LF Network Analyzer

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AMRAD

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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

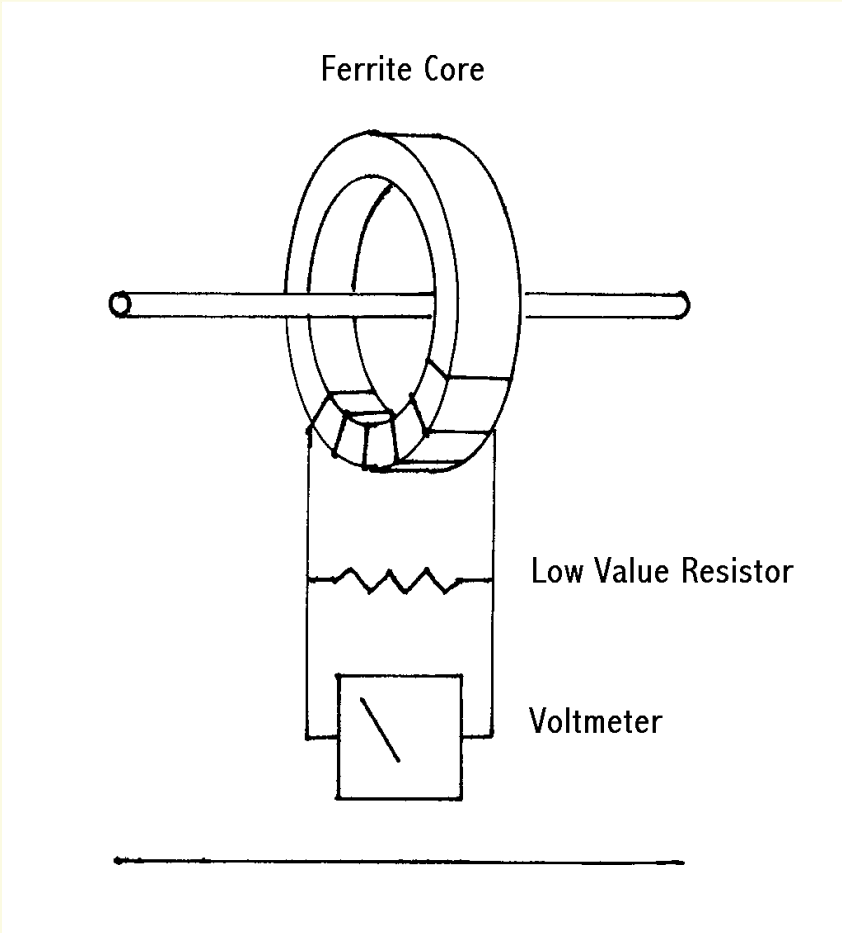
- FCC has issued an NPRM for amateur LF allocation
- AMRAD has experimental license for LF
  - Part 5 license issued by FCC
  - Single frequency of 136.75 kHz
  - AMRAD has been operating under this license and learning about LF.
- AMRAD Developing LF Technology
  - LF Test Equipment for:

“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

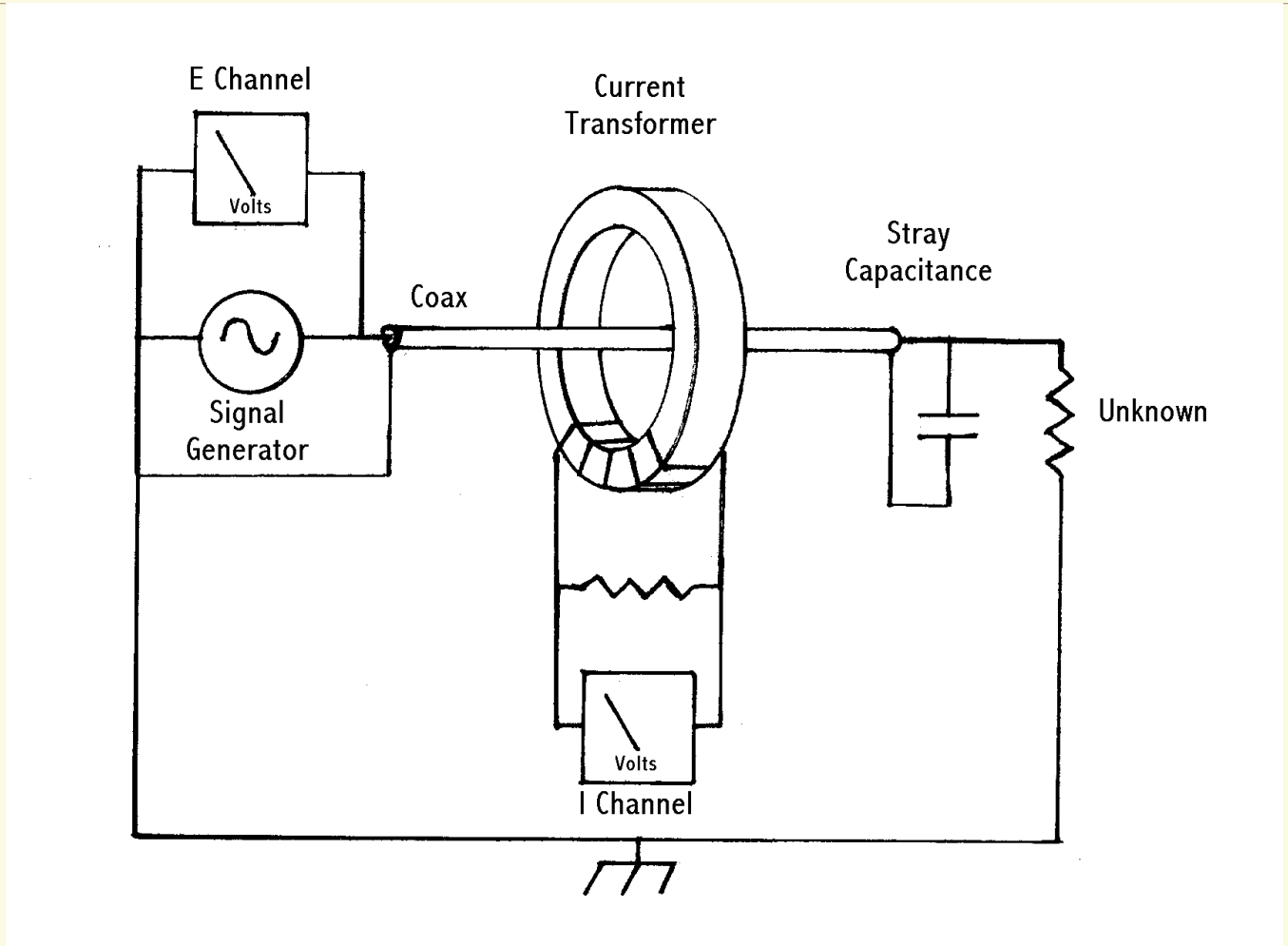
- Use current transformer to read load current
  - Current is measured as voltage
  - Phase angle measured between driving voltage and voltage from current transformer
- Meter reads load impedance magnitude and phase over a wide range
- Better than classic network analyzer or grid dip meter for the

“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