Data Logger Manual

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Part 1. Circuit description

A data logger records and converts an instrument signal to a digital output. If the instrument output is small, additional amplification is often necessary. An *instrument amplifier*, a fundamental circuit composed of operational amplifiers and resistors (See Fig. 1A), is used to amplify a signal output. An *operational amplifier* (op amp), a type of integrated circuit, has two inputs and one output (Fig. 1B). The difference between the input voltages is amplified at the output. This basic circuit component can be used to perform different operations– addition, multiplication, integration, etc. An instrument amplifier combines two operational amplifiers in a single integrated circuit, along with other components, to precisely amplify small signals. The amplification is controlled by a single resistor (R1).

A diagram of a data logger with an instrument amplifier is illustrated in Fig. 2. The schematic shows sufficient detail for other scientists to build it. The device amplifies a differential signal to a 0 – 3.3 V output. Voltage offsets are used to adjust the differential output signal within the range of the analog-to-digital convertor of the microcontroller. An additional operational amplifier is powered between 0 – 3.3 V, to protect the microcontroller from a negative voltage input, which can destroy it.

The device described here requires a *microcontroller*. A microcontroller is a computer on a chip, an integrated circuit with a processor core, memory, and programmable input/output peripherals. These devices are found in many modern devices (microwave ovens, automobiles, etc.). The *mbed LPC 1768* microcontroller is used in this application to convert a signal to a digital form, communicate this information to a computer, and power the data logger. Specifications and pin diagram are found at https://developer.mbed.org/platforms/mbed-LPC1768.
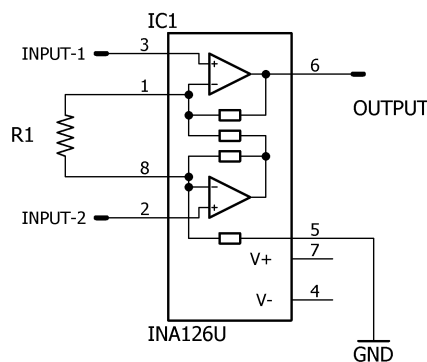

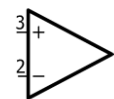**Fig. 1A. Instrument amplifier diagram.**
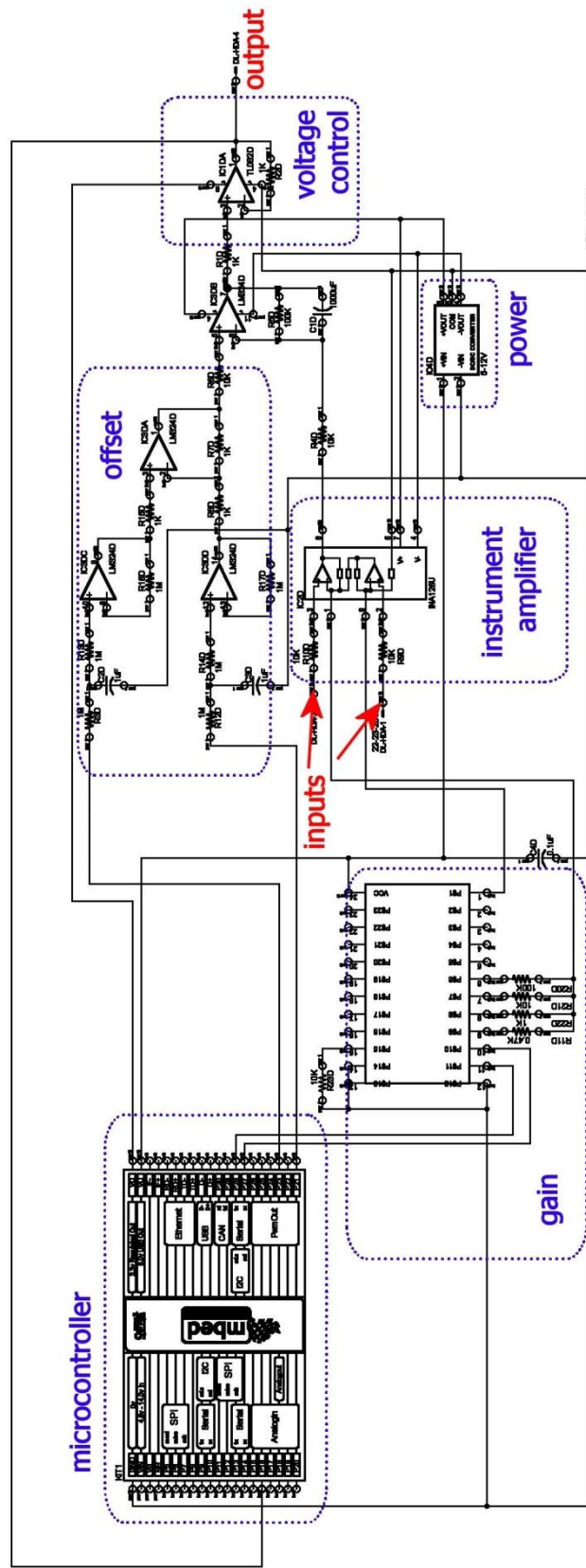
Fig. 1B. Operational amplifier symbol.

