



Software Defined Radio

Joe Reynick

▼ KC3DKU

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What is Software Defined Radio?

- ▼ Software Defined Radio (SDR) is a radio whose functions are implemented in software or firmware on a personal computer or embedded system within the radio
- ▼ Superior performance: compared to similarly priced “traditional” dual or triple conversion superheterodyne transceivers
 - ▼ Compared to similarly priced non-SDR receivers/transceivers
 - ▼ Typically $>15\text{dbm}$ noise floor and significant phase noise improvements

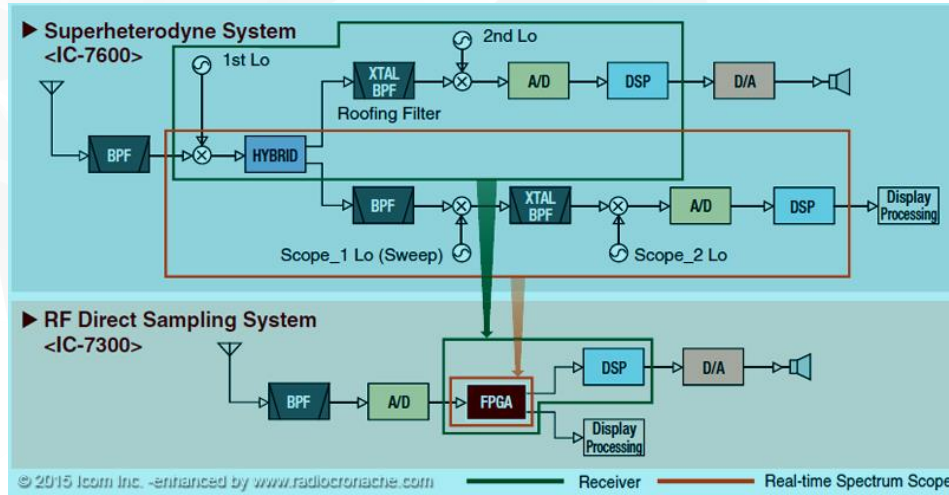
Advantages of Software Defined Radio

- ▼ Software Defined Radio (SDR) is a game changer for Ham radio
 - ▼ **Bold statement:** Similar to the impact from the transition from tubes to solid state
- ▼ Lower cost: due to simpler design and fewer parts
 - ▼ Allows additional features like touch screen waterfall displays at the same price
- ▼ USA and Europe have led the SDR charge until now
 - ▼ Flex, Elad, SunSDR, RFSpace, Winadio, RaspberryPI
- ▼ Japanese manufacturers are jumping in now
 - ▼ ICOM
 - ▼ Others - TBD

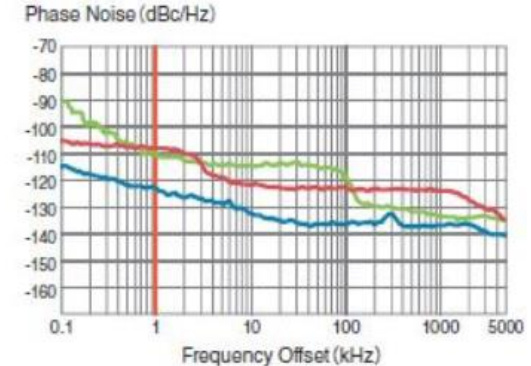
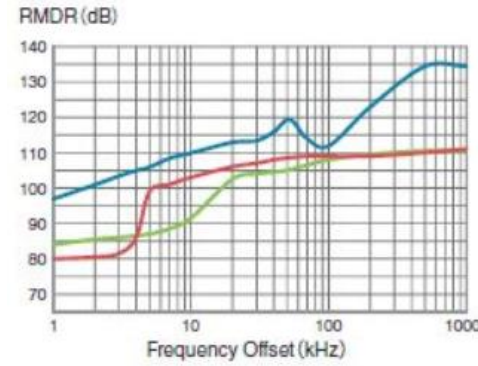
Some Definitions to Get Started...

