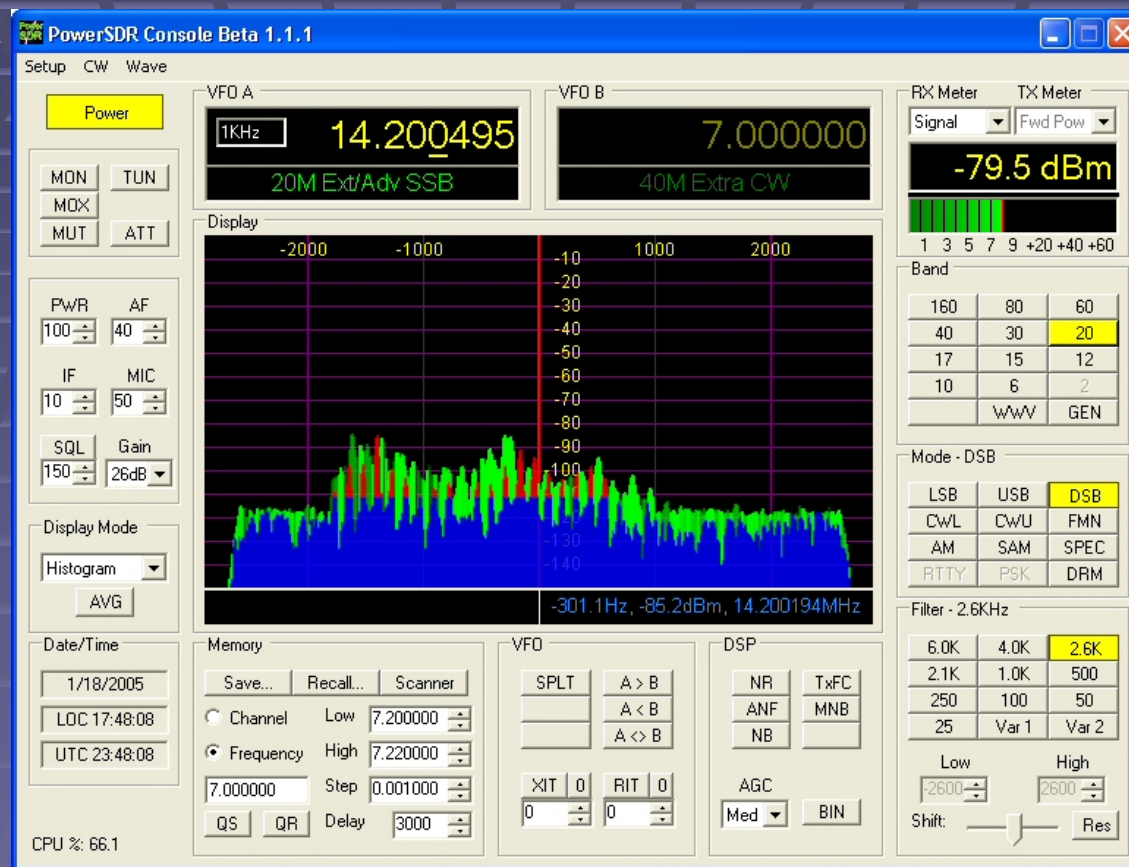# Software Defined Radio

A simple introduction to SDR.

Conventional Receiver

- Complex construction & design
- Big & heavy - chassis / cabinet / shielding.
- Multiple stages of conversion.
- Design dictates radio's capabilities.
- Cost $300 to $1000 and more.

Software Defined Radio

- Simple construction & design.
- Small with little or no shielding.
- Single conversion to base band audio.
- PC with <u>stereo</u> sound card required.
- Software defines the radio's capabilities.
- Cost under $100 for basic unit (plus PC).

Quadrature Sampling Detector

- <u>Quadrature</u>: Separated in phase by 90°.
- Similar to direct conversion receiver.
- L.O. has two outputs in quadrature.
- Mixer produces Q & I signal at output.
- Q & I are audio signal in quadrature.
- Software processes Q & I signals into received audio.
- Pan adapter or band scope display.
- Width of display ≈ sound card sample rate.

Theory of Operation

- This receiver is patterned on the classic "direct conversion" receiver, in that it mixes incoming RF down to audio frequencies by beating the RF against a Local oscillator such that the mixer products are in the audio frequency range.

- Unlike the traditional DC receiver, the SDR does not "tune" the local oscillator's frequency to beat up against a desired RF signal. Instead, the local oscillator is at a fixed frequency. This fixed oscillator frequency is referred to as the "center frequency".

Theory of Operation

- As a result, the mixer products can vary in audio frequency from zero to +/- some theoretically high audio frequency. In fact, the practical limit is one-half the soundcard's maximum sampling rate.

- The "tuning" (and demodulation and AFC and other neat radio things) happen in the software part of the Software Defined Radio. It is the magic of Software that makes for the extraordinarily high selectivity in the direct conversion hardware (which is notorious for great sensitivity but terrible selectivity).

