GETTING THE MOST FROM YOUR HF TRANSCEIVER

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Topics

- Its mostly about the receiver…
- Transmitter/amplifier operation tips and tricks
- Common operating scenarios

Its Mostly About The Receiver

Commonly Available Controls

Multi-Function Screen

Preamp/ Attenuator

Passband Tuning (DSP) Filter & IF Shift

Notch Filters*

Operating Mode

”Roofing” Filter*

Adjusts *’ed Items

Receive Incremental Tuning

Noise Reduction/ Blanker*

RF Gain

Audio Gain

Access Function Screen

Pan Adapter/ Spectrum Scope

CW Auto Tune

VFO Tuning

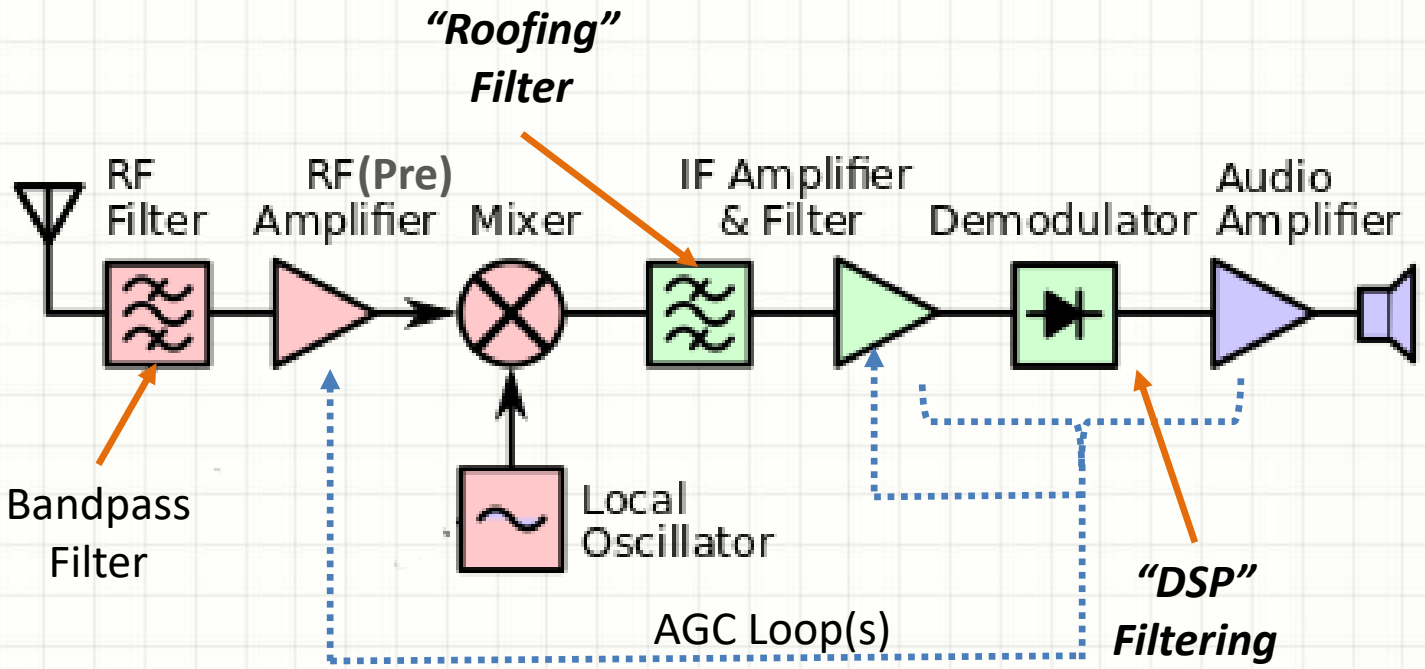
Its Mostly About The Receiver - Some Terms

Bandwidth, Dynamic Range and Signal to Noise Ratio

- ***Bandwidth*** – tools to limit your receiver so it "hears" only what you want to hear and to protect it from overload
  - Mostly about filters
- ***Dynamic Range*** – the difference between the loudest and the weakest signal you rig can handle
  - Want to maximize Dynamic Range for the ***target signal***
  - Mostly about adjusting for optimum RF gain and operation of Automatic Gain Controls
- ***Signal to Noise Ratio*** – the relative power between the signal you are trying to hear (good) and noise/interference (bad)
  - Noise reduction processors to reduce noise along with proper use of other controls

Its Mostly About The Receiver

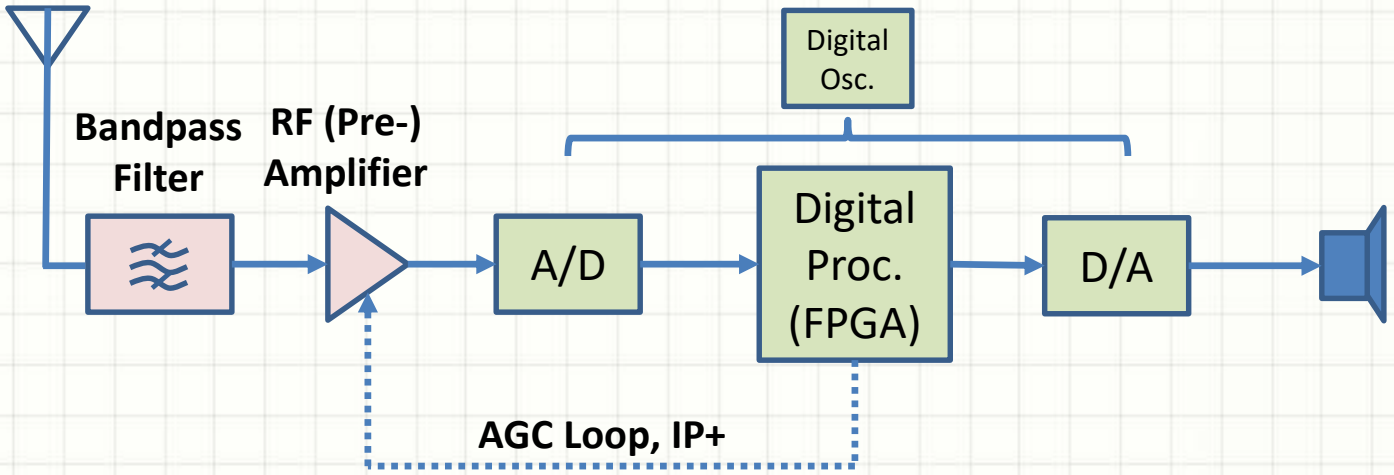
Basic Receiver Elements (Single Conversion Analog)



- Filters limit ***Bandwidth*** to reject unwanted signals, preventing them from adversely effecting performance
- The Automatic Gain Control (AGC) System attempts to maximize ***Dynamic Range*** within Weak Signal Receiver Stages
  - Critical to maintain linearity to prevent distortion products
- DSP Adaptive Filters are use to reduce noise which improves ***S/N Ratio***

Its Mostly About The Receiver

Basic Receiver Elements (Direct Sampling ex. IC-7300)



- Most filtering, all noise reduction and signal detection steps are performed digitally
- AGC System must maximize A/D converter resolution ***for the desired signal***
- Many possible sources of non-linearity are eliminated
  - A/D Converter Resolution and Oscillator Phase Noise become the main performance limiters
  - Digital processing speed and algorithm performance also matter

Its Mostly About The Receiver

Controls to Optimize Weak Signals

Preamp/ Attenuator

Passband Tuning (DSP) Filter & IF Shift

Adjusts *'ed Items

Noise Reduction/ Blanker*

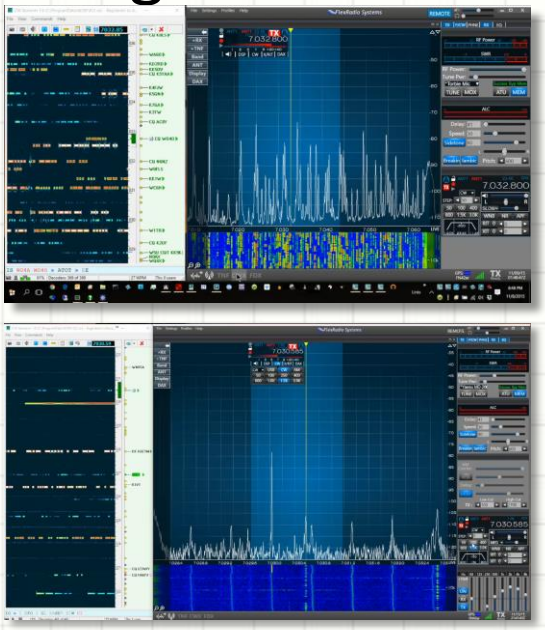
RF Gain

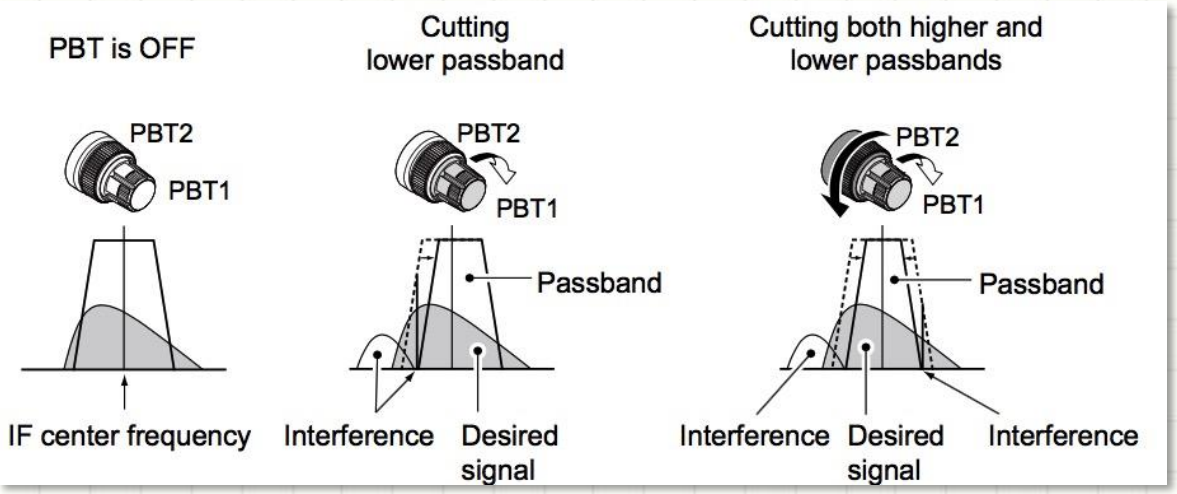
Access Function Screen (AGC Controls)