- Analog to Digital Converter (ADC or A/D): converts analog signal to digital data (0/1)
- Aliasing: Distortion caused by improper digital sampling
- Band Pass Filter (BPF): Filter that is used to minimize aliasing distortion before or after sampling by filtering out-of-band of frequencies
- Digital to Analog Converter (DAC or D/A): converts digital data to analog signal (RF)
- Digital Signal Processor (DSP): specialized processor that is good for custom/software defined filtering like notch filters, impulse, or random noise filtering
- Field Programmable Gate Array (FPGA): Heart of the SDR hardware. This is a programmable IC that contains logic gates, memory, and specialized functions like A/D, D/A microprocessor, and DSP circuits.
- Quadrature Data (IQ): Directly-sampled RF is converted to digital IQ data and applied to software that defines the operation of the radio. Samples are at 90
- Sampling: digital measurements of an analog signal. The sample rate is at least 2X the analog frequency

Dual Conversion vs SDR Receiver Design



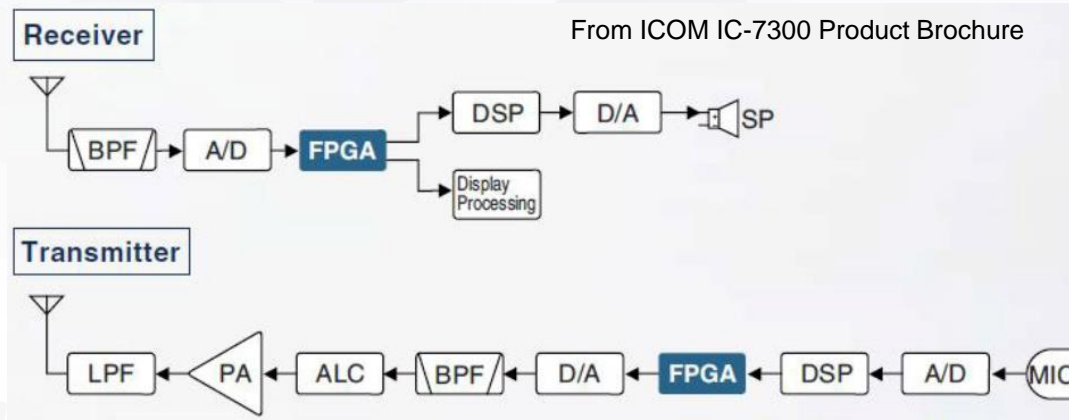
From ICOM IC-7300 Product Brochure



— IC-7300 — IC-7200 — IC-7100

- ICOM IC-7600 (Superhet) vs IC-7300 (SDR)
 - Each IF stage introduces Phase Noise (jitter) and reduces RMDR (overload sensitivity)
 - IF Stages are replaced with FPGA/DSP
- Example of RMDR and Phase noise reduction
 - Fun exercise – compare to IC-7850 – only slightly better than the IC-7300

Anatomy of SDR Hardware



Receiver (left to right):

- BPF limits bandpass to A/D which does direct sampling of the RF
- FPGA processes the binary data and DSP provides various filter/noise reduction functions
- D/A provides clean audio to the speaker/headphones

Transmitter (Right to Left):

- Mic or CW is sampled by A/D, and noise is cleaned-up by DSP
- FPGA further processes data, and D/A converts to analog RF
- BPF limits spurious emissions, and ALC keeps the power amplifier in the linear/legal range

