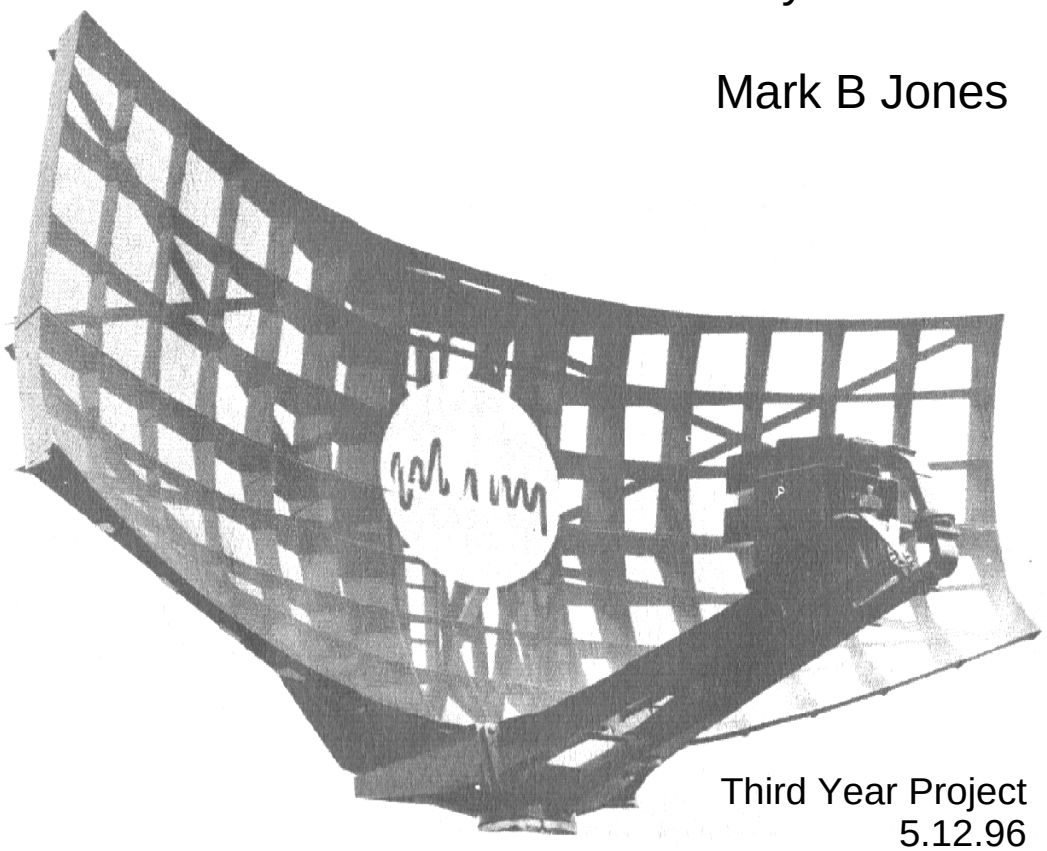
Surface Acoustic Wave Filters: Analysis and Simulation

Presented by :

Mark B Jones



Third Year Project
5.12.96

The Radar Problem

- Minimise Transmission Power
- Maximise S/N of Received Signal
- Minimise detection of ‘false’ echoes, eg from Ground Obstacles
- Minimise loss of ‘real’ echoes by making signal pulse narrow

- Match filter: auto-correlation fn
- Narrow pulse $\Rightarrow$ high bandwidth
- Pulse Compression

