# Introduction to Software Defined Radios

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Digital Communications Conference

# Agenda

- Why Software Defined Radios?
- What is a Software Defined Radio?
- Block Diagrams
- Technical Challenges
- Amateur Contributions
- How to Build A SDR
  - The DSP-10 As a SDR
- Supporting Documentation
- Conclusion

# Why Software Defined Radios?

- Comments of ARRL:

"ARRL is most interested in this proceeding, not only because of the utility of the Amateur Radio Service as a testing ground for different configurations of SDRs, but also because of the potential long-term opportunities for SDRs to effect substantial changes, even conceptual changes, in traditional frequency assignment and spectrum allocations decision making in all services."

ARRL comments to the Notice of Inquiry Regarding Software Defined Radios dated June 14, 2000 (ET Docket No. 00-47 released March 21, 2000).

http://www.fcc.gov/searchtools.html

# Why Software Defined Radios?

- Dale Hatfield, WØIFO,

  Chief, Office of Engineering and Technology,
  Federal Communications Commission

  "This could stimulate a whole new generation of amateur innovation that not only includes the more spectrally efficient systems I mentioned earlier, but also radios that could adapt to their environment as well."

  Speech to AMRAD's 25th Anniversary Dinner June 17, 2000
  http://www.fcc.gov/Speeches/misc/dnh061700.html

# What Is a Software Defined Radio?

## Software Defined Radio (SDR)

Performs the majority of signal processing in the digital domain using programmable DSPs and hardware support, but some signal processing is still done in the analog domain, such as in the RF and IF circuits.

# What Is a Software Defined Radio?

## Software Radio (SW)

The ultimate device, where the antenna is connected directly to an A-D/D-A converter and all signal processing is done digitally using fully programmable high speed DSPs. All functions, modes, applications, etc. can be reconfigured by software.

