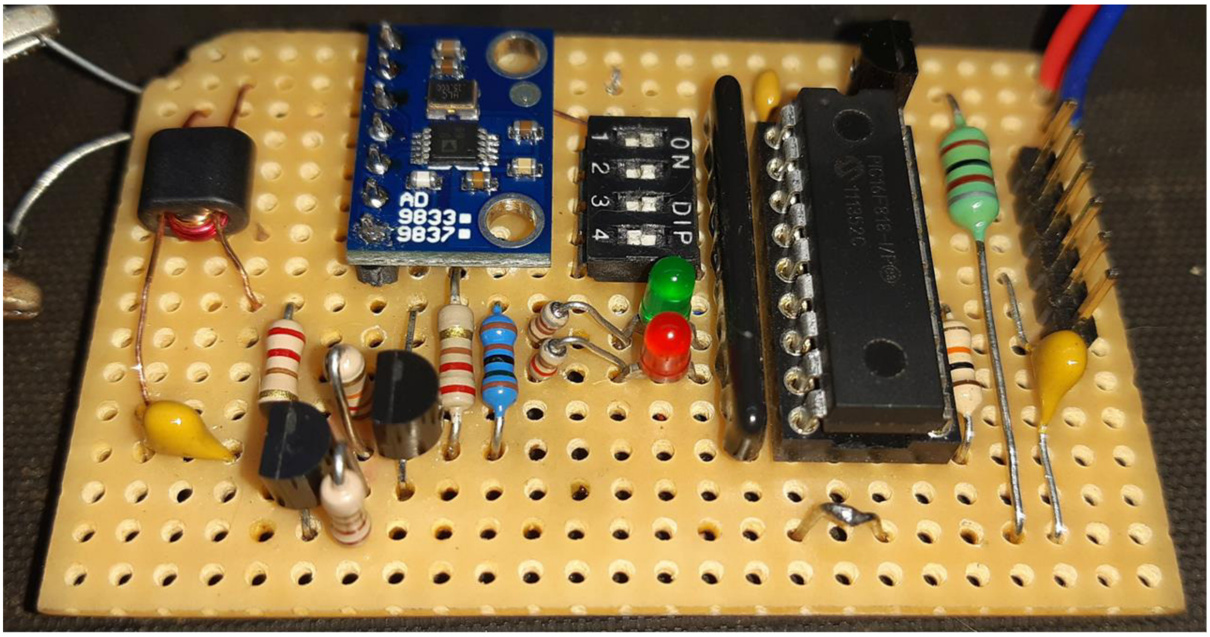
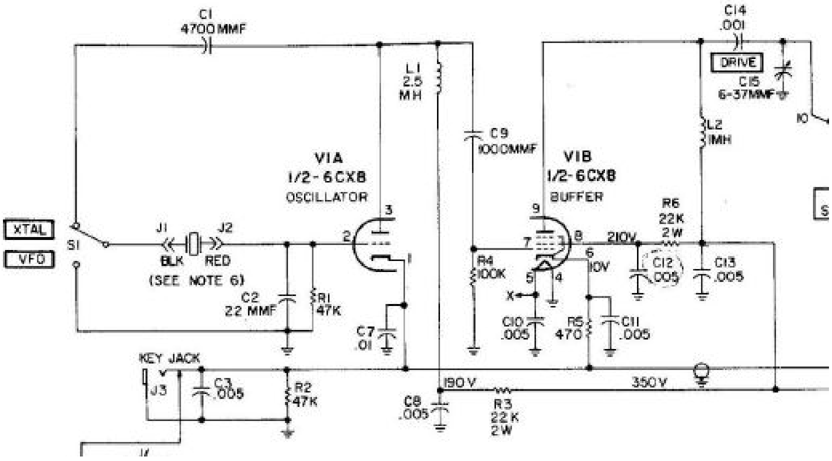
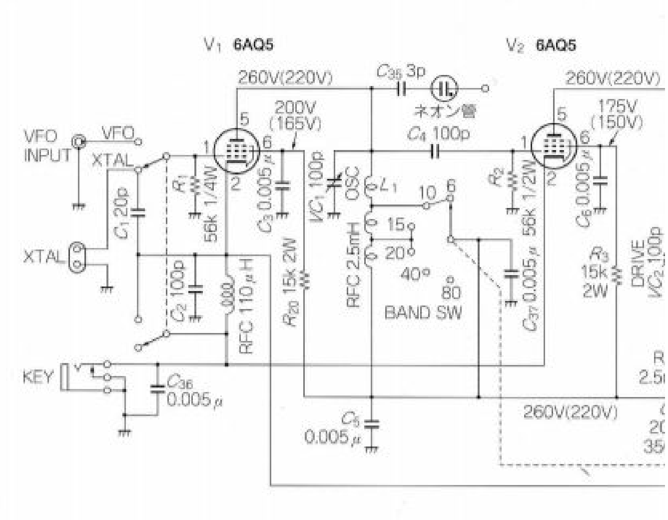


