Measuring Coupled Signals on Active Ship-Based Communication Systems

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***Abstract*—Ships present a unique challenge for measuring the amount of coupled energy to a communication system. This paper proposes a coupled energy measurement system that takes into account multiple networked communication systems, limited space, and non-invasive requirements to make a ship-based communication system easier to study. The proposed measurement system would be mobile, non-invasive, and allow for multiple systems to be measured in unison**

I. Introduction

Signal integrity is an important component of any RF communication system. One of the most common reasons for poor signal integrity is other sources of interfering RF energy in the environment, which can couple energy onto the system. This extra coupled energy can be measured by recording current state of the communication system, then noting the difference while the unwanted RF emissions are active. Based upon the measurements, RF front end protection can be added to lessen negative effects to signal integrity.

In most communication systems, taking the unwanted signal emissions measurements is simple, but ship-based scenarios bear more consideration. When measuring coupled emissions aboard a ship there are three major considerations that need to be made:

- There are several types of communication systems which all need to be measured.
- The systems are built into the ship and any form of invasive measurement is highly discouraged.
- Getting equipment onto a ship is difficult, especially when the ship is away from land.

These three ship based considerations necessitate a special mobile measurement system be built. This mobile system needs to be sensitive enough to measure the coupled emissions, be non-invasive to the communication systems, and be small and mobile enough to be moved into small spaces. It is also desirable if the system has the ability to measure multiple communication systems simultaneously, for time efficiency.

This paper proposes a system that can meet all the considerations for ship-based coupled emission measurement. The focus will be on the need for a custom cable sensor that can be used in any tight space, but has the ability to capture the samples necessary to determine the front end RF protection needed to reduce the effects to signal integrity.

II. System Components

The coupled emissions measurement system will require four subsystems. These subsystem components are a non-invasive RF cable sensor, sampling recording equipment, a data storage system, and network creation.

The non-invasive RF cable sensor is a critical part of this proposed system. This sensor needs to be small, mobile, and have the ability to capture the needed data at low possible power levels. A possible approach would be a current sensor attached to a spectrum analyzer. This approach would allow for all the data needed to be captured. However, the spectrum analyzer is expensive, and has a small number of inputs. Furthermore, there must be some sort of cable connecting the current sensor to the spectrum analyzer, creating an issue with wire management. The spectrum analyzer will also take far more samples then required to detect an issue for RF front end protection.

A more innovative approach would be to create a current sensor that can work without having to physically connect to the data collection system. One could look at how wireless AC power monitoring systems work. These systems have a passive system that is powered by the constant AC source on the wires; the sensor then samples and sends the information to a collection base station [1]. In the case of RF communication systems, a constant power level can not be relied upon, therefore a way to power the sensor is needed. The wireless current sensor must be designed with battery and power efficiency in mind.

With the current sensor consideration detailed above, it seems best to think of a system that can uses as little power as possible. The current sensor will consist of an inductive loop current sensor probe [2], a local oscillator and mixer attached to wireless network chip which is powered by small D cell batteries. The analog output from the current sensor probe will be overplayed onto the carrier wave frequency of the wireless network. The network chip could be as simple as a Zigbee card allowing for automatic peer-to-network setup of several wireless current sensors. This setup would move the burden of computation from the sensor to the wireless collection node and allow for the low power requirements.

An approach that would reduce energy use in the wireless measurement device is to have it controlled by the local collection hub. Instead of the sensor working autonomously with the