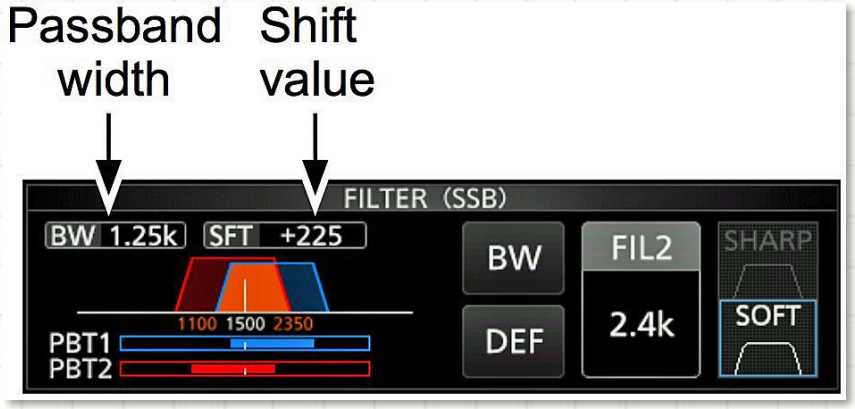
- Filters Limit ***Bandwidth*** and optimize adjacent signal rejection
- RF Gain Control, Preamp/Attenuator, and AGC Time Constant settings optimize ***Dynamic Range***
- Adaptive Noise Filtering is used to reduce noise; improving ***S/N Ratio***

Its Mostly About The Receiver

Using Your Filters

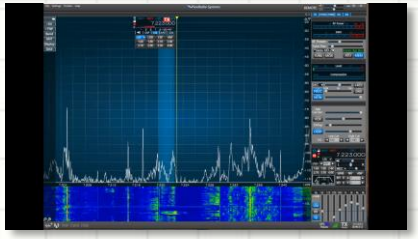






Minimize Noise BW/Interference:

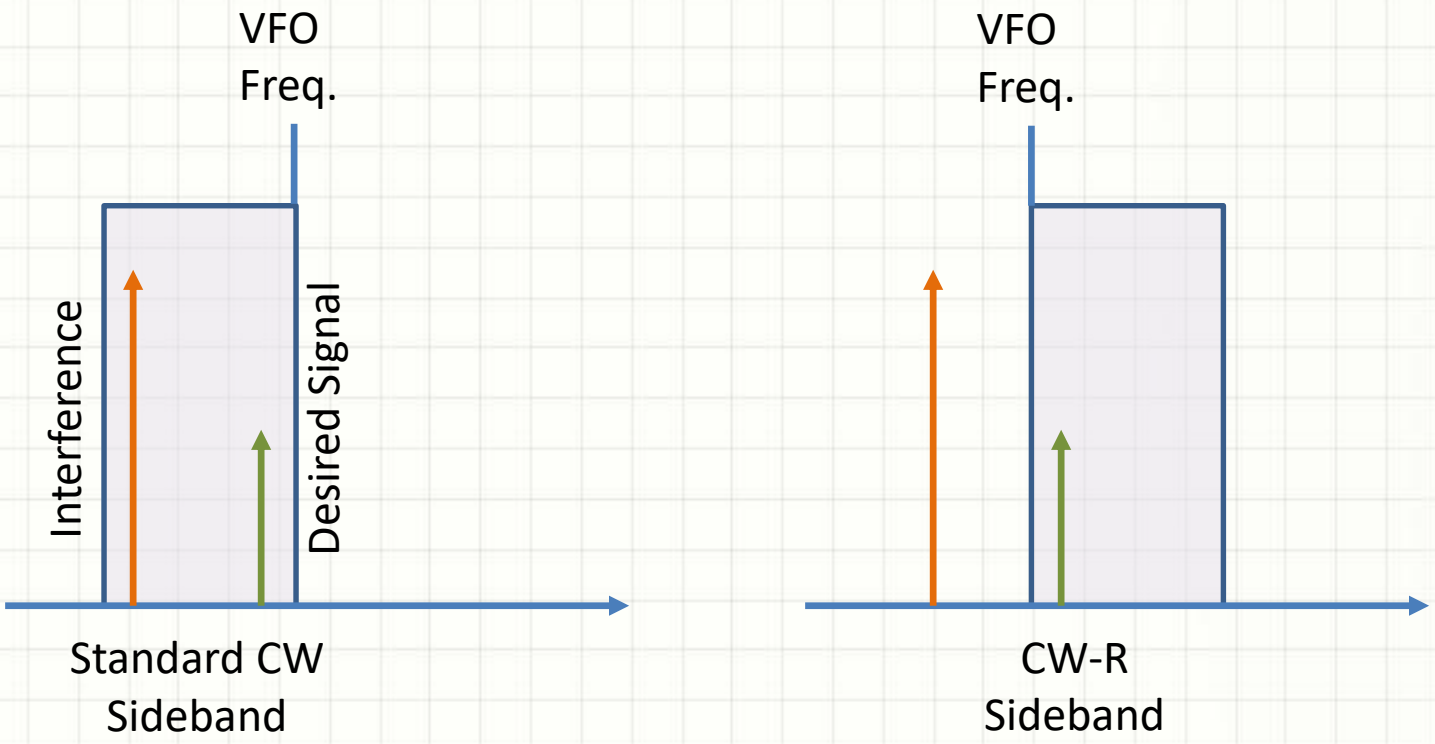
- Roofing Filters – typically “fixed” BW filters applied before IF stages
- DSP filters – Digital Signal Processing after IF stages
- Both are realized in Digital Processor of the IC-7300



IF Shift Example

Its Mostly About The Receiver

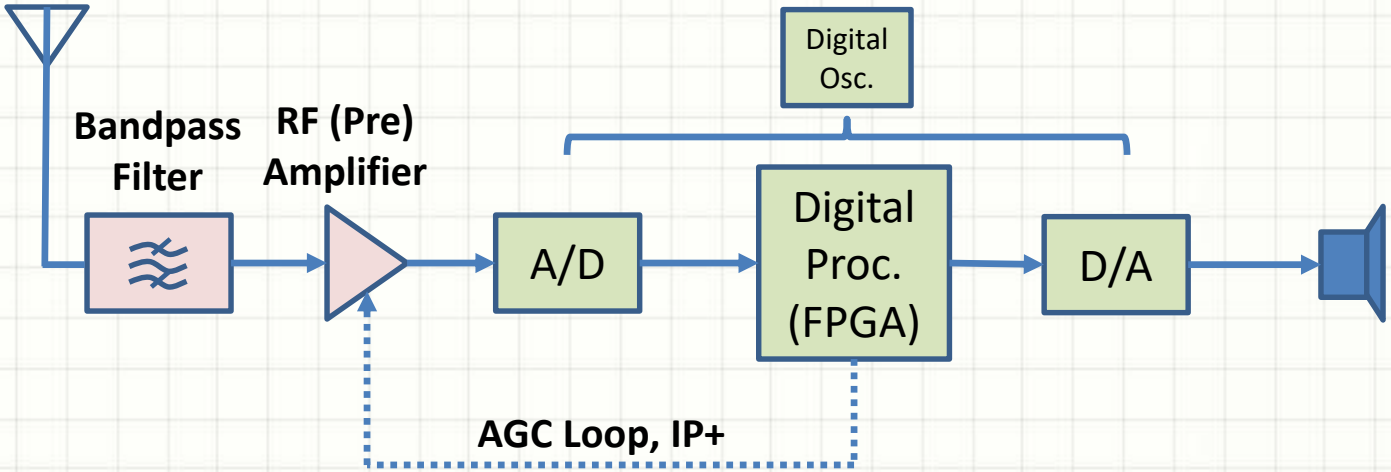
CW Reverse Sideband (CW-R)



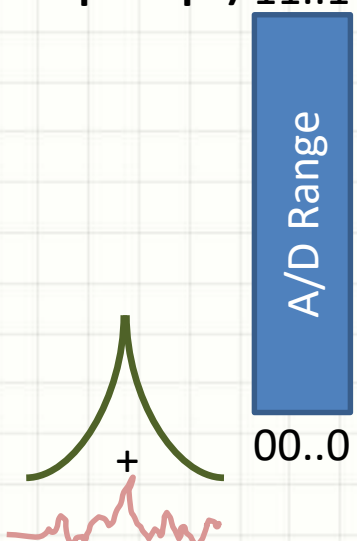
Reversing CW Sideband to Improve Adjacent Signal Rejection