Fig 6

Before I go ahead with DDS to radio connection attempt number 2 let's have a look at the HT-40 and Trio oscillator schematics.



HT40 oscillator schematic



Trio TX88 oscillator schematic

The Colpitts oscillator arrangement of the Trio TX88 features a switch for either crystal control or external VFO control by a front panel switch. As seen in the diagram the switch simply connects the crystal or switches to the external VFO connector. In both modes the ground is not interrupted, both crystal and rear panel VFO input socket have a permanent connection to ground. There is also no reference or feedback loop to V1's plate voltage, in both modes the grid G1 is available on the front panel. The trace leading off the junction of C1,C2 and RFC1 is the spot function oscillator sampling point only. The DDS oscillator worked perfectly in the VFO mode with the output of the transformer on the VFO input socket. Polarity does not matter since we included the 2:1 transformer isolating the DDS oscillator. The first test was using a 40m crystal and the transmitter managed 6W into a metered dummy load. Using the DDS on 3615Khz the power output was at 8W and 4.5W on 40m. More results next month. Just one final comment for this session is that there is no loading caused by the transmitter on the DDS oscillator at all.

The Pierce oscillator arrangement of the HT40 is somewhat different. In VFO mode the Black terminal of the crystal socket is grounded to chassis with the Red terminal connected to G1 of oscillator valve V1. In crystal mode the Red terminal remains on G1 but the black terminal is connected to feedback capacitor C1. I suspect we need to keep our DDS oscillator far away from C1 with 190V just behind it! I did not try connecting the DDS crystal to the HT40 in this mode, even with the assurance of the isolation transformer. I don't think it can harm the oscillator but in the interest of saving my AD9833 I cannot report on any possible issues. I'll have some results for you next month as my HT40 stopped working and needs repair, perhaps I'll call Wally and ask him for his radio :-)

Next month I'll conclude the project with transmitter emissions results and for those that would like to attempt this type of DDS project I will make available a pre-programmed micro with enough bits to get your own AD9833 DDS working, details to follow.

References:
https://www.analog.com/media/en/technical-documentation/data-sheets/ad9833.pdf
https://www.analog.com/media/en/technical-documentation/application-notes/AN-1070.pdf
http://ww1.microchip.com/downloads/en/DeviceDoc/39598F.pdf
https://microchip.com

Hallicrafters HT40

Trio TX88

RME

HERE is the nearest approach to an ideal medium powered transmitter for the amateur. Rated at 400 watts input, this compact unit gives reliable communication service under trying conditions.

THE RF section consists of a 6A6 crystal oscillator and harmonic generator, 2–42s in push-pull as buffers, 2–801s as intermediate amplifiers, and 2–50Ts in the final class C stage.

IN the audio amplifier is found 1–6C6, 2–76s, 2–45s, and 2–50Ts arranged as class B modulators to give full output to the transmitter. The entire power supply to the various stages is conservatively loaded at all times.

