1.0 Instrument Details

1.1 Detailed Description

1.1.1 List of Components

- **Temperature and Relative Humidity Sensor:** A Vaisala HMT330 series humidity and temperature transmitter with an HMT337 heated RH probe and an additional temperature probe (RTD) is used to measure the ambient temperature and RH. We have configured the sensor to output the calculated dew point and an error code in addition to the temperature and RH.
- **Data logger:** A Campbell Scientific CR23X datalogger.
- **Serial Multiplexers:** Campbell Scintific SDM-SI04.
- **Ethernet Devices:** Campbell Scientific NL-100 and Allied Telesyn AT-MC13 Ethernet Media Converter. Users Manual.

1.1.2 System Configuration and Measurement Methods

HMT 337 Humidity and Temperature Transmitter

NOTE: Data collection at Atqasuk ceased in December 2010.

HMT337 sensors are located at 2-m and 5-m levels of the tower. The HMT330 series transmitter can be configured to work with various probe types. We chose the HMT337 probe option. This probe is typically used in high-humidity environments and has a warmed probe head. The warmed probe head is continuously heated so that its temperature is always higher than the environment. The actual RH of the air is calculated using the temperature of the RH sensor, the temperature of the air, and the RH of the heated sensor. An additional RTD is used to measure the ambient air temperature. It is located away from the heated RH sensor in an RM Young aspirated solar shield so it is not affected by the heated probe. The RH sensor is mounted in a portion of the Vaisala HMT330MIK, Meteorological Installation Kit. We modified the kit so that only the RH section was used. A temperature probe retainer made out of PVC was manufactured to hold the PRTD inside the RM Young aspirated solar shield.

Sensor heating is user-controlled, and the HMT337s are installed with factory defaults. The default settings are set so the heating begins when RH values are above 95% RH, the heat temp the probe gets to 100 °C, and the heat time is 30 seconds. During heating the RH output is held to the last RH measured prior to the heating sequence.

The HMT337 also has numerous other default settings that affect the measurements taken by the unit. The following setting have been changed:

1. Interval purge has been turned off—this setting is typically done at 720-minute intervals. The unit heats the probe head to burn off contaminants.
2. Power-up purge has been turned off—this setting heats the probe head to burn off contaminants.

3. Filter is turned off. The default setting is for the “standard or short filtering” to be on, and this filter is an “approximately 15-s moving average”. Another extended filter is available, and it is an “approximately 1-minute average”.

Figure 1. HMT337 Installation at Atqasuk.

We don’t use any filtering as the logger program uses the raw 2-second readings to calculate the mean and standard deviations of the variables each minute.

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The following serial settings are used for communication between a Serial Data Multiplexer in the logger enclosure and the HMT337 transmit units:

- Baud rate: 4800
- Parity: Even
- Data bits: 7
- Stop bits: 1.

Additionally, a maintenance port is available for communication, and with the proper cable (order code: 19446ZZ from Vaisala) users can use any terminal program with the following settings:

- Baud rate: 19200
- Parity: None

- Data bits: 8
- Stop bits: 1
- Flow control: None.

The HMT330 transmitter unit outputs a variety of quantities, both measured and calculated. For our purposes we only output three variables: Temperature, Relative Humidity and Dew Point, each to two decimal places. An Error code is also output at the end of the output, and this variable is also captured. The error code is a four-digit code representing a binary error state for 4 variables: P, T, Ta, and RH. The value for no error is 0000, and the value for an error with each variable would be 1111.

The dew point is internally calculated in the HMT330 using the following equation:

$$Td = \frac{Tn/m}{\text{Log}((Pw/A)-1)}$$

Where Pw is the water vapor pressure. The parameters A, m, and Tn depend on temperature according to the following table (* used for frostpoint calculation if the dewpoint is negative):

t	A	m	Tn
<0 °C	6.1134	9.7911	273.47
0–50 °C	6.1078	7.5000	237.30
50–100 °C	5.9987	7.3313	229.10
100–150 °C	5.8493	7.2756	225.00
150–180 °C	6.2301	7.3033	230.00

Power Supplies and Power Distribution

There are two switched and fused adjustable power supplies located in two different enclosures at the base of the tower. One power supply is set to output 50V (A050HX300), and it feeds the tab regulator circuit located in the enclosure with the 15V power supply. The tab regulator circuit contains two tab regulators that regulate the 50V down to 32V DC and 36V DC. The 36V is used for the heaters on the ultrasonic wind sensor. The 32V is used to power the HMT337 probes. The HMT337 main body is also on a mount arm attached to the tower itself. The Tab Regulator circuit contains a 511-LM117K 1.2–37V positive adjustable voltage regulator with anodized heat sink.

