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APPLICATION NOTE 3892

Overview of iButton® Sensors and Temperature/Humidity Data Loggers

Aug 21, 2006

Abstract: This application note defines a basic iButton data logger and shows how these products can vary to track temperature and/or humidity data. Typical applications are presented. The article explains how the data logger is constructed, tested, and certified to pass various safety and EMI standards. Flexible and programmable, each iButton data logger is designed to be set up (a step called 'missioning') by the user to collect data for an application. The software for missioning is discussed and made available to the reader. The formats for data presentation are shown.

Introduction

Businesses need to guarantee customers the best quality and freshness in their products or services. For many businesses, this means that tracking temperature and humidity throughout a product's lifetime, through the duration of a service, or through various stages of manufacturing and delivery, are critical. To support this business need, Maxim designed several digital thermometers and temperature/humidity data loggers.

Digital Thermometer

The DS1920 iButton is a digital thermometer that reads the temperature of the environment or of the object to which it is attached. Simply touching a 1-Wire® probe to the DS1920 reveals the surrounding temperature, measured from -55°C to +100°C.

Temperature Data Loggers

The Thermochron® family of iButtons are globally addressable, dedicated 'trackers' that accompany products vulnerable to temperature fluctuations, wherever they go. The tiny, durable Thermochron monitors time and temperature, and then stores the data. The data can easily be uploaded and analyzed to detect possible thermal damage to the product.

There are several iButtons from which to choose. The DS1921G, DS1921H, and DS1921Z are standard Thermochrons. The DS1922L, DS1922T, and DS1922E are high-capacity Thermochrons with more logging memory, increased accuracy, and increased resolution.

The computer chip embedded in the Thermochron integrates a 1-Wire transmitter/receiver, a globally unique address, a thermometer, a clock/calendar, a thermal history log, and 512 bytes of additional memory to store user data, such as a shipping manifest or a mission authentication certificate (see application note 1200, "White Paper 7: Thermochron Mission Authentication and Security"). The recyclable Thermochron logs data for more than 10 years. For a method to keep track of the remaining battery energy, see application note 3761, "DS1922/DS1923 Battery Gas Gauge."

Digital Hygrometer

Our Hygrochron™ iButton (DS1923) adds an embedded humidity sensor to the temperature-logging capability of the Thermochron. The tiny opening in the Hygrochron's lid uses a special filter that allows water vapor to pass through and reach the internal humidity sensor, but repels liquid-phase water (**Figure 1**). Gathering both temperature and humidity data, the Hygrochron logs relative humidity as a function of time.

Figure 1. Illustration of the Hygrochron data logger shows the small size of the canister and how an outer filter allows water vapor to reach the device's internal humidity sensor.

For applications where both temperature and humidity are important (for example, with foods, chemicals, powders, HVAC systems), the Hygrochron delivers unprecedented performance in an unbelievably compact, portable package.

Rugged iButtons Attach to Almost Anything

The 16mm iButtons (about the size of five stacked U.S. dimes) attach unobtrusively to almost any surface: a wall, bottles, totes, boxes, crates, pallets, air cargo containers, refrigerators, semi-trailers, railroad freight cars, etc. The iButton's stainless steel armor withstands dirt, moisture, and rough treatment.

EMC, Safety, and Food Transport Certifications

All of our data logging iButtons have gone through extensive testing by independent labs. They have passed FCC and CE electromagnetic compatibility (EMC) testing. The DS1921G, DS1922H, DS1922T, and DS1923 have undergone UL safety certification to the UL#913 standard. These parts are certified as intrinsically safe equipment for use in hazardous locations. Finally, the DS1921G and DS1922H have been certified to meet the EN12830 European standard, which involves performance and suitability testing for the transport, storage, and distribution of chilled, frozen, deep-frozen/quick-frozen food and ice cream. While all iButton data loggers are calibrated/validated against NIST traceable reference devices, Maxim offers a web application to generate validation certificates for the DS1922 series and DS1923 data loggers. For more information, see application note 4629, "iButton Data-Logger Calibration and NIST Certificate FAQs."

Versatile Data Storage: Log and Histogram Formats

The Thermochron and Hygrochron iButtons wake up to take time-stamped temperature and/or humidity readings at equal time intervals, and then store the data in a log format in on-board 'data log' memory. The standard Thermochron (DS1921G/H/Z) allows 2048 readings with time intervals of 1 to 255 minutes; the high-capacity Thermochrons/Hygrochrons allow 8192 readings with time intervals from 1 second to 273 hours. Additionally, the Hygrochron allows simultaneous temperature and humidity logging and offers selectable resolution settings.