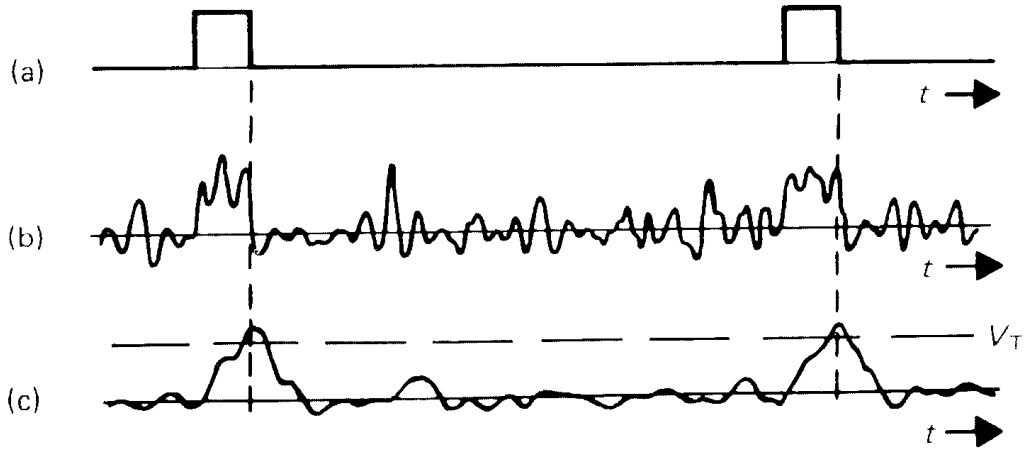
The Match Filter

- need not preserve wave-shape
- must provide maximum output

- designed with time-reversed impulse response of received signal

- Performs Auto-Correlation Function

- Symmetrical around central peak



- Operates upon signal energy
- Not perfect, but minimises errors

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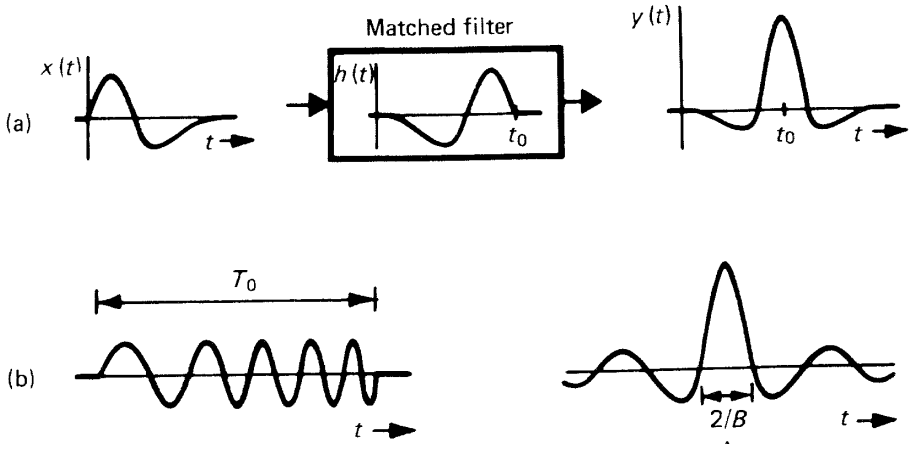
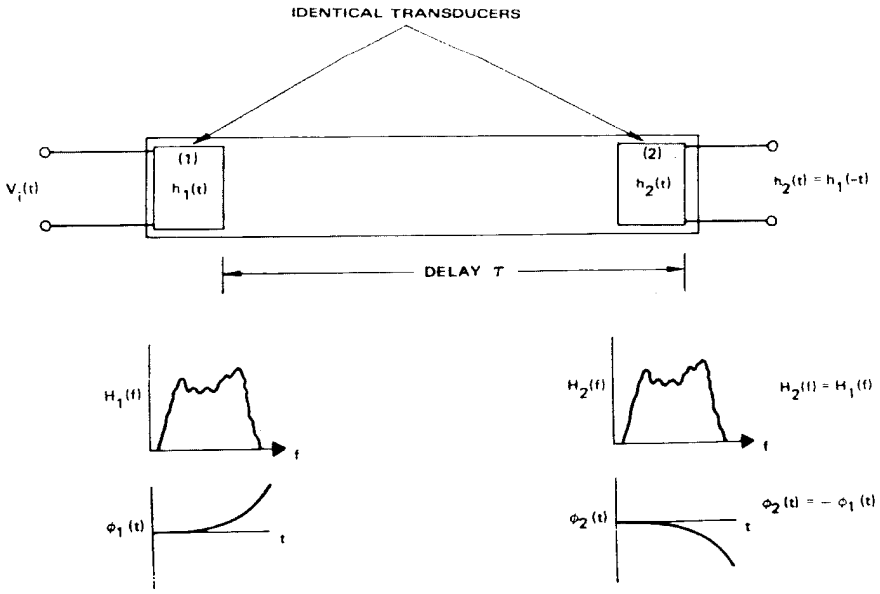
Pulse Compression

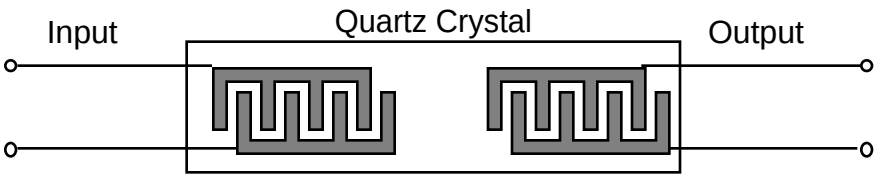
- very sensitive to filter design
- reduces average power
- use a Linear FM signal



Where does the SAW filter enter all this?