Fig. 2. Circuit diagram for a data logger illustrating the microcontroller, gain control, inputs, instrument amplifiers, power supply, and other electrical components.

Part 2. Board Assembly

Instruments and materials needed to assemble a printed circuit board (PCB) are listed in Table 1. A reflow oven (model T-962, Puhui Technology), which is a temperature-controlled infrared heater, is optional for board assembly. A multimeter is needed to check resistances and voltages on the PCB board. A digital oscilloscope, which is optional, is useful in trouble shooting boards. The surface mount components, listed in Table 2, can be obtained from DigiKey or Mouser.

Instructions for assembling and troubleshooting the board are found in the instructional videos (www.kissinstruments.com). Ensure that IC's are positioned in the correct orientation. Pin 1 is to the upper left of the line on the integrated circuit as illustrated in Fig. 3. Alternatively, a white dot on the IC indicates pin 1. Utilize

Fig. 3. Op amp with stripe used in identifying pin numbers

the diagram in Fig. 4 to properly place components on the printed circuit board (PCB) for the data logger. Apply solder paste sparingly to the PCB, and then add the appropriate components to the board.

If a reflow oven is used, set the board in the oven and run the correct temperature program for the solder paste (refer to solder paste specification sheet). After the board is cool, visually inspect board to ensure that the components are attached correctly and that there are no solder bridges. The remaining components, power supply, and header, are hand soldered to the board. Connect two female jumper wires to PCB header to output signal of instrument. Use USB cable supplied with microcontroller to power the board.

Table 3. IC power inputs indicating pin number and voltage value

IC	Pin/(Voltage)	Pin/(Voltage)
1	8/(+12V)	4/(−12V)
2	7/(+12V)	4/(−12V)
3	4/(+3.3V)	11/(0V)
4	24/(+5V)	12/(0V)

Troubleshooting. A multimeter is needed to check resistances and voltages on the PCB board. A digital oscilloscope, which is optional, is useful in trouble shooting boards. Use the USB cable supplied with microcontroller to power the board. Check that voltages supplied to the IC's as listed in Table 3.

Additional Hardware. Any instrument with an analog output should work with this PCB board (i.e. this board can be used to replace a strip chart recorder). The *Excel* template has an offset to compensate for differences in the computer and instrument ground.