Its Mostly About The Receiver

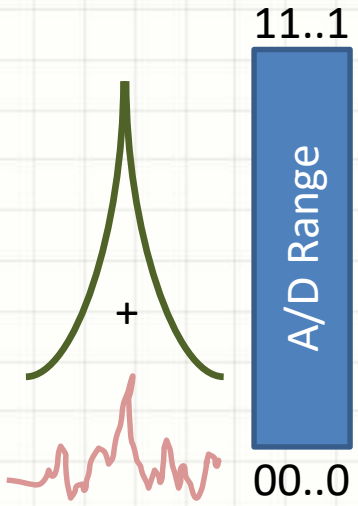
Dynamic Range – Its About Optimal Gain Control



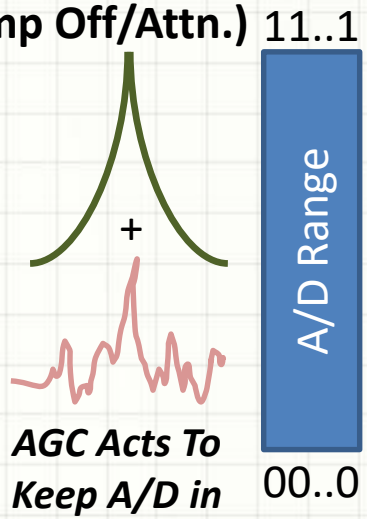
Too Little Base Gain (Preamp Helps)



Optimal Base Gain



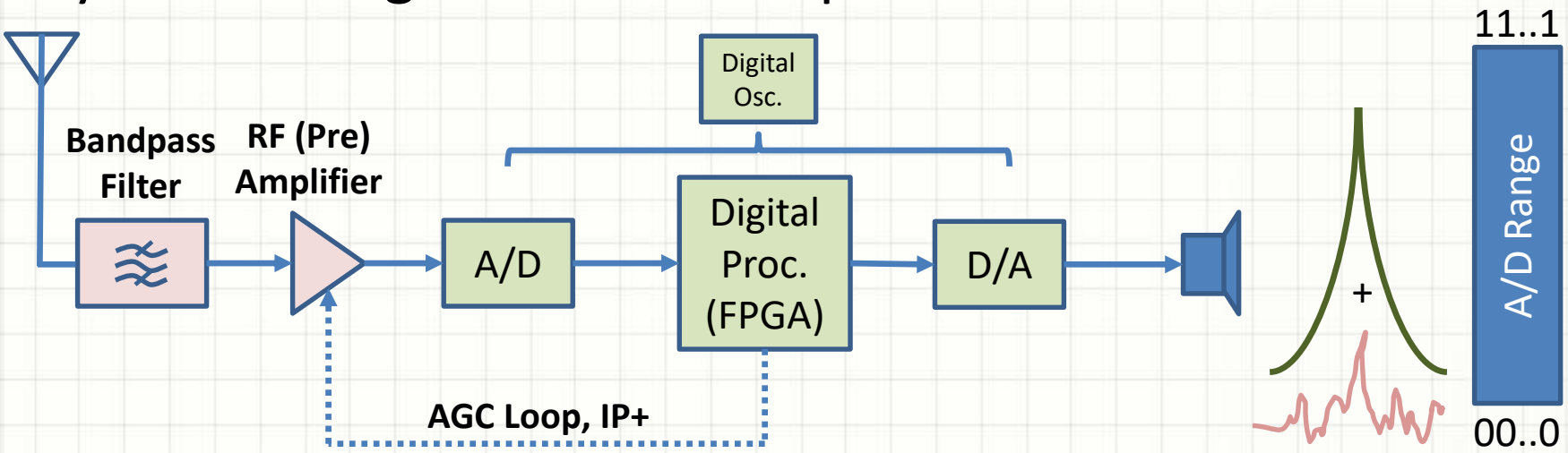
Too Much Base Gain (Preamp Off/Attn.)



AGC Acts To Keep A/D in Range

Its Mostly About The Receiver

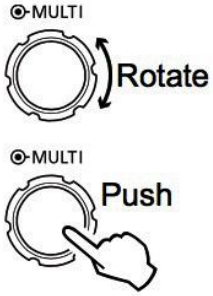
Dynamic Range – Its About Optimal Gain Control

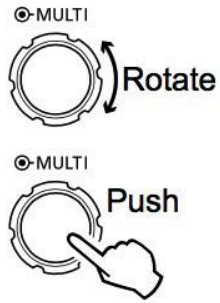


- Goal is to add enough gain to amplify the desired signal for maximum converter resolution
  - Hard when, signals are very weak and close to the noise floor
- Receiver controls to use:
  - Preamplifier/Attenuator – base setting to get in the “ball park”
  - AGC Time Constant – set to match characteristics of the desired signal
  - RF Gain Control – manual adjustment to fine-tune AGC operation
  - IP+ and similar controls – proprietary ”magic” to optimize AGC Loop to reject de-sensitation effects due to adjacent signal interference

Its Mostly About The Receiver

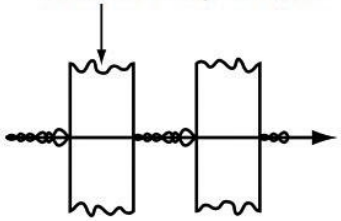
Noise Reduction – Digital Magic to Reduce Noise





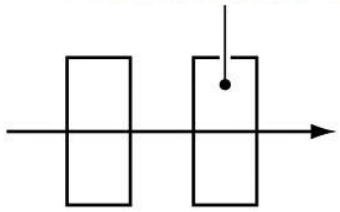
Noise Reduction OFF
NR level 0

Noise components



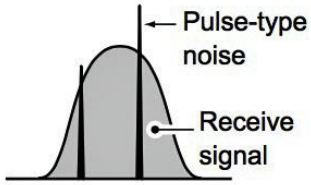
Noise Reduction ON
NR level 4

Desired signal (CW)

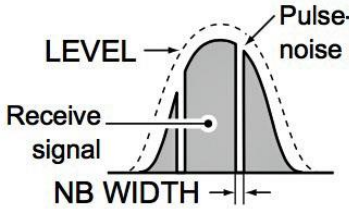


Adaptive digital filter estimates random noise characteristics to cancel

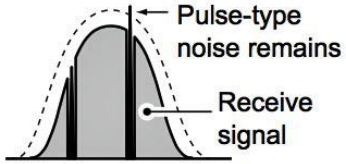
Noise Blanker OFF



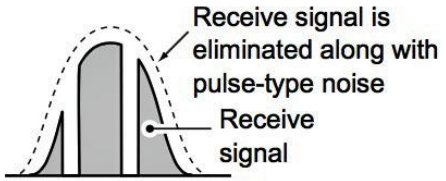
Noise Blanker ON



Noise Blanker ON
(Not enough DEPTH)



Noise Blanker ON
(WIDTH set too long)



Detects pulse oriented noise and eliminates using short-duration blanking

Use these sparingly, especially if desired signal is weak

Its Mostly About The Receiver

Starting Point for Receiver settings

- Set preamplifier/attenuator so that the noise floor is close to "S0" on your signal meter
- Set RF gain at Max. and AGC speed setting matched to mode:
  - Fast for CW mode
  - Medium for Digital modes
  - Slow for Voice modes (SSB, AM)
- Roofing/DSP filter(s) matched to mode, no IF shift:
  - 2.4 - 3.0 KHz for Voice or digital pass-band modes
  - 500 Hz for RTTY
  - 400 - 500 Hz for CW (wider when tuning a split pileup)
- Set DSP Noise Reduction levels for ***modest improvement*** in noise level
- Leave Noise Blanker off unless you are dealing with a ***strong repetitive pulse noise source***

Its Mostly About The Receiver

Pulling in and Cleaning Up a Weak Signal

1. Narrow your filters to reduce noise and reject interference
2. Shift your IF to reject adjacent signal interference and match passband to desired signal characteristics
3. Try CW-R if a strong adjacent signal is interfering
4. Back off or increase noise reduction levels and settings
5. As you do steps 1-4, pay attention to desired signal intelligibility, not levels of signals and noise
6. Try manual RF gain control (be careful, especially if wearing headphones)
   - Back off RF gain until receiver is quiet, crank AF gain to max.
   - Slowly increase RF gain until desired signal just rises out of the noise
7. Try turning on the attenuator (especially in a crowded band situation like a contest) and repeat the above steps
   - This may bring your rig into a more linear range of operation

Its Mostly About The Receiver

Other Important Features

Adjusts *'ed Items

Receive Incremental Tuning

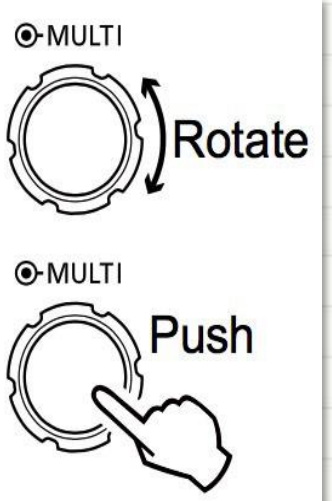
Notch Filters*

CW Auto Tune

- Auto Notch Filter – the "Tuner Up'er Control"
  - Can protect your ears, especially when wearing headphones
  - Don't use it with CW or Digital Modes
- Manual Notch Filter*
  - Very useful for "birdie" elimination
  - Don't forget to turn it off when before you move to a new frequency
- CW Auto Tune – handy for zero-beating but you should also learn to do it manually
- RIT to true up station using slightly different Tx and Rx frequencies (not zero beat)