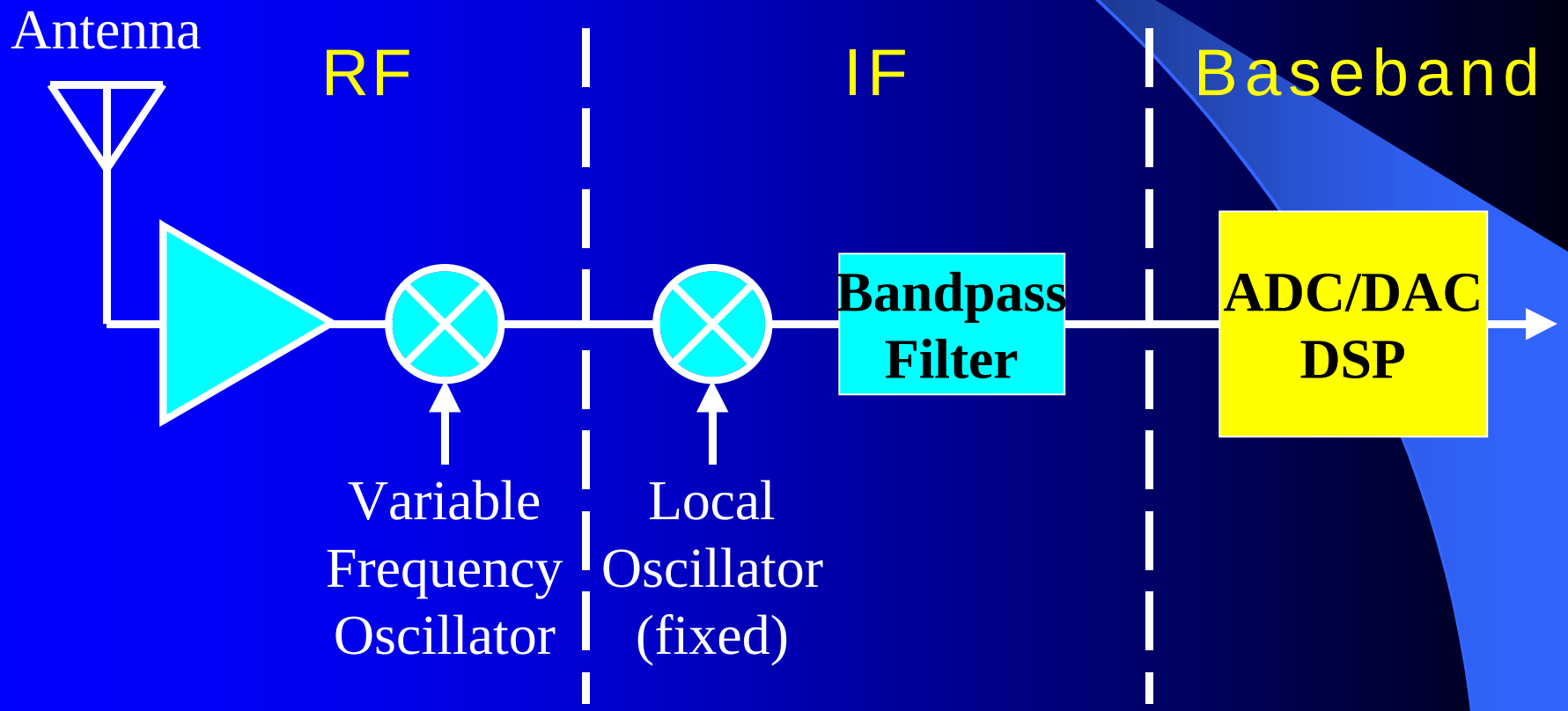
# Benefits of SDR

- Flexible
- Reduced Obsolescence
- Enhances Experimentation
- Brings Analog and Digital World Together