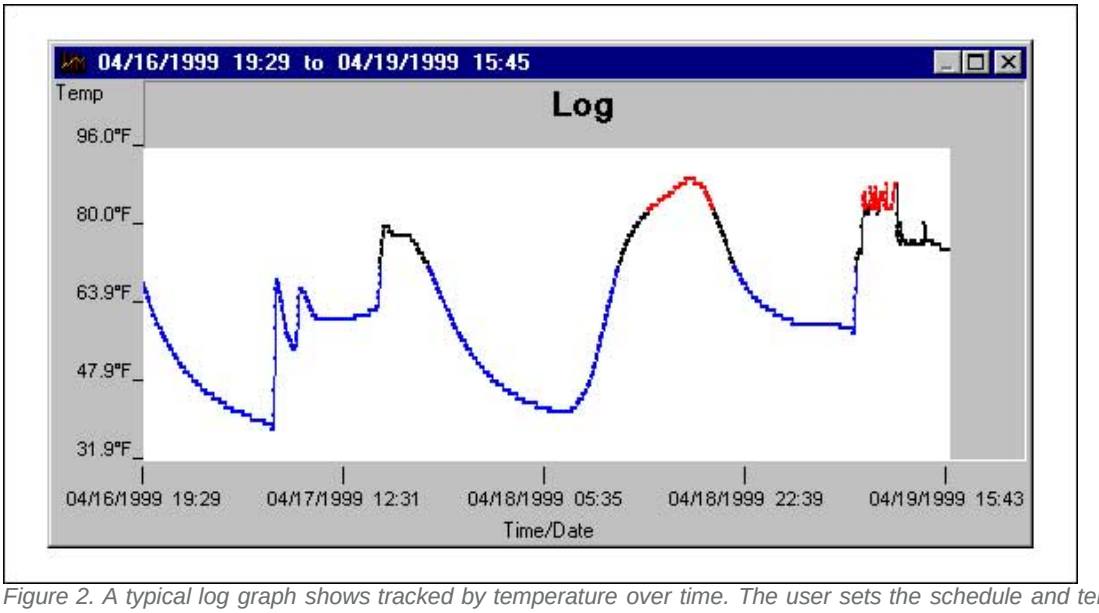

Figure 2. A typical log graph shows tracked by temperature over time. The user sets the schedule and temperature range for monitoring.

The user can setup how the iButtons will log data. This is called 'missioning' the iButton. Typically during missioning, the user chooses when to begin temperature/humidity readings, sets a sampling rate, and sets high- and low-alarm thresholds (**Figure 2**). The user also determines what to do when the data log memory fills up: whether the device should continue recording data and overwrite the oldest data records (called 'rollover'), or whether the device should simply stop logging. Once the iButton has been missioned, it can be attached to the object to be monitored. When a critical thermal/humidity exposure occurs, the event will be recorded, and thus accountability can be assigned for any resulting damage to product quality.

The standard DS1921G, H, and Z Thermochrons also simultaneously store each temperature sample in a histogram. The histogram memory consists of 63 bins in 2°C increments for the DS1921G, or 64 bins in 0.5°C increments for the DS1921H/Z devices. Each bin holds 65,500 temperature readings for up to 10 years. The histogram method of data storage is perfect for applications that need long-term monitoring but have less strict accuracy requirements. The higher capacity Thermochron and Hygrochron lines do not have the histogram function, but they have nearly four times the data logging memory.

Thermochron Family of Products

Our standard Thermochron, the DS1921G, logs temperatures over a wide temperature range of -40°C to +85°C. The DS1921H and DS1921Z are high-resolution versions of the device. The DS1921H is designed for the human temperature range, while the DS1921Z is designed for applications needing high-resolution around 0°C. See **Table 1** for basic data logger specifications.

The DS1922L, DS1922T, and DS1922E are high-capacity Thermochrons. The DS1922L logs temperatures over -40°C to +85°C. It has an 8192 byte temperature log with accuracy correctible (by software) to ±0.5°C from -10°C to +65°C. It also has selectable 8-bit (0.5°C) or 11-bit (0.0625°C) resolution. The temperature log values are selectable between 8-bit or 16-bit. Similar to the DS1922L, the DS1922T Thermochron has a higher temperature logging range (0°C to +125°C) that can be used in manufacturing processes involving sterilization. The DS1922T's accuracy is software-correctible to ±0.5°C from +20°C to +75°C. The DS1922E's temperature logging range extends from +15°C to +140°C. The device is calibrated for ±1.5°C accuracy from +110°C to +140°C. (Software-correction does not apply.)