Its Mostly About The Receiver

Other Important Features



VFO/ Memory Mode

Recent Frequency Memory Pad

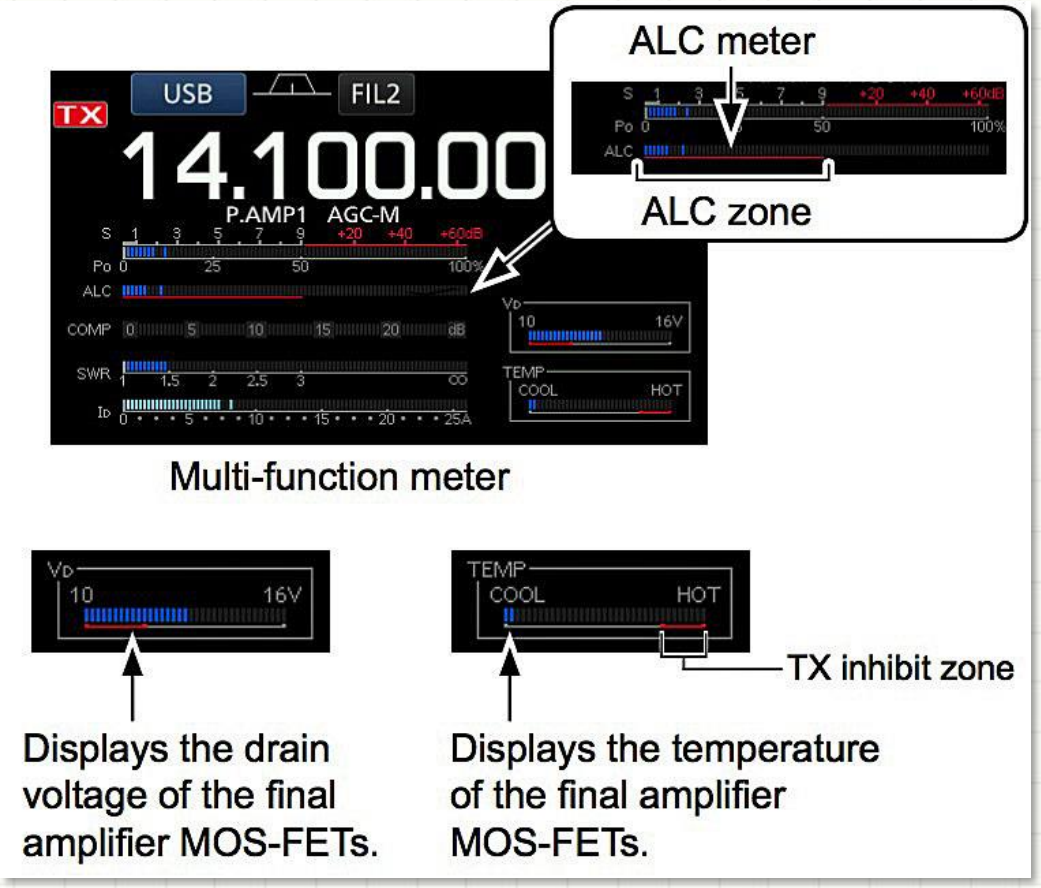
- CW "Side Tone" setting – a personal choice
  - Higher frequencies enable faster speeds for folks with good hearing
  - 600 – 800 Hz range is a good place to start
- Radio Memories
  - Useful to get to favorite watering holes quickly (ex. digital sub-band)
  - Good idea to set these up for 60m operation (two sets – CW and SSB)
  - Return to recent frequency, programmed scans, repeaters, …
- Receive Equalizer Settings (Menu setting)
  - Great if your hearing is not perfect
  - Adjust for best intelligibility and pleasant audio for your situation
- Learn to use on-air recording/playback features (they will come in handy at times)

Transmitter Tips and Tricks

Your Transmitter

Understanding Your Meters

- **S0**: Receive Signal Strength
- **Po:** Output Power
- **SWR:** Displays Antenna's SWR when in Tx
- **ALC:** Automatic Level Control Limits
- **COMP:** Speech Compression Level
- **VD:** Final Amp Drain Voltage
- **ID:** Final Amp Drain Current
- **TEMP:** Final Amp Temperature



Your Transmitter

Important Controls

Multi-Function Screen

Tx Functions

Manual Tx

Operating Mode

Split Controls

Adjusts Tx Pwr, Mic Gain

Tx Incremental Tuning

Auto Tuner

VOX / CW Break-in

Access Function Screen

VFO Tuning

Your Transmitter

Adjusting Microphone Gain, Compression, Tx Bandwidth

Mic Gain Knob or Multi-Function Knob

- Turn off compression, turn power down/amp off, connect a Dummy Load
- Set Tx bandwidth for SSB phone consistent with band conditions
  - 2.4 KHz if operating in crowded band conditions
  - Can open to 3.0 KHz for rag-chew operation in a lightly filled band
- Set ALC so that you have ~50% deflection on the peaks of your audio
  - Test with close-in speech to microphone and a little louder than normal
- Its OK to use a modest amount of speech compression but ***don't overdo it!***
  - Avoid compression if there is significant background noise
  - Adjust to compensate for variations in voice, moving away from mic a bit
  - With proper adjustment, compression should not be detectable by other stations

Your Transmitter

Other Important Adjustments

CW Break-In/ VOX

SSB TX Bass (Default: 0)

SSB TX Treble (Default: 0)

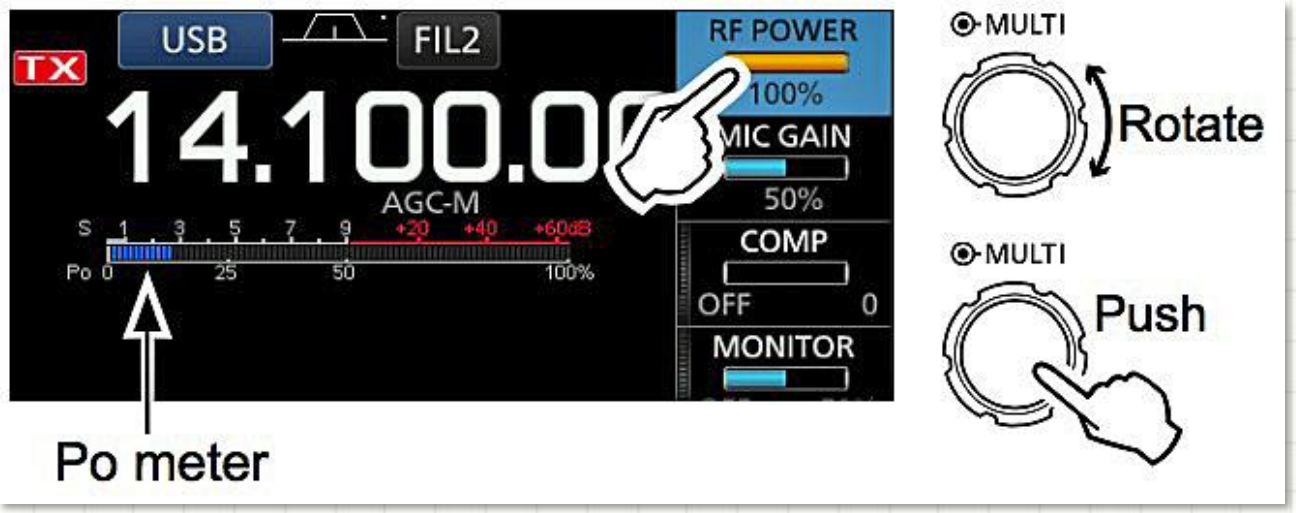
Sets the bass or treble level of the receive audio.
• Range: –5 ~ +5

Adjust Tx Audio and VOX for Microphone and Operating Environment

- Tx Audio Equalization is very important
  - Basic Tx Treble and Bass adjustments are adequate
  - Choice in setups – warm audio for rag chewing and crisp, easy to copy audio for DX'ing and Contesting
  - Ask someone who has good audio on the air to help you with setup
- VOX – Can use in quite conditions and adjust properly for you mic and environment
  - Don't forget to turn it off when done!
- Built-in CW Keyers – set for your key, learn to adjust speed, set break-in mode

