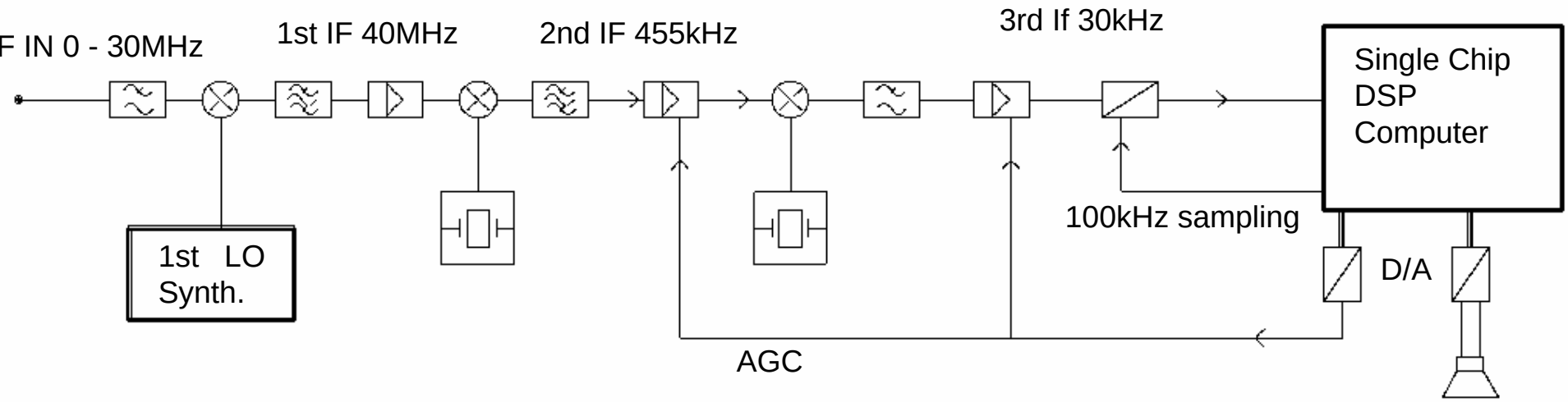
SOFTWARE DEFINED RADIO

Andy Talbot G4JNT

The Modern Digital Radio

- Conventional analogue RF front end
- Input filter(s)
- Mixer — As for any analogue radio
- IF amplification
- Mixer to 30kHz (typical)
- Digitisation + DSP filtering / demodulation — Specific to DSP radio

Conventional modern Digital Receiver



What Digital IF Processing can do

- Unlimited filter bandwidths / shapes
  - Without expensive crystal or mech. filters
- New modulations, analogue or digital
- No-Hardware upgrade, software download only

