INSTRUMENTATION SYSTEM FOR MONITORING WIND SPEED, DIRECTION AND STRUCTURAL RESPONSE

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INTRODUCTION

Long term environmental monitoring of wind direction strength and resultant structural response has always provided a challenge to the system engineer. After involvement with two extended monitoring projects Refs.[1,2] and the proposal for a third, it was decided to design and construct a new monitoring system with the flexibility to adapt to several remote sites. This system is required to operate over extended periods in an aggressive environment ie. high levels of radio frequency radiation and may be subject to sub-zero temperatures while only providing limited access for installation and maintenance. With this in mind it was decided to design a modular system which could support up to six anemometers with two accelerometers associated with each, located over distances up to 500 meters.

Modular design provides several advantages including flexibility in layout and capacity. It also provides a system with inbuilt redundancy, improving the operational probability, by reducing the extent of lightning damage. The system configuration is shown in Figure 1. A maximum of 6 interface modules provide analog to digital conversion and power for the transducers, digital data is transmitted to a central multiplexer unit which combines data onto one twisted pair cable. This data is transmitted to a base computer which controls operation of the system.

It is possible to alter system configuration to suit different requirements ie. the use of one or two interface modules connected directly to a base computer, provides the minimum system, maximum topography would be several groups of 6 interface modules connected to two multiplexer modules which are connected by two cables to a base computer.

INTERFACE BLOCK

This interface module will be located at the furthest point from the system base, and provides an interface to the measurement transducers, in this case anemometers and accelerometers which will be located within 5 meters of the interface block and powered from the block.

The design aims of this module were to provide analog to digital conversion of transducer output and transmit this as a digital data stream to the data multiplexer, while providing spare capacity and inbuilt flexibility. This is important as system requirements will vary.

The function is to sample all eight channels at an appropriate gain, 40 times per second. Although eight channels cannot be sampled simultaneously there is only 100 micro seconds delay between each sample. However because there is a 25ms delay between each set of samples, it is necessary to synchronize the sampling period of all interface blocks. This is achieved by sending a synchronization signal simultaneously to all interface blocks.

The 12 bit digital data is transmitted in two bytes, channel 0 is always labelled with a unique code to designate the start of a data set. There is no explicit time stamping of the data. Data is transmitted to a multiplexer module through an optically isolated twisted pair at 9600 baud.

MULTIPLEXER MODULE

This module [Figure 3] takes the output from up to 6 interface modules and multiplexes the output into a data stream transmitted to the base station. While the system will function without any of the interface modules, this module must be functional for operation.

Data is packaged into sets taken at the same time. A control program determines which interface module data is used, for example data from accelerometers may require the full 40 samples a second while wind speed and direction outputs require only 5 samples a second due to their slower response.

BASE STATION

The base computer serves three functions, firstly monitoring of incoming data and storage of data when appropriate, secondly to provide real time display of data being sampled and lastly to provide communications with a distant site over the telecom switched network.

The base computer consists of an IBM 80386 compatible with 100 megabyte hard disk. Data is received as a serial data stream at 54000 baud through an optically isolated data line. This data stream is decoded and the channels are monitored for appropriate levels, when these levels are detected all data is logged to the hard disk for a period of between 1 and 15 minutes. (the 15 minute file will be approximately 2.5 megabytes).

A modem connects the computer by phone line to a control site from where parameters can be set and data can be transferred from the remote site. Interaction from the control site is only required on an infrequent basis, ie to transfer any data files, or to change trigger parameters.

Software to control the operation of the base computer will be similar to that used in previous data logging systems, it will be re-written and expanded in its real time display capability. Wind speed and direction is displayed with a graph of accelerometer response. Real time display simplifies system set-up and calibration and provides a visual check of system integrity.

POWER SUPPLY

While some installations have distributed 240 VAC power, most will not. A separate power supply is required for modules distributed over a distance up to 500 meters, this supply can be powered from either 240 VAC or if required a Lower voltage DC supply.

A primary consideration is the susceptibility to lightning damage through the distributed power supply. By using an AC power supply [Figure 4] it is possible to provide 4 Kvolt isolation at each module using a transformer, 20 Khz supply frequency allows the use of small transformers which operate above the audible frequency range. A 70 volt distribution line does not present electrical safety problems, while currents are not excessive.

Each module is linked to the 70 volt line by a small transformer which provides three lower secondary voltages, these are rectified and regulated to the required voltages. Lightning protection is provided on the main 70 volt line as shown in figure 4, Any surge in line voltage due to lightning strike is passed to ground by a gas arrester, while the metal oxide varistors provides improved response to a fast rising surge.

