UPDATING METEOROLOGICAL DATA COLLECTION
SYSTEMS AT REGULATED FACILITIES

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Abstract

All nuclear power plants, material processing facilities, and other NRC-regulated facilities have meteorological monitoring systems used in their safety and emergency preparedness programs. Most of these systems were designed, fabricated, and installed years ago when the facilities were first constructed.

Advances in electronic data collection over the past decade allow today's facility operator to improve system performance, accuracy, and reliability by upgrading the data collection portion of the meteorological monitoring system. Specific examples of these upgrades are noted.

1. Introduction

Safety regulations governing nuclear power plants were established by the NRC at the beginning of the nuclear power era. Safety Guide 23[1] (SG 23)was one of the first documents governing meteorological monitoring at these facilities. A revision to SG 23, proposed as Regulatory Guide 1.23[2] (RG 1.23), was drafted in the early 1980's but never finalized. ANSI/ANS-2.5-1984[3] was published in 1984.

Figure 1 shows a summary of the dates of commercial operation for 115 nuclear power units in the United States. Since meteorological monitoring systems were typically installed early in the life of the plant, and since most of these plants began construction and entered commercial operation prior to the electronics revolution of the past decade, it is clear to see that many plants had older generation data acquisition systems when they were first installed.

Very few plants have updated their meteorological systems since they began commercial operation. Few changes are made to systems outside the power block as long as they continue to cause few problems, since the cost to modify these systems involves both the new equipment cost and the time required to modify the systems' extensive documentation.

However, many of the original meteorological systems are beginning to reach the end of their design lifetime. In fact, some system suppliers are no longer in business. Also, improvements in electronic technology over the past 25 years have resulted in data acquisition systems with improved performance, accuracy, and reliability than the original systems. This paper will discuss how modern data acquisition systems can improve overall performance of a meteorological monitoring system and result in higher availability, lower cost operation, and improved data quality.

2. Older Systems

A diagram of a typical meteorological system of the early 1970's is shown in Fig. 2. The sensors monitor the actual meteorological conditions. Connected to the sensors are the signal conditioners which supply excitation signals to their respective sensors and convert the sensor outputs to proportional linear voltages. The voltage signals are recorded at the meteorological tower site by strip chart recorders, a data logger, and a 9-track reel-to-reel tape recorder. A photograph of a typical system is shown in Fig.3. Some systems also relay the data from the meteorological tower to the plant control room, the emergency operations center, or both. This was typically done with with data modems which convert the analog signals to audio level digital pulses, transmit the pulses on a signal line or via a radio system, and then convert the pulses back to analog voltages in the control room. The voltage signals are then recorded in the control room, in tandem with the system at the tower, on strip charts and the plant computer system.

The weaknesses of this system are both theoretical and practical. Theoretically, the accuracy of the system can be expressed as the root sum of squares (RSS) of the errors of each system component. The RSS of this typical system is shown in Fig. 4. This shows that while the system will meet the NRC accuracy specifications, the calculated error totals are close to tolerance as set by the guidance. Should any operational factors increase the error of a particular component of the system, the actual total error could be greater than allowed.

From the practical standpoint, this early generation system has the following failings:

A. Maintenance: There are many components in this system, all of which require maintenance. With parameters like temperature and delta-T, since the calculated accuracy is close to the regulated tolerance, a high level of maintenance is required to keep this measurement from drifting out of tolerance. These older systems are becoming very expensive to maintain.

B. Reliability: The older equipment was designed before the advent of compact electronics. Not only is there a greater number of equipment items, each item has more printed circuit boards (PCB's) and electro-mechanical components than a similar item would have today. All of these PCB's are items which could fail. Older data loggers typically had 6-10 PCB's while newer units have only one or two. Other potential problem sources include:

Reel-to-reel tape recorders which are sensitive to the dust typical of the meteorological instrument shelter environment. They also had many PCB's.

Strip chart recorders, while less sensitive to the dusty environment, would be sensitive to humidity fluctuations causing paper jams, ink pens blotting on the paper, and costly maintenance requirements.

These older data recorders required AC (mains) power. To achieve the calculated availability factor required of the system, standby motor generators were often included with the system. These would require frequent maintenance and testing, and the fuel storage would require filling, testing, and could potentially leak and cause environmental damage. Some systems with standby battery banks also required extensive maintenance, and there was always a potential hazard of leaking battery acid or excessive charging causing an explosive hydrogen gas build-up in the shelter.

