

Noble Micro Logger User Manual

Introduction

This Data Logger is built from a kit and illustrates the use of a microcontroller to sample and record the level of an analogue signal over a period of time. The solution has a light sensor as its input and an array of LEDs to give visual feedback. There are two recording modes. In the first the input is sampled frequently and the measured values can be stored over a period of up to a minute. In the second mode the samples are taken much less frequently such that recording can span a full day. This mode also illustrates the capability of the microcontroller to be switched into a low power “sleep” state between making measurements so that the supply battery can be made to last for years. In both cases the recorded data can be played back and displayed on the LED array.

How to use the Data Logger

1. Modes

The Data Logger has four different modes of operation

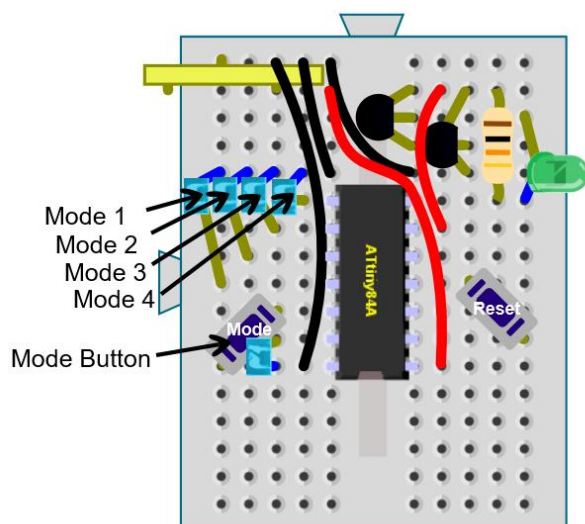
Mode 1 - fast record of analogue data

Mode 2 - slow record of analogue data

Mode 3 – play back

Mode 4 – memory status

To find out which mode the Data Logger is currently working in, press and release the Mode button and observe which blue LED lights up (see picture below). Please note that if the processor is currently asleep (no LEDs flashing) then you will need to keep the Mode button pressed for up to five seconds before getting a response from the LEDs.



To change the mode, press and hold the Mode button until the LED display cycles round to the desired Mode (see picture above) then release the button. If the processor is asleep you may have to hold down the button for up to five seconds before the LEDs begin to cycle.

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To restart the data acquisition

Press the Reset button when the processor is in Mode 1 (fast record), Mode 2 (slow record).

To restart the data replay

Press the Reset button when the processor is in Mode 3 (playback).

What happens in each mode.

Mode 1 – fast record. The analogue input from the light sensor is sampled eight times per second. The LEDs display the input value by showing a proportional number of LEDs. The input value is divided by 256 and any remainder that is mid-range is used to flash the most significant LED. For example for an input value of 650, two LEDs would be shown and the remainder (650-512) would cause the third LED to be flashed.

After truncating from the 10 bit Analogue to Digital converter result to 8 bits for storage, each value is saved in the next available location the EEPROM (Electrically Erasable Programmable Read Only Memory) within the chip. It takes just over one minute until the memory is full. The processor then goes into a sleep state but first gives a warning that this is about to happen by making the LED bar display appear to move from side to side as seen in Knight Rider.

Mode 2 – slow record. This is a power saving mode. The input circuit (LED and transistors) is powered from a digital output of the ATtiny84. Normally this output is “off” and the processor is in a sleep state so that minimal current is consumed (about 4 microamps). Approximately every 4.5 seconds the processor is woken by the watchdog timer that is an integral part of the ATtiny84. The input circuit is then energised and an input value obtained. This value is added to a running total and the average is taken and stored in EEPROM only once every 39 samples. While the processor is awake the memory usage is displayed by lighting the appropriate number of LEDs, thus two LEDs on indicates that the memory is between 50% and 75% full. The activity LED is flashed on every other input cycle. On completion of an input cycle the processor returns to its sleeping state. In this mode it takes just over 24 hours to fill the memory.