FPGA Overview

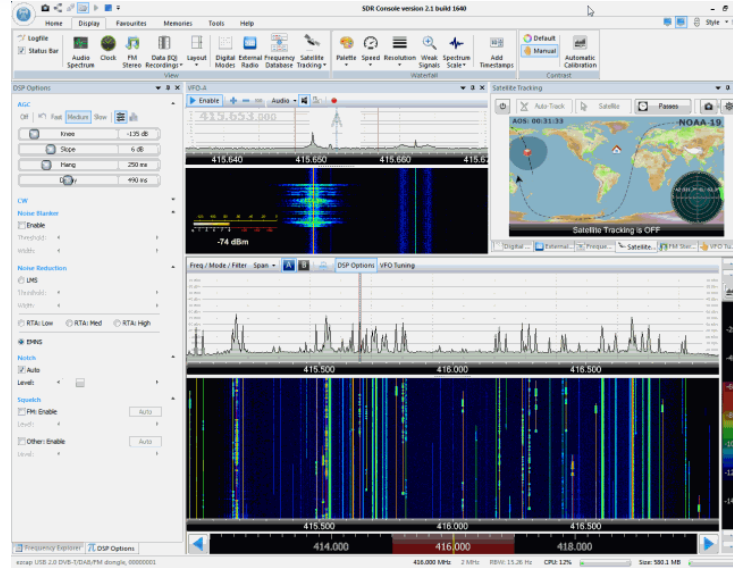
- ▼ Example FPGA used in the Flex 6500: Xilinx Virtex-6 LXT
 - ▼ DSP filtering/processing
 - ▼ High speed PCI Express serial interface
 - ▼ Clock managers
 - ▼ 20,000 programmable logic blocks
 - ▼ 1.7MB memory
 - ▼ 4 Ethernet interfaces (MACs)
 - ▼ 240 Msps (mega samples per second) sampling rate
 - ▼ 600 IO's
- ▼ *FPGA's are not a fixed design – they can be reprogrammed to accommodate new SDR features or bug fixes*

The Range of SDR Hardware Products

- ▼ El-cheapo SDR dongles that are good for experimentation and learning fun!
 - ▼ Example: RTL-SDR dongle
 - ▼ Example: SoftRock SDR
 - ▼ Example: Raspberry PI running Raspbian Linux with RTL-SDR dongle!
- ▼ Black-box SDR's that require an external PC with SDR software to operate
 - ▼ Example: Flex 6500
 - ▼ Example: Elad FDM-DUO
- ▼ SDR's with Knobs and Displays that look like traditional radios and can be run with or without an external SDR software.
 - ▼ Example: ICOM IC-7300
 - ▼ Example: SunSDR MB-1



Images from rtl-sdr.com

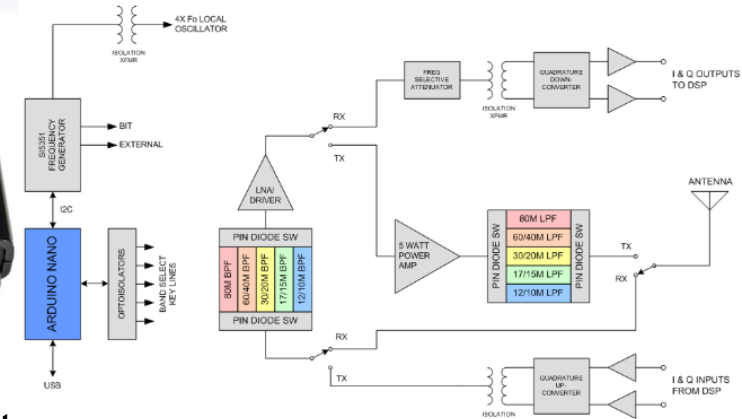


- This is a Software Defined *Receiver*
- Can be found on Amazon with Antenna for around \$25!
- Uses IQ access to various software
- Extra (cheap) filters are sold to prevent FM/AM BCB interference
- Shown with free SDR Radio V2 software. There are other free software solutions like OpenSDR that also use IQ access to the dongle

New! HobbyPCB RS-HFIQ QRP SDR Transceiver – Thanks Chuck!



Images from hobbypcb.com and amazon.com

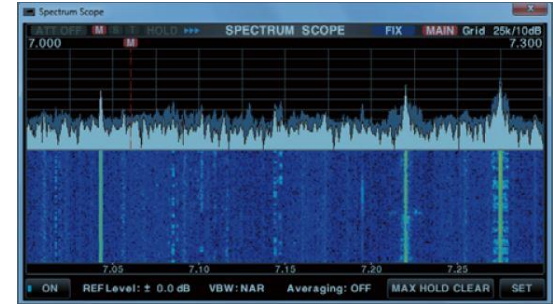
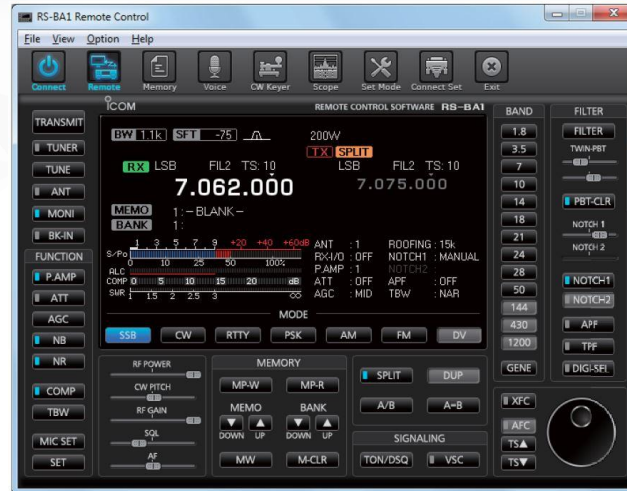


