

Digital TIGER Radar Receiver - an outline of

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Introduction

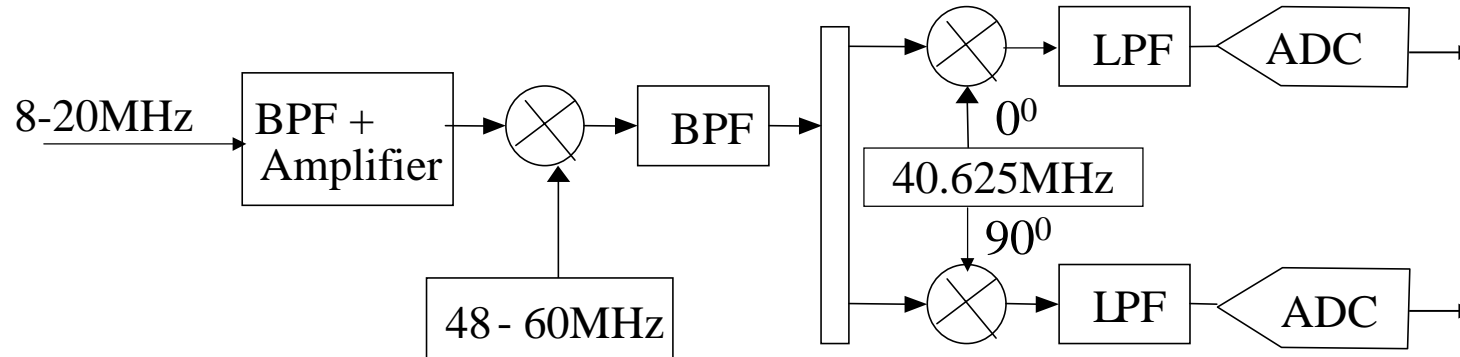
In recent years, the use of digital receiver technology in telecommunication systems has led to a dramatic increase in performance and reduction in cost. Digital techniques continue to replace analogue functions in communication systems as improvements are made in digital integrated circuit and analogue to digital conversion (ADC) technologies.

At La Trobe University we are researching a digital implementation of the current analogue TIGER radar receiver. The proposed digital receiver will work in the range 8-20MHz with a 100KHz bandwidth. Compared with the analogue design, a digital version can provide better performance and more flexibility.

A Field Programmable Gate Array (FPGA) implementation has been chosen due to their relatively low cost and inbuilt reconfigurability. The proposed digital receiver will have, as a minimum, the same specifications as the current analogue receiver. However, new digital techniques should allow greater configurability so that the receiver can be optimised for different operational modes. Three different architectures: direct sampling, IF under sampling and RF sampling, have been investigated and compared.

Direct Conversion

- The modulated RF signal is up converted with the local oscillator to produce the IF signal at 40.625Mhz.
- The signal is split and quadrature down converted to the base band.
- The signal is digitised after filtered by the LPF.



Direct Conversion – Block Diagram

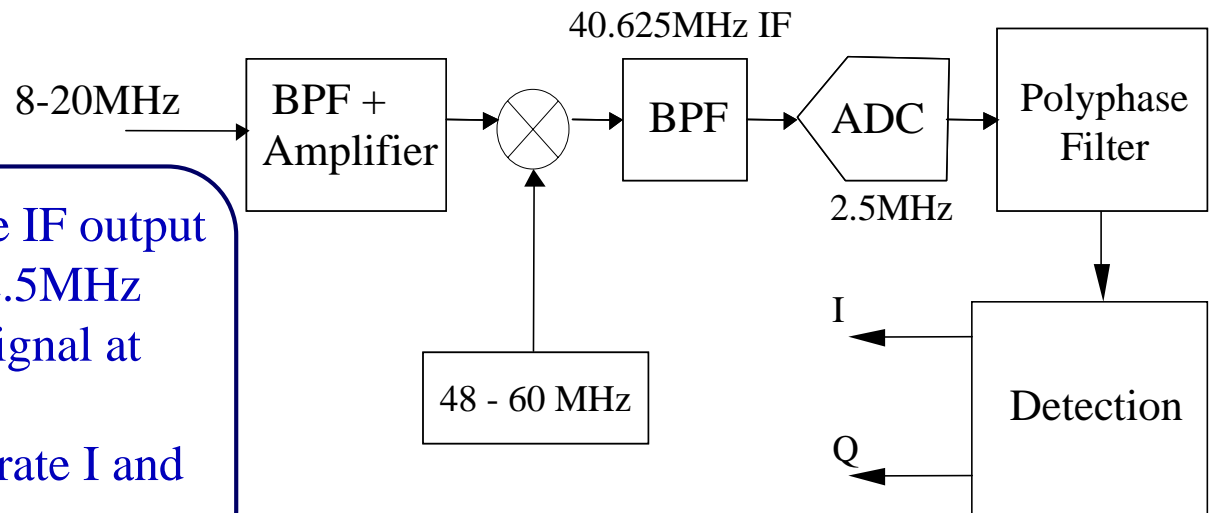
Advantages

- Less resources
- Does not require fast ADC
- The back end digital section can be implemented using DSP processors as well as FPGA technology.