3. Newer Systems

A diagram for a meteorological system with a modern data acquisition system is shown in Fig. 5. In this system, the signal conditioners, the 70's era data logger, the reel-to-reel tape recorder, and the strip chart recorders have all been replaced with a compact, low power, modern data logger.

The sensors are connected directly to the data logger which converts the sensor outputs to digital values. This system runs on 12 VDC power, so the motor-generator and battery bank can be eliminated. Backup power is supplied by a float-charged, sealed 12 VDC battery which can operate the system for 2-3 weeks without AC power. Data are stored on-site in storage modules, PCMCIA memory cards, or internal memory, and relayed to the control room via digital modems. This eliminates the strip chart and tape recorders, and the errors of voltage-digital-voltage data modems.

The RSS analysis of the meteorological system with a modern data acquisition system is shown in Fig. 6. The calculated system accuracy for each measurement is better (smaller errors) when compared to the older system.

Comparing the reliability of this system to the older system, just count the total number of assemblies in the two systems. In the older system, with the data logger and tape recorder each having 6-10 PCB's, there would be at least twenty items that could fail and cause data to be lost. In the newer system, there are five major assemblies along the route of the data from the sensor to the storage module. The newer system has much greater reliability than the older system since it has many fewer major assemblies that could fail.

4. The Question of Strip Charts

RG 1.23 calls for data to be recorded with both a digital data logger and on analog strip chart recorders. The newer system eliminates the strip chart recorders. How do we "get around" the RG 1.23 requirement?

The purpose of the strip chart recorders is to allow plant personnel to quickly view trends in the meteorological data. This can be especially important when meteorological conditions change during a plant emergency. Frontal passage or sea breeze onset are just two examples. The modern system stores high frequency data (1-minute averages) in the storage modules. These are also available in real-time. The data can be plotted on a computer, either locally in the instrument shelter or in the control room via the modem link and software provided with the system. Therefore, the trend information is easily available to the operators without the problems inherent in the strip chart recorders.

5. Benefits of the Modern System

The modern data acquisition system has improved reliability and maintainability since there are fewer parts in the system, and each part of the system is more reliable than what it replaced in the older system. The modern system has greater accuracy since there are fewer sources for errors.

The operators of a system that was installed last year report the following:

Fewer outages: The system was only out of service for regular maintenance and calibration. There were no un-planned outages.

Shorter outages: System calibration time was reduced from five days to one day. Another minor modification to be made this year should further reduce this to a half day.

Lower maintenance cost: The old strip chart recorders required over $60,000 worth of maintenance annually. The new system, which included all new sensors, a data acquisition system, and installation and calibration, cost less than $53,000. Thus, the new system has already paid for itself, and will accrue these savings each year that it is in operation.

Lower training costs: The new system is so easy to use that it has been removed from the list of systems at this plant which require advanced technical training. This results in an additional cost savings.

Higher data quality: Health physics personnel at this plant use the data from the new data acquisition system directly and have said that their results are more accurate than when using the data from the older system.