Your Transmitter

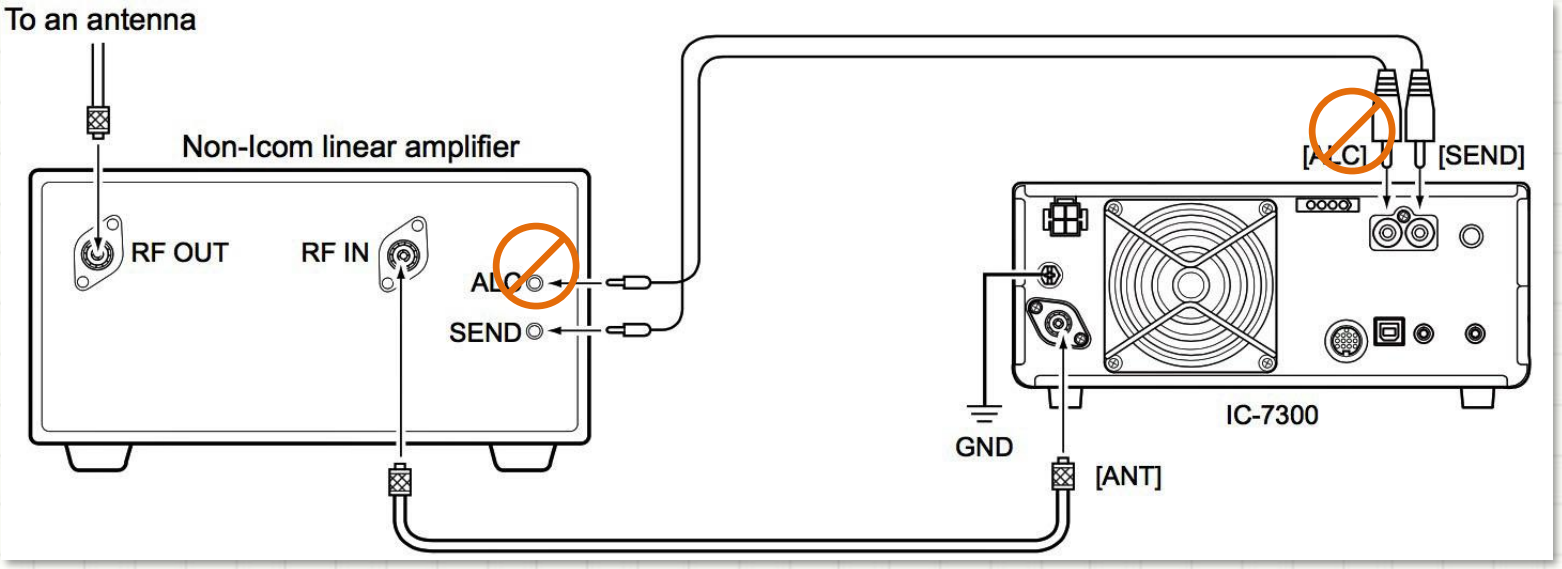
Tuners, Antenna Switches, Power and Monitoring



- Antenna Tuners – use sparingly
  - They have loss and are generally not needed if SWR is ≤ 1.5:1
  - Most built-in tuners will handle a 2:1 mismatch
  - If you must tune up on the air, ***do it at low power and off the operating frequency of others***
- If you rig has automatic antenna switching, configure it to put you on your best antenna for each band
- Your station should be configured to ***monitor output power and SWR at all times while Transmitting***
- Key an eye on temperature meter if you are operating in digital modes for long periods and/or at high duty cycles

Your Transmitter

Using an Amplifier

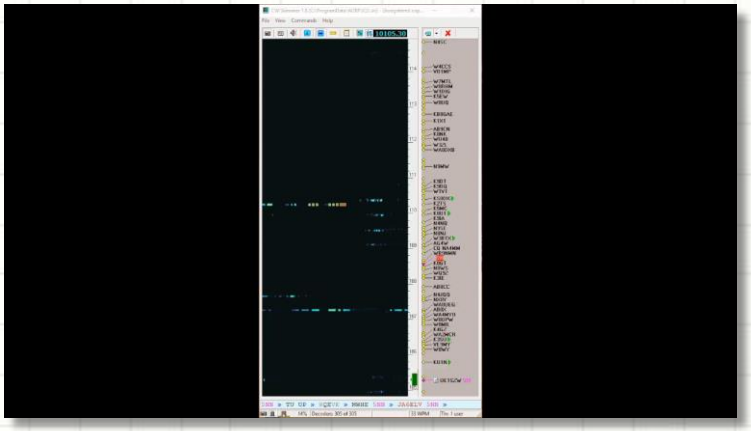


Usually 30 – 50W Drive Will Create Full Output – AVOID OVERDRIVING!

- Best to configure amplifier to start up in Standby mode – check out tune and SWR in "barefoot" mode and adjust Tx power on your rig
- Avoid using ALC, adjust Tx power (Drive) on your rig to maintain linear operation
- Have a dummy load and use it to adjust your amplifier before going on the air
- Learn to quickly fine tune on the air and ***do it it off the operating frequency of others***
- In all cases, your station should be configured to ***monitor output power and SWR at all times while Transmitting***
- Key an eye on temperature meter if you are operating in digital modes for long periods and/or at high duty cycles

Common Operating Scenarios

Split Operation



- Station Transmits on one Frequency and listens at a different place
  - ”Listen Frequency” can be a single one or a range
  - Most will listen “Up” but can be “Down” as well
- Typical split scenarios:
  - CW or RTTY – up 1 (Listening up 1 KHz or in a range starting there)
  - SSB – up 5 or up 5 to 10 (Listening up 5 KHz or in a range starting there)
- Strategies for working a split station
  - Set you receiver to the DX’s Tx frequency, ***enable split*** and use XFC or a second receiver to tune through the stations Tx range
  - Find the last station worked – open your receive filter up for CW, listen for 5NN
  - Try to pattern the operator and select the best place to call
  - Consider that operator may be working the edges of the pileup (CW) or may be looking for someone “in the clear”

Your Transmitter

Working Split

2 Enables Split Mode

5 Tx Incremental Tuning

3 Swaps or Matches Tx and Rx VFO

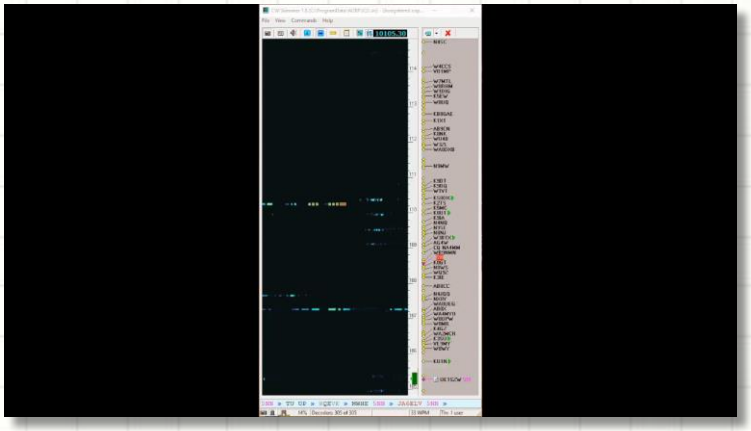
4 Listen on & Adjust Secondary (Tx) VFO

1 VFO Tuning

4

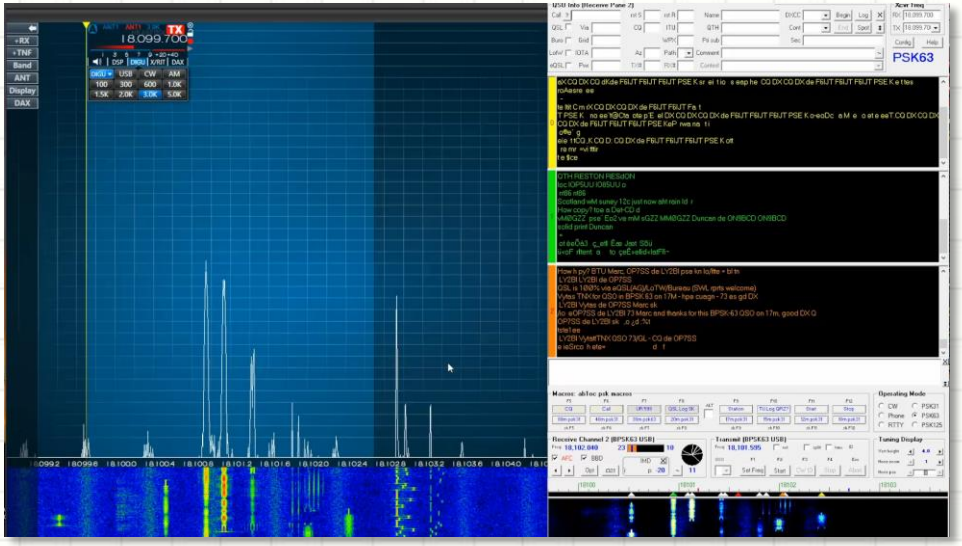
1. Tune to DX Transmit Frequency
2. Enable split mode
3. Set Tx and Rx VFOs to same frequency
4. Hold XFC and adjust secondary VFO to where the DX is listening
5. May use Tx Incremental tuning to change your signal's tone to stand out

Busting Pileups



- ***Make sure you hear the other station before beginning***; try to pattern them before calling; d***ouble check that your rig is in split if need before calling***
- Its mostly about timing
  - Drop in your callsign at just the right time
  - Avoid calling out of turn – don't be QRM
  - Don't use partial callsigns – Ops trying to maximize their rates won't work you
  - Wait enough time for most of callers to stop
- Try calling with a slightly different tone (use ΔTx control if you have one)
  - +/- 100 Hz off the pileup for CW
  - + 300 to 500 Hz for SSB
- Tail-end calls – ***use caution***
  - Listen first to see if operator is working these
  - Full callsign, fast, and ***only when you can hear both ends of the previous QSO***

Digital Mode Operation



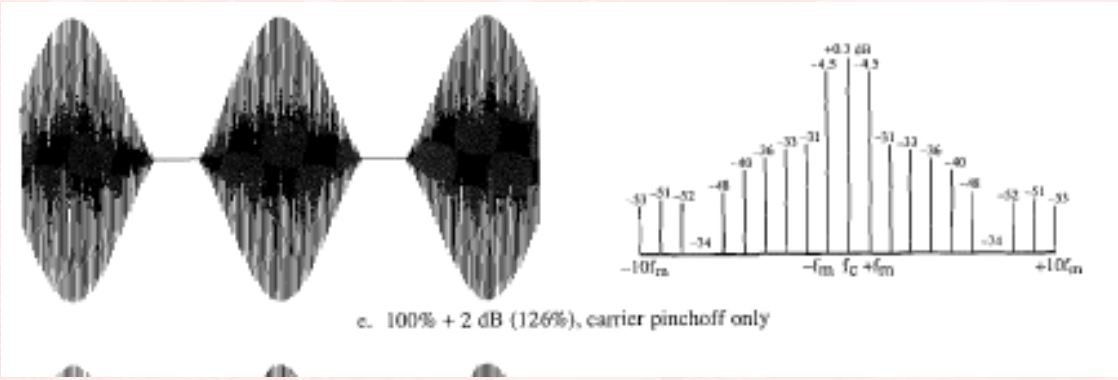
- Use ***Digital Mode*** setting or disconnect microphone/disable audio processing
- Set your audio drive just below the point where you see ALC meter deflection
- Be mindful of power levels when operating in “shared passband” modes like PSK or JT65
  - If not, you’ll be the ***strong, close-in interferer*** that everyone dislikes…
- Use noise reduction sparingly as the distortion it causes can impair decoding
- If calling CQ, use your receive filters to improve S/N ratio, adjacent signal rejection and AGC operation

Getting To Know You, ….

