LF Network Analyzer
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What and Who Is AMRAD?

- AMRAD is the Amateur Radio Research and Development Corporation
- AMRAD develops technologies for amateur radio and functions much like a radio club
- AMRAD meets once a month locally
- AMRAD meets informally once a week on Saturdays at Tippy’s Taco House on Lee Highway at around 12:30
What Is AMRAD Doing for LF

- FCC has issued an NPRM for amateur LF allocation
- AMRAD has experimental license for LF
  - Part 5 license issued by FCC
  - Single frequency of 136.75 kHz
  - AMRAD has been operating under this license and learning about LF.
- AMRAD Developing LF Technology
  - LF Test Equipment for:
    - “The Well Equipped LF Laboratory”
LF Current Transformer Design

- Texts generally describe current transformers poorly
  - Assume short circuit across output
  - Neglect magnetizing current
  - Limits wideband use for accurate measurement
  - AMRAD developed more complete understanding of LF current transformer
Current Transformer
AMRAD Current Transformer Model

- Accounts for magnetization current
- Leads to more optimum design
- Use computer spreadsheet to optimize designs
- Suggests a simple approach to an impedance meter
  - Minimize sources of error on spreadsheet
LF Analyzer Concept

- Use current transformer to read load current
  - Current is measured as voltage
  - Phase angle measured between driving voltage and voltage from current transformer
- Meter reads load impedance magnitude and phase over a wide range
- Better than classic network analyzer or grid dip meter for the “Well Equipped LF Laboratory”
LF Analyzer Transformer

- Use coaxial test lead through core
  - Test current down center conductor
  - Confine stray currents back through shield
  - Current Transformer output magnitude only reflects actual load current
- Minimize phase shift in transformer
  - Current transformer output phase accurately reflects voltage and current phase relationship
Network Analyzer Transformer
Implementing LF Analyzer

Option 1
✓ USE DDS for signal source
✓ Use Logamp to measure signal amplitudes
✓ Control DDS and read logamp signal with microprocessor

Option 2
✓ Use DDS for signal source
✓ Use second DDS and DBMs with IF amps and digital attenuators to read signal levels
✓ Use microprocessor to control DDSes and attenuators
✓ In both cases, use PC to control and report results
LF Analyzer Utility

✓ LF Measurement Swiss Army Knife
✓ Wider Z range than classic network analyzer
  ✓ Coil inductance and Q
  ✓ Antenna impedance before tuning
  ✓ Quartz crystal impedance
  ✓ Capacitance
  ✓ Amplifier input impedance
  ✓ RF transformer impedance
Initial Tests

- Current transformer can be made to cover 10 kHz to 16 MHz with low residual errors
- Inexpensive logamps can cover 60 dB with magnitude errors less than 1 dB
- LF current transformer design seems to center on 1 amp = 1 volt.
  - Large excursions present too much error
- Testing with voltmeters on both E and I channels suggests impedance magnitude could be expressed in dB re: 1 ohm
Transformer Design

✓ FT-50-75 Core, permeability of 5000
✓ Primary: 1 turn, brass tubing with coaxial wire
✓ Secondary: 25 turns #30 wire wrap wire
✓ Secondary termination: 50 ohms
✓ Shielding to concentrate stray capacitance to “guard” terminal only
Conclusion

✓ LF Network Analyzer based on a wideband current transformer can be made to cover a wide range of impedances
✓ Use of DDS and microprocessor control can simplify use, measurements and error corrections
✓ Use simple version as VSWR meter alternative