Radio Frequency Filters

an overview
RF Filters - purposes

• To separate wanted from unwanted frequency-domain signals
  – E.g. Channel filter

• To suppress unwanted signals
  – Mixer output intermodulation products (2fc, 3fc, 2fc-flo, 3fc-2flo etc.)

• To suppress mixer image responses (e.g. at $f_{rf} + 2f_{lo}$)
Filter - functions

**High-pass Filter**
- **Ideal Response**
- **Practical Response**
- **Gain vs. Frequency**
- **Pass Band**
- **Stop Band**

**Low-pass Filter**
- **Ideal Response**
- **Practical Response**
- **Gain vs. Frequency**
- **Pass Band**
- **Stop Band**

**Frequency 1**
- **fL**

**Practical Response**
- **Gain vs. Frequency**
- **Gain** vs. **V in** vs. **V out**

**Ideal Response**
- **Gain vs. Frequency**
- **Gain** vs. **V in** vs. **V out**
Filter - functions

**Band-pass Filter**
- **Ideal Response**
- **Practical Response**

**Band-stop Filter**
- **Ideal Response**
- **Practical Response**

**Parameters:**
- **GAIN**
- **V in**
- **V out**
- **fL**
- **fC**
- **fH**
Filter terms

• Insertion Loss
• 3dB bandwidth
• Fractional (relative) bandwidth \( (f_{3dB}/f_c) \)
• Rejection frequencies

Figure 1: Illustration of RF Filter performance characteristics
Filter structures

- T-section
- PI-section
- Both high-pass filters (transform the branches to provide LP, BP etc.)
- Different termination impedances at DC (short, open)
Filter structures

- T-section
- PI-section
- Band pass filters
Filter design classes

- Choices to be made –
- Group delay distortion
- Cut-off rate
- All dependent on positioning of poles and zeros
Filter Implementation

• A huge variety of implementation techniques
• Mass production, low cost filters
  – Ceramic bulk resonators
  – SAW filters
  – Microstrip filters (above approx. 5GHz $f_c$)
• High performance filters (large)
  – Cavity filters
  – Interdigital filters
  – LC filters
Discrete LC filter

- LP or HP or BP?
Cavity filter

Figure 8: Helical filter structure
SAW Filter dimensions (tiny)
Microstrip Filter
Just for interest – a hobbyist’s 2-section low-pass LC filter
Diagrams in these notes are taken from the following sources, which are also recommended for further reading:

http://www.mpdigest.com/issue/Articles/2010/may/anatech/Default.asp an article on filter types