LESS than 5% distortion at 100% modulation is obtained. The audio range extends from 100 to 10,000 cycles with less than 5 db deviation.

MUCH can be said about the design and appearance of the cabinet into which this transmitter has been built. With double side walls, between which the cable, interconnecting the chassis units, runs, — with front panel doors to keep out dust and protect tuning adjustments, — with meters recessed behind the front panel, — the entire unit presents typically modern construction.

For complete details our folder T505 is available. Write for your copy.

MODEL

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PEORIA, ILLINOIS, U. S. A.

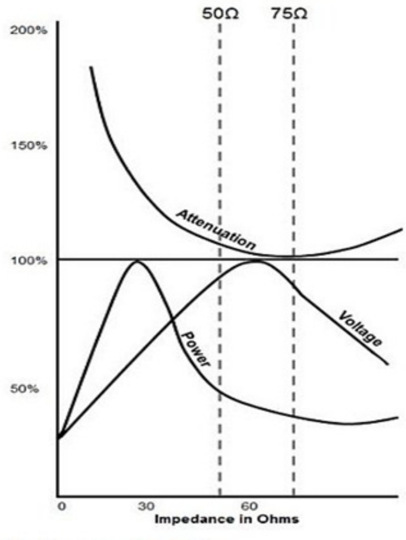
Receiver Testing for the Radio Amateur Using Simple Equipment.

By Chris Turner – ZS6GM / G4HKP and Richard Dismore ZS6TF / F4WCD

Radio amateurs, particularly those who collect, restore and use vintage antique equipment, often want to compare the actual performance of a receiver with the design specification. They may just want to compare the performance of two different radios or measure the change in performance of a radio after it has been repaired or restored.

This article provides the amateur with a number of simple tests using low cost test gear which the amateur may already possess or is able to borrow or buy at a flea market. Clearly these tests will not be laboratory grade as conducted for design, production, or product review, but will nevertheless provide a useful and repeatable benchmark of receiver performance.

To be concise the authors have limited this article to communication type receivers using super-heterodyne architecture and analogue techniques for AM/SSB reception and audio listening up to 30 MHz. This would cover most serious HF receivers and receiver sections of transceivers from 1935 to 1975. Typical candidates would be the HRO senior through HRO-5, AR88, R1155, TCS, 51J-4, and RA17, S-line, and the hybrids.
A radio receiver may be considered as an RF voltage to AF power converter. The voltages at the input (at the antenna) are very small measured in micro(10^{-6})volts, and the audio power at the output relatively large measured in watts. It is hard to relate the two without complex mathematics unless the decibel concept is fully appreciated. It originated in the Bell telephone labs around 1930 for easy calculation of telephony transmission line and equipment losses and gains in multiple links where the losses and gains in dB can just be added to give the overall path gain/loss. 1 dB is around the smallest change in audio level detectable by the human ear.



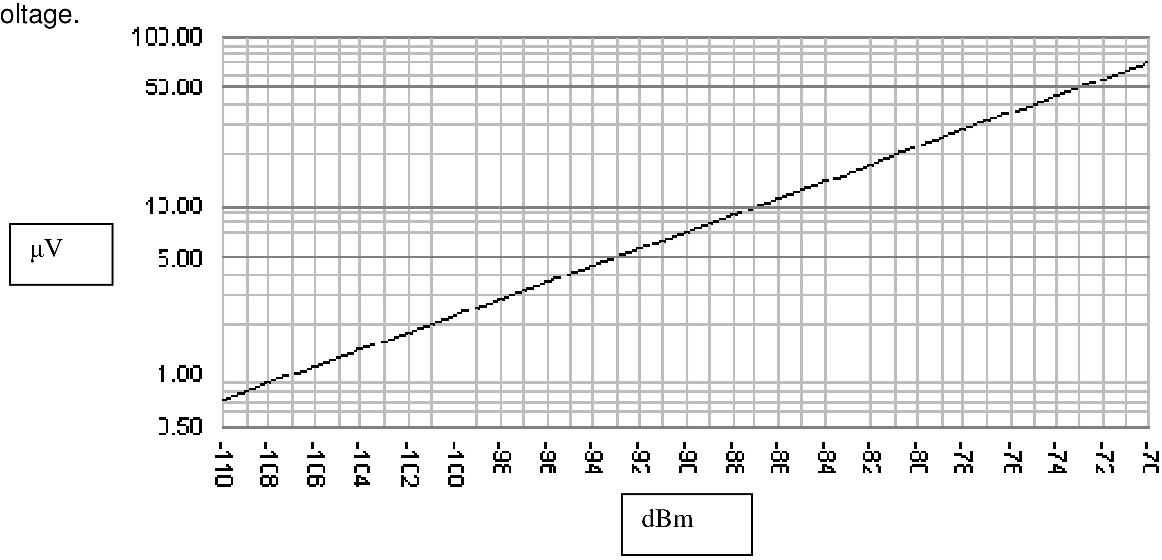
For a power ratio $10\log_{10}\left(\frac{P1}{P2}\right) = \text{dB}$