Disadvantages

- Gain and phase imbalance from LPF
- Signal distortion at analogue mixer
- Component performance alters with changes in environmental parameters
- Selectivity of BPF is a major problem

IF Under Sampling



IF Under Sampling – Block Diagram

- The ADC has been moved to the IF output
- The signal is under sampled at 2.5MHz which produces an alias of the signal at 0.625MHz
- Polyphase filtering used to generate I and Q outputs

Advantages

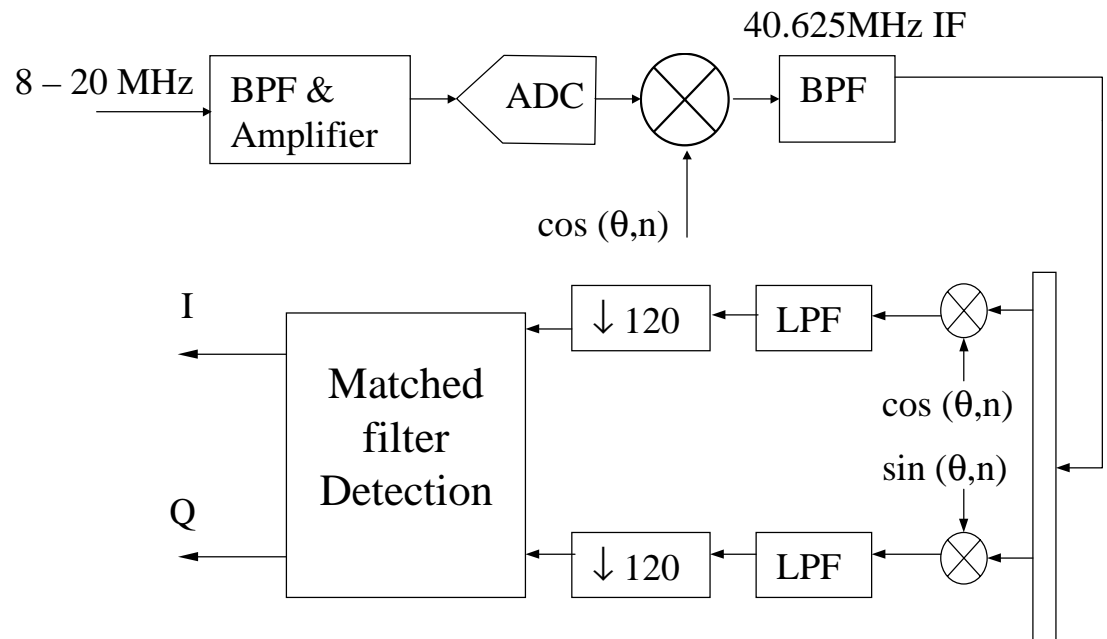
- Digital components (ADC, FPGA) are readily available
- All mixing, decimation and filtering processes are moved to polyphase filter
- No distortion from analogue components in IF section
- Can be implemented with current FPGA technology

Disadvantages

- Requires use of fixed-point arithmetic
- Results in some quantisation noise
- Heavy computational load when more bits are used

RF Sampling

- The signal is sampled at 120MHz
- ADC has been move to sample the RF directly
- All signal processing is in the digital domain



RF Sampling – Block Diagram

Advantages

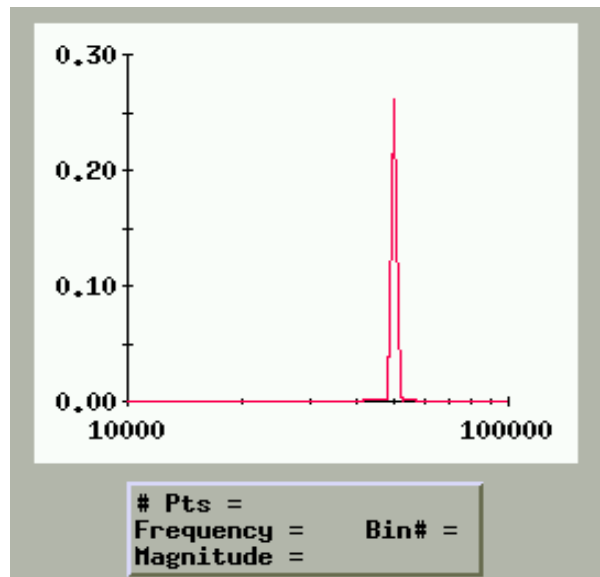
- Signals processed in the digital domain
- Compact - due to small number of analogue parts
- Less error and distortion
- Easier to construct - all receivers identical with no tuning required

