datalogd

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Contents

datalogd is a data logging daemon service which uses a source/filter/sink plugin architecture to allow extensive customisation and maximum flexibility. There are no strict specifications or requirements for data types, but typical examples would be readings from environmental sensors such as temperature, humidity, voltage or the like.

The user guide and API documentation can be read online at Read the Docs. Source code is available on GitLab.

Custom data sources, filters, or sinks can be created simply by extending an existing `DataSource`, `DataFilter`, or `DataSink` python class and placing it in a plugin directory.

Data sources, filters, and sinks can be arbitrarily connected together with a connection digraph described using the DOT graph description language.

Provided data source plugins include:

- `LibSensorsDataSource` - (Linux) computer motherboard sensors for temperature, fan speed, voltage etc.
- `SerialDataSource` - generic data received through a serial port device. Arduino code for acquiring and sending data through its USB serial connection is also included.
- `RandomWalkDataSource` - testing or demonstration data source using a random walk algorithm.
- `ThorlabsPMDataSource` - laser or light power measurement using the Thorlabs PM100 or PM400 power meter.
- `PicoTC08DataSource` - thermocouple or other sensor measurements using the Pico Technologies TC-08 USB data logger.

Provided data sink plugins include:

- `PrintDataSink` - print to standard out or standard error streams.
- `FileDataSink` - write to a file.
- `LoggingDataSink` - simple output to console using python logging system.
- `InfluxDB2DataSink` - InfluxDB 2.x database system specialising in time-series data.
- `MatplotlibDataSink` - create a plot of data using matplotlib.
- `PyqtgraphDataSink` - plot incoming data in realtime in a pyqtgraph window.

Provided data filter plugins include:

- `SocketDataFilter` - bridge a connection over a network socket.
- `KeyValDataFilter` - selecting or discarding data entries based on key-value pairs.
- `TimeStampDataFilter` - adding timestamps to data.
- `AggregatorDataFilter` - aggregating multiple data readings into a fixed-size buffer.
- `CSVDataFilter` - format data as a table of comma separated values.
- `PolynomialFunctionDataFilter` - apply a polynomial function to a value.
- `FlowSensorCalibrationDataFilter` - convert a pulse rate into liquid flow rate.
- `CoolingPowerDataFilter` - calculate power dissipation into a liquid using temperatures and flow rate.

See *Data Logging Recipes* for examples of how to link various data sources, filters, and sinks to make something useful.

CHAPTER 1

User Documentation

1.1 Quick Start

This guide will run through the installation and configuration of the data logging daemon service.

1.1.1 Installation

Note: `pip3` and `python3` are used here because currently `pip` and `python` refer to python2 versions on some common Linux distributions such as Ubuntu. On Windows, or distributions like Arch where python3 is the default, `pip` and `python` may be used instead.

Note: These instructions assume a system-wide install, which requires root or administrator privileges. On Linux, either first switch to a root login with `sudo -i`, or prefix all commands with `sudo`. Alternatively, a user-level install can be performed by using the `--user` flag on `pip` or `systemd` commands, for example `pip3 install --user ...`, or `systemctl --user ...`

Ensure the `pip` python package manager is installed. For example:

```
# Debian, Ubuntu etc.
apt install python3-pip
# Arch Linux
pacman -Sy python-pip
```

Install using `pip`:

```
pip3 install --upgrade datalogd
```

Some plugins require additional packages. These will be listed when the plugin is attempted to be loaded. The optional dependencies can be also be installed with `pip`, for example:

```
pip3 install --upgrade pyserial pyserial-asyncio PySensors influxdb matplotlib
```

The executable should now be available. This will show the available *command line parameters*:

```
datalogd --help
```

On Linux operating systems, a systemd service file will be installed and enabled to run on startup. Automatic configuration to start on alternate operating systems (such as Windows) is not yet implemented, and therefore must be done manually. Once the configuration file has been prepared, the service can be started with `systemctl start datalog`.

1.1.1.1 Windows

There are several ways of getting the service to run automatically at startup. This is one example which can be configured as a standard user without admin privileges.

- Get the the datalogd.xml file and save it somewhere.
- Open Task Scheduler (windows key, type `taskschd.msc`, enter).
- Click `Action->Import Task...`, find and select the `datalogd.xml` file.
- Click `Change User or Group...` button, type your user name, click `Check Names`, then `OK`, and `OK`.