For a voltage ratio $20\log_{10}\left(\frac{V1}{V2}\right)\ \text{dB}$

A gain or loss may expressed in terms of power or voltage and is related to the impedance in the circuit. The gain (or loss) in a circuit is the ratio expressed in dB between the output voltage (or power) and input voltage (or power).
The ratio becomes more useful if it is a ratio to a standard, and the most widely used standard is the milliwatt (10^{-3}) watts and the unit is called the dBm which has become widely adopted in the radio and audio fields.
In 1929 Bell Labs also did some original research into optimal impedances for power transfer, voltage, and loss in transmission lines for carrier telephony. Their results are summarised in the graph below. For highest voltage, the optimal impedance is around 60Ω. For highest power transfer around 30 Ω, and for lowest loss around 77Ω.

The compromise standards of 50 and 75Ω are evident although widespread adoption only occurred after WW2.

Bringing the two together for the purpose of this topic, the graph below will assist in converting µV to dB at 50Ω and vice versa in a range encountered at a receiver input. Outside this range add or subtract 20 db for each decimal point change in voltage.



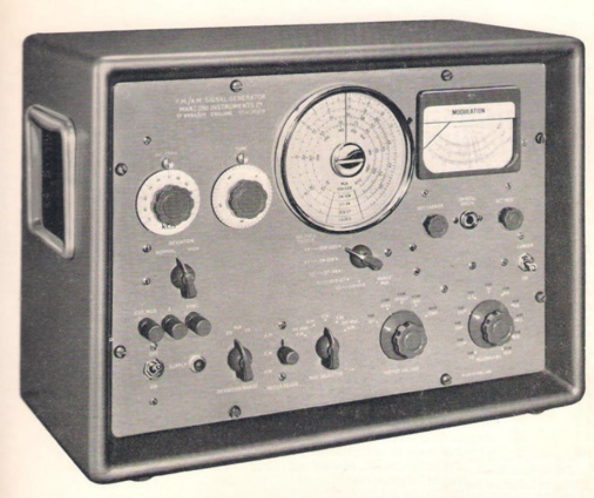
	µV (rms, Relative to 50Ω)	dBm
S9+10dB	160	-63
S9	50.2	-73
S8	25.1	-79
S7	12.6	-85
S6	6.3	-91
S5	3.2	-97
S4	1.6	-103
S3	0.8	-109
S2	0.4	-115
S1	0.2	-121
	V (rms, Relative to 600Ω)	**dBm**
1mW	0.775V	0
0.1mW	0.245V	-10

Here are some useful practical levels.