Reading The Manual, Reading The Fine Manual For Your Rig….

N1FD.org TECH NIGHT Jan 10, 20117 Transmitter Monitoring

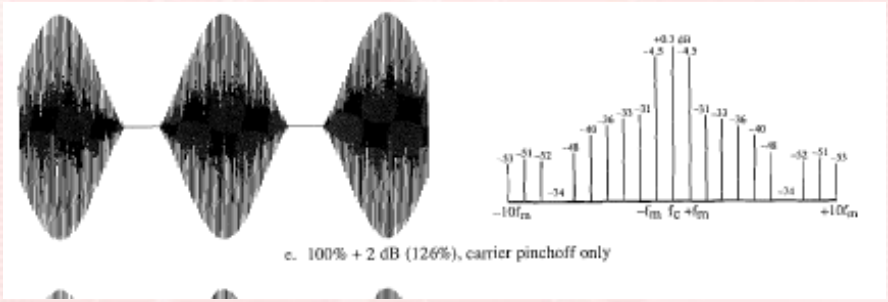
WHY ?..... I set the radio to punch out 800 watts and the ham across the valley can hear me !



Yep, and the next door neighbors' radio hears you loud & clear

N1FD.org TECH NIGHT Jan 10, 20117 Transmitter Monitoring

- WHY ? I set the radio to punch out 800 watts and the ham across the valley can hear me !



Technician License Test: Section T7B (2014): Common transmitter and receiver problems: symptoms of overload and overdrive; distortion; causes of interference

T7B06-2014: Which of the following actions should you take if a neighbor tells you that your station's transmissions are interfering with their radio or TV reception?

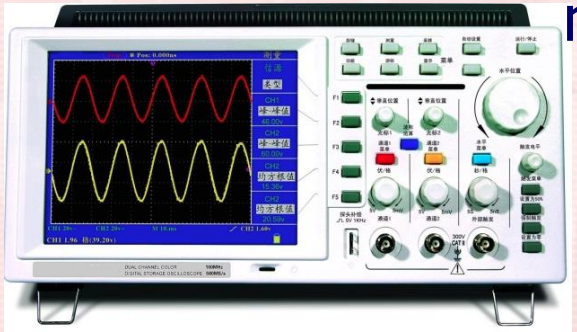
Make sure that your station is functioning properly and that it does not cause interference to your own radio or television when it is tuned to the same channel

Transmitter Monitoring Devices in the Radio Shack

YOU

Radio analog/digital meters

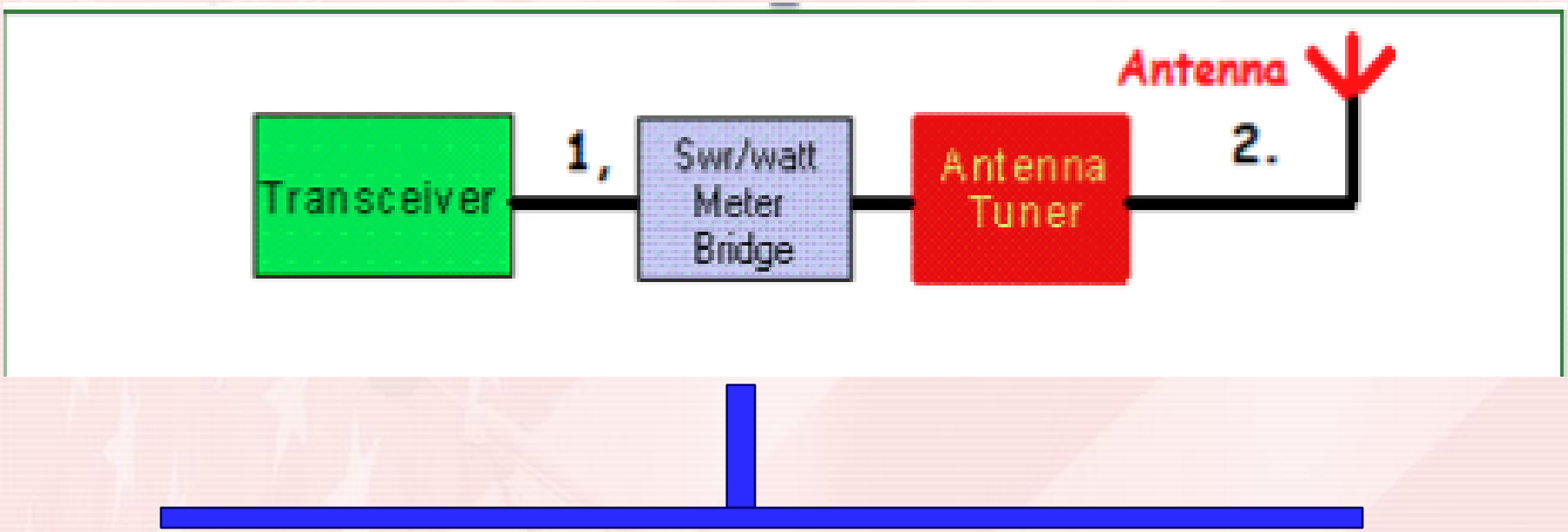
Stand alone power/SWR meter

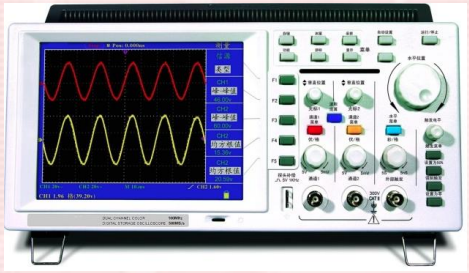


Oscilloscope with RF sampler

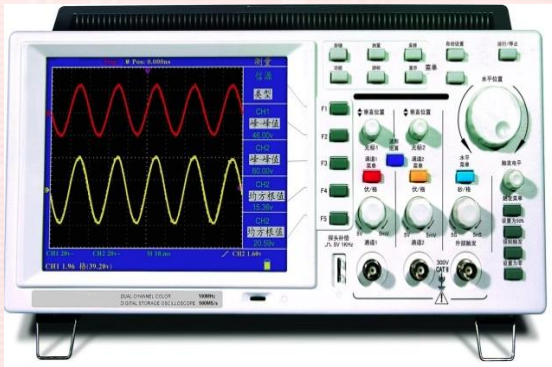
Dedicated Station Monitor

Transmitter Monitoring Devices in the Radio Shack





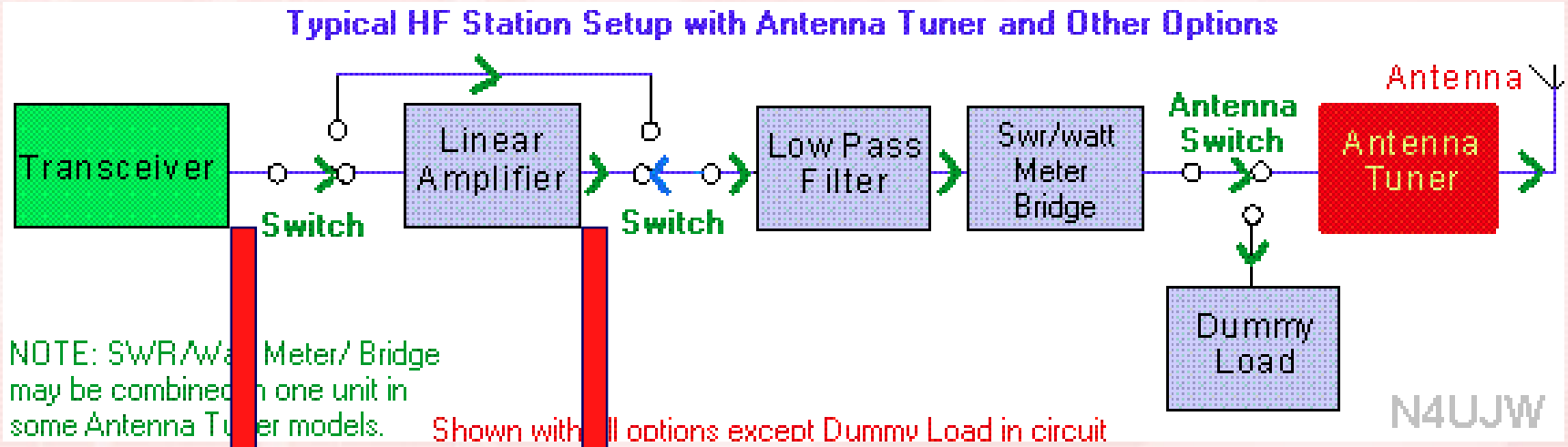
Transmitter Monitoring Devices
Is Your Power Meter Accurate ?