LIGHTNING PROTECTION

Of all the environmental risks to the data acquisition system, lightning is the most severe. With the high energies involved in a lightning strike it is practically impossible to prevent damage, rather the aim is to limit damage to the immediate module, which will usually be the interface module with exposed anemometers. All data lines are optically isolated and protected with surge arresters. The power supply system must be carefully protected to prevent damage to the entire installation, as it is connected to every module. While being connected by a 4 Kvolt isolation transformer,this can only limit current and disturbance rise time. Additional protection is provided by gas filled surge arresters (SPV) and metal oxide varistors (SIOV), a fusible link is provided after the gas arrester in an attempt to reduce the frequency of damage. Further protection is provided on the module side of the transformer using zener diodes which provide a series of protection devices to prevent damage through the power system.

CONCLUSION

The data logging equipment being developed will provide a flexible system for field data acquisition. This is a complex system requiring significant development, but will provide features not available in commercial equipment, ie. sampling rate, lightning protection and operation in areas of high radio frequency field strength.

REFERENCES

1 Macindoe L.C., Stevens T.J., Holmes J.D., Banks R.W. 'Measurement and Analysis of the Response of a Large Antenna System to Wind Loads'
Second National Structural Engineering Conf., Adelaide 3-5 October 1990, pp.115-119

2 Holmes J.D., Glass T., Cook B.W., Schafer B.L., Banks R.W. 'The Dynamic Characteristics and Response to Wind of Tall Free-standing Lattice Towers'
Second National Structural Engineering Conf., Adelaide 3-5 October 1990, pp.19-22