6. Summary

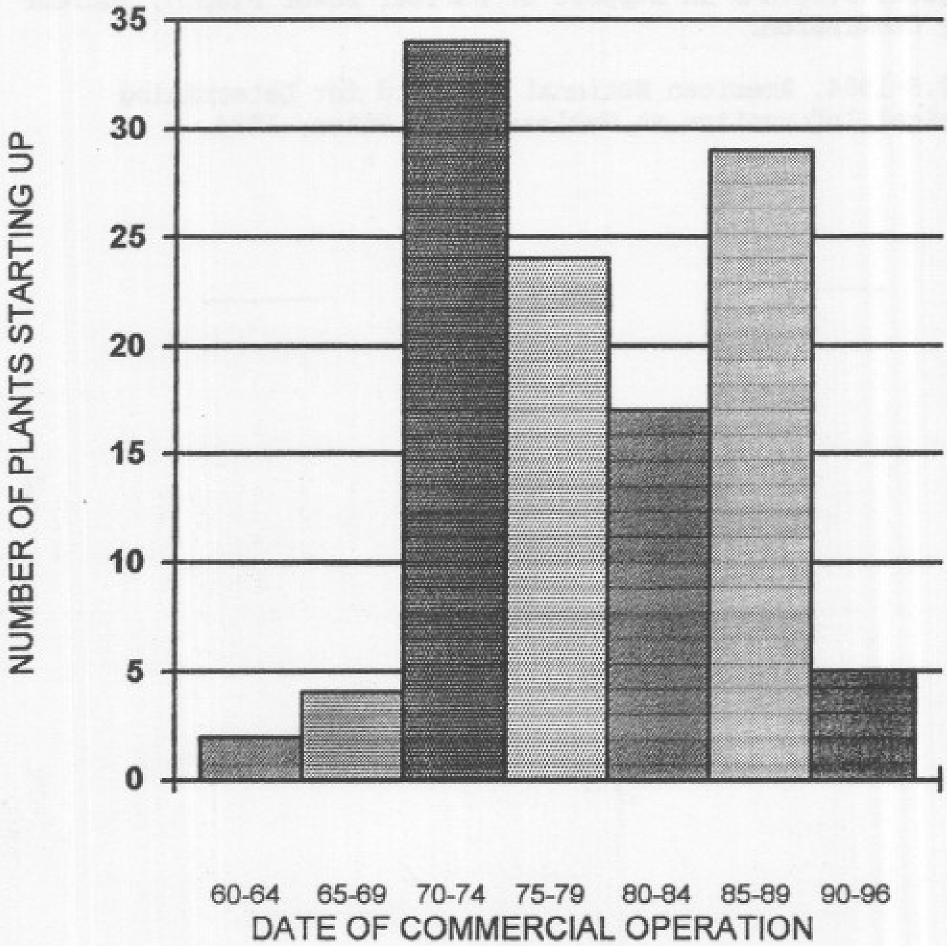
We have shown that data acquisition systems at nuclear power plants, while state of the art when installed, have been surpassed by more modern systems developed over the past 25 years. New data acquisition systems will provide improved reliability and higher data quality when installed in place of the older systems. They also can pay for themselves after only one or two year's of operation.

7. References

1. Safety Guide 23, <u>Onsite Meteorological Programs</u>, Nuclear Regulatory Commission, 2/17/72.

2. Regulatory Guide 1.23, Proposed Revision 1 to Regulatory Guide 1.23, Meteorological Programs in Support of Nuclear Power Plants, Nuclear Regulatory Commission.

3. ANSI/ANS-2.5-1984, American National Standard for Determining Meteorological Information at Nuclear Power Sites, 1984.



NUMBER OF PLANTS STARTING UP
35
30
25
20
15
10
5
0
60-64
65-69
70-74
75-79
80-84
85-89
90-96
DATE OF COMMERCIAL OPERATION