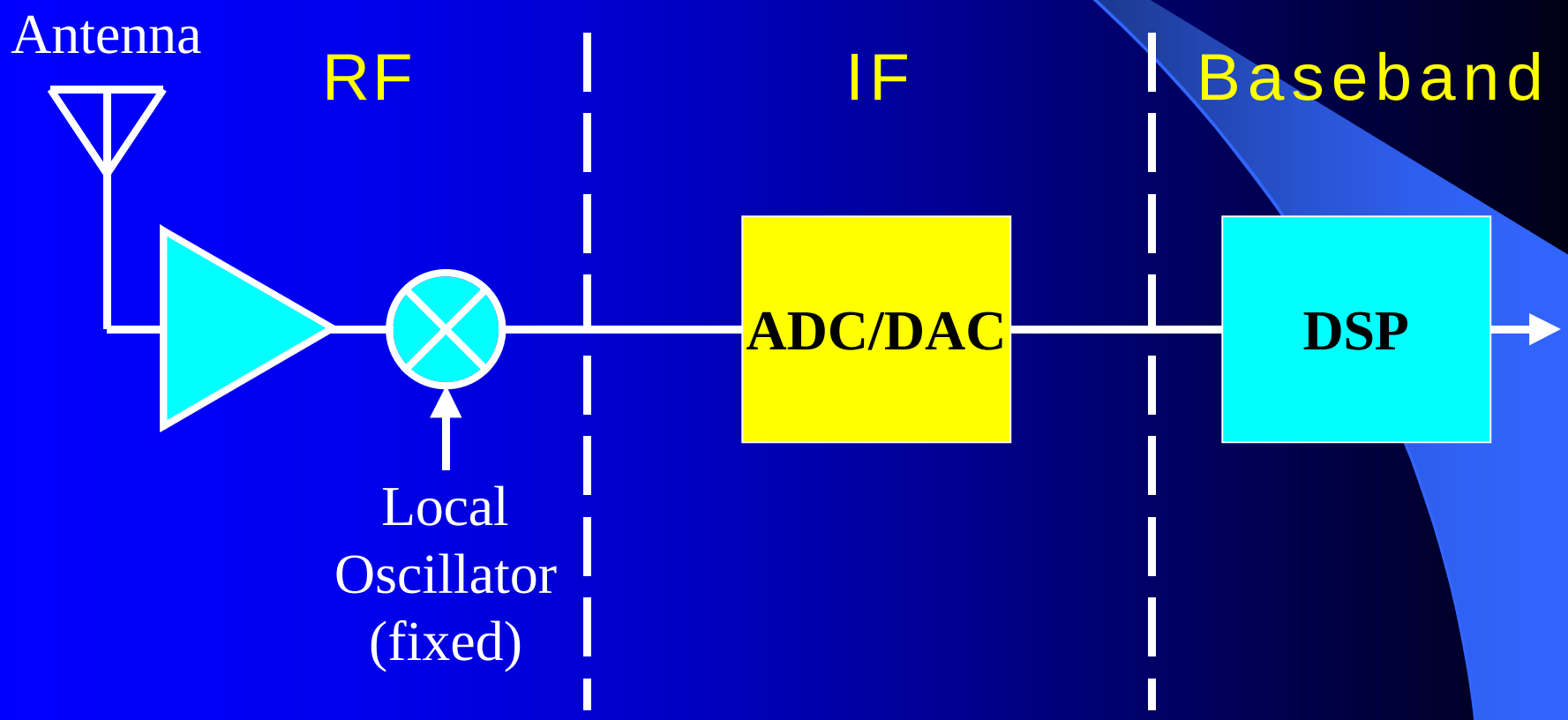
# New Breed of Radio

- Reprogrammable
- Multiband/Multimode
- Networkable
- Simultaneous voice, data, and video
- Full convergence of digital networks and radio science.

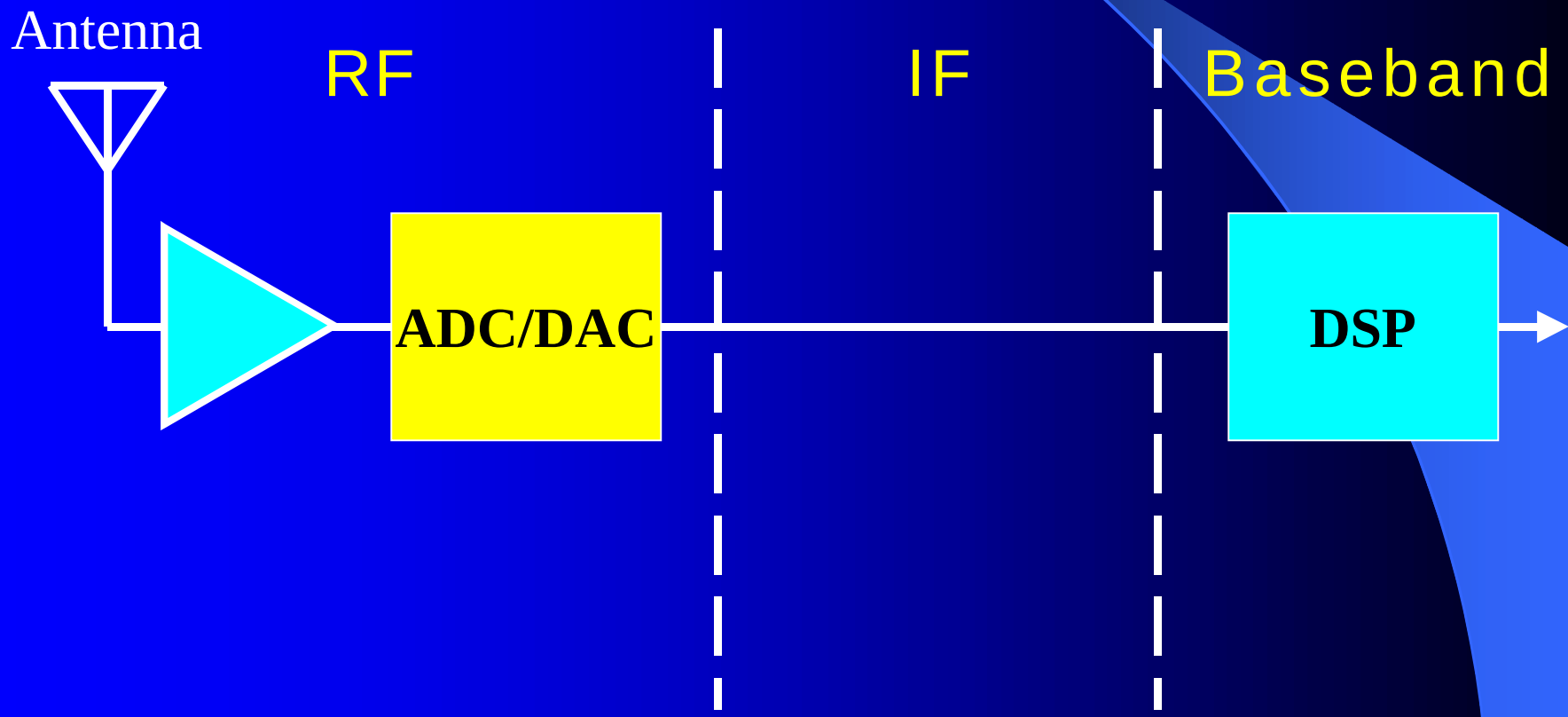
# Block Diagram
# Software Defined Radio