The 15V DC power (A015MX100) supply is located inside the enclosure with the regulator circuit. The voltage from it is used to power the measurement circuit of the ultrasonic wind sensor at 10 m.

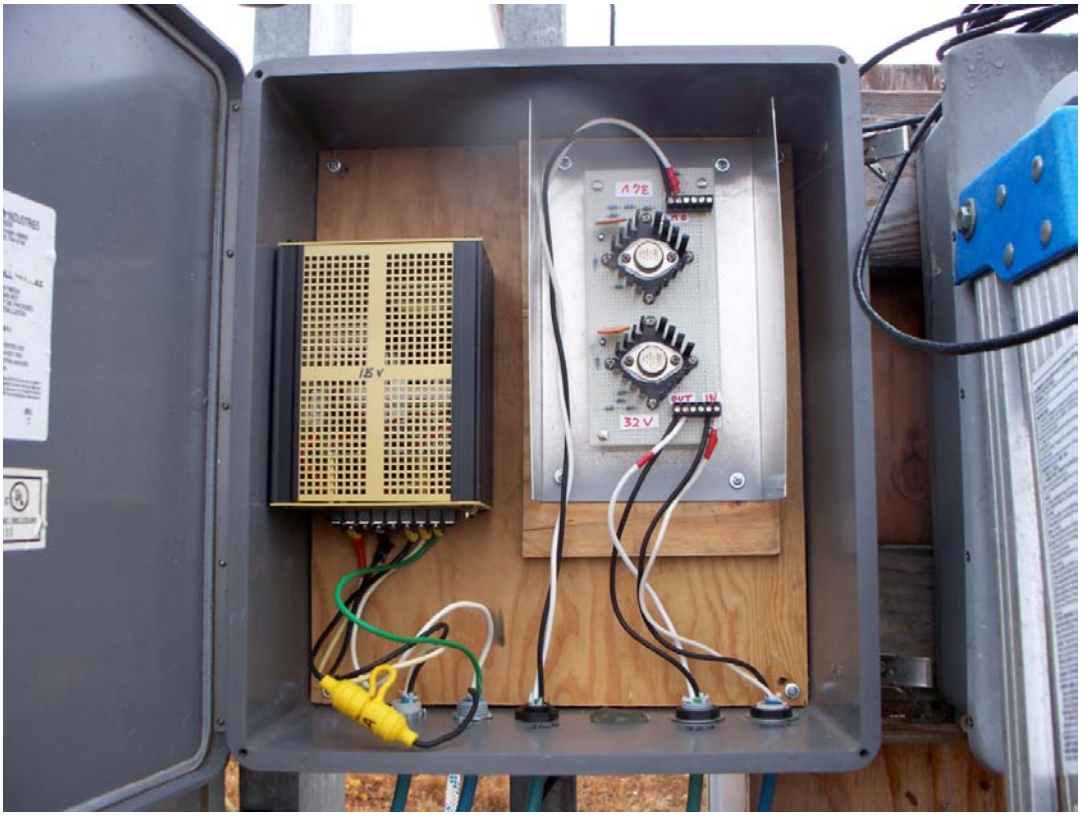

Figure 2. Tab Regulator Circuit (right) and 15V Power Supply (left) in enclosure.

Serial Data Multiplexer

Two Campbell Scientific serial data multiplexers (SDM-SI04) are used to collect data from the serial devices and serial sensors. The barometer, present weather sensor (PWS), chilled mirror hygrometer (CMH), and Ultrasonic wind sensor are collected by one SDM. The HMT337s located at the two levels are collected by another SDM. The SDM converts the serial data it collects to a form the CR23X data logger can understand using complex filters supplied by the user. The SDM stores complex commands required to request data from the serial devices. These commands are also user-supplied or defined by the manufacturer. Each SDM has four serial ports that are independently configured to communicate with different sensors.