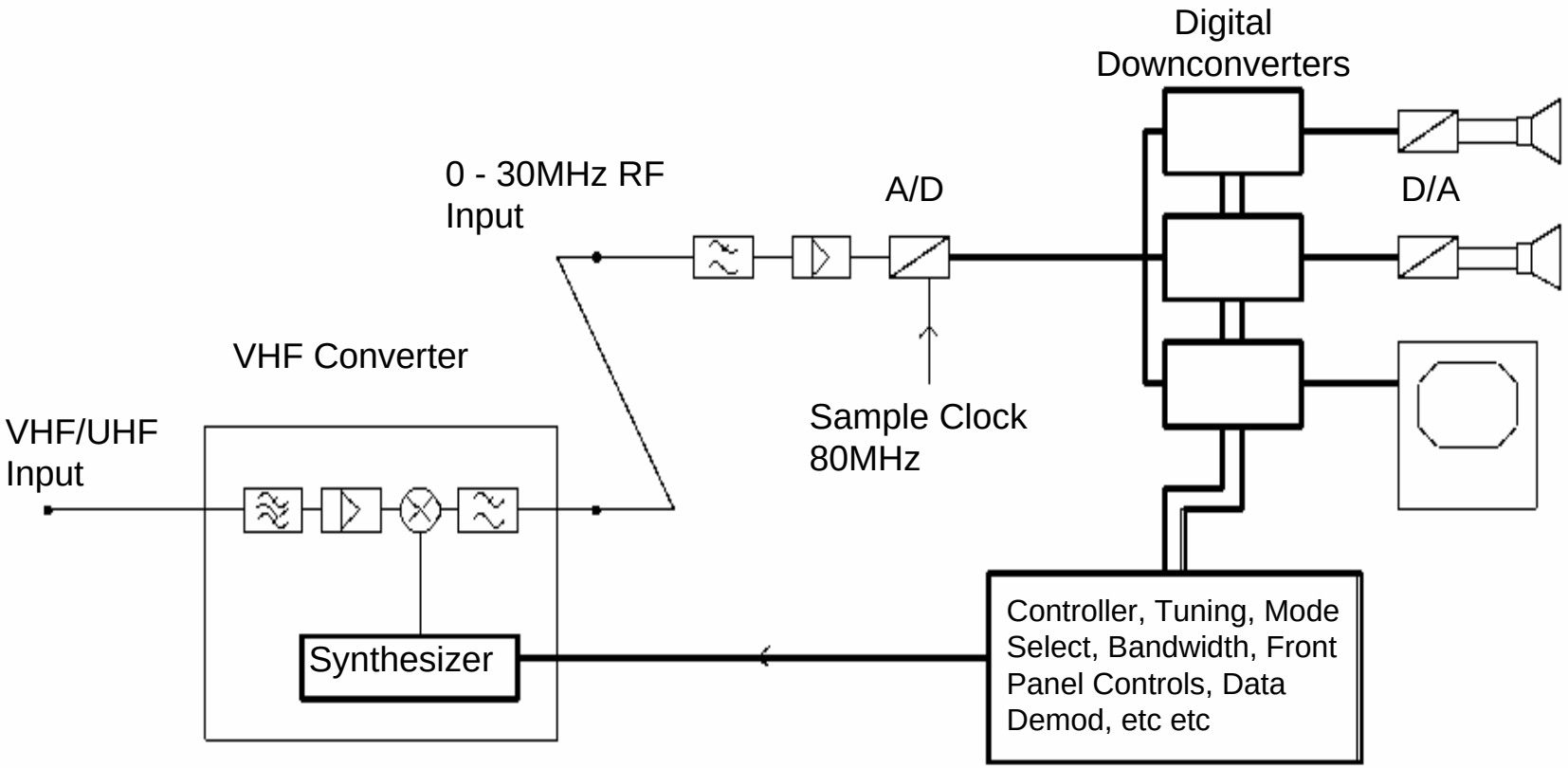
- BUT

- Still needs RF and first crystal filter, two or more I/Fs, mixers

The Software Defined Radio

- Natural progression from the DSP Radio
- Digitise a large chunk of RF spectrum in one go
- Downconvert and filter in software
- One frequency conversion only, or possibly none at all !

TYPICAL SOFTWARE DEFINED RADIO ARCHITECTURE



A/D Converters

- Digitisation of spectrum dictates design of SDR
  - Current state of the art has been defined by the cellphone industry
  - Many MHz of spectrum in one go.
  - 14 bits is common, 16 bits beginning to appear. Device speed rising to 80MHz (3G phone technology) Number of bits dictates dynamic range
  - Analog Devices AD6645

A/D Converters cont.

- 6dB per bit means we can have theoretically 84dB dynamic range - although in practice more like 75dB over full bandwidth
- Rising to 85-90dB soon.
- Almost good enough for HF just by connecting antenna to A/D chip via LPF.
- BUT, after digital filtering processing gain give higher dynamic range

SDR. Architecture

- A/D converter
- Numerical controlled oscillator for tuning
- Downconvert to two 90 degree channels using zero freq IF
- Filter to lower bandwidth, reduce sampling rate (decimation) - processing gain
- Demodulate

Advantages

- No bandswitching, filters or wideband Local Oscillator for HF radio
- Single conversion for V/UHF means simple filtering and synthesizer, fewer sprogs
- Any mode possible - voice, digimode,
- Wideband / narrowband
- Rapid frequency agility

Current Technology

- AD6645 - 14bit, 80MHz sampling
  - Continuously improving
  - New devices appearing each year
- Entire HF spectrum in one go (almost)
- Digital downconverter chips
  - Numerical LO and filtering with demodulation in one chip
  - Multiple channels simultaneously