# Block Diagram
# Software Defined Radio



# Block Diagram
# Software Radio



# Smart Radios

The positive control over the transmitter's use of the spectrum has traditionally been the purview of the radio operators, who were guided and trained to follow the rules of engagement carefully crafted during the course of decades to prevent harmful interference to other users.

The control of radio functions by software algorithms embedded into the future "smart" communications device will directly affect the manner in which that device uses the spectrum.

# Smart Radio

- When combined with the software radio's ability to monitor the RF environment and precisely sense its location, the software radio opens the possibility of sharing spectrum among vastly different users.

# What Is a Software Defined Radio?

## Cognitive Radio

As radios embed increasingly complex and realistic models of their environments, users, and networks, they begin to approach what an outside observer might call rational, or common-sense behavior.

# Technical Challenges

- Dynamic Radio
- ADC/DAC Speed
- Smart Radio Algorithms

# Amateur Contributions

# How to Build a SDR

- DSP-10 by Bob Larkin, W7PUA

  *QST - Sep, Oct, Nov 1999*

  http://www.proaxis.com/~boblark/dsp10.htm

  http://www.arrl.org/tis/info/vhfproj.html

- R2-DSP by Rob Frohne, KL7NA

  *QST - Apr 1998*

  http://www.wwc.edu/~frohro/R2_DSP/R2-DSP.html

- A Panoramic Transceiving System for PSK31 by Skip Teller, KH6TY and Dave Benson, NN1G