In the real world the receiver is required to extract the wanted signal from noise comprising external natural and man-made noise, the static noise in the antenna and the thermal noise generated within the receiver. Receiver noise is the absolute level of noise generated by the receiver and measured with the receiver input connected to a resistive load. This limits the ability of the receiver itself to detect incoming signals. Natural Noise, sounding like white noise, originating from atmospheric discharges, galactic or cosmic sources is the 'bottom line' of the noise in any particular location. This is what you would expect if you were to set up a low noise receiver in a desert with no man-made sources of noise around you. Superimposed on this is incidental local noise (RFI), the aggregate of spurious HF emitters in the near distance for example from power-line carrier, broadband wireless, and power systems equipment. This added to the natural noise comprises the fairly constant “noise floor” for the location. Our receiver testing is conducted in an “island” screened system which eliminates all but the thermal noise due to the receiver alone provided that the RF generator is quiet. Furthermore the audio output is translated to a voltage measured on a meter because the ears are subjective, unreliable, and variable. It however takes no account of the efficiency and response of associated loudspeakers and headsets.

The tests described below measure sensitivity, AGC performance, Adjacent channel rejection, Image frequency rejection, IF feed-through, Receiver blocking, and 3rd order intermodulation (IMD). They are conducted with an input to the antenna from a signal generator (SG) and a multi-meter (MM) equipped with a dB scale across the audio output. Accuracy of the tests depends on screening of the set up as slight RF leakage can swamp low level measurements. Adjacent channel and blocking tests may be performed using a single signal generator. However, more accurate results will be obtained using two signal generators and a combiner.

The SG must be capable of delivering a stable harmonic free sine-wave signal at the “frequency of interest” with a variable output attenuator able to reduce the output to less than 2µV emf (open circuit) = 1 µV pd (potential difference when terminated with characteristic impedance, usually 50 or 75Ω). It is important to know which method of calibration applies to the generator to be used. AM modulation at 400 Hz and 1kHz should be available at 30% modulation.



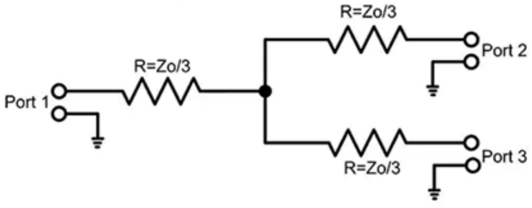
An example of a suitable SG is the Marconi TF995/2M from 1960 calibrated in emf from 1µV to 100mV and dB (caution) relative to 1µV.Maximum power transfer between a source (the generator) and the load (receiver) occurs when the impedance is perfectly matched. Even though the output impedance of the generator may be clearly defined, the input impedance of most older receivers can vary from 50 ohms to several thousand ohms.

For the sake of these tests , the output impedance of the generator/s is only relevant if loaded with a much lower impedance. This is unlikely as vintage receivers rarely have a precise value and are often high eg the HRO is 1700Ω. So it is reasonable to assume the mismatch between 50 and 75 ohms will make no significant difference to the results. For the 2 signal tests a second signal generator having the same characteristics is needed and a homebrew combiner network comprising a star arrangement of 3 x 18Ω carbon film or carbon composition non inductive resistors. The 3 ports are equivalent and interchangeable.

This is easily installed in a small lozenge tin or box made from blank PCB material with 3 BNC connectors and soldered up to complete the screening.

The Multi-meter (MM) should have a dB scale in addition to the 1-2.5-10 or 1-3-10 set of AC voltage ranges.

The dB scale is usually the inner scale so an anti-parallax mirror will increase accuracy of the reading. Suitable MM's are illustrated below.



A resistive combiner/splitter

The voltage scale intervals require a bit of thought. Where the Philips scales of 1, 3, 10, 30, 100, etc. are used. 20log(3/1)=9.5dB, and 20log(10/3)=10.5dB. This means for every click on the meter one adds or subtracts approximately 10dB. There is an error of ±0.5dB but it's close enough to suffice for a low budget solution. The Simpson and the AVO with ranges 1, 2, 5, 10, etc require additions of 6, 8, and 6dB or 20 dB per decade.

It is assumed by the authors that the reader has a working knowledge of the superheterodyne receiver and the function of its various stages.