Oscilloscope with RF sampler

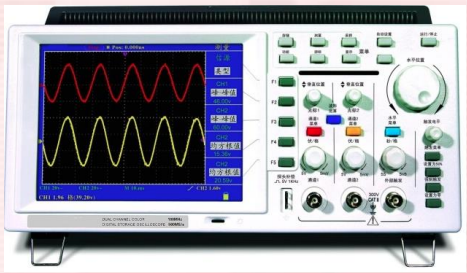
Oscilloscopes can provide an "adequate" calibration of the power setting on your radio and stand alone power meters

Transmitter Monitoring Devices
Is Your Power Meter Accurate ?



RF Sampler

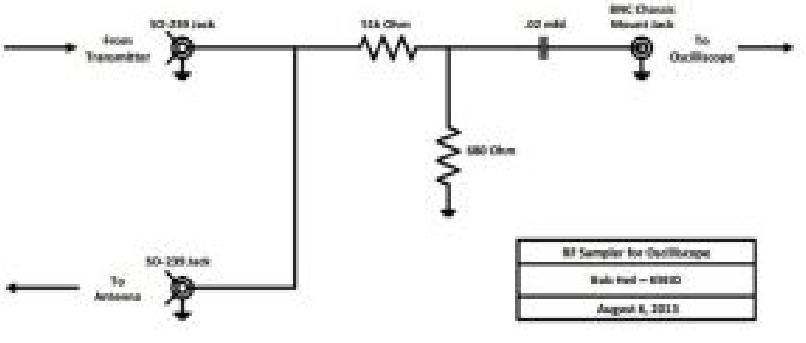
RF Sampler

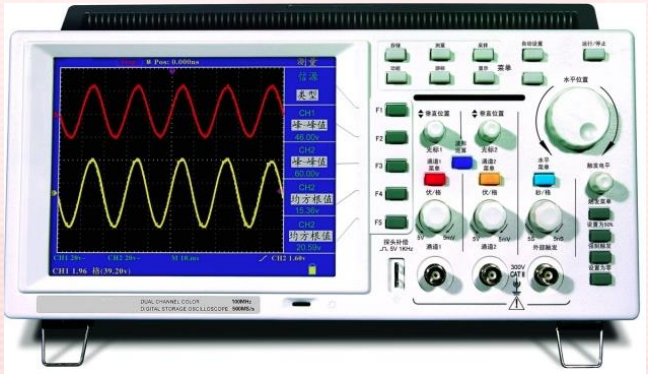


RF Sampler takes a very small percentage of the Tx power that can safely be sent to the ocilloscope

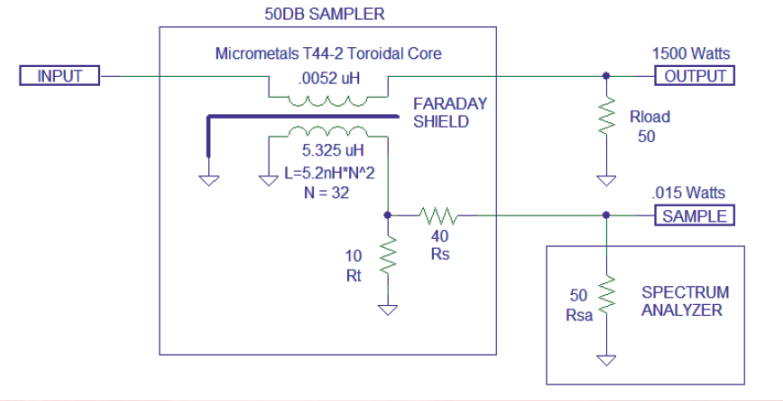
Transmitter Monitoring Devices
Is Your Power Meter Accurate ?

Resistor Divider RF Sampler





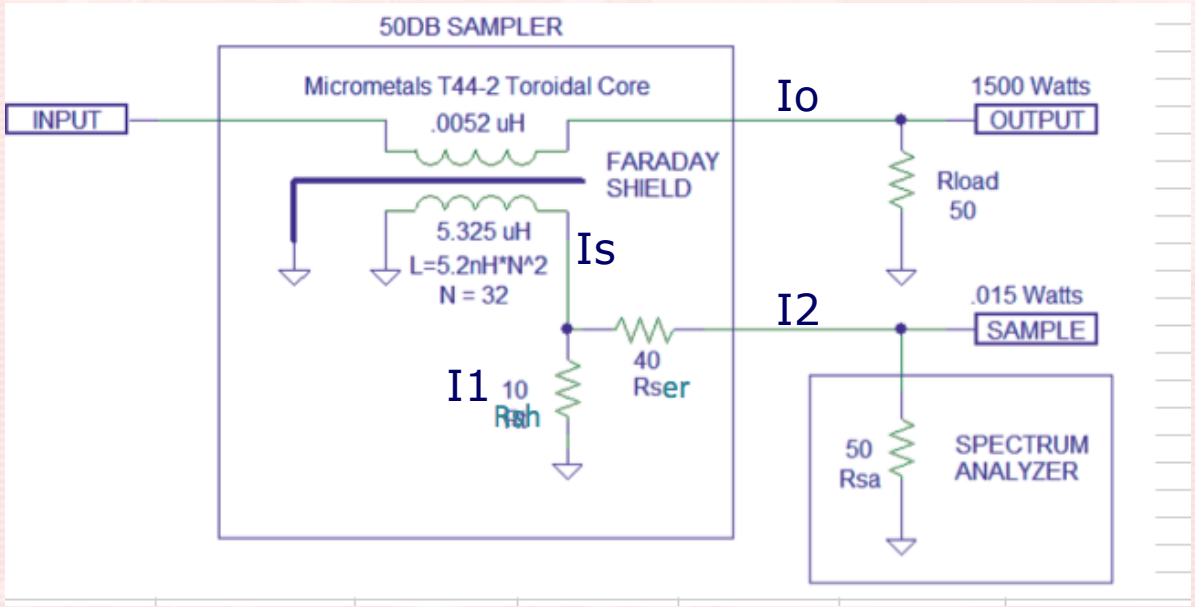
Current Transformer RF Sampler



Typical sampling power values are:

1:100 = -20 dB
1: 1000 = -30 dB
1:10,000 = -40 dB
1:100,000 = -50 dB

Design for a Current Transformer RF Sampler



Simplification: To maintain impedance balance and reduce required N for a given dB

Rsh + Rser = 50
Rload = Rsa = 50

Io = sqrt(Tx power / 50)

Is = Io/N

I1 = Is * (Rser + Rsa)/sum(Rj)

I2 = Is*Rsh/sum(Rj)

Rsh = 100 * N * sqrt (Psa/Po)

N = Rsh * sqrt (Po/Psa)/100

dB = 10 * log (Psa/Po)

Design for Current Transformer RF Sampler

TESTING RF SAMPLER CALCULATOR

POWER Max	VOLTS out	CURRENT out
1000	223.6067977	4.472135955

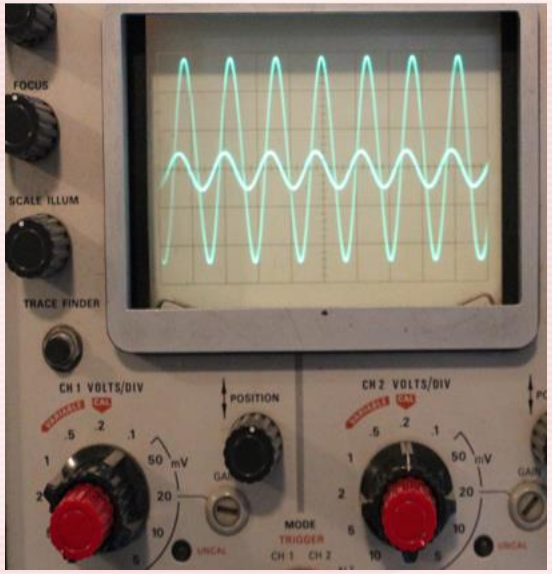
NOTE: R series = 50 - R shunt

Attentuation dB	R shunt ohms	Turns	I secondary	Shunt power	Rseries Power	Sample power	Sample volts rms	Sample volts peak to peak
-20	10	1	4.472135955	162	8	10	22.36067977	63.2360024
	20	2	2.236067977	64	6			
	30	3	1.490711985	32.66666667	4			
	40	4	1.118033989	18	2			
	50	5	0.894427191	10	0			
-30	10	3.16227766	1.414213562	16.2	0.8	1	7.071067812	19.99697977
	20	6.32455532	0.707106781	6.4	0.6			
	30	9.486832981	0.471404521	3.266666667	0.4			
	40	12.64911064	0.353553391	1.8	0.2			
	50	15.8113883	0.282842712	1	0			
-40	10	10	0.447213595	1.62	0.08	0.1	2.236067977	6.32360024
	20	20	0.223606798	0.64	0.06			
	30	30	0.149071198	0.326666667	0.04			
	40	40	0.111803399	0.18	0.02			
	50	50	0.089442719	0.1	0			
-50	10	31.6227766	0.141421356	0.162	0.008	0.01	0.707106781	1.999697977
	20	63.2455532	0.070710678	0.064	0.006			
	30	94.86832981	0.047140452	0.032666667	0.004			
	40	126.4911064	0.035355339	0.018	0.002			
	50	158.113883	0.028284271	0.01	0			