Theory of Operation

- The software requires the AF mixer products to be provided to the PC as two separate signals, each identical to the other, except that they are 90 degrees apart in phase ("in quadrature"). The SDR receivers achieves this by setting the local oscillator to a frequency that is 4 times the desired center frequency and then dividing that frequency 4 times (with attendant phase shifts to achieve quadrature).

- The output of the divider chain is two versions of the center frequency, identical in all respects but phase.
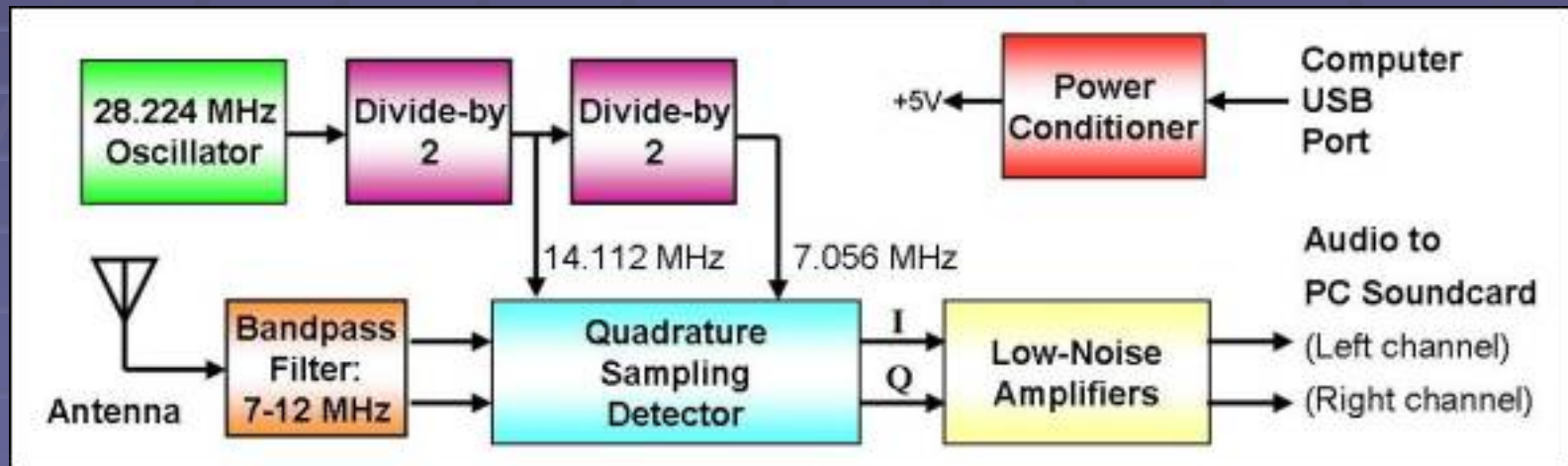
Theory of Operation

- The two center frequency signals are in quadrature and are fed into the mixer stage, which mixes the RF down to two audio signals that are also in quadrature.

- These two signals are provided to an amplifier stage where they are amplified to levels acceptable to the PC's soundcard stereo line-in inputs.

- A soundcard which can sample 48 kHz, can digitize an incoming "chunk" of audio frequency from 0 to 24 kHz. Such a soundcard, using its stereo line-in inputs for the I and Q signals, will yield an effective bandwidth of 48 kHz: 24 kHz above the center frequency and 24 kHz below the center frequency. The SDR software in the PC manipulates the digitized I and Q signals to deliver, demodulate, condition, and filter signals within this bandwidth.

