A Fiber Optic Wind Vane: A Conceptual View

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Introduction

The use of tall towers for the normal operation of meteorological instrumentation is ideal for ensuring that representative measurements are obtained relative to the nearby terrain. Tall towers also expose instrumentation to unwanted environmental "side-effects" such as lightning surges. The proximity of many industrial observation sites for meteorological towers also introduces unwanted problems including radio frequency interference (RFI) from radio, television, or microwave transmitters, explosive environments, and electrical power cabling. Typical meteorological instrumentation systems incorporate protective mechanisms such as grounding networks, surge protectors and electrical shielding to combat electrical problems. Still, even with elaborate protective systems, damages to instrumentation and a loss of valid data can occur which often results in extended outages.

The use of fiber optic technology in meteorological instrumentation holds great promise to eliminate many of the problems associated with monitoring on tall towers. A fiber optic sensor would be impervious to lightning surges and all forms of RFI. The sensor would provide a high signal to noise ratio output since little or no electrical interference would be involved in data transmission. A longer field life for mechanical devices such as a wind vane would be realized since all physical contact points, such as those found in a potentiometer, would be eliminated. Therefore, the precision, resolution, linearity, starting threshold and accuracy could be dramatically improved without the hindrance of moving parts.

Rationale and Need: Two Viewpoints

Both Met One Instruments, Inc. and Westinghouse Savannah River Company have similar views pertaining to the need for the development of a fiber optic based wind vane. The manner in which the two companies developed these views are somewhat different, however. In the end, the two companies have teamed together to attain the common goal of creating a fiber optic wind vane.

Met One

The potential gains from a fiber optic wind direction sensor are headed by the opportunity for unsurpassed accuracy. With a 9-bit optical encoder, direction can be measured to ±0.7° compared to ±3° for a potentiometer. This amounts to an increase of 4 times the typical wind direction sensor accuracy.

The ability to isolate sensitive opto-electronic components to an enclosure totally protected from harsh environments will considerably increase the ruggedness of the sensor. Fiber optic signals can be transmitted over long distances without concern for ground potential. Susceptibility to vibration and shock of the sensor as well as high ambient temperatures can be reduced during an appropriate robust manufacturing process.

Initially, the cost of a fiber optic wind direction sensor will be relatively high due to increased manufacturing costs. Therefore, the targeted customers will be companies or institutions seeking a very accurate sensor or having an application for monitoring in a harsh environment.

Westinghouse Savannah River Company (WSRC)

In the mid-1960's, meteorological instrumentation was installed (Parker and Addis, 1993) on a 1,200 ft television tower located near the Savannah River Site (previously known as the Savannah River Plant) to conduct a study of proposed tall reactor stacks. This meteorological monitoring system has remained in-use since then although several upgrades have occurred. A network of nine meteorological observation towers have also been installed within the confines of the Savannah River Site. In all cases, damages from lightning occur despite robust grounding systems. RFI at the television tower has long been a hindrance particularly to measurements taken near a local radio station transmitter. The use of fiber optic technology would be very beneficial in eliminating these problems.

Cooperative Research and Development Agreement

A Cooperative Research and Development Agreement (CRADA) between Met One Instruments and WSRC was created to build and test a fiber optic measurement based wind vane. This CRADA was enacted after discussions during a previous CRADA between Met One and WSRC to develop an aerodynamically improved wind vane revealed that a mutual interest in a fiber optic sensor was in place. The agreement was originally scheduled to cover about ten months, but an extension for an additional 9 months was implemented.

The essential plan called for Met One to build the prototype sensor and for WSRC to test the prototype in a wind tunnel and in the field. Collaboration during the entire development process has occurred.

Conceptual Plan: Development in Progress

The completion of this CRADA is not planned until September, 1996. However, at this time a conceptual plan for the project can be provided. Details for some of the components of the plan are purposely missing since the final product and report must be reviewed and approved by both Met One and WSRC before the dissemination of information is allowed as stated by the CRADA contract.

Figure 1 shows a schematic of the fiber optic wind vane measurement process. A light source is located in a nearby data building structure. Light travels through fiber optic cabling to the wind vane sensor. The vane's orientation is encoded into a light signal which travels from the wind vane via fiber optic cabling back to the data building. The light signal is converted into a digital signal (analog to digital), and the digital signal is conditioned through a logic module. The final output indicates the orientation of the wind vane.