To begin testing it is useful to obtain the manufacturers specified parameters for the receiver under test so that you know what result you are aiming for. In the absence of a specification particular specification the specification from a similar receiver may be used for reference purposes. Broadly speaking most receivers will have similar specifications
This data may be a scant set of single parameters averaged over the receiver frequency ranges or as in the case of the RCA AR88, a table of typical points within each waveband as given in the appendix at the end.
The test procedures follow..

1. Receiver Sensitivity tests [see9.6]

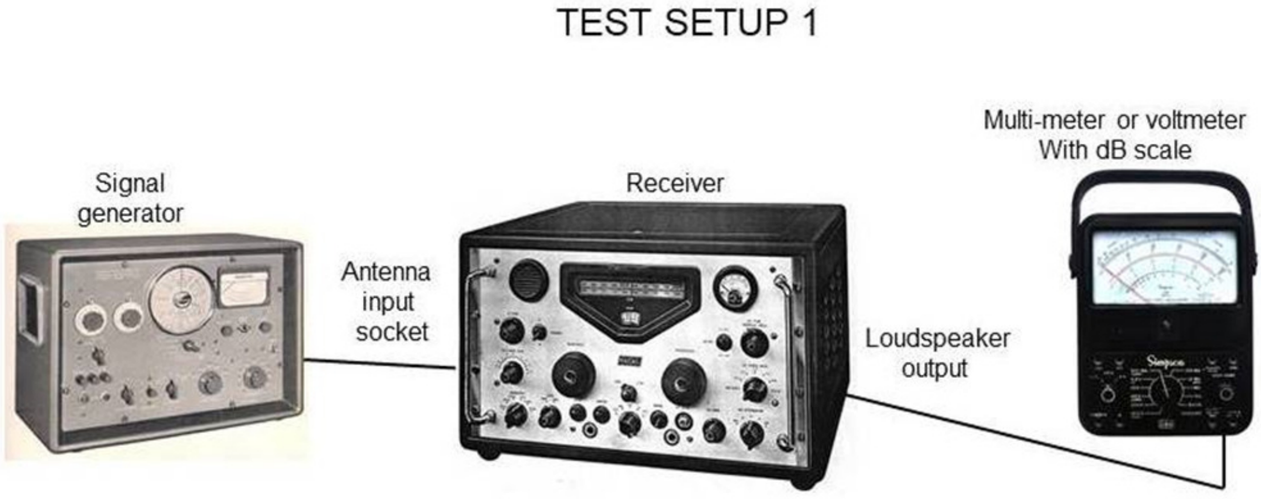


Figure 1

1.1 Connect the equipment as in figure 1

1.2 Set the signal generator output to 1mV modulated with 30% AM with a 1kHz tone.
1.3 Set the receiver to AM mode and tune the signal generator to the receiver frequency.
1.4 If the receiver is working then a modulated tone should be heard in the receiver speaker.
1.5 Adjust the audio gain control for a level of 0dB on the AC voltmeter.
1.6 Switch the SG modulation off and reduce the RF signal level until the receive audio output as read on the AC voltmeter on the receiver rises to a level of -10dB.
1.7 Switch the RF output on and off a few times while making sure that the audio output varies between—

10dB and 0dB.

1.8 Read the RF level off the generator attenuator. This is the receiver sensitivity in µV for 10dB signal to noise (S/N) ratio.

2. Receiver AGC performance

2.1 Connect the equipment as in figure 1.
2.2 Using the method above determine the RF level required to provide a 10dB S/N.
2.3 Increase the SG output level by 6dB and note the RF level and the audio output level
2.4 Increase the SG output and ensure that the audio output level increases by no more than 3dB.
2.5 When a point is reached where the audio output exhibits distortion or the audio output increases by more than 3dB – note the SG output level.
2.6 The ratio of the difference in SG output between the RF level noted in point 2.3 above and 2.5 is the AGC range in dB

3. Receiver Adjacent channel rejection – simple test

3.1 Connect the equipment as in figure 1.
3.2 Set the signal generator frequency equal to the receiver frequency + twice the IF bandwidth. (Example: Receiver frequency = 7100kHz; If Bandwidth = 10kHz; SG frequency = 7120kHz)
3.3 Test as in the sensitivity test above. The difference in level in dB between the sensitivity and the RF signal required to produce a 10dB signal to noise ratio on the test frequency is the adjacent channel rejection ratio.
3.4 Repeat the test at receiver frequency + three times IF bandwidth.
3.5 Repeat the test at receiver frequency – twice IF bandwidth
3.6 Repeat the test at receiver frequency – three times IF band width.