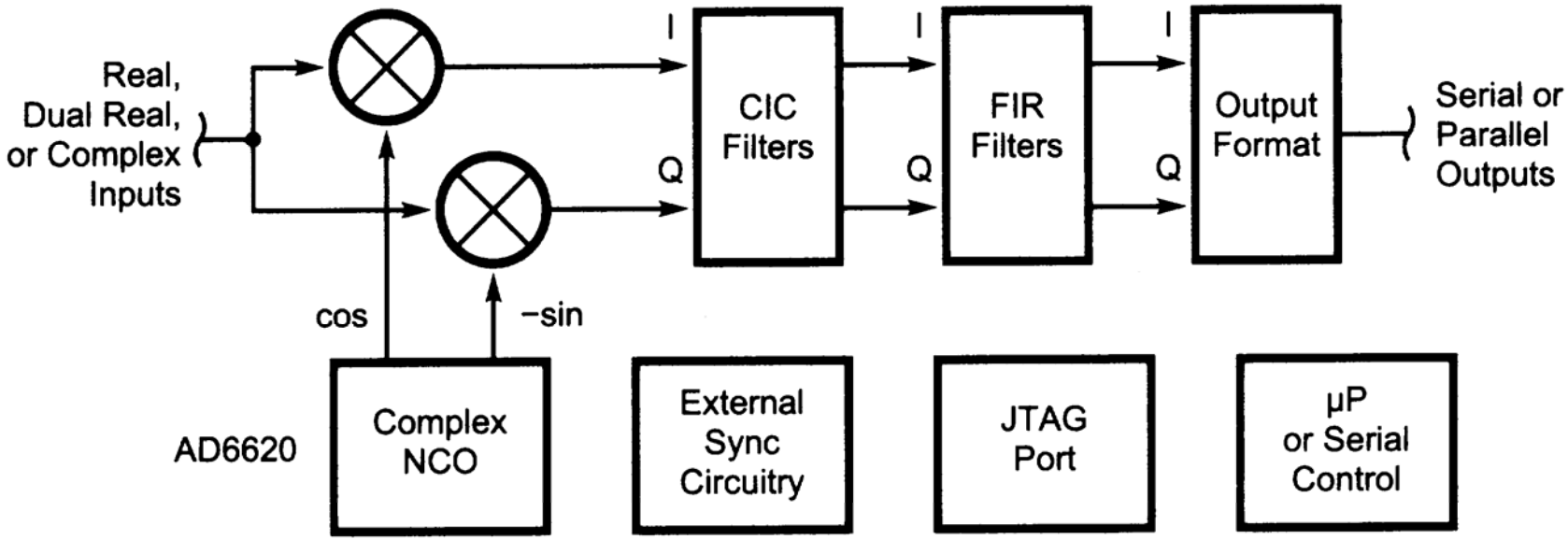


Fig 6—Simplified block diagram of the AD6620 RSP.

Digital Downconverter

Simpler Solutions
(The Homebrew option ?)

- I/Q conversion
  - Single LO downconvert to zero frequency
  - Needs accurate 0/90º phase split for sideband isolation
  - Matched I/Q low pass filters

- But if these can be done :

The PC SDR.

- I/Q Convert and low pass filter to audio bandwidth
  - One LO only (with 0/90º outputs)
  - Two matched mixers
- Use PC soundcard as I/Q input
  - Typically up to 20kHz audio bandwidth
  - Giving 40kHz total !
- Demodulate and filter in PC