To date, an instrument prototype has been conceived. This prototype is expected to be combined with the fiber optic cabling to produce a working fiber optic sensor. Also, a method of reducing the number of fiber optic cables from a multiple number to single fiber (Figure 2) has been submitted as an invention disclosure. Reducing the number of fibers would simplify installation and lower costs for the fiber optic wind vane. "Ruggedization" of the sensor and fibers will be a primary concern for developing a commercially viable sensor. Proper connectors for the sensor will also have to be adapted.

Path Forward

After a prototype is built by Met One, operational testing can be conducted. A wind tunnel dedicated to meteorological instrument testing and calibration is operated by WSRC. Measurements of the damping ratio, starting threshold, and distance constant will be made. Also, tests of the absolute and relative accuracy can be made. Field tests in an electromagnetically active environment will be made at the WSRC television tower meteorological monitoring facility.

A final report will be written at the end of the CRADA. If appropriate, results of the CRADA will be presented and published within meteorological venues. Approval of the final report will be made by Met One, WSRC, and the US Department of Energy.

Acknowledgments

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References

Parker, M. J. and R. P. Addis : 1993. Meteorological Monitoring Program (U). WSRC-TR-93-0106. Savannah River Technology Center, Westinghouse Savannah River Company, Aiken, SC 29808.

Conceptual View of the Fiber Optic Wind Vane

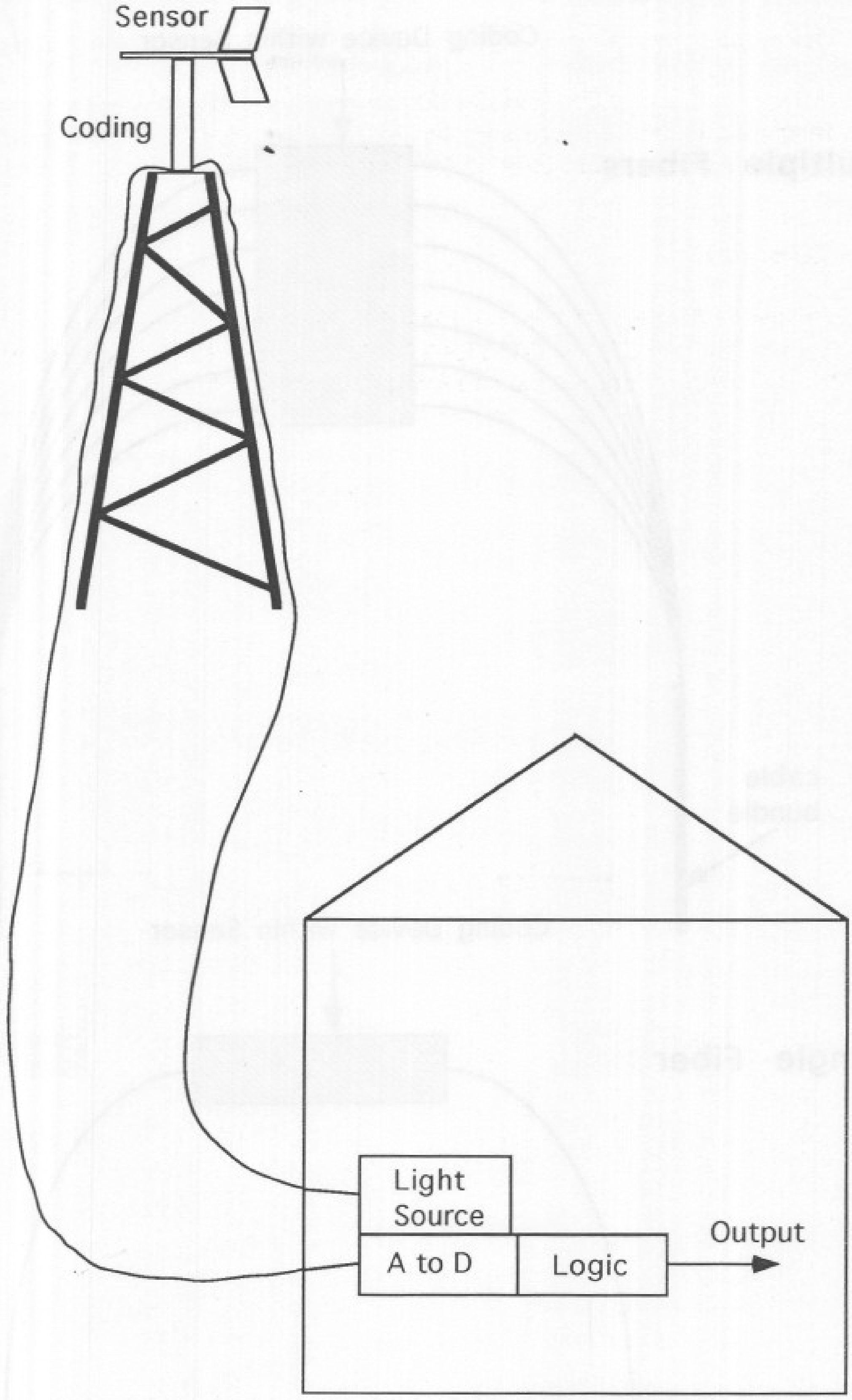

Figure 1. Schematic of the concept of the fiber optic wind vane.