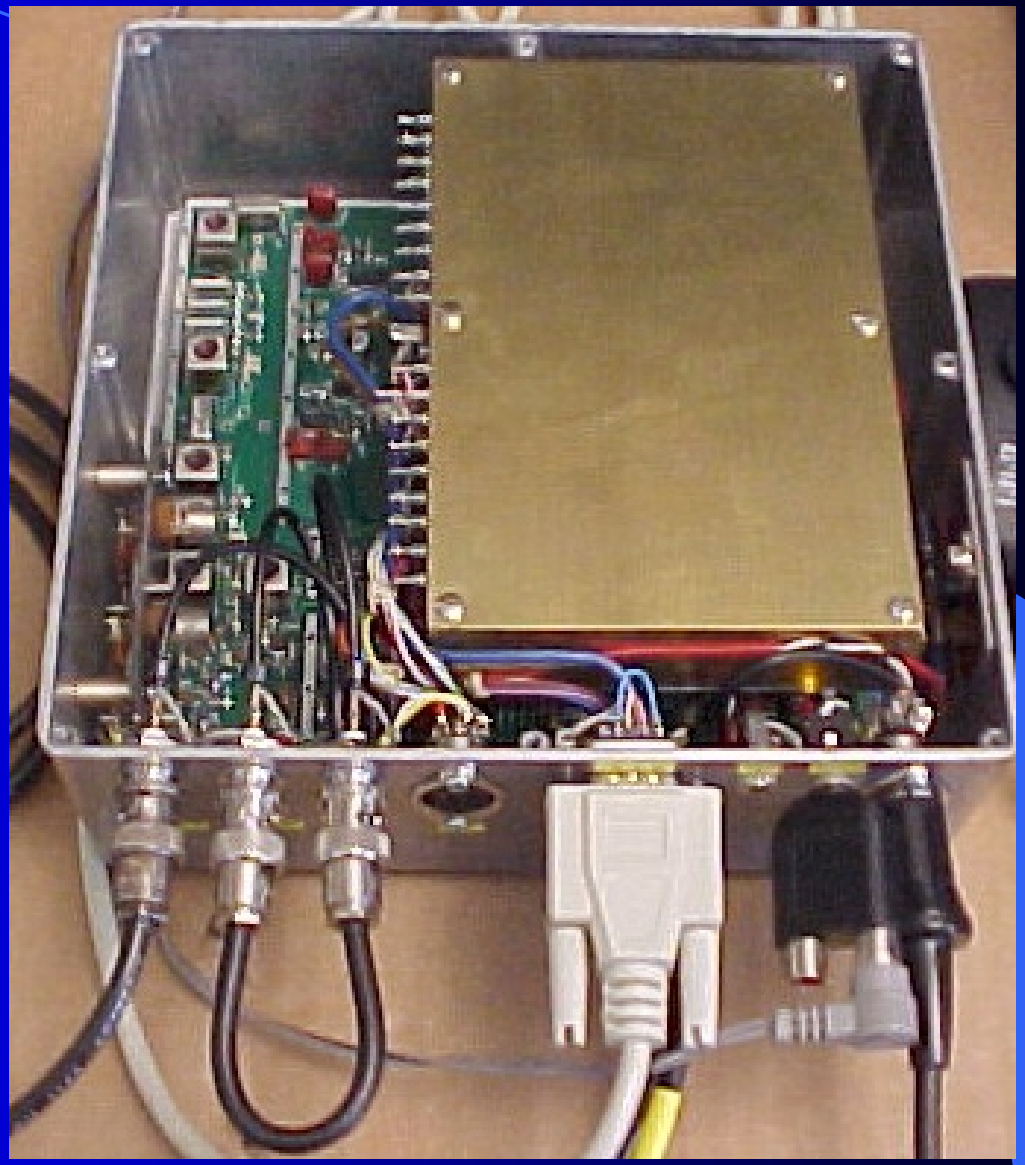
  *QST - Jun 2000*

