

## Crystal Sets to Sideband

Written by Hans Summers

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A Guide to Building an Amateur Radio Station

By Frank W. Harris, KØIYE

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**NOTE:** There is a Spanish translation of this book here: <http://www.ea2ry.com/libroradio/>

***REQUIRES ADOBE ACROBAT READER.***

**Table of Contents:**

## FOREWORD

### Chapter 1

#### THE FASCINATION OF RADIO

- Exploring the shortwave bands
- Growing up in the Morse code era
- The joy of building it yourself
- A brief history of radio communication
- Henry, Maxwell, Hertz, Tesla and Marconi.
- Fessenden, Edison, Fleming, DeForest and Armstrong
- The sinking of the RMS Republic and the birth of ham radio
- Ham radio in the last 80 years
- Becoming a radio amateur

### Chapter 2

#### HOMEBUILDING AMATEUR RADIO EQUIPMENT

- What qualifies as homebuilding?

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- When homebrewing is not appropriate
- Barriers to modern homebuilding
- Time, frequency stability and lead inductance
- Basic electrical knowledge
- Magnets & static electricity
- Voltage, current, resistance, energy and power
- (Illustrated with drawings of water & mechanical analogies)
- Conductors, Insulators and semiconductors
- Capacitors, inductors, transformers & alternators
- Home power distribution, transformers at low and high frequencies

## Chapter 3

### SETTING UP AN ELECTRONICS WORKSHOP

- R&D as recreation
- How to build radios (or anything else) in your basement
- Persistence, read books, keep a notebook, & work in small increments
- Minimum tools needed
- The ARRL Amateur Radio Handbook
- Soldering irons and small tools
- Drills & thread taps
- Wood carving gouges for making PC boards
- >50 MHz Oscilloscope
- Frequency counter
- Quality multimeter
- Lab power supply
- Calculator
- Lab notebook
- Collection of electronic junk
- Parts catalogs
- Capacitance meter
- Test leads & socket boards

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- Nice-to-have tools
- RF & audio generators, spice software & spectrum analyzer

## Chapter 4

### HERTZIAN WAVES IN THE BASEMENT

- The nature of radio waves
- Mechanical and LC electrical oscillators
- Antenna and transmission line theory
- Crystal set components
- LC tuner
- PN junction diode detectors
- P-type and N-type semiconductors
- Detection of AM signals
- Homebuilding the parts for a crystal set
- The Jamestown diode
- The Caribou headphone
- Revisiting Crystal Sets in 2006
- Learning to troubleshoot
- Selective tuning
- Recreating Hertz's radio equipment
- Transmitting and receiving as simply as possible
- The 1880 ten-meter communicator
- Proving that radio waves exist and aren't just capacitive or magnetic coupling
- Demonstrating standing waves to measure frequency
- Building homebrew transistors
- Bipolar transistors, PNP and NPN
- Demonstrating voltage gain
- The Boulder Rock Radio

### Chapter 5

#### GETTING ON THE AIR - DECIDING WHAT TO DO FIRST

- How to earn a license
- The rules of the homebuilding game Whatever makes you happy!
- Picking an HF band
- Getting acquainted with the HF ham bands, 160 10 meters
- Instant high quality HF communications
- VHF/ UHF handheld transceivers
- Building an antenna
- Dipoles, regular and folded
- Multi-band dipoles
- 80 meters when you dont have room for a dipole
- The curtain rod vertical
- A multi-band vertical antenna
- Lightning protection

### Chapter 6

#### BUILDING A QRP HOMEBREW

- A single-band, crystal-controlled, QRP module
- The transmitter mainframe
- HF construction methods
- Making your own PC boards
- "Dead Bug" and "Gouged Board" construction
- Superglue "Island Boards"