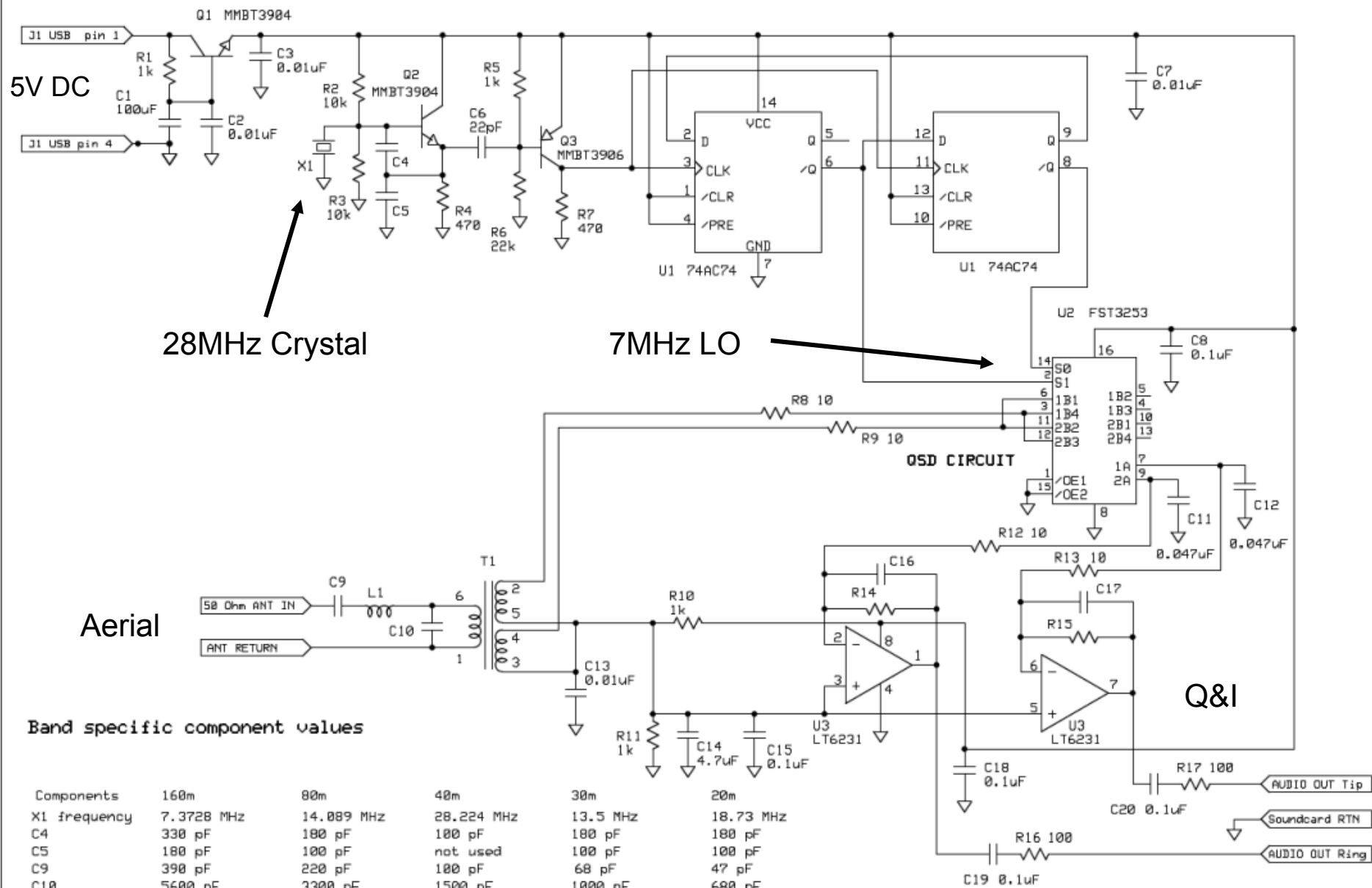# Sound card requirements for SDR

- SDR requires a good <u>stereo</u> sound card.
- The higher the sample rate the better.
- Most cards will sample to 48kHz.
- Better card sample to 96kHz or 192kHz.
- Lower sample rates do not affect audio quality.
- The sample rate limits the width of the pan adapter display.

Soft Rock 40

- Single band receiver designed for 40m.
- Crystal Oscillator @ 4x RX frequency

SoftRock Projects — SoftRock_40_R

J1 USB pin 1

5V DC

J1 USB pin 4

Q1 MMBT3904

R1 1k

C1 100uF

C2 0.01uF

C3 0.01uF

R2 10k

Q2 MMBT3904

X1

R3 10k

C4

C5

R4 470

R6 22k

R5 1k

C6 22pF

Q3 MMBT3906

R7 470

C7 0.01uF

28MHz Crystal

VCC 14

D 2 / Q 5
CLK 3
/CLR 1
/PRE 4
GND 7

U1 74AC74

D 12 / Q 9
CLK 11
/CLR 13
/PRE 10
/Q 8

U1 74AC74

7MHz LO

U2 FST3253

S0 14
S1 2
1B1 6
1B4 3
2B2 11
2B3 12

1B2 5
1B3 4
2B1 10
2B4 13

/OE1 1
/OE2 15

1A 7
2A 9

8

OSD CIRCUIT

C8 0.1uF

R8 10

R9 10

R12 10

R13 10

C11 0.047uF

C12 0.047uF

Aerial

50 Ohm ANT IN

ANT RETURN

C9

L1

C10

T1

6
2
5
4
1
3

C13 0.01uF

R10 1k

R11 1k

C14 4.7uF

C15 0.1uF

U3 LT6231

C16

R14

C18 0.1uF

C17

R15

U3 LT6231

Q&I

R17 100

C20 0.1uF

AUDIO OUT Tip

Soundcard RTN

R16 100

C19 0.1uF

AUDIO OUT Ring

Band specific component values

Components	160m	80m	40m	30m	20m
X1 frequency	7.3728 MHz	14.089 MHz	28.224 MHz	13.5 MHz	18.73 MHz
C4	330 pF	180 pF	100 pF	180 pF	180 pF
C5	180 pF	100 pF	not used	100 pF	100 pF
C9	390 pF	220 pF	100 pF	68 pF	47 pF
C10	5600 pF	3300 pF	1500 pF	1000 pF	680 pF
L1	19.6 uH	9.1 uH	5.0 uH	3.5 uH	2.5 uH
	67T,#30,T30-2	52T,#30,T25-2	38T,#30,T25-2	36T,#30,T25-6	30T,#30,T25-6
T1 primary	1.4 uH	0.73 uH	0.35 uH	0.18 uH	0.18 uH
	18T,#30,T30-2	14T,#30,T25-2	10T,#30,T25-2	8T,#30,T25-6	8T,#30,T25-6
T1 secondaries	9T,bifilar,#30	7T,bifilar,#30	5T,bifilar,#30	4T,bifilar,#30	4T,bifilar,#30
C16/C17	1500 pF	1500 pF	1500 pF	390 pF	390 pF
R14/R15	1.00 k	1.00 k	1.00 k	4.99 k	4.99 k