- This is a front-end to a software designed radio system
 - Low cost transceiver – Current price is \$235
 - Innovative crowd-sourced project funding to cover R&D costs!
 - No expensive FPGA - Requires a PC and soundcard to complete the system
 - Uses IQ for interfacing to various (free) SDR software
 - HobbyPCB recommends the Startech ICUSBAUDIO2D external USB soundcard
 - Soundcard works with Linux and Windows
 - Fun project for a low cost SDR around \$300:
 - RS-HFIQ + Startech Soundcard + Raspberry PI 3 (Linux) PC + OpenSDR software

ICOM IC-7300 and RS-BA1 Software



Images from icom.com

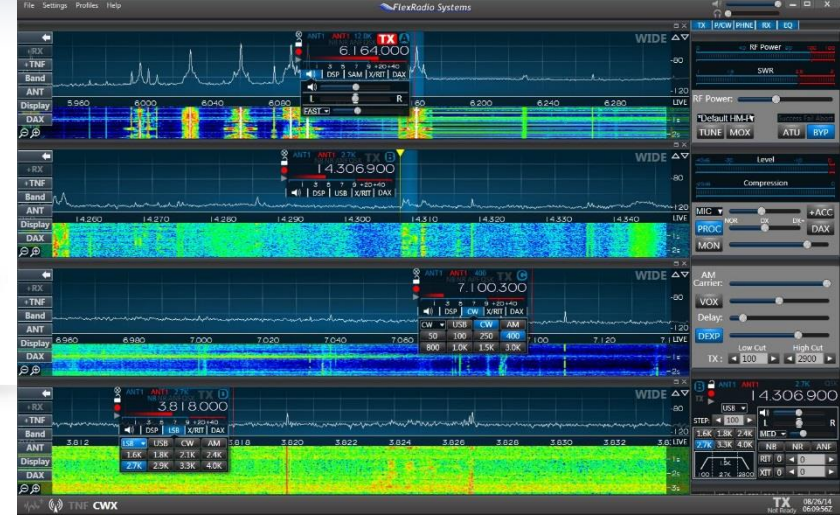


- Replaced IC-7200 in the ICOM line-up (second from the bottom of the line)
- Amazing receive performance for it's price point – pretty close to the IC-7851
- Small size, may work well for some mobile applications
- Ethernet interface with CI-V commands – good for remote operation
- No IQ interface capability, so locked-in to ICOM RS-BA1 software
- Nothing similar from Yaesu or ICOM that I am aware of so far

Flex 6500 and SmartSDR Software



Images from flexradio.com

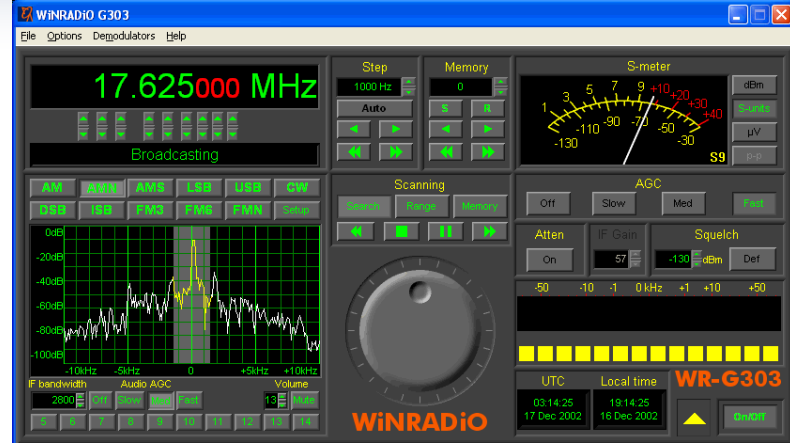


- Flex Signature series is the high end of the SDR market
- Noted for exceptional performance in all categories, including AM Ham use
- The 6500 SDR box has 4 Receivers that can run simultaneously
 - 4 independent IQ channels
- Maestro control unit for those knob-turners who like running without a PC/mouse
- SmartSDR software shown running waterfall on the 4 independent receivers
 - Actually 4 spectrum slices