Figure 1

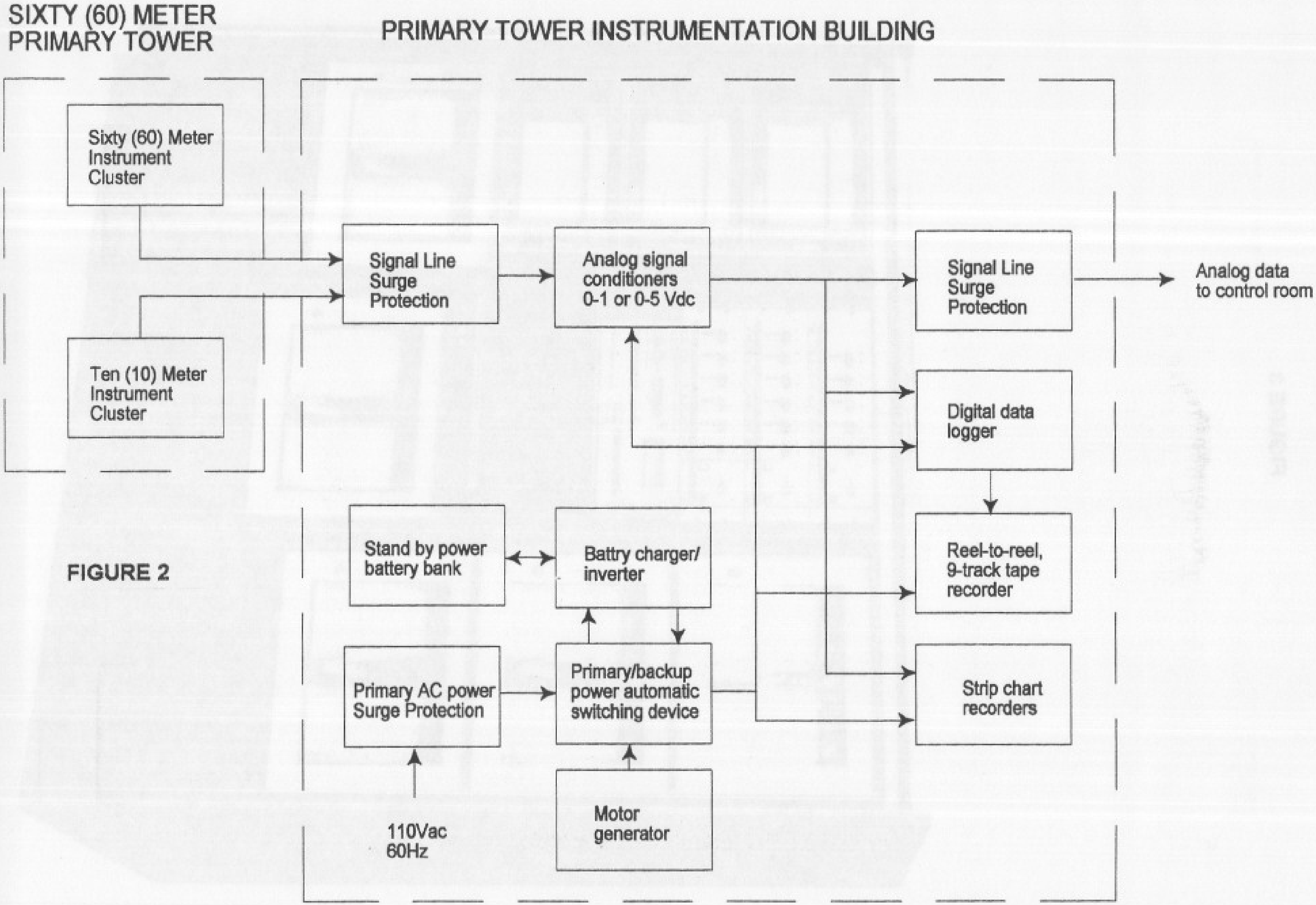


FIGURE 2

TYPICAL 1960'S , NRC 1.23 METEOROLOGICAL DATA ACQUISITION SYSTEM FOR NUCLEAR GENERATING STATIONS.