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- Coax jumpers
- Shielded boxes
- The complete QRP crystal-controlled transmitter
- Transistor amplifiers and oscillators
- How an amplifier becomes an oscillator
- Class A and Class C amplifiers
- Stabilizing the operating point, bypass caps and emitter resistors
- Quartz crystals the key to frequency stability
- The 40 meter QRP circuit
- Oscillator and buffer
- Inductors, RF transformers and impedance matching
- Tapped toroid inductors
- How to wind them (and mistakes you might make)
- The final amplifier stages for the QRP
- Tuned versus broadband - Use both for best results
- Bifilar wound, broadband transformers
- How to wind them (and how you might screw up)
- Ferrite bead RF chokes, expensive RF power transistors, heat sinks & output connectors
  
- Conquering inductors
- Calculating resonance
- Calibrating trimmer capacitors
- Calculating turns on powdered iron and ferrite toroids
- Chebyshev output low pass filters
- Keying your QRP
- MOSFET power transistors
- A "spot switch" for the QRP

## [Chapter 7](#)

### [BUILDING A CODE PRACTICE RECEIVER](#)

- A simple, direct-conversion receiver

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- A great first project for a new ham
- Excellent sensitivity and good stability
- Poor selectivity
- Adding 700 Hz audio filtering
- High pass and low pass filters
- Cascaded bandpass filters increase selectivity
- Operational amplifiers
- Building with integrated circuits
- AM broadcast filter
- Getting rid of the image

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## Chapter 8

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## POWER SUPPLIES

- Line powered power supplies
- Power supply safety features
- Isolation, 3-conductor cords, fuses, switches, ratings
- Supply performance and regulation
- Rectification, ripple, chokes, capacitors, & bleeders
- Zeners, linear regulators, switching regulators
- A QRP regulated power supply
- A battery power supply for the radio shack
- Solar cell charging, low drop-out regulators
- Battery powered shack lighting

### Chapter 9

#### ACCESSORIES FOR THE TRANSMITTER

- A straight key
- An electronic bug
- Building dummy loads
- "T" type antenna coupler
- A low pass filter
- How to stay legal with a homebrew transmitter
- Antenna and power relays
- Homebrew QSL cards

### Chapter 10

#### VARIABLE FREQUENCY OSCILLATORS

- Drift is a big deal today
- Low frequency VFOs drift less than high frequency VFOs
- JFET transistors
- The oscillator circuit
- The buffer, final amplifier and output filter
- The 50 secrets of avoiding drift
- JFETs, single-side PC boards, cast metal box, multiple NPO caps, small variable caps, precision voltage regulation and more
- Vernier tuning
- Varactor tuning elements advantages and disadvantages
- A precision power supply



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- A voltage doubler power supply for battery use
- Square wave generator with a multivibrator
- Squaring up the square wave
- Charge pump, diode/ capacitor voltage doubler
- Schottky diodes for efficiency
- Temperature compensation methods
- Positive coefficient capacitive trimmer compensation
- How to adjust the compensator
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## Chapter 11

### Building a VFO for the higher bands (PMOs)

- Old approaches that no longer work
- Frequency multiplication
- High frequency oscillators
- PreMix Oscillator method of frequency translation
- A VFO-controlled QRP module
- Crystal oscillators are stable, aren't they?
- Crystal oscillator circuits
- Butler oscillators and big crystals
- Mixers, bipolar transistor and dual-gate MOSFET
- Optimum drive requirements
- Direction of tuning, drift error cancellation
- Multistage filters and filter/amplifiers
- The QRP final amplifier stages

### Chapter 12

#### FINAL AMPLIFIERS

- The basic features of a modern linear power amplifier
- It looked easier in the Handbook
- Linear "noise mode" operation
- A tuned 50 watt class B amplifier
- Ferrite balun transformers
- An untuned, sort-of-linear, class B, amplifier
- Keying the 50 watt transmitter
- A linear Class AB amplifier, this time for sure
- Single Sideband (SSB) needs a linear
- Biasing without thermal runaway
- Clamp diodes prevent runaway
- Mechanical construction

### Chapter 13

#### BUILDING A HOMEBREW HF RECEIVER

- Building a receiver - an unusual adventure
- Whats a reasonable goal?
- An "adequate performance" HF communication receiver
- Does it have to be so complicated?
- Planning your receiver