CR23X Data Logger

A Campbell Scientific CR23X data logger is used to acquire and process the data collected by the SDM from the various sensors. Once per second the SDM for the HMT337s requests data from them.

Once-per-minute data are sent from the CR23X to the PC upon request. The data are sent via Ethernet through a Campbell Scientific NL-100 network interface, then to an Allied Telesyn media converter through which the data are sent to a partner media converter via fiber optic cable. Once the data reach the end of the fiber, the media converter sends the data through Ethernet cable to a network switch and then onto the PC. The CR23X data logger includes a 4 MB extended memory option, allowing the storage of over 2 million data points in the event of a communication outage. The data logger has an extended temperature option giving it a valid operating temperature range of -40 to +60 C. The CR23X has been

modified so that the Input/Output connectors are removable, allowing for quick connect/disconnect for easy data logger replacement.

NL-100 Network Link Interface

A Campbell Scientific NL-100 network interface is used to communicate with the Campbell Scientific CR23X data logger. The NL100 uses an Ethernet 10 Base-T communications link between itself and the Allied Telesyn media converter. The NL100 is configured to act as a Serial Server in the TCP/IP network. The unique IP address for the system is stored within the NL100.

AT-MC13 Ethernet Media Converters

The AT-MC13 media converters are used to convert the data from the CR23X (through the NL100) to fiber optics. Converting to fiber optics and using the media converters allows for a 2-kilometer maximum operating distance of the network. Two media converters are used; one is located at the base of the towers in the data logger enclosure, and the other is located inside the building at each location. The media converters operate at 10 Mbps and feature half- and full-duplex operation. The media converters also have a MIDI/MDI-X switch. This switch is used to configure the twisted-pair port on the media converter as either MIDI or MIDI-X, eliminating the need for crossover cables regardless of the type of network device that is connected to the unit. The media converters also have a Fiber Link Test switch that allows testing of the fiber optic connection without requiring the twisted-pair port to be connected.

Computer

The PC used at both Barrow and Atqasuk is a Dell GX620 Small Form Factor. The operating system installed on the PC is Microsoft Windows XP Professional using NTFS. The PC was configured to conform to the ARM core PC requirements. The PC is configured to automatically restart and log on after power disruption, eliminating the need for human intervention. Campbell Scientifics' LoggerNet software is loaded on the PC and is configured to initialize at startup. LoggerNet is the software application that enables communication and control of the CR23X data logger. Radmin software is also loaded on the PC, allowing remote connection to or control of the local PC. A shareware program called InternetTime is used to verify and adjust the time of the PC clock once a day. A PERL script called "split_working_cdl.pl" is used to handle the output data file from the LoggerNet software. This script has been installed on both systems in C:\ARM\bin and is scheduled to run once an hour in the LoggerNet task manager. This script creates uniquely named hourly files and places the files in a folder from which the Data Collection System can access, collect, and delete them. FTP software allows the Data Collection System to access the PC.

LoggerNet

LoggerNet software is an application that allows the setup, configuration, and retrieval of data from a network of Campbell Scientific data loggers. LoggerNet also allows sharing of data over an Ethernet communications network. LoggerNet is written using advanced "client-server" architecture. The server is a software program that runs in the background, handling all of the data logger communications. The server also takes care of storing the data and providing information to manage the data logger network. Client software programs in LoggerNet are used to create data logger programs, view and graph data, verify communications on the network, and run other software or tasks.

1.1.3 Specifications

Temperature and Relative Humidity Sensor

The HMT337 probe contains a Vaisala HUMICAP 180C sensor for the RH measurements and a Pt100 RTD for the temperature measurements. Each temperature probe is mounted in an R.M. Young Model 43408-2 aspirated radiation shield. A brushless DC blower provides aspiration. The RH probes are mounted in an HMT330MIK shield for the heated T2 probe. The RH probes are unaspirated. The following is the manufacturers listed accuracy:

- For -40 to +180 °C =/- (1.5 +0.015 x reading) % RH, factory calibration uncertainty is +/- 0.6% RH (0–40%) and +/- 1.0% RH (40–97%).
- The typical accuracy of the additional RTD temperature probe is 0.1 °C.