Disadvantages

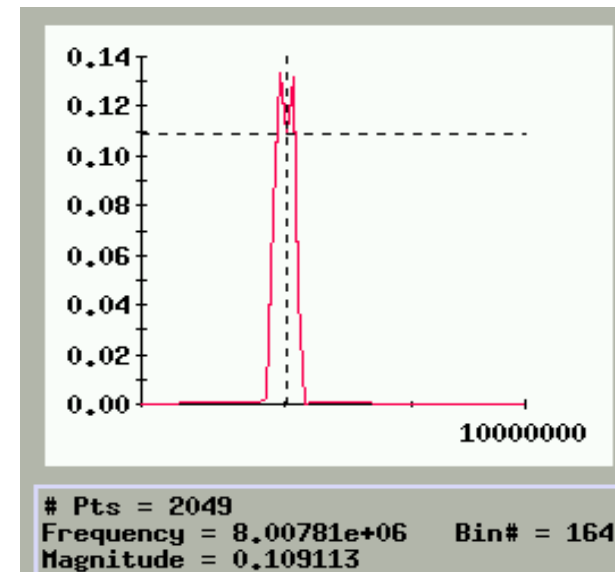
- Requires very fast ADC - expensive!
- Requires minimum 16 bit ADC but only 12 or 14 bit available at required speed
- Extremely heavy computational load
- Difficult to implement with current FPGA technology

Simulations

- Simulations undertaken using the *Cadence SPW* (Signal Processing Workstation) package.
- Analog components simulated using floating-point calculations while digital components simulated using 16bit fixed-point twos-complement calculations.
- The input signal of 50kHz is mixed with a 8MHz carrier to create a DSB modulated signal at 8MHz with a 100KHz bandwidth.
- The modulated signal is injected into each of the three system models
- Simulations assume no external noise