Testing the -50 dB RF Sampler

TESTING THE -50 DB RF SAMPLER CIRCUIT

7300 POWER SETTING	Power Meter CN 801 READING	DIRECT 10X PROBE P-P VOLTAGE	DIRECT RSA P - P VOLTAGE	DIRECT 10X RMS VOLTAGE	RSA RMS VOLTAGE	DIRECT POWER CALC.	RSA POWER CALC.	dB of RF Sampler
10.0	9.5	65	0.19	23.0	0.07	10.6	9.03E-05	-50.7
25.0	20	92	0.27	32.5	0.10	21.2	0.000182	-50.6
50.0	47	150	0.44	53.0	0.16	56.3	0.000484	-50.7
75.0	70	180	0.53	63.6	0.19	81.0	0.000702	-50.6
95.0	95	200	0.60	70.7	0.21	100.0	0.0009	-50.5
							AVG =	-50.6



Scope: Chn 1 = 56 v p-p
Chn 2 = 0.180 v p-p
dB = -49.8

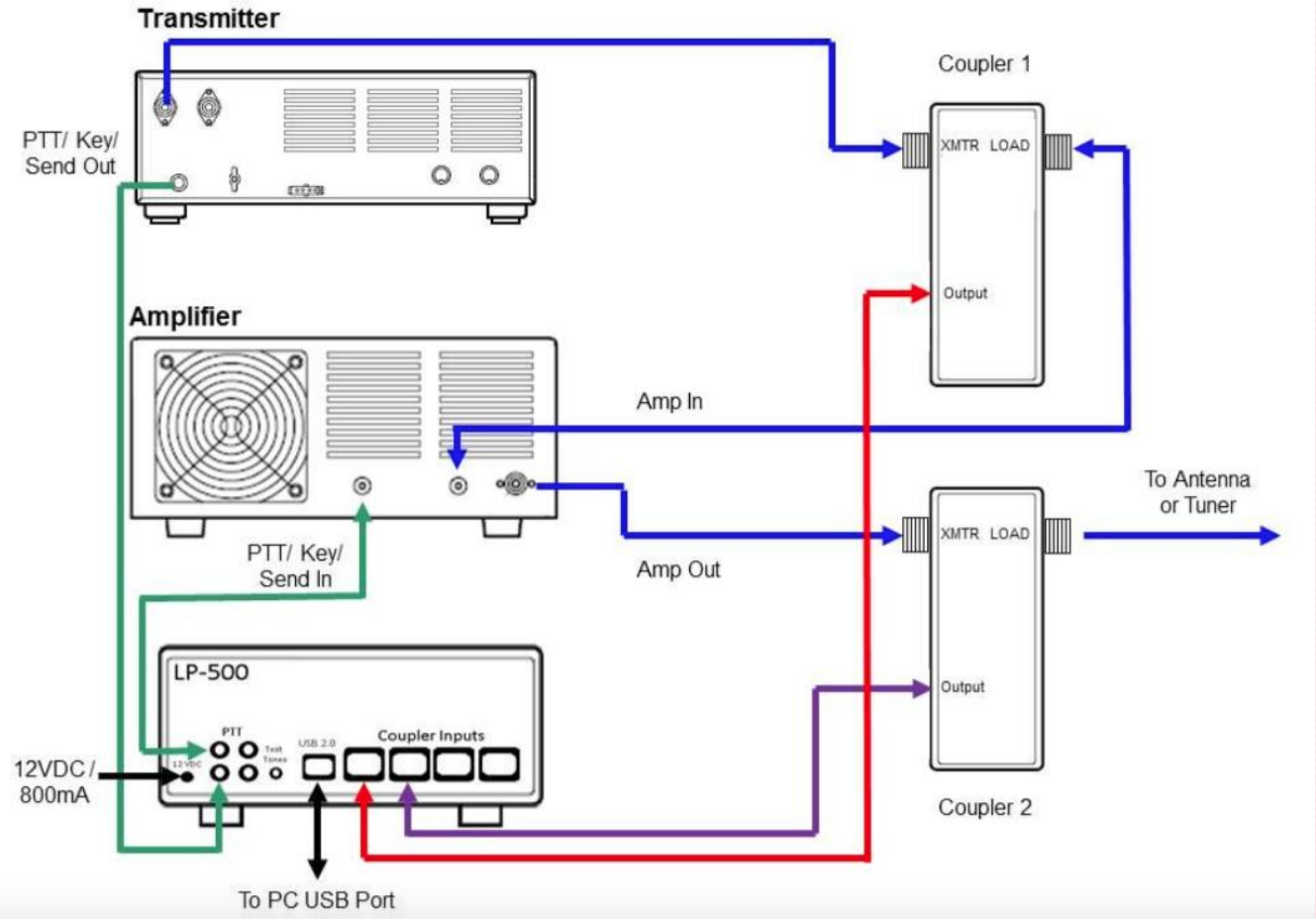
Digging Deeper with a Full Station Monitor

TelePost Inc.
49100 Pine Hill Dr., Plymouth, MI 48170 734.455.3716 email

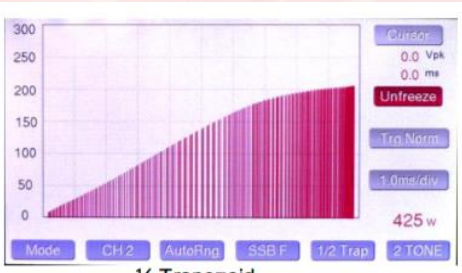
- Frequency Counter
- Power (avg, peak, PEP)
- SWR
- Waveforms (CW, SSB AM, FM, Digital)

❑ Keying envelope
❑ AM Modulation distortion
❑ SSB 2 Tone Test
❑ Trapezoid Linearity

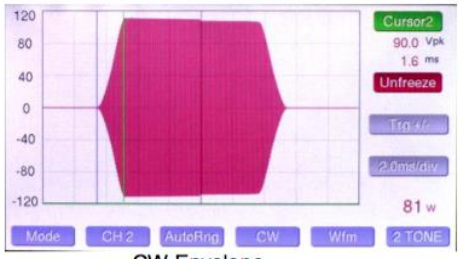
Digging Deeper with a Full Station Monitor



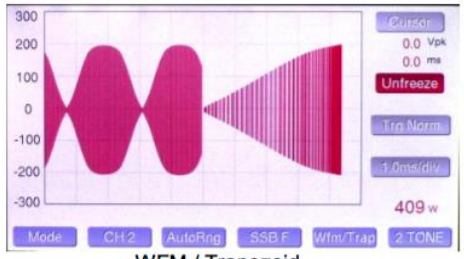
Digging Deeper with a Full Station Monitor



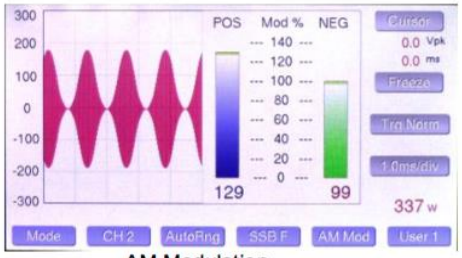
½ Trapezoid



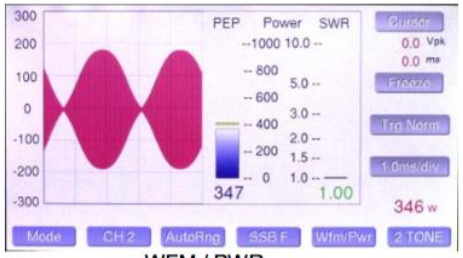
CW Envelope



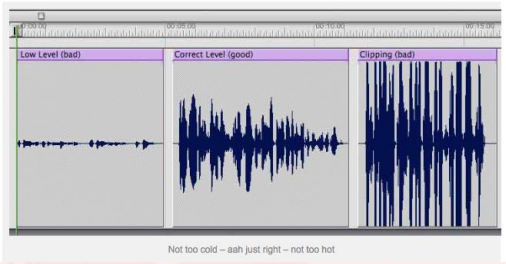
WFM / Trapezoid

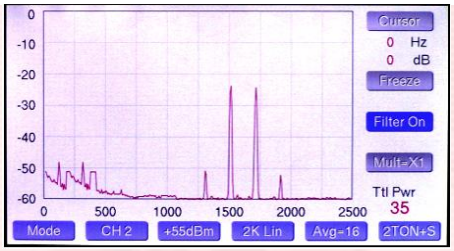


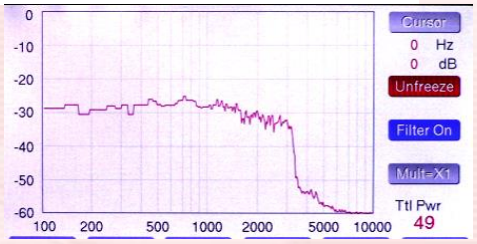
AM Modulation



WFM / PWR







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- **Oscilloscope Fundamentals Tektronix: circuitslab.case.edu/manuals/Oscilloscope_Fundamentals_-_Tektronix.pdf**
- **ARRL's book Oscilloscopes for Radio Amateurs by Paul Danzer, N1II**

2. RF Samplers

- **Measuring Transmitter Power with the Oscilloscope: http://preciserf.com/wp-content/uploads/2012/04/Appnote-4-Power-tests1.pdf**
- **Build a Quality RF Sampler by Don Jackson, W5QN:** www.collinsradio.org/wp-content/.../Build-a-Quality-RF-Power-Sampler-Jackson.pdf

3. Toroids, etc

- **Copper Wire, Toroids, and Transformers: http://cromwell-intl.com/radio/copper-wire/**
- **Micrometals Website & Catalog**

4. General topics on Scopes, RF Samplers, Toroids, and more

Any Youtube by W2aew (Alan Wolke, Tektronix Field Application Engineer)