4. Receiver Adjacent channel rejection – 2 Signal test. 2 Signal generators and a combiner

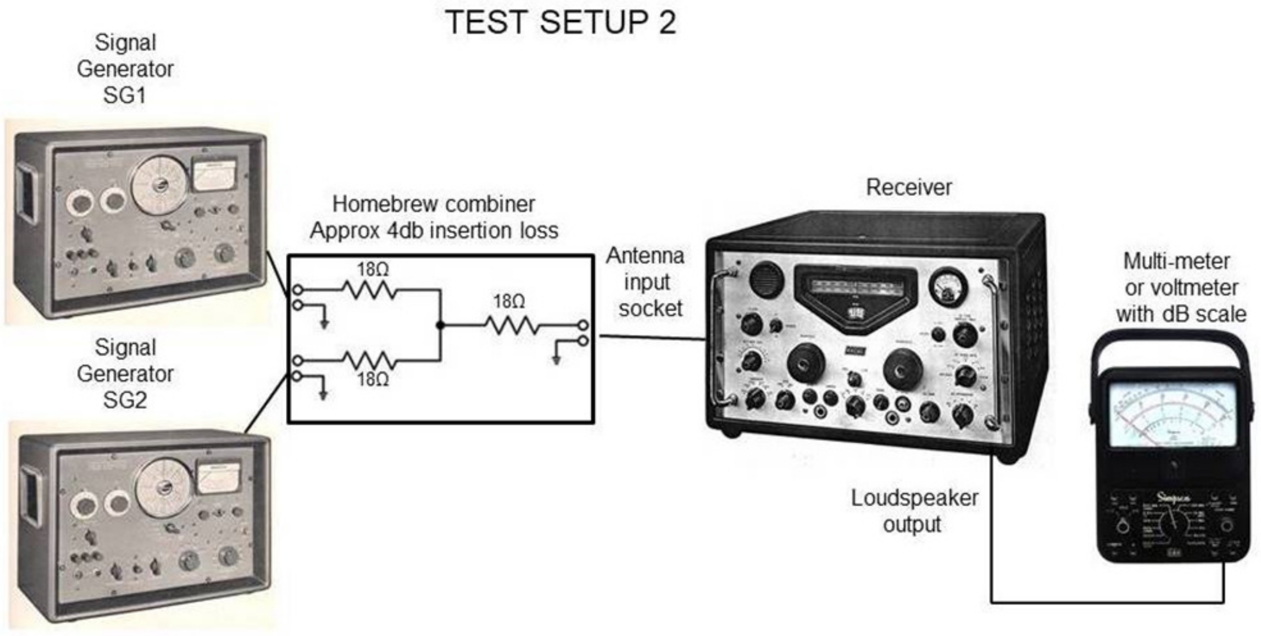


Figure 2

4.1 Connect the equipment as in figure 2.
4.2 Adjust SG number 1 for a level to provide a receiver sensitivity at 10dB S/N. Then increase the RF SG output by 6dB
4.3 Adjust SG 2 to a frequency equal to the wanted signal + twice IF bandwidth removed from SG 1 frequency. Modulate SG2 with a 400Hz tone at 30% modulation. (Example: Receiver frequency = 7100kHz; If Bandwidth = 10kHz; SG2 frequency = 7120kHz)
4.4 Increase the level of SG2 until the signal to noise ratio of the wanted signal returns to 10dB.
4.5 The ratio of the output level of SG1 and SG2 in dB is the adjacent channel rejection ratio of the receiver.
4.6 Repeat this test for a SG2 frequency at separations of + 3 x IF bandwidth, – 2x IF bandwidth and -3x IF bandwidth from the receive frequency (SG1).
4.7 By comparing results at twice and three times the IF bandwidth removed provides a rough idea of the slope of

the IF band-pass.