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- Direct conversion versus superhetrodyne
- Why not single conversion?
- Start with a single-band, single-conversion superhetrodyne
- How do modern digital receivers do it?
- Receiver construction build with shielded modules connected by thin coax.
- The 80 meter preselector
- Reception on 80 meter and 160 meters is aided by a tuned transmatch
- The Variable Frequency Oscillator
- Mixer magic
- Mixers will give you lots of static and howls and squeals
- A practical homebrew mixer made from discrete parts its harder than it looks
- Dual gate MOSFET mixers
- Not all MOSFETS work equally well
- Crystal ladder filters essential for CW
- All 9.000 MHz crystals arent equal
- Using the BFO oscillator to match crystals
- Switch in filters with a rotary switch
- The IF amplifier
- Lessons learned from a dual-gate IF amplifier
- The cascode amplifier strip - variable gain with constant Q
- Automatic Gain Control (AGC) - not a luxury
- The product detector
- Nearly anything works at least a little
- The AF amplifier a vital part of the signal dynamic range
- Protecting your ears from strong signals
- How Hi-Fi should it be?
- Driving a speaker
- HF converters for the other ham bands
- Crystal oscillators
- Bandswitching
- Receiver power supplies
- Use a linear regulator, not a switching regulator

## [Chapter 14](#)

## [OLD-TECH VACUUM TUBE RADIO](#)

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- How old can radio technology be and still be used on the air today?
- Why bother with vacuum tubes?
- Glowing filaments, colored plasmas & Jules Verne glass envelopes
- Power supplies for tubes
- High voltage power supply safety
- The old-tech QRP transmitter
- Vacuum tube amplifiers
- The three roles of the triode filament
- RF sinewave oscillator
- Quartz crystals
- Triode and pentode oscillators
- Old-tech voltage regulation big, crude, expensive, but beautiful
- The travails of triode tubes
- The oscillator and buffer
- The final amplifier triodes chirp
- The transmitter power supply
- An inadequate supply from a 1935 radio
- A good power supply made from cheap, modern, boring parts
- How to check out junk power transformers
- A complex but adequate supply made from ancient parts
- It works! No one suspects its old and its a success on todays 40 meter band
- An old-tech receiver
- A super regenerative receiver made from ancient tubes
- The power supply
- Super-regen on the modern hambands
- Lots of fun, but not up to modern QRM & QRPs - back to the drawing board!

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### [Chapter 15](#)

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### [THE NOBEL PRIZE FOR SIDEBAND](#)

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- It cant be that hard! Want to bet?
- The sideband generator how it works
- The 9 MHz oscillator / amplifier
- The audio amplifier
- The balanced modulator
- Building your own crystal ladder filter
- Decoupling the power supply leads
- Getting rid of RF feedback - RF filtering for all inputs
- Tuning and testing
- Using the generator for AM modulation and CW
- Moving the 9 MHz SSB signal to a hamband
- Move the SSB only once!
- No wonder most ham rigs are transceivers
- Moving the 9 MHz signal to the difficult HF hambands
- Move the VFO first, then mix it with the SSB 9 MHz.
- Pick your oscillator and VFO frequencies carefully
- Hearing your own VFO in the receiver
- The hardest band 17 meters
- Covering the widest band 10 meters
- A linear sideband QRP, VFO-tuned module
- All stages must be linear and low distortion
- All gain stages should be broadband to prevent oscillation
- Sometimes high pass filter output is needed & not the usual low pass
- Checking out the generator
- Driving a 50 watt linear amplifier

## Chapter 16

### ANCIENT MODULATION

- Defining amplitude modulation
- Modulating vacuum tube final amplifiers

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- Plate, screen & cathode modulation
- A "collector modulator"
- Converting a MOSFET keyer into a modulator
- Generating AM with an SSB balanced modulator
- Compensating for non-linearity
- Compression by accident
- You probably don't need to build a compressor
- Ham TV - The old way
- Fun with an ancient flying spot scanner TV camera

*In conclusion:*

*Homebrew ham radio is never complete - when it works perfectly and does all the latest stuff, the hobby is over. Not likely. Long live homebuilding!*

*Thanks for reading my book.*

*73's Frank W. Harris, KØIYE*