EMBEDDED PASSIVE TAGS TOWARDS INTRINSICALLY LOCATABLE BURIED PLASTIC MATERIALS

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MAIN OBJECTIVE

Pipeline is considered as one of the safest means of transportation. However, there are still risks of incident that can occur due to natural and man made events especially for plastic pipes.
Accurate and reliable locating, identifying and characterizing the buried plastic pipes from ground surface can reduce the likelihood of happening such event.

- Design and development of passive harmonic radar RF tags.
- Investigate on-tag sensing capabilities and efficient data transmission.
- RF tag must be able to withstand high temperature processing of plastic and stress involved with horizontal tunneling/drilling of buried pipes.
- Develop a learning based pipeline hazardous prognostics methodology using discrete sensing data.

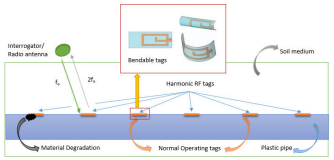


Fig.1 Bendable RF tags embedded on plastic pipe

PROJECT APPROACH/ SCOPE

- A new harmonic radar (frequency doubling) RF tags can be embedded on the buried plastic pipes.
- The low-cost, small and efficient passive RF tags are highly sensitive to their surroundings as well as detectable from ground surface. It helps reduce clutter.
- The tag response can be translated into location, identification and characterization of the buried plastic pipe.

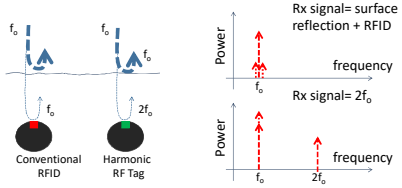


Fig.2 Harmonic radar frequency doubling

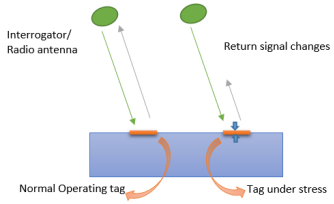
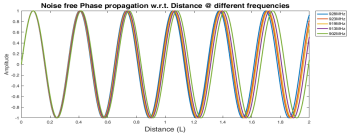
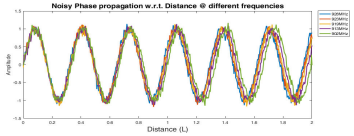


Fig.3 On-tag sensing capabilities

- The passive tag has a very long lifespan. With the modern day technology and in right environmental conditions a tag can last for a decade or more.
- The harmonic radar approach eliminates the reflection interference from different objects and cross-coupling between integrators.
- The burial depth of the tag can be computed by extracting phase from the harmonic signal.
- The transmission of signal at few different frequencies gives a linear phase shift in a linear medium, which could be used to calculate the distance from the source. Time gating can also be used.
- Various experiments and simulations of frequency response with soil medium needs to be performed in order to select the operating frequency band.





FREQUENCY	NOISE FREE PHASE	NOISY PHASE
928-MHZ	67.2°	63.94°
923-MHZ	54.84°	52.27°
919-MHZ	46.0°	47.32°
913-MHZ	30.83°	33.23°
902-MHZ	4.8°	1.28°

g.4 Signal phase @ different frequencies

- A few common reasons for failure of any buried plastic pipes are: material degradation, leakage, assembly defects and impingement.
- The response from tag could vary in accordance to the above mentioned failure reasons or may not respond due to any serious condition.

RESULTS TO DATE

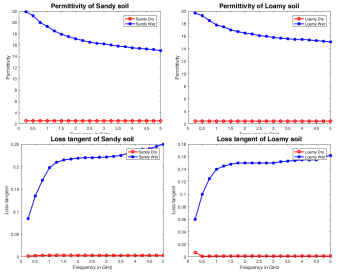


Fig.5 Frequency vs dielectric permittivity and loss tangent in dry and wet conditions

- A few common soil types have been studied to understand the electromagnetic behavior. Soil is the mixture of different minerals, organic matter, liquid and many more different thing whose concentration continuously changes with the change in location, depending upon the weather conditions or human involvements.
- The tracking operation in dry environment is way more easier than wet conditions. The increase in frequency, conductivity and loss factor also increases dispersion.
- A simulation of power transmission is performed using COMSOL. The relative permittivity (2) and conductivity (0.002 S/m) are set for dry conditions.

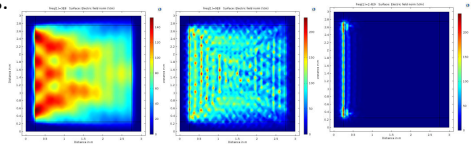


Fig.6 Field strength vs Distance for 0.3, 0.9 and 2.4 GHz

- The passive harmonic RF tag is designed based on a double slot antenna.
- A new harmonic radar (frequency doubling) RF tags can be embedded on the buried plastic pipes.

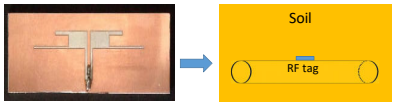


Fig.7 2.5 & 5 GHz RF tag design

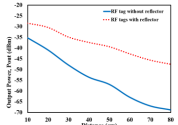


Fig.8 Output vs Distance at 2.5 GHz

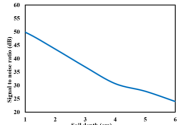


Fig.9 SNR vs Depth

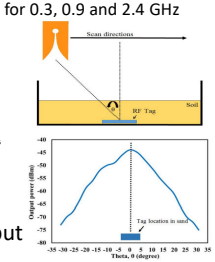


Fig.10 Tag detection along axis

- The field strength and SNR falls off with distance shown in Fig. 8 and Fig. 9.
- The buried tag is located by interrogator with a very low received power but the receiving antenna has acceptable signal-to-noise ratio.
- The experiment of second harmonic power reception at different moisture levels, confirms the previous statement.

Fig.11 5-ft long container for experiments and 915 MHz T_xR_x with tags

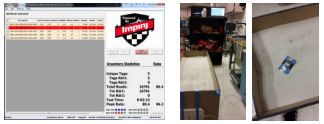


Fig.12 Identified tags at 5-ft depth

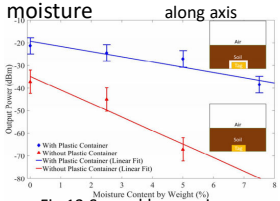


Fig.13 Second harmonic power vs moisture at 2.5 GHz

Acknowledgements

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References

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Public Project Page

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