SoftRock Projects

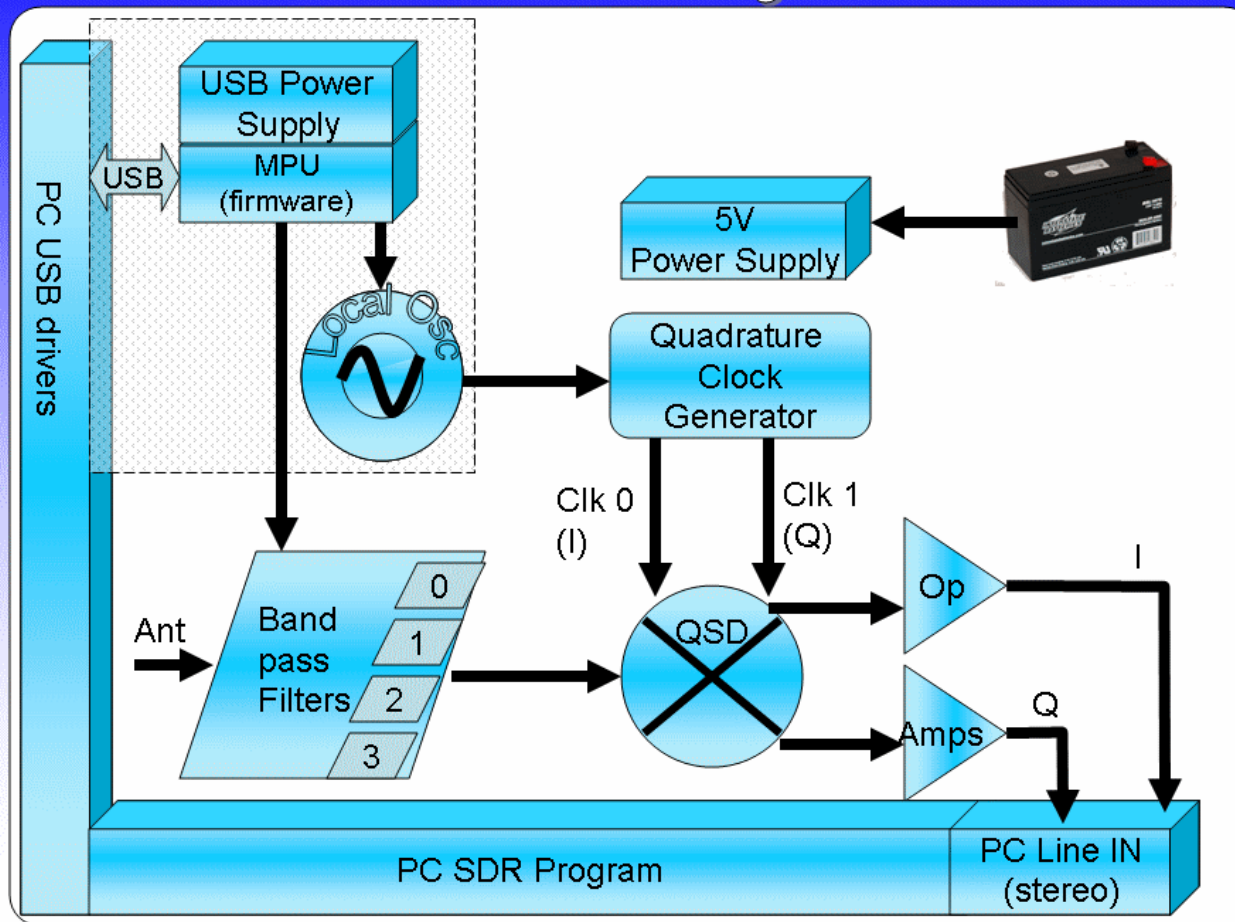SoftRock_40_R

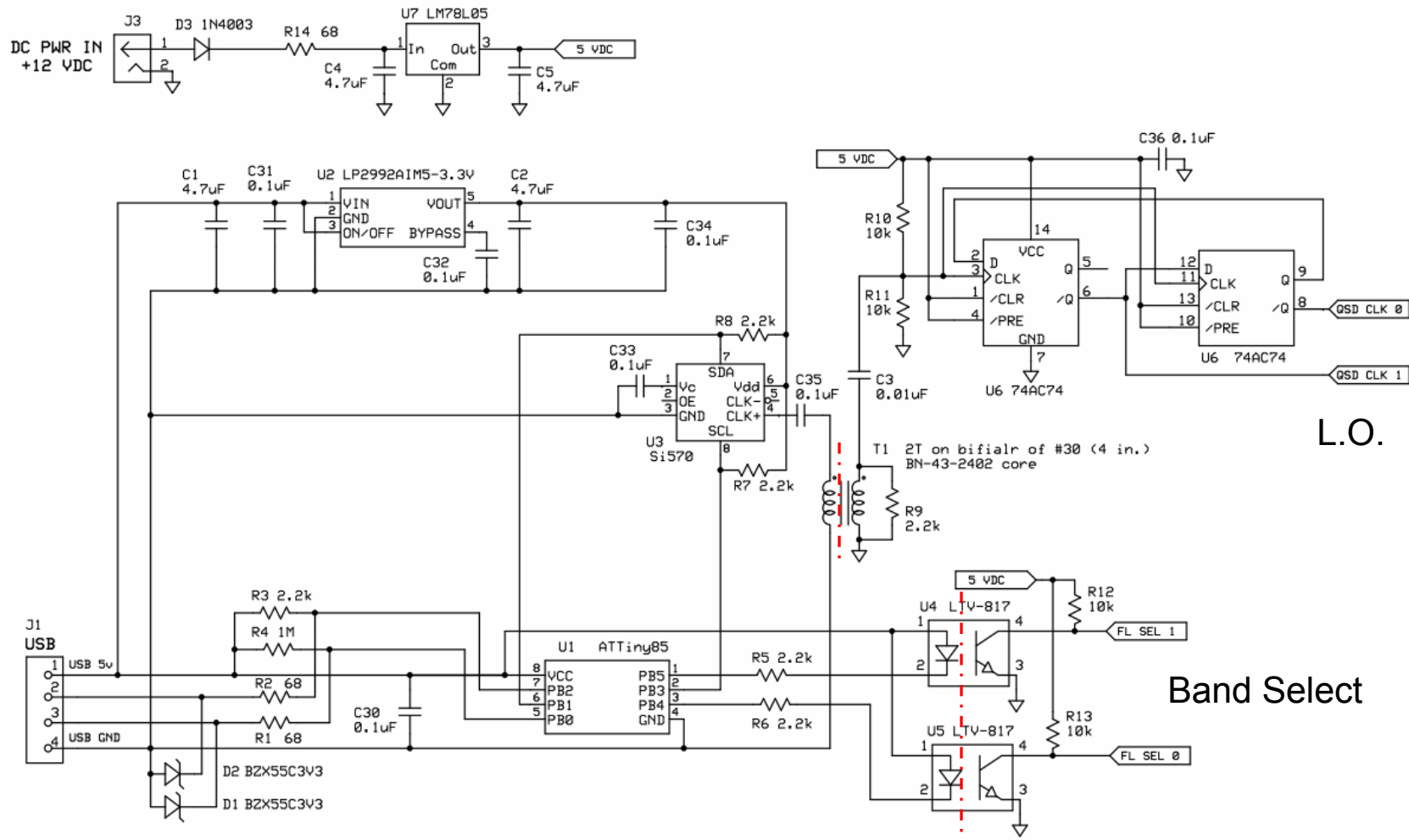Tony KB9YIG   2/26/12   Page 1 of 1

Soft Rock Ensemble II RX

- Full coverage HF receiver
