Development of a Tera-Hertz Reflectometry-Based System

Presented to:

The Aging Transport Systems Rulemaking Advisory Committee (ATSRAC)

Presented by:

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Presentation Outline

- History and Program Description — R. Hall
  - Related R&D
  - Technical Approach
  - Anticipated Outcome

- Technical Review — U. von Wimmersperg
  - Why Tera-Hertz Radiation
  - Research Issues and Status
    - material properties
    - generation & coupling
    - detection and noise

- Discussion — All

Related R&D

- Programs supporting electrical system aging phenomena for 18 years
- Wire degradation studies for the past 10 years
- FAA Tera Hertz project funded September 2001
- Study on critical infrastructure (power, telecommunication & cyber) to start August 2002

A Partnership …

Airbus, United Airlines, QED Consulting

The Approach

Goal: To develop a robust, non-destructive, non-intrusive technique capable of detecting and trending early signs of wire insulation degradation

- **Generate tunable beam via the National Synchrotron Light Source and also a Backward Wave Oscillator.**
- **Investigate material characteristics at high frequency.**
- **Determine best options for Tera-Hertz reflectometry.**

The Approach (cont'd)

- Test a proof of principle system.
- Design a practical instrument.
- Move to commercialization.

Fast Track Scheduled – September 2003

Anticipated Outcome

(Remember – this is a research project)

- A monitoring system suitable for ground and in-flight corrective/preventive maintenance applications
- "Prototype" and design specifications
- Commercializer selection and roadmap
- Basic understanding of materials at Tera-Hertz frequencies

Why Tera Hertz Radiation?

Task: **Reveal hidden damage in wire insulation, but do not CAUSE hidden damage**

- **Excess voltage tests ruled out**
- **Conductor tests irrelevant**

Method: **Propagate signal within the insulation itself and observe reflections from discontinuities**

- **Use high frequency signal to expel current from conductor**
- **Suppress radiative propagation** $f^3 c/nd$

Material Properties

Problem: **Data in THz regime are largely unknown**

- **Determine properties (absorption, refractive index, dispersion) by actual measurement as a function of frequency**

Method: **Use FIR spectrometer at NSLS**

- **Optical wave guide containing bulk insulator medium**
- **Integrate bolometer against electron current**

Generation and Coupling

Need: **Tunable, pulsed THz source required; should be small, light, robust and reliable, cheap.**

→ **mission slightly impossible**

Options: **Synchrotron radiation, backward wave oscillator, optical rectification, other?**

→ **work in parallel : HAS to be practical**

Generation and Coupling (contd.)

Coupling: **Interface between electrical and optical phenomena can be used in a variety of ways to launch and retrieve Goubau waves (4-pole directional coupling, TIR cylindrical optics).**

→ **choose coupling suited to generation method**

Detection and Noise

Problem: **Preferential amplification of Fourier envelope of frequencies; signal to noise at a premium after dielectric absorption**

→ **conventional mixing techniques difficult to adapt**

Possible Solution: **PRF coding**

→ **gated and triggered oscillator GATO**

→ **lock in to pulse spacing**

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