FIGURE 3

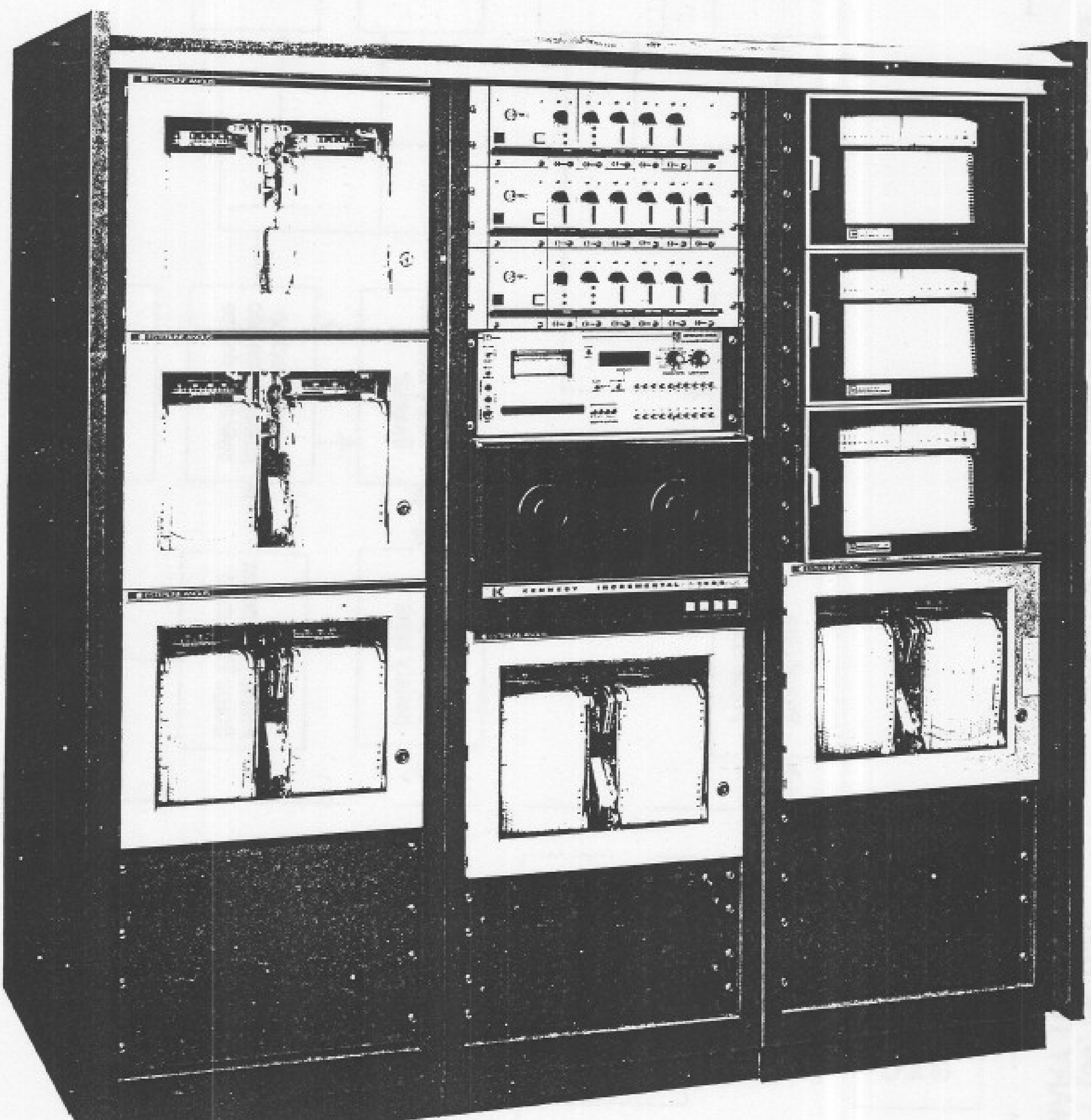


FIGURE 4

SK001015
Job No. 7432
Customer: Generating Co.
July 21, 1983

METEOROLOGICAL SYSTEM RSS ERROR ANALYSIS
COMPONENT ACCURACY (1)

Parameter	Met. Tower Sensor	Signal Translator Accuracy	Signal Translator Temp. Coef.(2)	Telemetering Transmitter	Telemetering Receiver	Current Driver	RSS Calculated Accuracy	Reg. Guide 1.23 Requirements
Wind Speed (3) (100075)	.15mph	±0.20% (.05)	.4% (0.10)	±0.2% (0.20)	±0.2% (0.20)	±0.2% (0.20)	±.39mph	±.5mph
Wind Direction (100076)	±2°	±0.20% (1.10)	.4% (2.16)	±0.2% (1.10)	±0.2% (1.10)	±0.2% (1.10)	±3.67°	±5°
Temperature (100826)	±.21°F (4)	±0.20% (.28)	.4% (.56)	±0.2% (.28)	±0.2% (.28)	±0.2% (.28)	±.82°F	±.9°F
Delta Temp. (1000826)	±.036°F(5)	±0.20% (0.08)	.4% (.16)	±0.2% (0.08)	±0.2% (0.08)	±0.2% (0.08)	±.23°F	±.27°F
Dew Point (101197)	±1.8°F	±0.20% (.28)	.4% (.56)	±0.2% (.28)	±0.2% (.28)	±0.2% (.28)	±1.97°F	±2.7°F
Precipitation (100097)	±1% (6)	±0.2%	.4%	±0.2%	±0.2%	±0.2%	±1.15%	±10%