- Auto switched band pass filter
  - 160m
  - 80m & 40m
  - 30m, 20m & 17m
  - 15m, 12m & 10m
- Si 570 digital frequency synthesizer
- Atmel ATTiny85 micro controller
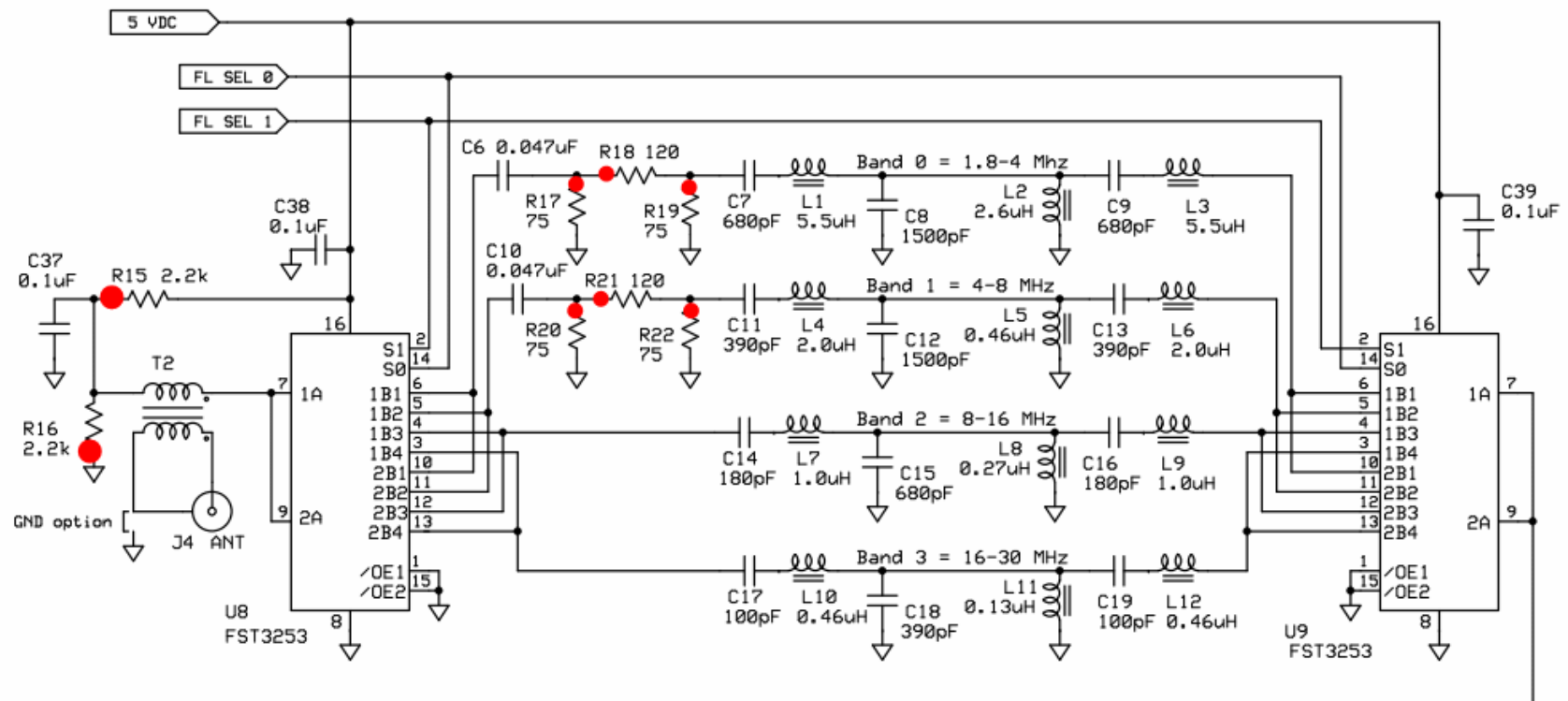
Soft Rock Ensemble II RX