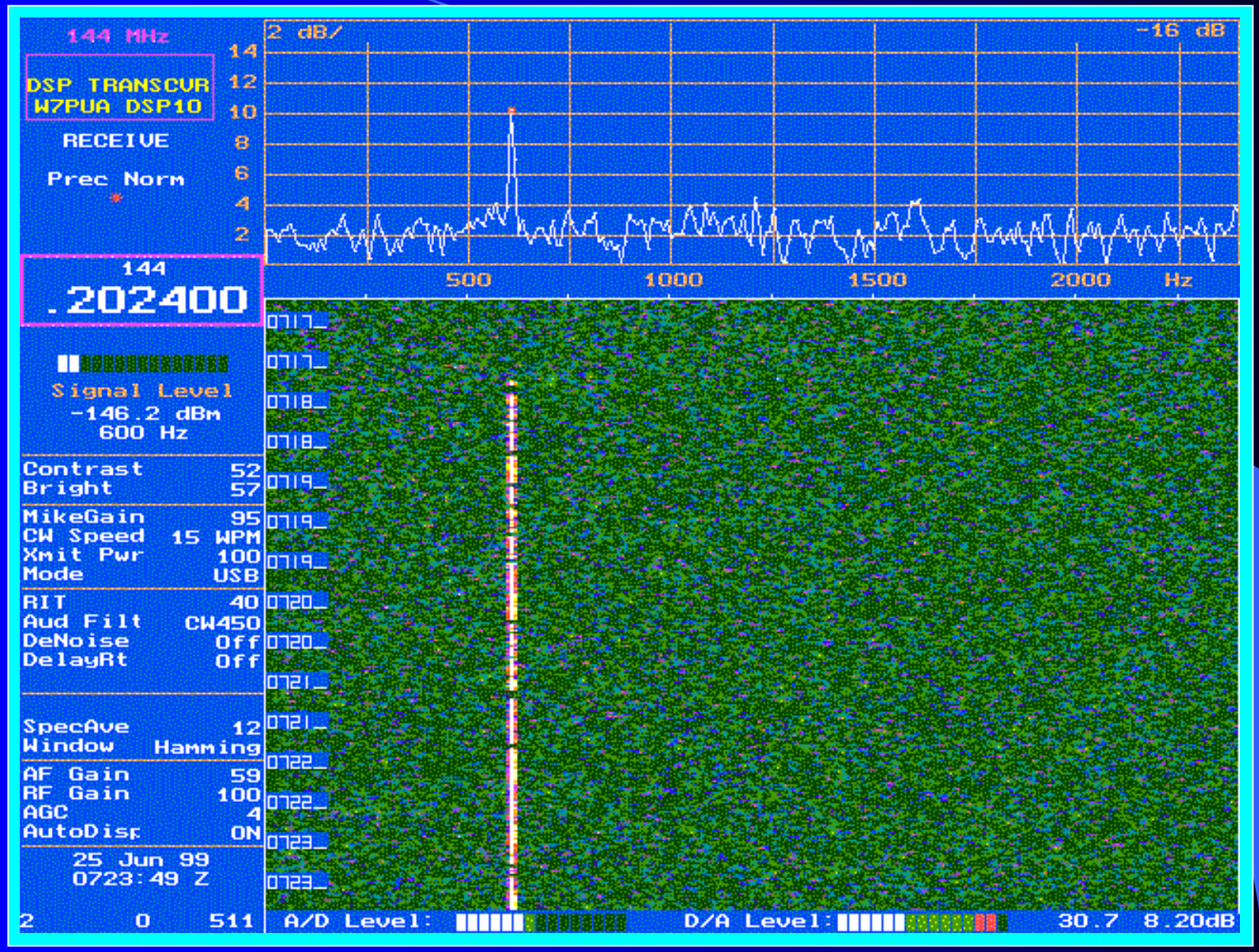
  http://www.arrl.org/tis/info/psk31.html