Mode 3 – playback. This mode uses the bar graph display to show the values recorded in memory. The values are always played back at the rate of eight per second irrespective of whether they were recorded in fast or slow mode. At the end of the playback the Knight Rider appears and the processor goes into its sleep state.

Mode 4 – memory status. The number of LEDs lit up indicates the amount of memory currently used for storing input values. No LEDs means that the memory is empty and can accept 508 readings. Four LEDs means that the memory is full and that the processor will go into a sleep state since no more values can be recorded.

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Description of the kit

Microcontroller

The ATtiny84A is an 8-bit AVR® RISC-based microcontroller in a 14 pin package and it features 8KB ISP flash memory, 512-Byte EEPROM, 512-Byte SRAM, 12 general purpose I/O lines, 32 general purpose working registers, and 2 timers/counters (8-bit/16-bit) with two PWM channels each, internal and external interrupts, 8-channel 10-bit A/D converter, programmable gain stage (1x, 20x) for 12 differential ADC channel pairs, programmable watchdog timer with internal oscillator, internal calibrated oscillator, and four software selectable power saving modes. The device operates between 1.8 and 5.5 volts.

Kit contents

In your kit you should find:

- a) A breadboard with a pre-programmed ATtiny84A microcontroller plugged in
- b) Two red and three black connecting wires
- c) Two press-button switches
- d) Two transistors (PN2222A)
- e) A 10k ohm resistor
- f) Five blue LEDs and one green LED
- g) A 3 volt lithium cell

Please see the card that comes with your kit for instructions on how to build the kit. On the reverse of the card is the circuit schematic.

Circuit layout

On the input side there is a reverse biased green LED which acts as a light sensor. The small current from this LED is amplified by two transistors acting as a Darlington pair to form the input to the A/D converter in the chip. On this side of the chip there is also the Reset button and two locations that can be used to create a serial data connection to another computer.

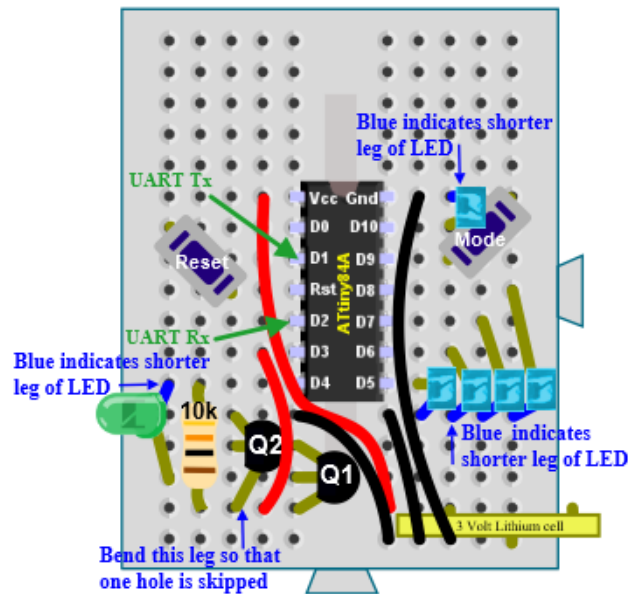
On the output side there is a row of four blue LEDs that act like a bar graph to show the value being read or re-played. A further blue LED flashes to indicate when the processor is active. On this side is also the Mode button which is used to show the current mode and to change modes.

The 3-volt cell connects between pin 1 (Vcc) and pin 14 (Gnd) of the chip.

The component layout is shown in the following diagram with hints for assembling the kit.