Table 1. Basic Specifications for the iButton Data Loggers

Part	Temperature Range (°C)	Humidity Range	Temperature Accuracy* (°C)	Temperature Resolution (°C)	Humidity Resolution	Data Log Memory (Bytes)
DS1921G	-40 to +85	N/A	±1	0.5	N/A	2048
DS1921H-F5	+15 to +46	N/A	±1	0.125	N/A	2048
DS1921Z-F5	-5 to +26	N/A	±1	0.125	N/A	2048
DS1922L	-40 to +85	N/A	±0.5, software correction (SC)	0.5 or 0.0625	N/A	8192
DS1922T	0 to +125	N/A	±0.5 (SC)	0.5 or 0.0625	N/A	8192
DS1922E	+15 to +140	N/A	±1.5	0.5 or 0.0625	N/A	8192
DS1923	-20 to +85	0 to 100% RH	±0.5 (SC)	0.5 or 0.0625	8-Bit (0.6%RH) or 12-Bit (0.04%RH)	8192

**The temperature accuracy shown in this table is effective over most of the temperature range for the part. For full-range accuracy, please refer to each part's data sheet.*

Missioning a Thermochron

Missioning a Thermochron or Hygrochron iButton is done with a PC or handheld computer. The iButton connects to a Blue Dot™ receptor (a low-cost reader interface) which, in turn, is connected to a 1-Wire Adapter attached to a computer. This website provides free evaluation software to set start time, sampling rate, and alarm thresholds (see the *How to Download Free Evaluation Software* below).

The low-cost reader interface includes:

DS1402D-DR8 Blue Dot Receptor
DS9097U-S09 1-Wire to RS-232 Adapter
Or
DS9490R 1-Wire to USB Adapter

How to Download Free Evaluation Software

There are two elements to downloading the free evaluation software. First, install the 1-Wire Drivers, version 4.00 or above. It is available for download here and includes a link to download and install the OneWireViewer, which is a Java™ program that supports the entire iButton family of data loggers. The software, of course, requires the correct hardware installed on a PC. To do this, plug the 1-Wire Adapter into the PC, connect the Blue Dot Receptor to the adapter, and plug a Thermochron or Hygrochron into the Blue Dot. Then, run the OneWireViewer and click on the iButton's serial number. This starts the program/mission wizard, a guide through the steps to setup a temperature/humidity logging mission.

Briefly, the steps include:

1. Set the clock.

2. Set the time alarm.
3. Set the sample rate.
4. Set the temperature/humidity alarm.
5. Set the mission start delay.
6. Check when mission will end; select data rollover or not.
7. Finish.

Instructions on how to download and install the software and how to operate the program/mission wizard are found in application note 4373, "OneWireViewer and iButton Quick Start Guide" and application note 3358, "OneWireViewer User's Guide."

Programmers: The following kits contain example applications to mission and download Thermochrons/Hygrochrons.

- 1-Wire SDK for Windows (Visual Basic) contains standard Thermochron support. The 1-Wire Drivers package contains .NET support for high-capacity Thermochrons and Hygrochrons.
- 1-Wire API for Java contains OneWireViewer source code.
- 1-Wire Public Domain Kit (C) contains 'humalog' program with source code for Hygrochrons and high-capacity Thermochrons. It also comes with the 'thermodl' program with source code supporting standard Thermochrons.

Starter Kit Available

If you want to get your Thermochron up and running quickly, just use the DS1921K Thermochron iButton Starter Kit. This kit contains all the hardware necessary to configure a Thermochron iButton and review the resulting data. The data can also be saved or imported into other applications.

The kit includes:

- DS1921G Thermochron iButton
- DS9093F iButton Keyring Fob Attachment
- DS9490R 1-Wire to USB Adapter
- DS1402D-DR8 Blue Dot Receptor with RJ-11 Connector
- Instruction Sheet

The DS1921K Starter Kit can be ordered from our on-line store.

Thermochron FAQ

Visit the Thermochron FAQ section.

Thermochron/Hygrochron Solutions

We have several partners that developed hardware and software solutions around our Thermochron and Hygrochron products. This includes software products that run on both PC and handheld platforms and let you mission, upload, and manage the data from thousands of Thermochrons. Hardware products range from small electronic devices to mission Thermochrons and read their alarm status, to data collection devices for HACCP applications. Visit our online Solutions Search for all our partners' products.

Related Parts	
DS1921G	Thermochron iButton
DS1921H	High Resolution Thermochron iButton Range H: +15°C to +46°C; Z: -5°C to +26°C
DS1921Z	High Resolution Thermochron iButton Range H: +15°C to +46°C; Z: -5°C to +26°C
DS1922E	High-Temperature Logger iButton® with 8KB Data-Log Memory
DS1922L	Temperature Logger iButton with 8KB Datalog Memory
DS1922T	Temperature Logger iButton with 8KB Datalog Memory
DS1923	Hygrochron Temperature/Humidity Logger iButton with 8KB Data-Log Memory

More Information
For Technical Support: http://www.maximintegrated.com/support
For Samples: http://www.maximintegrated.com/samples
Other Questions and Comments: http://www.maximintegrated.com/contact

Application Note 3892: http://www.maximintegrated.com/an3892
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