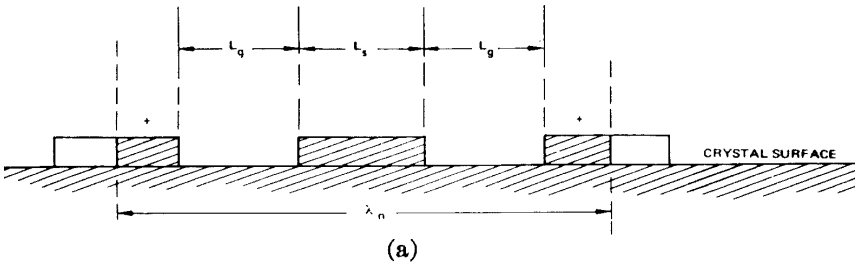


SAW Filter Implementation

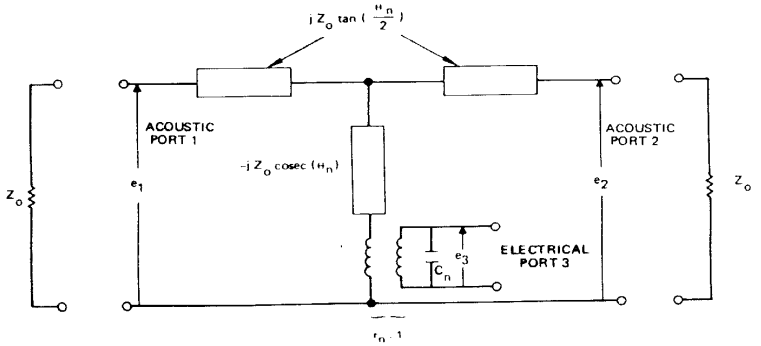


- resonance across the transducer permits selective gain adjustment
- dispersive delay lumps energy

The Mason Equivalent Circuit :



(a)

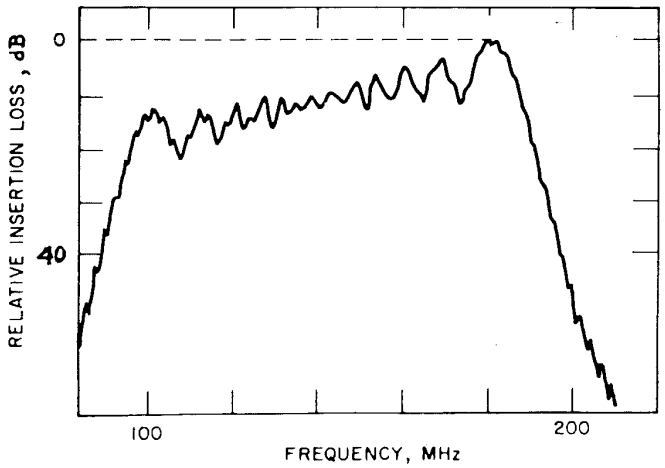


(b)

SAW Filter Characteristics

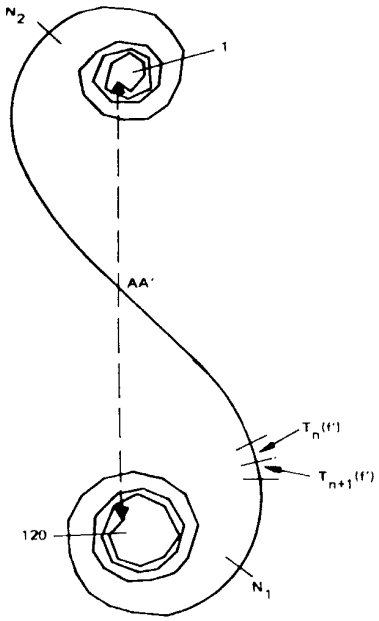
Frequency Response :

- $\Sigma \sin(x)/x$

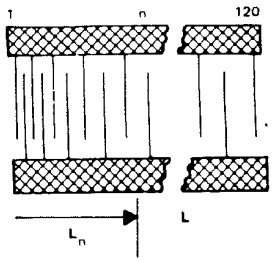


Cornu Spiral :

- Cosine Apodization
- Approximate by removing coils



Graded Profile SAW Filter :



SAW Filter Parameters

Bandwidth of Signal

- Determined by number of fingers

Inter-digit Spacing

- One digit required every π phase change (but see below)
- Determined by one quadratic equation per finger

Apodization

- Used to flatten frequency response
- Problems with diffraction
- Alternative : place fingers according to amplitude required rather than phase

Software Simulator

Data supplied by the User:

- input waveform equation
  (Linear FM; Delta Function)
- inter-digit separation equation
- SAW Filter Transfer Function
- apodization function(optional)

Systems generates (filter output):

- Amplitude Response
- Frequency Response
- Phase Response
- Cornu Spirals across a continuous spectrum

In addition to this:

- Input waveform time and frequency graphs

Design Issues

Forget Matlab - think Mathematica!

- Booch Object Design

Facilities:

- equation editor (display & evaluation)
- polynomial root finder
- equation database (hierarchic)
- operations database

Transformers:

- applies operations to equations
- outputs $\rightarrow$ displays | transformers

User-defined custom solutions:

- free-form design
- visually rich
- very flexible

Implementation Issues

Programming Language:

- C++

Algorithms required :

- Equation parser
- Equation evaluator
- FFT and iFFT algorithms
- Display Mapping Functions

Architecture:

- PowerMac
- 601 PowerPC
- Metrowerks Codewarrior 9 IDE

User Interface :

- Apple Guidelines - UI Standards
- Powerplant - GUI visualisation
- ResEdit - Resource structuring

Concluding Remarks

- current state of Project
- best-case conclusion for project

But, isn't this too ambitious?

- object design permits incremental development

Why hasn't more design been done to date?

- research > 20 papers and books
- conquering the subject!
- Booch methods studied in-depth
- 15 pages of draft project complete

Projected Timetable:

- design & begin implementation in the Christmas vacation
- experimental investigation term 2