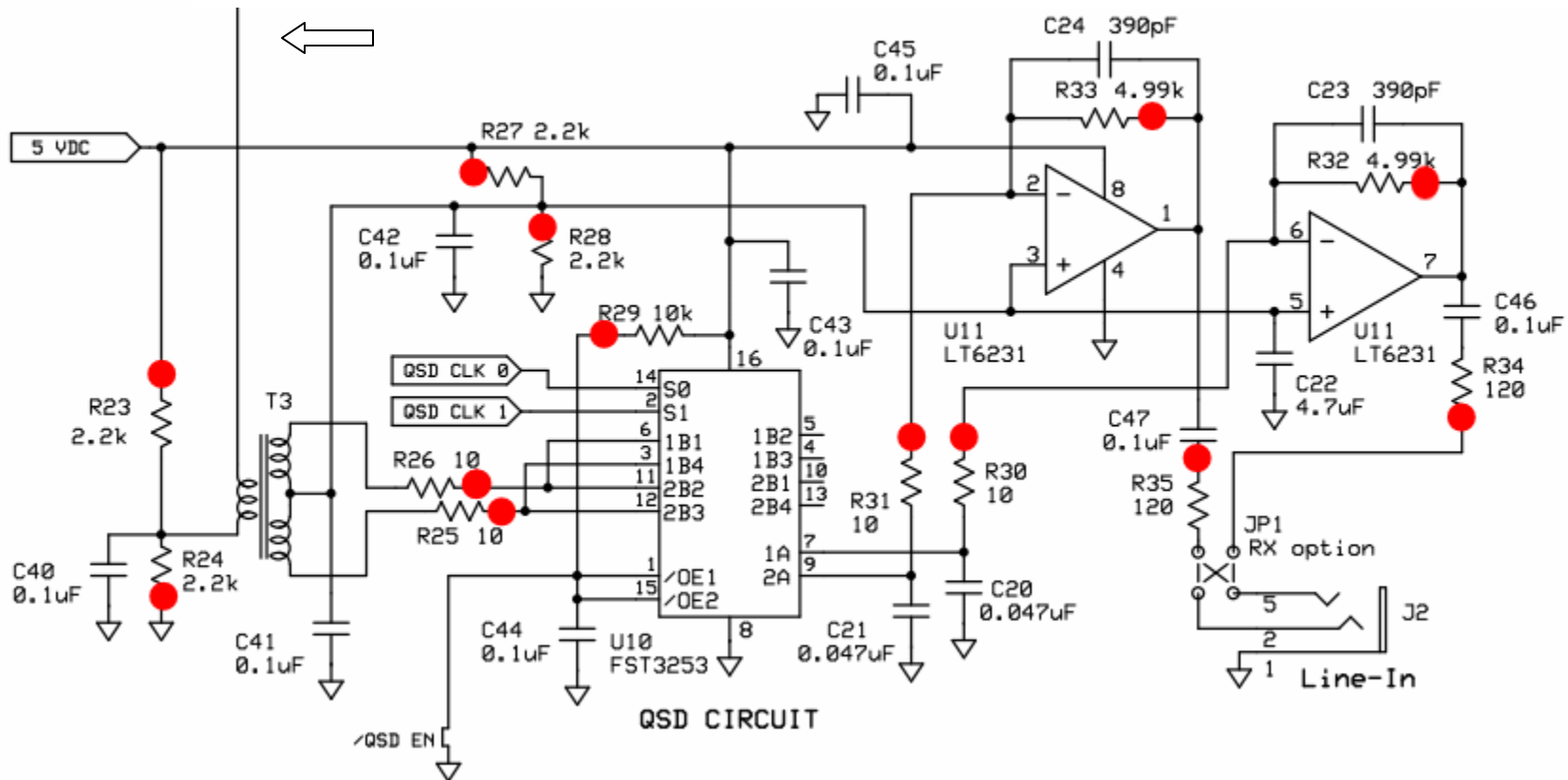Ensemble RX Block Diagram