5. Image Frequency Measurement

If you are not sure whether the local oscillator frequency is below the first IF frequency or above the first IF frequency then the following test must be conducted at the receive frequency – the first IF frequency and at the receive frequency + the first IF frequency.
5.1Equipment connection as in Figure 1.
5.2 Adjust the SG frequency for the image frequency and apply AM modulation 1 kHz at 30%.
5.2 Increase the SG RF output level until the signal is detected at the receiver output.
5.3 Conduct a signal to noise test in the same manner as the sensitivity test in para 1.0 above.
5.4 The difference in RF signal level between the sensitivity at the wanted frequency and at the image frequency is the image rejection ratio in dB

6. IF Feedthrough

6.1 Equipment connection as in Figure 1.
6.2 Adjust the RF signal generator to the First IF frequency.
6.3 Measure the sensitivity as in test 1.
6.4 The ratio in dB in level between the wanted signal and the test signal is the IF rejection of the receiver in dB.
6.5 The same method may be used to test 2nd and subsequent IF rejection in double and triple heterodyne receivers.

7. Receiver blocking

This test measures the ability of the receiver to cope with strong in-band signals and requires two SG's.
7.1 Connect the equipment as in figure 2.
7.2 Adjust SG1 for a level to provide a receiver sensitivity at 10dB S/N as in test 1. Then increase the RF SG output by 6dB
7.2 Adjust SG2 to a frequency at least 10 times the IF bandwidth removed from SG 1 frequency. Modulate SG2 with a 400Hz tone at 30% modulation.
7.3 Increase the level of SG2 until the signal to noise ratio of the wanted signal returns to 10dB.
7.4 The ratio of the output level of SG1 and SG2 in dB is the blocking ratio of the receiver.

8. Receiver (3rd order) Intermodulation - two signal method

8.1 Connect the equipment as in figure 2.
8.2 Adjust SG1 modulated with a 1kHz tone at 30% modulation depth at the wanted frequency + 20kHz
8.3 Adjust SG2 unmodulated at the wanted frequency + 40kHz
8.4 Increase the level of both generators together keeping their output levels matched until a signal is heard in the receiver output.
8.5 Adjust the levels of both generators to give a 10dB S/N at the receiver output.
8.6 The ratio of the difference in level between the receiver sensitivity as measured in test 1 above and the level of test generators is the 3rd order intermodulation rejection. This is sometimes mistakenly called cross modulation rejection ratio.

9. Notes:

9.1. SSB receivers may be tested as in test 8 except that SG1 is unmodulated and the RF frequency is adjusted to provide a 1kHz tone in the receiver output.
9.2. A generator calibrated in µV emf or µV pd will usually depend on where the generator was manufactured. British and most European generators will be calibrated in µV emf (open circuit) whereas US made generators will generally be calibrated in µV pd (potential difference) across a 50 ohm load. A rule of thumb, 0.5µVpd = 1µV emf.
9.3. If the experimenter has access to a so called SINAD (Signal, Noise and Distortion ratio) meter used to test mobile radio communications equipment then the signal to noise ratio may be read directly off the meter scale instead of switching the SG modulation on and off. SINAD meters are calibrated for 12dB SINAD but the results are similar to measuring 10dB S/N ratio.
9.4. A resistor of appropriate value eg 4 or 8Ω can be applied in place of the loudspeaker when taking protracted measurements.
9.5. If one does not have a signal generator with a good quality variable attenuator then a switchable attenuator may be constructed from readily available parts.
9.6. For an authoritative article on the principles behind these tests read G3RZP Peter Chadwick's "Understanding receiver parameters" from February/March 1982 Practical Wireless, now downloadable from the AWA website http://www.awasa.org.za/

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