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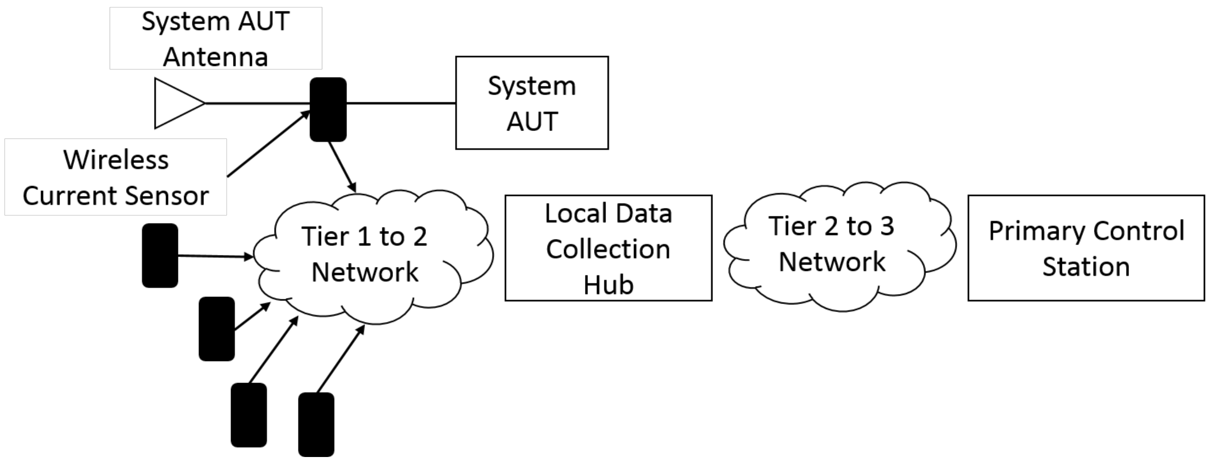

Fig. 1. Proposed coupled energy measurement system for ship based communication system study.

use of a network card, the sensor could have a control system that is triggered based on the signal it receives. The sensor on and off state and level of measurement activity would all be controlled allowing for energy saving configurations to be implemented.

The wireless sensor setup could also include a secondary unit, in order to add controllable coupled energy to the communication system cables. Instead of measuring the coupled energy from an unknown RF source a secondary wireless unit could couple coded pulses on the cables being measured. The pulses would be coded and then a code division multiple access (CDMA) protocol could be used to organize the returns for each of the wireless couple energy measurement devices. The coded pulses and a CDMA protocol would lead to a coupled measurement system that has increased accuracy.

Determining if RF front end protection is necessary is based on the level of the outside source. Therefore, the sampling and recording component of the system needs only enough samples to be able to reproduce a level of interference to the communication system being analyzed. This number of samples is relatively low and could be accomplished with a universal software radio peripheral (USRP). The USRP would then be connected to the wireless network and take samples of the incoming signals from several wireless current sensor devices. Due to the low sampling requirements of the data, more current sensors could be connected than allowed by a spectrum analyzer.

The data storage is a question of how many layers to the wireless network would be acceptable and how expensive certain components should be. We propose a third tier to the wireless network that would be the control and data storage center for the measurement system. This third tier will have the most power requirements do to the higher levels of data flow and computation required to control the network. However, it is feasible that such a device can be placed on the deck of the ship during data collection.

The wireless network for the measurement system must work well in a environment that has high scattering conditions, due to the metallic construction of some ships which results in scattering the transmitted and received signals. Moreover, these environments vary based on the state of bulkhead doors and other movable equipment. This causes signal collection for networks without a large amount of redundancy or signal reconstruction to be less considerable. There are several papers that discuss the capabilites of wireless networks below deck in ships, with the current ones focusing on current communication practices similar to [3]. With current network practices in mind, an OFDM system with the CDMA sensors could possible overcome the ship-based networking problems.

A basic flowgraph of the proposed measurement system can be seen in Fig. 1. The figure shows the tiers of the network that would exist and how the data transfer paths.

III. Conclusion

This paper proposes a coupled energy measurement system that would make ship based communication system easier to study. The proposed measurement system would be mobile, non-invasive, and allow for multiple system to be measured in unison. This system has not been built and tested yet, which would be the next steps in the research and implementation process. Future work would also need to focus on the creation of ways to increase the accuracy of measurements and increasing the battery life of the wireless current sensor.

References

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