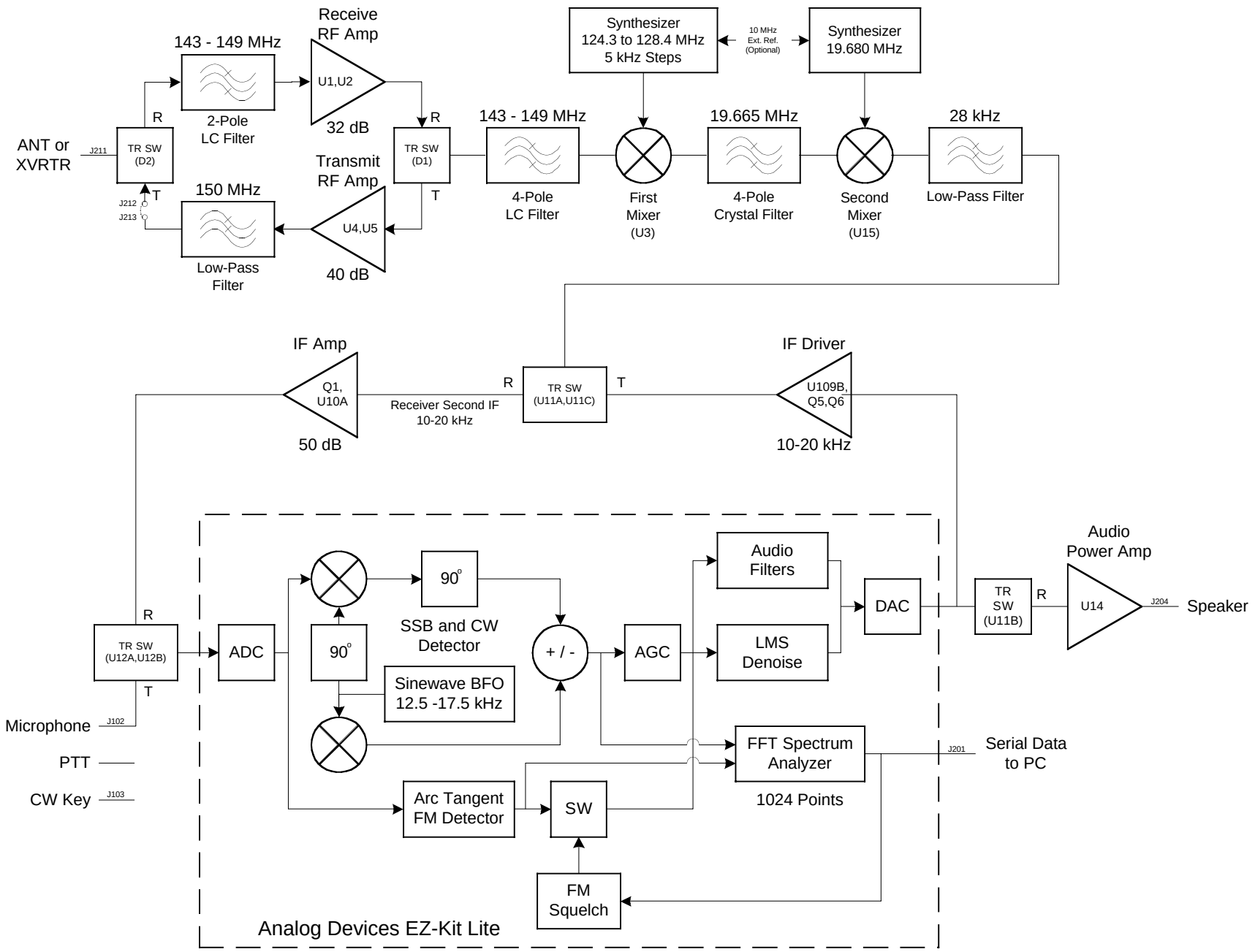
# The DSP-10 As a SDR

# DSP-10

Constructed by
Ernie Manly, W7LHL




144 MHz
DSP TRANSCVR
W7PUA DSP10
RECEIVE
Prec Norm
144
.202400
Signal Level
-146.2 dBm
600 Hz
Contrast 52
Bright 57
MikeGain 95
CW Speed 15 WPM
Xmit Pwr 100
Mode USB
RIT 40
Aud Filt CW450
DeNoise Off
DelayRt Off
SpecAve 12
Window Hamming
AF Gain 59
RF Gain 100
AGC 4
AutoDisp ON
25 Jun 99
0723:49 Z
2 0 511
2 dB/
-16 dB
14
12
10
8
6
4
2
500
1000
1500
2000
Hz
A/D Level:
D/A Level:
30.7 8.20dB


Receive
RF Amp
143 - 149 MHz
U1,U2
32 dB
2-Pole
LC Filter
R
ANT or
XVRTR
J211
TR SW
(D2)
T
J212
J213
150 MHz
Transmit
RF Amp
U4,U5
40 dB
Low-Pass
Filter
TR SW
(D1)
R
T
Synthesizer
124.3 to 128.4 MHz
5 kHz Steps
10 MHz
Ext. Ref.
(Optional)
Synthesizer
19.680 MHz
143 - 149 MHz
4-Pole
LC Filter
First
Mixer
(U3)
19.665 MHz
4-Pole
Crystal Filter
Second
Mixer
(U15)
28 kHz
Low-Pass Filter
IF Amp
Q1,
U10A
50 dB
Receiver Second IF
10-20 kHz
TR SW
(U11A,U11C)
IF Driver
U109B,
Q5,Q6
10-20 kHz
Audio
Power Amp
U14
J204
Speaker
TR
SW
(U11B)
DAC
Audio
Filters
LMS
Denoise
AGC
+ / -
90°
SSB and CW
Detector
Sinewave BFO
12.5 -17.5 kHz
ADC
TR SW
(U12A,U12B)
Microphone
J102
PTT
CW Key
J103
FFT Spectrum
Analyzer
1024 Points
J201
Serial Data
to PC
Arc Tangent
FM Detector
SW
FM
Squelch
Analog Devices EZ-Kit Lite

# Supporting Documentation

- Signals, Samples and Stuff: A DSP Tutorial
  by Doug Smith, KE6DX
  *QEX - Mar, May, Jul, Sep 1998*
  http://www.arrl.org/tis/info/dsp.html
- Basics of Digital Receiver Design
  by Brad Brannon, N4RGI
  *QEX – Sep/Oct 1999*
- A DSP-Based Audio Signal Processor
  by Johan Forrer, KC7WW
  *QEX – Sep 1996*
  http://www.peak.org/~forrerj/ASP/article.html

# Conclusion