Reducing the Number of Fiber Optic Cables

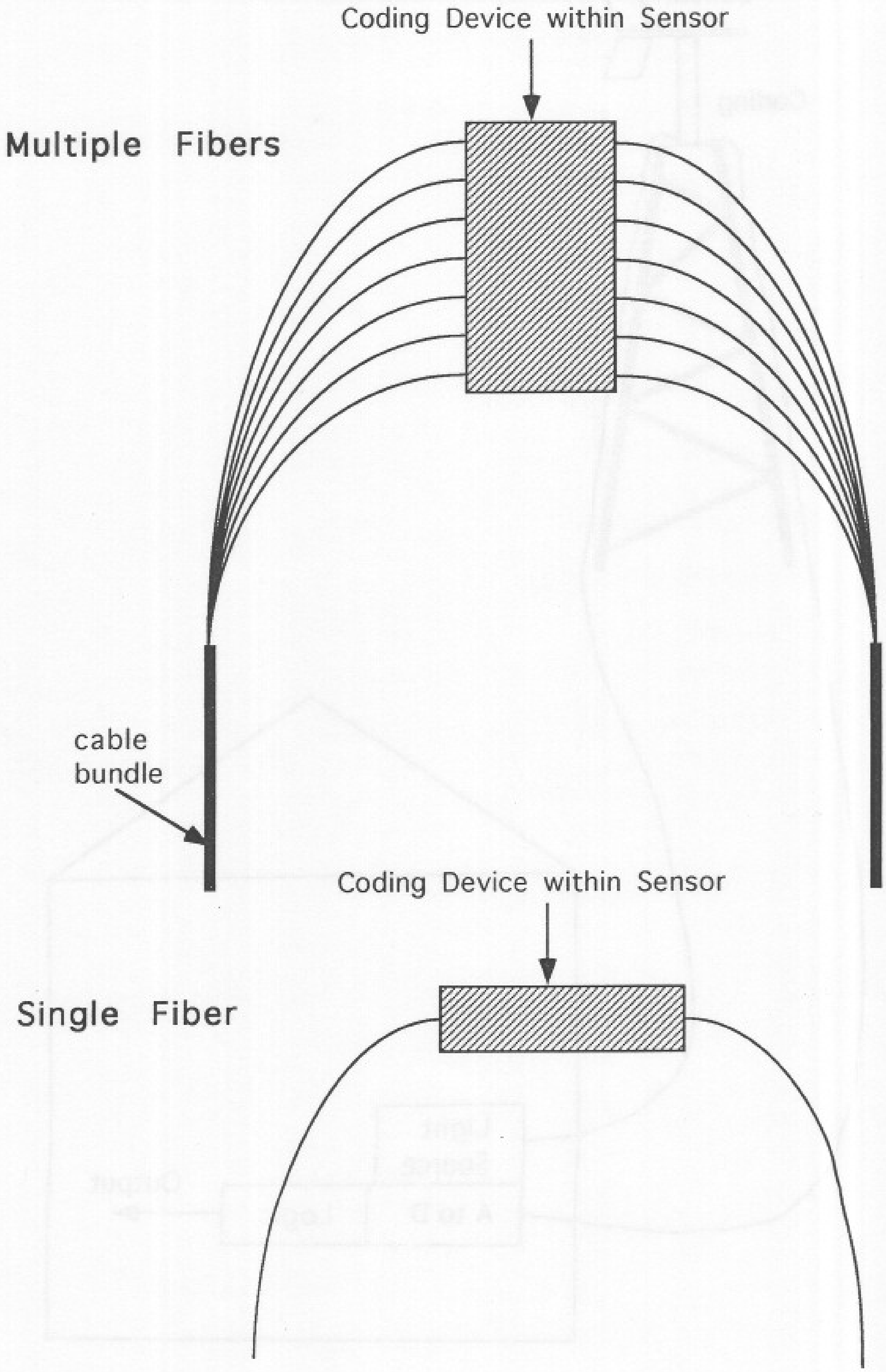

Figure 2. Method of reducing fiber optic cables from multiple to single.