PC Based SDR From QEX Jul/Aug 2002

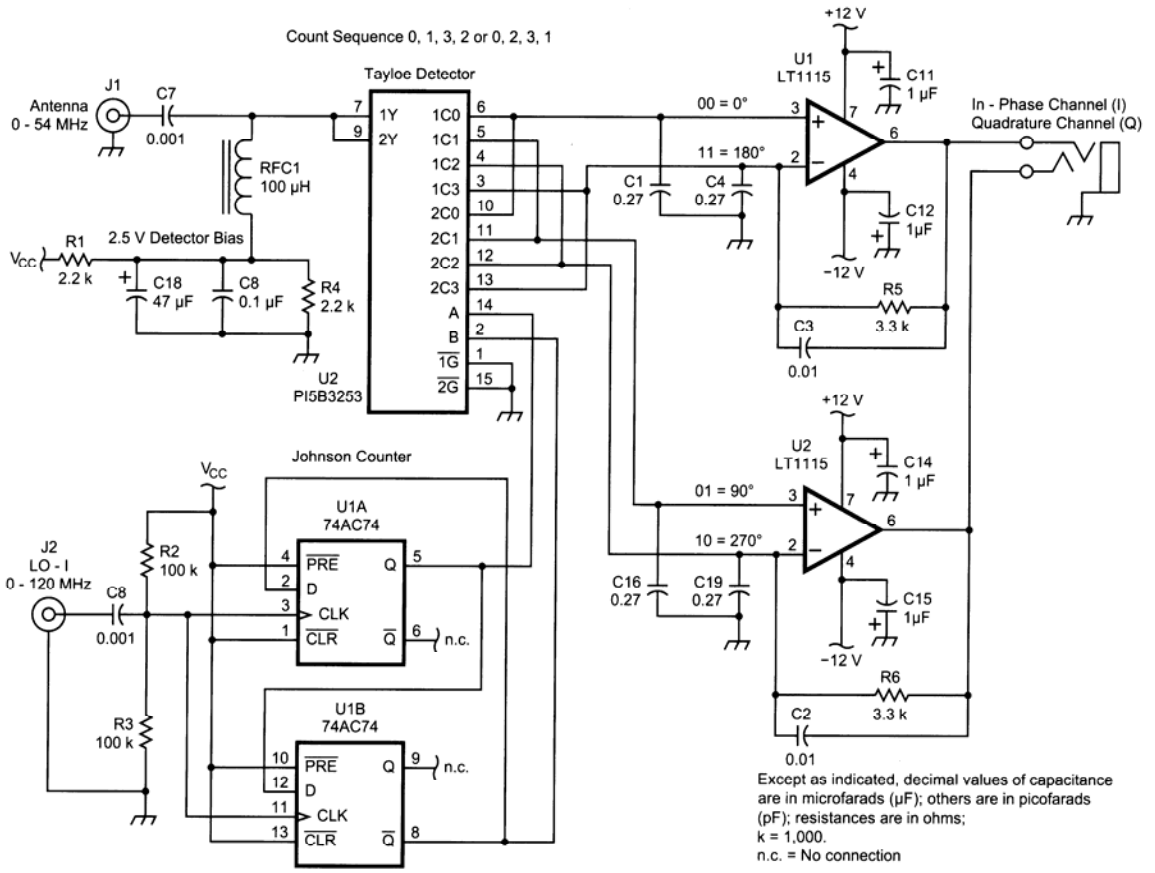


Fig 12—Singly balanced Tayloe detector.

PC Based SDR From QEX Jul/Aug 2002

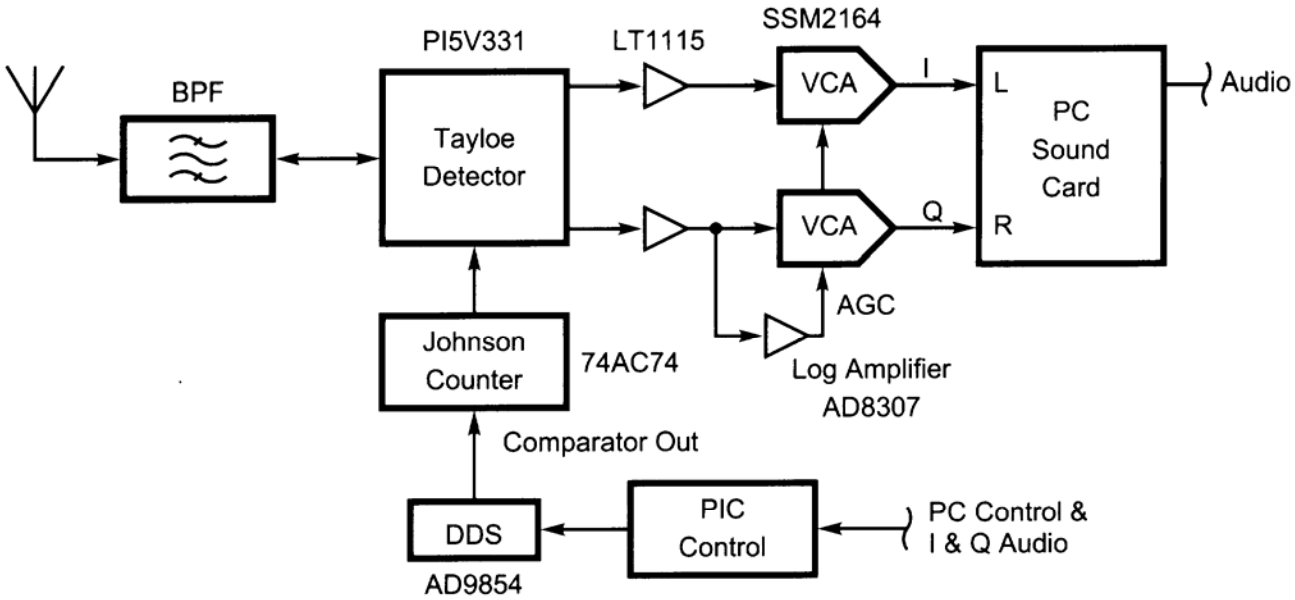


Fig 14—PC SDR receiver hardware architecture: After band-pass filtering the antenna is fed directly to the Tayloe detector, which in turn provides *I* and *Q* outputs at baseband. A DDS and a divide-by-four Johnson counter drive the Tayloe detector demultiplexer. The LT1115s offer ultra-low noise-differential summing and amplification prior to the wide-dynamic-range analog AGC circuit formed by the SSM2164 and AD8307 log amplifier.

- Soundcards do not respond to DC, so may have a notch at centre freq (or use offset)
- Requires the ability to write Windows software for Soundcard
- OR use a separate DSP card - stand alone radio

Conclusions

- SDR gives the ultimate flexibility
- One piece of hardware allows virtually any band / modulation format
- Easy upgrade route
- Fast reconfiguration
- Cheaper ?????