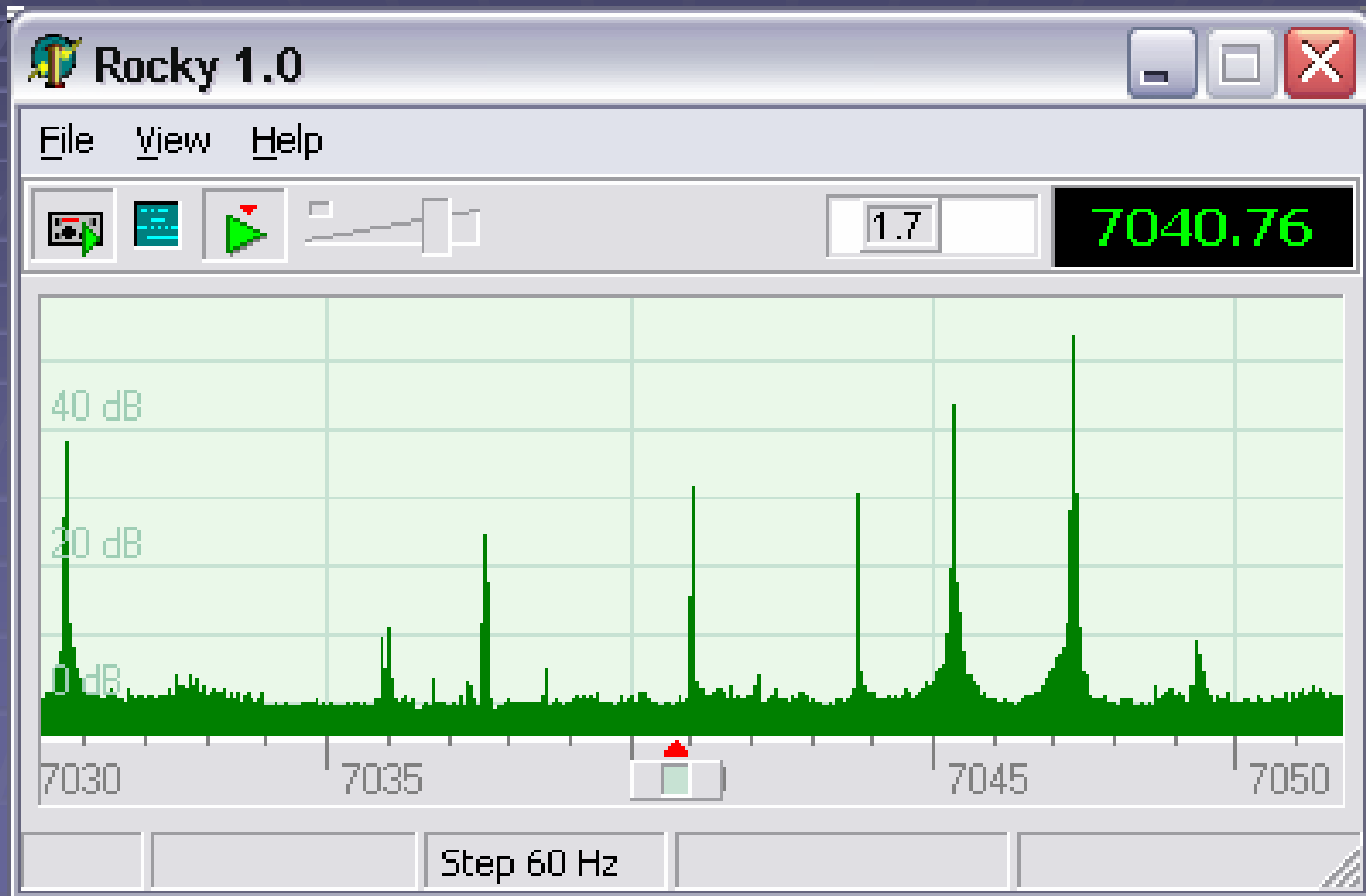
Soft Rock Ensemble II RX