1.2 Theory of Operation

Tower meteorological data are collected at the ARM Climate Research Facility North Slope of Alaska (NSA) site at Barrow, Alaska, and were collected through December 2010 at Atqasuk, Alaska. At the site in Atqasuk, data were collected at the base of a 10-meter tower with Temperature and RH collected at 2 m and 5 m.

The data are collected at the base of the tower using Campbell Scientific CR23X data loggers. The data loggers are polled once a minute by Campbell Scientific LoggerNet software. The LoggerNet software runs on a Dell Optiplex GX620 small form-factor computer using Microsoft XP Professional as the operating system. The computer system is configured such that if power is interrupted it will automatically restart, eliminating the need for human intervention. The LoggerNet software has been added to the Start menu so that it will automatically begin to collect data from the data loggers as soon as the system has rebooted.

The data from the data loggers are stored in a single location, and the data are appended to an ever-increasing file. A PERL script has been written to search the data file once an hour to capture a single hour's worth of data (00–59) and copy the data to another file location with a unique time and date name. The file is then deleted, preventing a large, single file that continues to grow. The hourly files created by the PERL script are collected once an hour using FTP, and the collected file is then deleted from the local PC.

Remote Administrator (RAdmin) software has been loaded to both computers so that remote access is available for loading new programs, troubleshooting, etc. Access is limited to the site observers, mentors, and selected operations personnel.

Temperature and relative humidity are collected once every second from the different levels of each tower. The one-second serial data are collected via serial cables and sent to the CR23X data logger, where they are accumulated to create one-minute averages and other calculated variables.

The serial data from all sensors are sent to, or requested by, a Campbell Scientific serial data multiplexer (SDM-SIO4). Each SDM-SIO4 has four ports and a unique address so that multiple SDMs can be connected to each logger. The Atqasuk system has two SDMs. Each SDM contains programming for the

communication protocols (baud rate, data bits, etc.) and filters so data can be converted to a form the CR23X can accept.

The data collected by the logger are requested by the LoggerNet system once per minute. The data are sent by the CR23X data logger to the computer via a network connection. A Campbell Scientific NL-100 network interface is used to send the data via an RS-232 serial connection from the logger to the computer. The NL-100 allows each data logger to have a unique network address. The data are passed from the NL-100 to an Allied Telesyn AT-MC13 media converter via a Cat-5 Ethernet cable. The media converter sends the data via a fiber optic cable to another media converter inside the building where they are sent through a network switch and onto the computer.

The data that are collected from the data logger can be viewed locally at each site's computer. A program contained in the LoggerNet software package called Real Time Monitor and Control (RTMC) is used to plot graphs of the data and view data values, allowing observers to verify proper operation of the system and sensors. The raw one-second data can also be viewed to assist in troubleshooting.

1.3 Calibration

1.3.1 Theory

The NSAMET and NSATWR sensors are not calibrated as a system. The sensors along with the Sensor Collectors and the instruments are calibrated separately. The system was installed using components that had a current calibration.

1.3.2 Procedures

The below explanations are simplified explanations. Detailed procedures can be viewed by accessing the User's.

Daily Checks

The data from the tower are checked each day during daily rounds. Temperature and relative humidity data from the 2-m level and the CMH from the MET datastream are compared to determine if the data appear reasonable. The T/RH data between the difference levels are compared also to determine if the data appear to be reasonable. Any discrepancies are noted on the daily rounds forms. The wind speed and direction is compared and checked against local conditions. A viewscreen has been built which displays 24 hours of data graphed along with text values for the current readings. The graphs allow checks of the data to be made to determine if problems have occurred during the most recent 24 hours. Long gaps in data, long periods of or many data spikes, and flat line data (no change in values over extended periods) will be apparent and are noted on the daily forms.

Annual Checks

<u>HMT337D Temperature and Humidity Transmitters</u>

The HMT337s are checked against a calibrated standard check probe prior to installation. Any sensor falling outside the acceptable range is sent to the manufacturer for repair. Removed sensors are also

checked to determine any sensor drift since installation. The removed sensors are then sent to the ARM Southern Great Plains site, where they are calibrated using the Thunder Scientific Calibration Chamber located there. If the sensor is unable to be adjusted or fails any threshold tests at the SGP facility, the sensor is then forwarded to the manufacturer for repair or replacement.