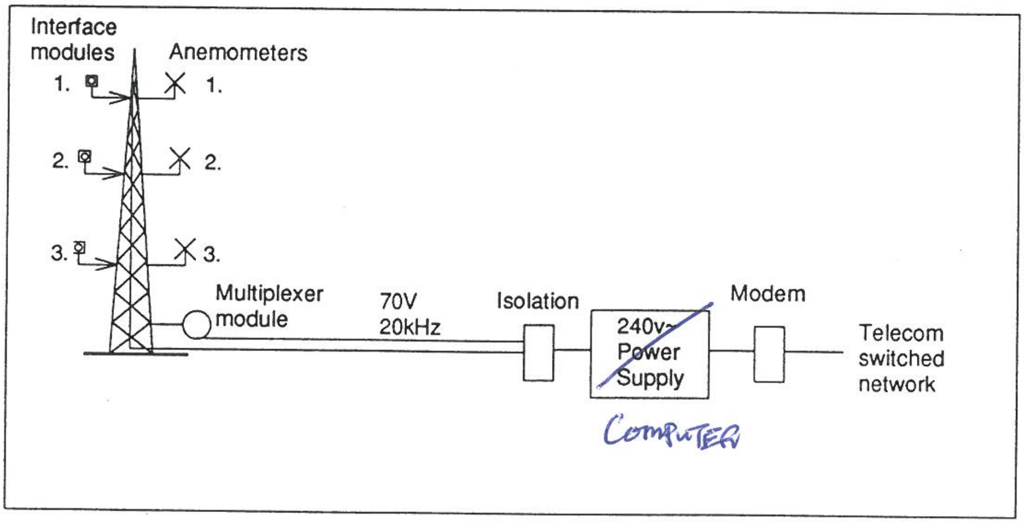

Figure 1

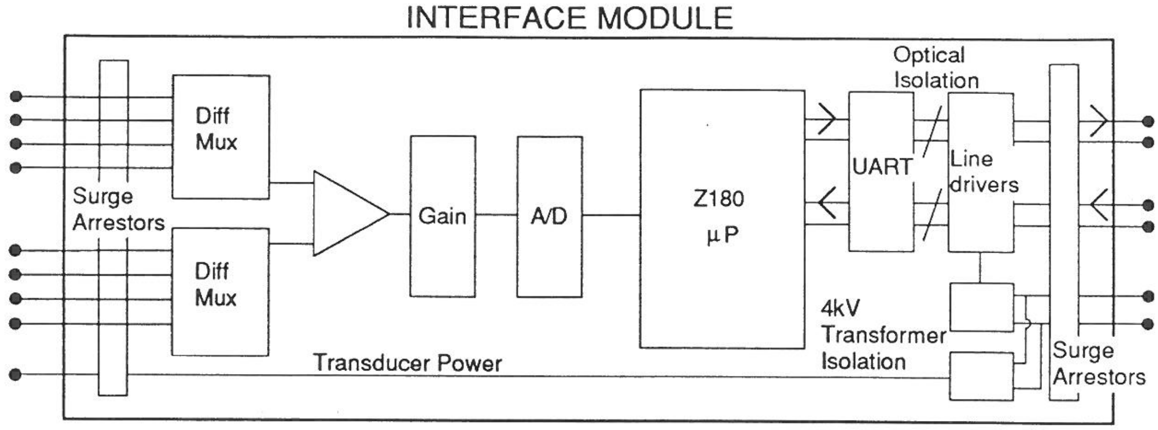

Figure 2

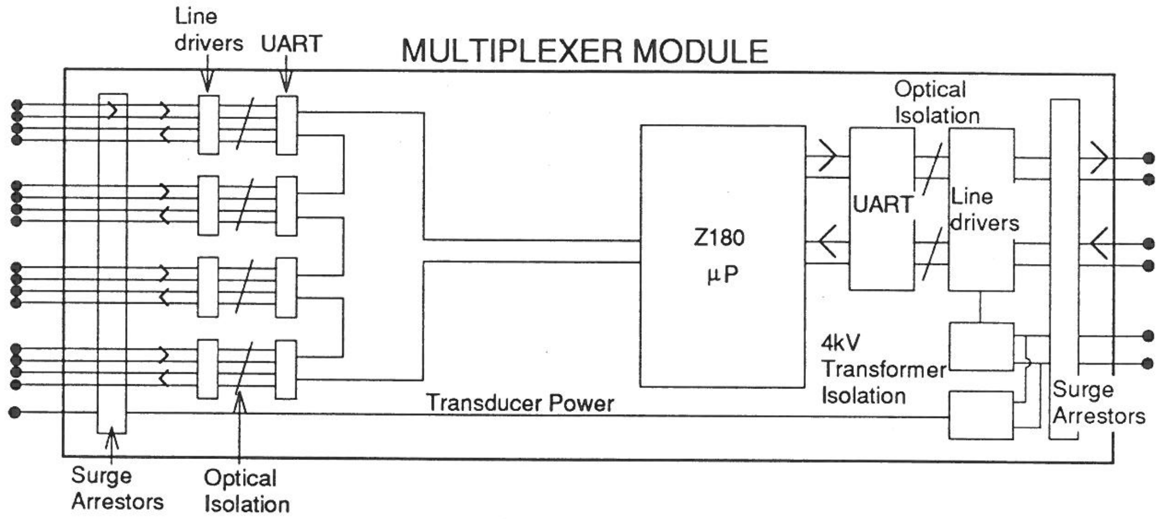

Figure 3

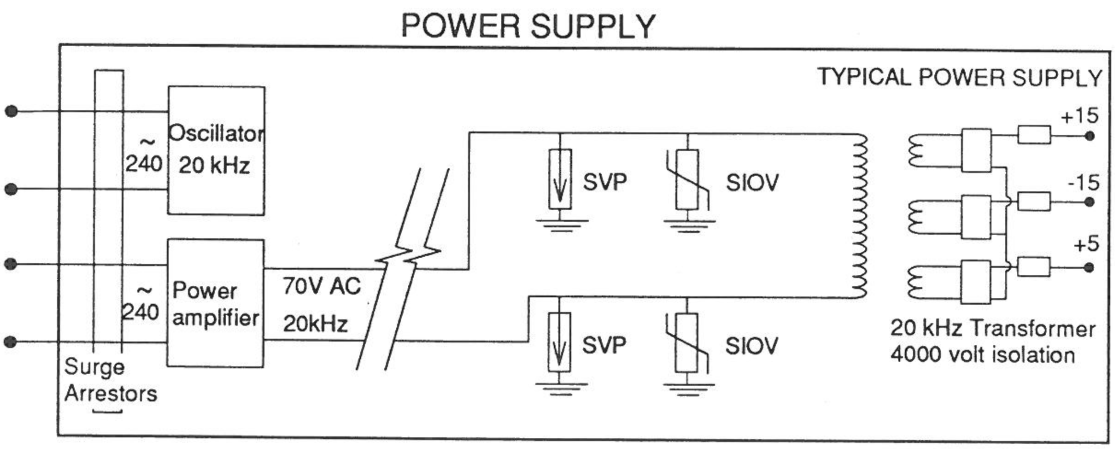

Figure 4