Table 1. Instruments and materials needed to assemble PCB			
Instrument	**Part**	**Type**	**Source**
Solder station	YiHua 968 DB	YiHua	Amazon.com
Infrared IC heater	T-962	Puhui Technology (Taian)	www.tech168.cn
Solder paste	SAC 305	ChipQuik	www.chipquik.com
Multimeter	Any type/model will suffice		

| Table 2. Components needed for PCB				
Component	**Type**	**Part**	**Source**	**Quantity**
Circuit Board	See supplemental material		Sunstone	1
Microcontroller	Mbed LPC1768	OM11043	DigiKey	1
Power Supply	Murata	580-MEJ1D0512SC	DigiKey	1
Op Amp	TL082	296-1284-1-ND	DigiKey	1
Op Amp	LM324	497-1580-1-ND	DigiKey	1
Instr. Amp	INA126U	296-31643-1-ND	DigiKey	1
MUX	Analog Switch	863MC74HC4067ADWG	Mouser	1
Resistor	1M	CR0603-JW-105GLFCT-ND	DigiKey	6
Resistor	100K	CR0603-JW-104GLFCT-ND	DigiKey	2
Resistor	10	CR0603-JW-103GLFCT-ND	DigiKey	6
Resistor	1	CR0603-JW-102GLFCT-ND	DigiKey	6
Resistor	0.47	CR0603-JW-471GLFCT-ND	DigiKey	6
Capacitor	0.1uF	490-1532-1-ND	DigiKey	1
Capacitor	1uF	490-1543-1-ND	DigiKey	3
Enclosure	3" x 2" x 1"	2701801	Radio Shack	1
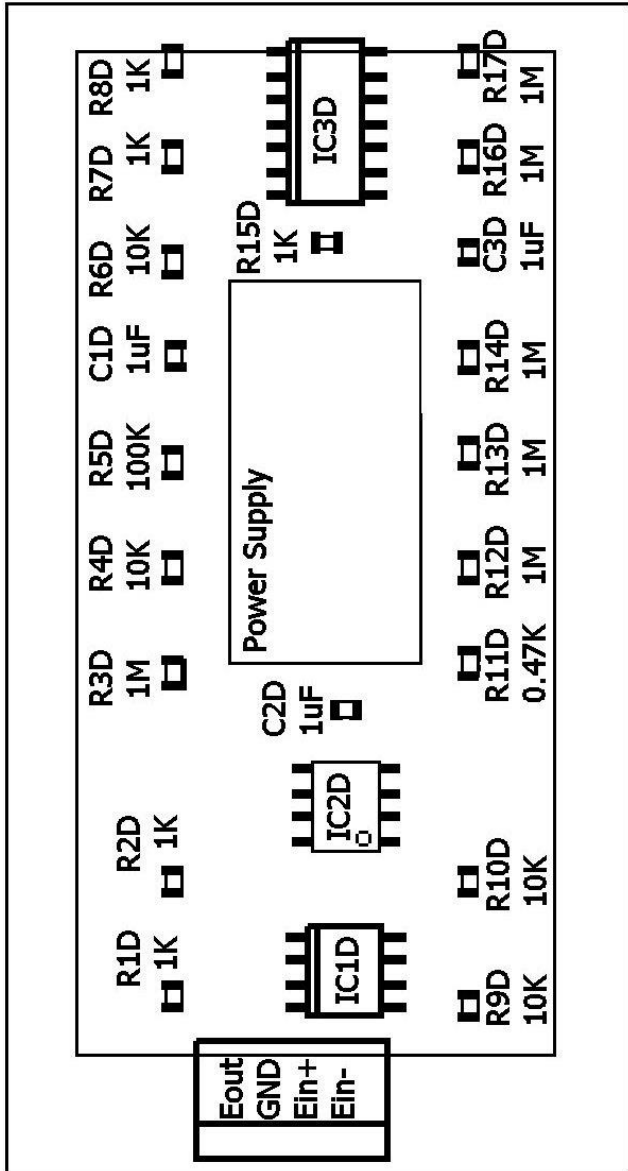
Fig. 4. Circuit board component layout for data logger. Reverse side of board illustrated below.
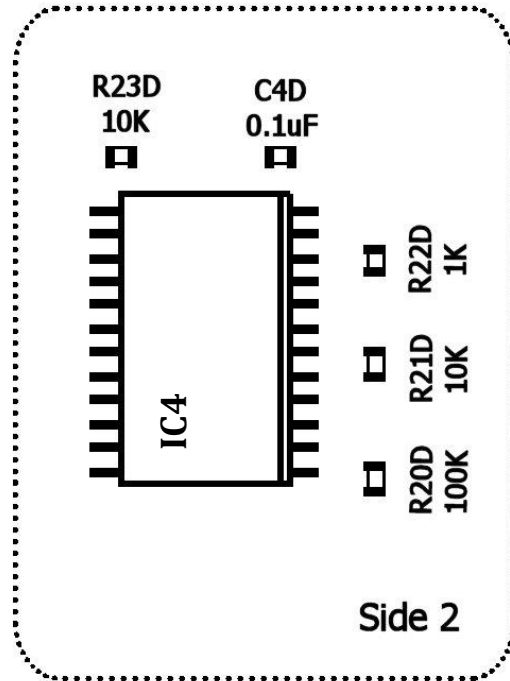
Part 3. Software