Soft Rock Ensemble II RX

Soft Rock Ensemble II RX
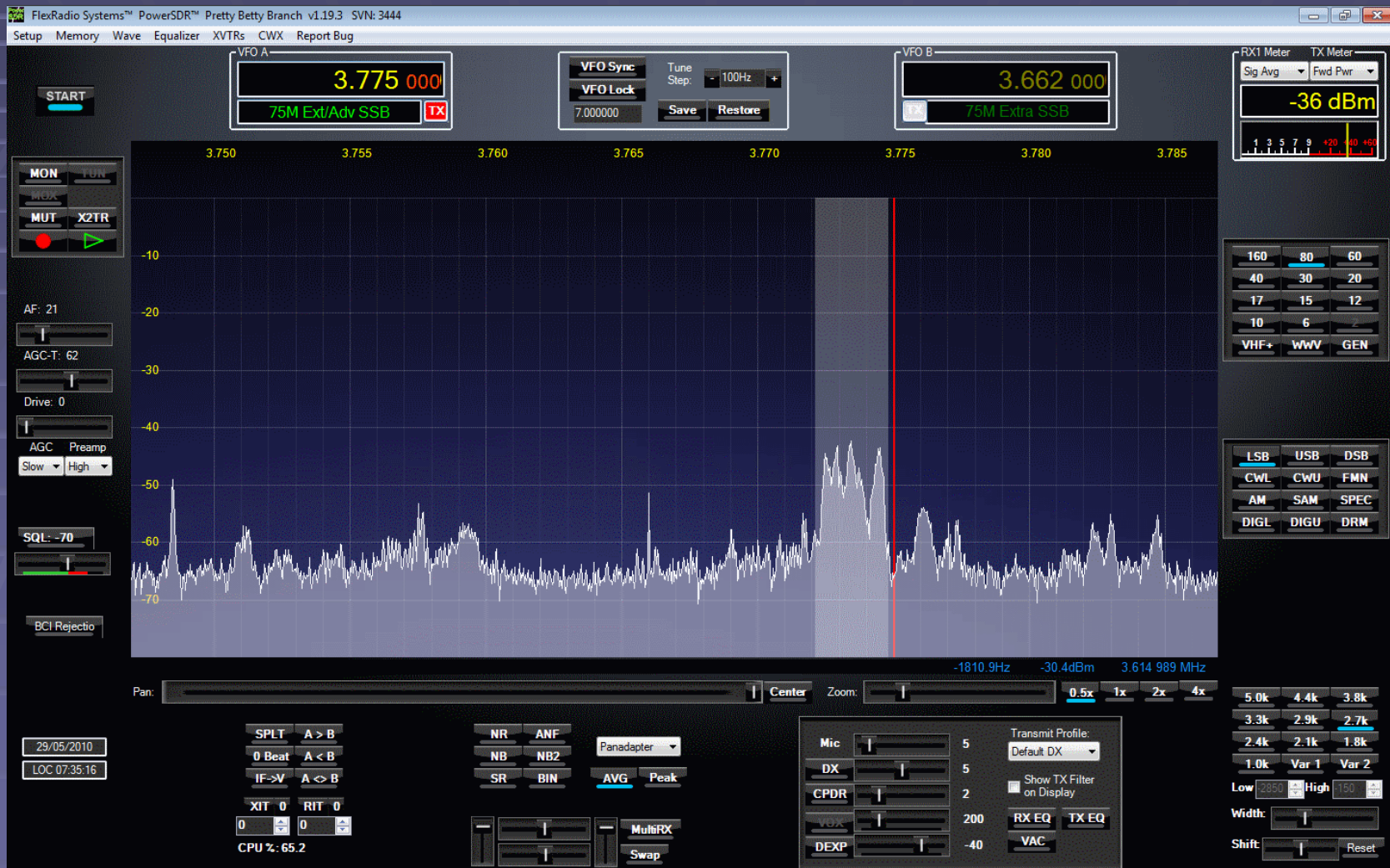

RF from band pass filter

SDR Software – The original Rocky

SDR Software - SDRadio

SDR Software- PowerSDR IQ

Questions?

Time to listen

But wait, there's more!

- Full HDTV with FM & DAB receiver.

- Basic spectrum analyzer.

- Monitor the IF of an existing receiver or transmitter.

- An SDR IQ transceiver is available.

Soft Rock kits

- Designed by Tony Parks [KB9YIG](KB9YIG)

- Construction guides at [WB5RVZ](WB5RVZ)

- Use ChangeDetection.Com or similar service to get email alerts when kits become available.