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Kit 4 Data Logger

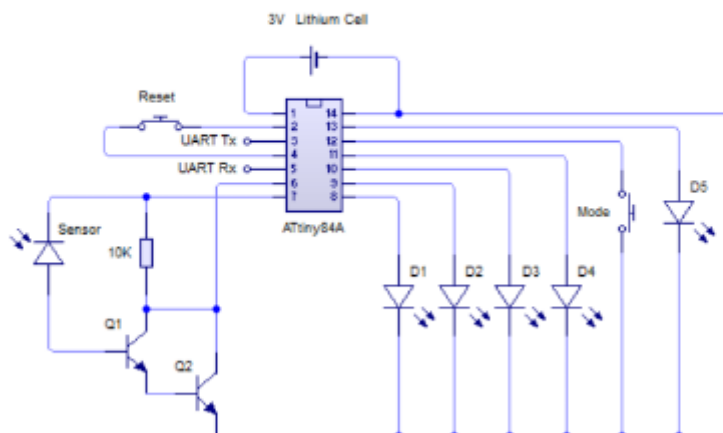


Build order:

1. Turn the breadboard so that there is a lug on the right and a lug at the bottom.
2. Insert the red and black wires
3. Insert the press button switches (Reset and Mode) diagonally as shown.
4. Insert the transistors and resistor. See the note about bending the leg of Q2
5. Insert the LEDs, take care with the orientation of these.
6. Finally add the Lithium cell. Two legs only are used.

The circuit schematic is as follows:

Kit 4 Data Logger Circuit Schematic



Notes:

ATtiny pin 7 provides the switched sensor Vcc. The sensor consists of a reverse biased LED with Q1 and Q2 as an amplifying Darlington Pair to provide the input signal at pin 6. D1 through D4 form an LED bar for visual feedback while D5 indicates when the ATtiny is active.

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Serial Communication with the Data Logger

The Data Logger supports serial communication with an external computer. Data is transmitted by the Data Logger on pin 3 of the ATtiny84 (Tx) and received on pin 5 (Rx). The transmission rate is set at 9600 bits per second and there is no hardware or software flow control.

In order to connect to an external computer the Tx signal from the ATtiny84 must be connected to the Receive data (Rxd) of the external computer's serial interface and the Transmit data (Txd) signal from the external computer must be connected to the Rx pin of the ATtiny84. In addition there must be a common ground connection between both systems.

Care must be taken about voltage levels presented and expected by the external computer. The ATtiny84 works at 3 volts and so the external computer must work at compatible voltage levels otherwise damage to the ATtiny84 may result. A good choice for the external computer is the Raspberry Pi as it works at 3.3 volt levels.

Data sent by the Logger

Initialisation

When the Data Logger is initialised (powered on or reset) the software version is transmitted as, for example,

V,1.1.11

Record and playback

In fast record mode (Mode 1) and in playback mode (Mode 3) each logged value is sent in the format
D,nn

Where nn is the logged value (range 0 to 1023).

The accuracy of the displayed results is different for record and playback. In record mode the full 10 bits from the A/D converter are available. When the values are stored in memory they are first shifted right by two bits to form an eight bit value for storage. Thus the least significant two bits are lost. When values are retrieved from memory they are shifted left to create a ten bit value but the least significant two bits will always be zero. This is equivalent to rounding the magnitude of the input values to the nearest four.

Mode change

When the operating mode is changed the new mode is transmitted in the format

M,n

Where n is the new mode (range 0 to 3).

Change of state

When the processor is about to sleep and when the mode has been changed a status message is sent in the format

S,m,s,p

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Where m is the mode, s is the program state and p is the memory position. Mode is in the range 0-3 while program state can be 2 (going to sleep) or 3 (active). The memory position can be from 4 to 512 where 512 means that the memory is full.

Data received by the Logger

The data logger responds to the letter “K” being sent by the external computer by sending the acknowledgement message

A,K

This is a keep awake command and once received by the ATtiny prevents it from going into a sleep state even when the memory is full. Thus the input continues to be sampled and the values sent to the external computer even though the data is not stored in memory. This means that the fast recording mode (Mode 1) can be used for data acquisition over a long period.

The keep awake status is cleared when the processor is reset or restarted.