MS/1/W

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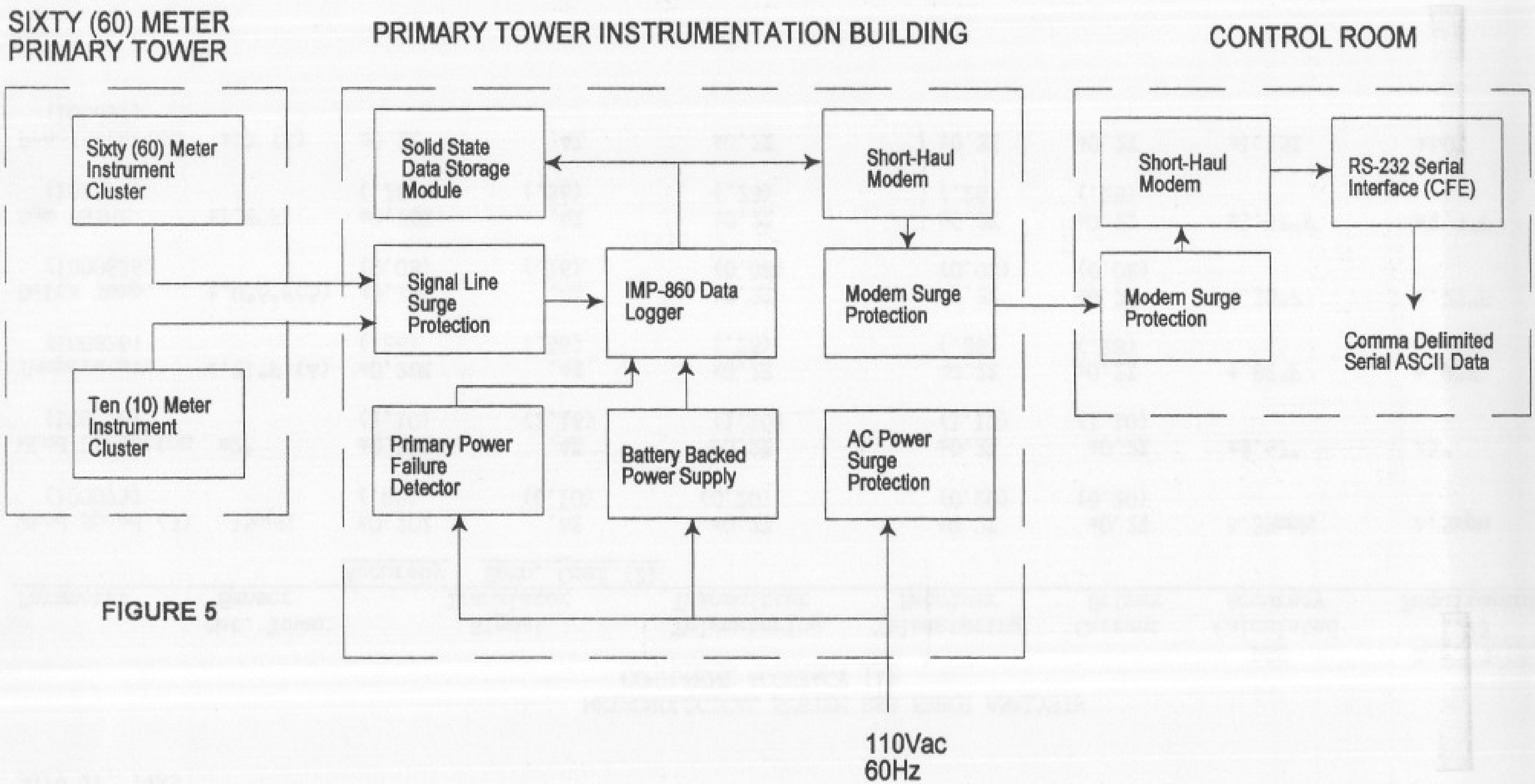

FIGURE 5

TYPICAL DIGITAL DATA LOGGER MODIFICATION FOR PRIMARY AND EMERGENCY METEOROLOGICAL DATA ACQUISITION SYSTEMS AT NUCLEAR GENERATING STATIONS.

TYPICAL DIGITAL DATA ACQUISITION SYSTEM RSS ERROR ANALYSIS

COMPONENT ACCURACY

Parameter	Met. Tower Sensor	IMP-860 Accuracy	RSS Calculated Accuracy	Reg. Guide 1.23 Requirement
Wind Speed[2] (100075)	.11 m/s (.25 mph)	±.2% (.05)	±.12 m/s (.26 mph)	±.22 m/s (.5 mph)
Wind Direction (100076)	±2°	±.2% (1)	±2.2°	±5°
Temperature (100093)	±.24°C[3] (±.43°F)	±.2% (.16)	±.29°C (±.43°F)	±.5°F (±.9°F)
Delta Temp. (100093)	±.028°F[4] (±.05°F)	±.2% (0.06)	±.057°C (±.08°F)	±.15°C/50m (±.27°F/50m)
Rel. Humidity (102273)	±2%	±.2%	±2.01%	-----[5]
Precipitation (100097)	±1%	±.2%	±1.02%	±10%
Solar Rad. (101655)	±75 W/m^2	±.2% (3)	±75 W/m^2	None
Baro. Press. (102272)	±1.1 hPa	±.2% (1)	1.49 hPa	None

FIGURE 6