Show & Tell – WinRadio WR-G303i



Images from winradio.com



- Early consumer SDR – released in 2006 – no longer supported since XP went away
- Software Defined *Receiver* – last IF and user interface are PC based.
- ISA internal PC interface – an external USB version was made as well.
- SoundBlaster Sound card interface
- Dual conversion super heterodyne design
- Included options for DRM, AM Synchronous detection, and improved sensitivity

Recommendations

- ▼ Beware of OS/Company obsolescence
 - ▼ Windows Support
 - ▼ Recommendation: IQ SDR \leftrightarrow PC Interface with USB, PCIe, or Ethernet
 - ▼ Recommendation: Consider Linux
 - ▼ Strong SDR user community
 - ▼ Open Source (OpenSDR/GNURadio)
 - ▼ Drivers (share object libraries) for your SDR
 - ▼ Inherently secure – an OS that was actually thought-out
 - ▼ Can bring that old Win2k PC back to life!
- ▼ Recommendation: Second receiver is useful – maybe even RTL-SDR
 - ▼ if only for displaying waterfall and finding contacts
- ▼ Recommendation: Make your next transceiver an SDR!

Future Products and Predictions

- ▼ ICOM will be releasing the ICOM IC-7610 to the US Market in July timeframe
 - ▼ Replacement in ICOM lineup for the current IC-7600
 - ▼ Initial MSRP is \$3100 – less than IC-7610
 - ▼ Targeting contesters – twin IC-7300 tuners, DVI video outputs
- ▼ Flex-radio will continue to be the high end of the performance/price market
 - ▼ Perhaps pressure from Japan will bring down costs
- ▼ The rest are catching up....
 - ▼ Elecraft?
 - ▼ Yaesu??
 - ▼ Kenwood?

Links to SDR Hardware/software Products

- ▼ RTL-SDR dongle/antenna/filters and overview of free software
 - ▼ <https://www.amazon.com/RTL-SDR-Blog-RTL2832U-Software-Telescopic/dp/B011HVUEME>
 - ▼ <http://www.rtl-sdr.com/big-list-rtl-sdr-supported-software/>
- ▼ HobbyPCB RS-HFIQ
 - ▼ <https://www.hobbypcb.com/rs-hfiq>
 - ▼ <https://www.amazon.com/StarTech-com-ICUSBAUDIO2D-Adapter-External-Digital/dp/B00F7120TQ>
 - ▼ <https://www.amazon.com/CanaKit-Raspberry-Clear-Power-Supply/dp/B01C6EQNNK>
- ▼ ICOM IC-7300, IC-7610 Transceivers and RS-BA1 Software.
 - ▼ <http://www.icomamerica.com/en/products/amateur/hf/7300/default.aspx>
 - ▼ <http://www.ab4oj.com/icom/ic7610/main.html>
 - ▼ <http://www.icomamerica.com/en/products/amateur/hf/rsba1/default.aspx> Flex-6500 Tranceiver, Maestro
- ▼ Hardware Interface, and SmartSDR software:
 - ▼ <http://www.flexradio.com/amateur-products/flex-6000-signature-series/flex-6500/>
 - ▼ <http://www.flexradio.com/amateur-products/flex-6000-signature-series/maestro/>
 - ▼ <http://www.flexradio.com/amateur-products/flex-6000-signature-series/smartsdr/>
- ▼ FPGA:
 - ▼ https://www.xilinx.com/support/documentation/data_sheets/ds150.pdf
 - ▼ https://en.wikipedia.org/wiki/Field-programmable_gate_array



Thank you and 73...

... for the excellent questions from those who managed to stay awake!