A USB driver is available at https://developer.mbed.org/handbook/Windows-serial-configuration. Additionally, two files (an Excel template and microcontroller program), are necessary and links are found under products at www.kissinstruments.com. These files include (A) an *Excel* template for collecting data (DL-v500.xls) and (B) a compiled *mbed* program (DL-v100_LPC1768.bin

Install programs.

1. Install USB driver. The USB driver is available at https://developer.mbed.org/handbook/Windows-serial-configuration. Run *mbedWinSerial_16466.exe* and follow prompts. This program installs a serial communications program on microcontroller so data can be collected through the USB cable.
2. Copy DL-program (DL-v100_LPC1768.bin) onto microcontroller. This program runs on the microcontroller. Using the Control Panel, Device Manager, identify the serial port used by the microcontroller.
3. Open the *Excel* template, *DL-v100.xls*. This template is used to communicate with the microcontroller. *Do not copy this template onto the microcontroller.*
4. Set communication ports. The COM port used by the microcontroller and spreadsheet need to be the same. In *Excel*, under the spreadsheet tab labelled "Parameters" change the COM port value as appropriate. The COM port value must be between 1–4. In the *Windows Device Manager*, set the COM port to the appropriate value (see Fig. 5).
5. Using the *Excel* template, record data by clicking on start/stop as necessary.

Scale Adjustment. If appropriate, adjust instrument attenuation and zero offset until the full scale is observed on the *Excel* spreadsheet. Both the attenuation and offsets can also be controlled by the data logger. On the *Parameter* tab of the spreadsheet template (see Fig. 5), a pulldown menu allows the user to control the gain. If necessary, the data logger offsets are also adjusted with sliders. These sliders change the applied voltages to the offsets (see labelled circuit). The offsets are likely to depend on the condition of the detector filaments.
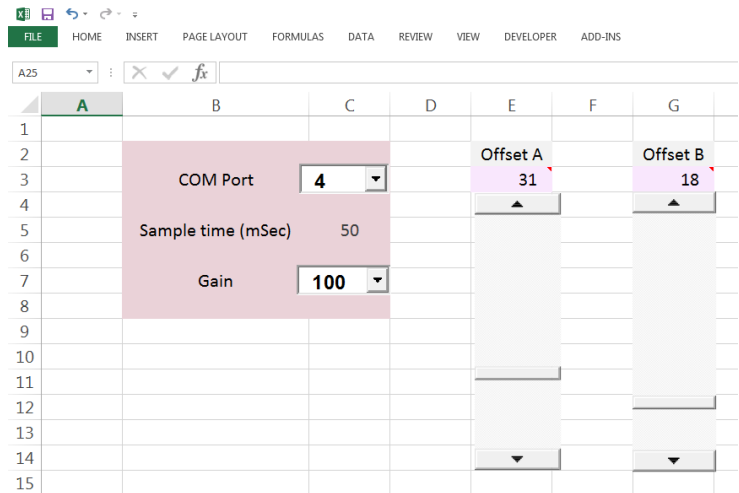

Fig. 5. Worksheet utilized to establish communication, gain and offset to data logger.