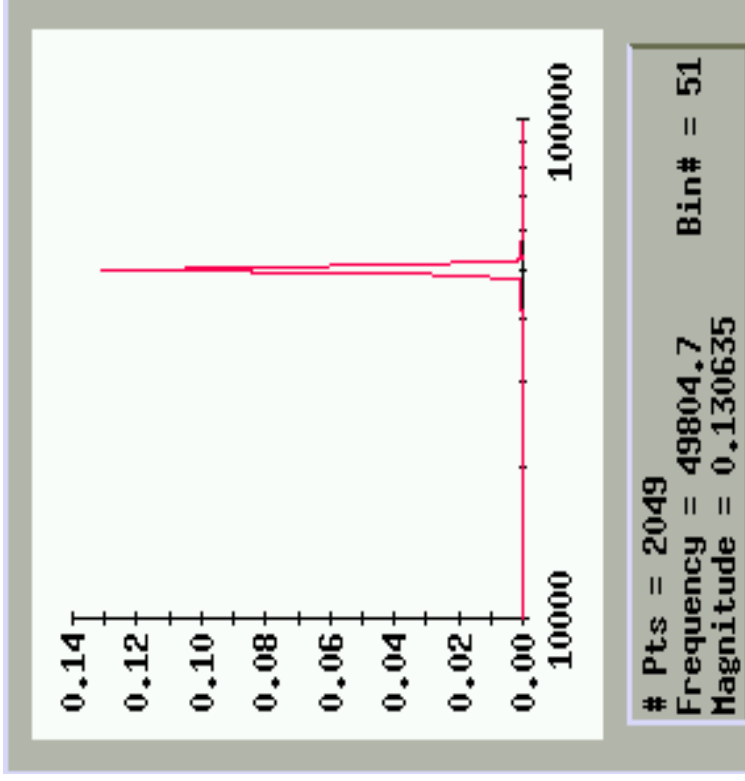


Input signal - 50 kHz

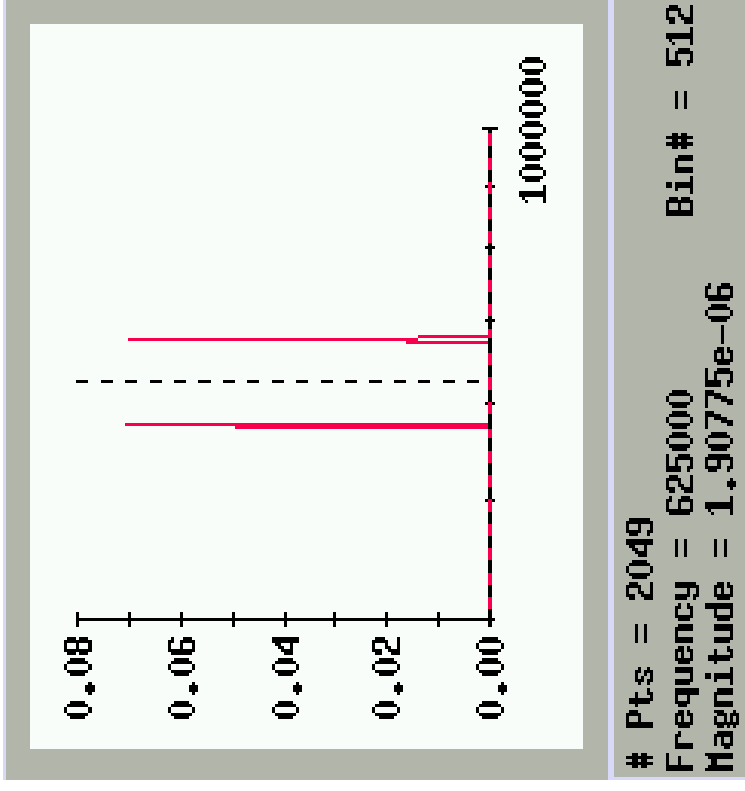


Modulated Input signal - 8MHz carrier

Simulation Results

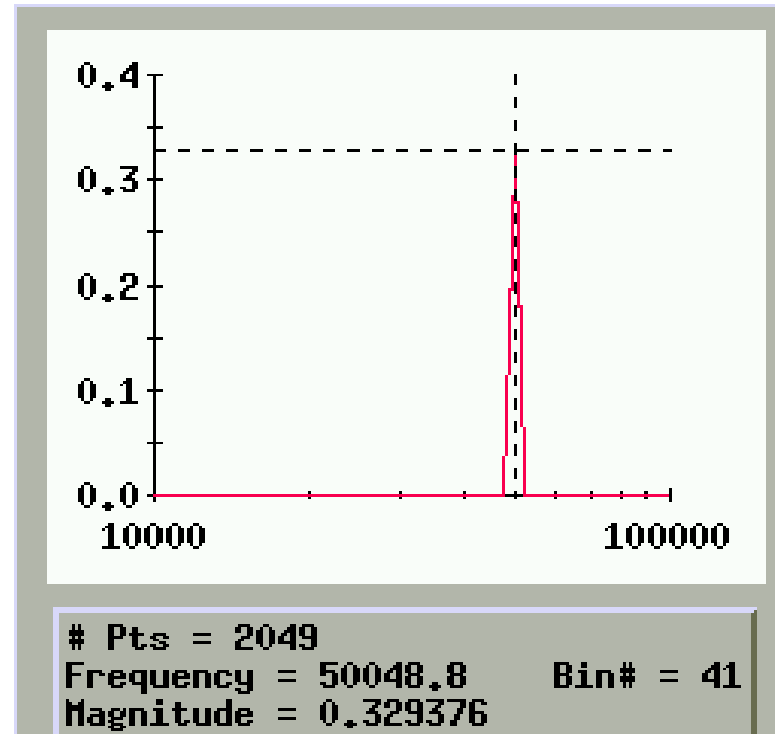


*Direct Conversion - output spectrum
(50kHz signal recovered)*



*IF Under Sampling - signal spectrum
following digitization at 2.5MHz
(aliased carrier frequency 0.625)*

Simulation Results



*IF Under Sampling - output spectrum
(50kHz signal recovered)*

The RF sampling system produces the same results as the IF Under Sampling method (above).

Conclusions

- Several methods for the digital implementation of the TIGER receiver have been investigated.
- The IF undersampling method provides a good compromise between available technology and performance.
 - It can provide better performance than the Direct Conversion method with significantly less resources than that required by the RF sampling method.
 - The Polyphase filter technique provide opportunities to perform decimation, frequency translation and filtering with less computational load.
- The RF sampling method promises greater benefits although more difficult to produce at present.
 - Will become easier to produce as FPGA and Analogue to digital conversion technology continues to develop.
 - Definitely warrants further work to refine the method to meet emerging technology advances.