1.1.2 Configuration

The default configuration has no function, and so will not run. Configuring the daemon is performed by either creating or editing a configuration file, or passing parameters on the command line.

1.1.2.1 Configuration Files

To obtain the location of the default configuration files, run with the `--show-config-dirs` command line option.

```
datalogd --show-config-dirs
```

```
INFO:main:Default configuration file locations are:
  /etc/xdg/datalogd/datalogd.conf
  /root/.config/datalogd/datalogd.conf
```

All config files will be read, with any options in the later files overriding the earlier ones. Note also that a custom config file may be specified on the *command line*, and will be read last. Configuration specified as *command line parameters* will override any configuration read from files.

A configuration file should take the form of:

```
[datalogd]

plugin_paths = []

connection_graph =
  digraph {
    source [class=NullDataSource];
    sink [class=NullDataSink];
    source -> sink;
  }
```

The options are:

- `plugin_paths` - path(s) to directories containing custom source/filter/sink plugins. See the *Plugins* section for details on creating custom plugins.
- `connection_graph` - declaration of plugin nodes, parameters, and the connections between them. See the *Connection Graph* section for details on the connection graph syntax.

1.1.2.2 Command Line Parameters

```
datalogd --help
```

```
usage: datalogd [-h] [-c FILE] [-p DIR [DIR ...]] [-g GRAPH_DOT] [--show-config-dirs]

Run the data logging daemon service.

optional arguments:
  -h, --help            show this help message and exit
  -c FILE, --configfile FILE
                        Path to configuration file.
  -p DIR [DIR ...], --plugindirs DIR [DIR ...]
                        Directories containing additional plugins.
  -g GRAPH_DOT, --graph-dot GRAPH_DOT
                        Connection graph specified in DOT format.
  --show-config-dirs    Display the default locations of configuration files, then
↪exit.
```

1.2 Plugins

This section describes how to create plugins, specify the connections between them, and then run the complete data logging pipeline.

Plugins are python classes which extend one of the base plugin types. The class can be defined in any python source code file, and multiple plugin classes may be defined in a single file. The directory containing plugin source code can be specified in a configuration file, or in command line parameters.

1.2.1 Data Sources

Data source classes must extend *DataSource*. In addition, their class name must have the suffix "DataSource".

The following code is a simple example of a functional data source plugin. It sends the string "Hello, World!" to any connected sinks once every 10 seconds:

Listing 1: `plugin_demos/helloworld_datasource.py`

```
import asyncio
from datalogd import DataSource

# Must extend datalogd.DataSource, and class name must have DataSource suffix
class HelloWorldDataSource(DataSource):
    def __init__(self, sinks=[]):
        # Do init of the superclass (DataSource), connect any specified sinks
        super().__init__(sinks=sinks)
```

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```
        # Queue first call of update routine
        asyncio.get_event_loop().call_soon(self.say_hello)

    def say_hello(self):
        "Send ``Hello, World!`` to connected sinks, then repeat every 10 seconds."
        self.send("Hello, World!")
        asyncio.get_event_loop().call_later(10, self.say_hello)
```

Note the use of the `asyncio` event loop to schedule method calls, as opposed to a separate loop/sleep thread or similar.

Data sources will have their *`close()`* method called when the application is shutting down so that any resources (devices, files) used can be released.

1.2.2 Data Sinks

Data sinks accept data using their *`receive()`* method, and do something with it, such as committing it to a database. They must extend *`DataSink`*, and must use the suffix "DataSink".

A simple example data sink which prints received data in uppercase to the console is:

Listing 2: `plugin_demos/shout_datasink.py`

```
from datalogd import DataSink

# Must extend datalogd.DataSink, and class name must have DataSink suffix
class ShoutDataSink(DataSink):
    # Override the receive() method to do something useful with received data
    def receive(self, data):
        "Accept ``data`` and shout it out to the console."
        print(str(data).upper())
```

Data sinks will have their *`close()`* method called when the application is shutting down so that any resources (devices, files) used can be released.

1.2.3 Data Filters

Data filters are in fact both *`DataSource`*s and *`DataSink`*s, and thus share the functionality of both. They must extend *`DataFilter`*, and must use the suffix "DataFilter".

The *`NullDataFilter`* is the most simple example of a filter, which accepts data and passes it unchanged to any connected sinks. A slightly more functional filter which performs some processing on the data is:

Listing 3: `plugin_demos/helloworld_datafilter.py`

```
from datalogd import DataFilter

# Must extend datalogd.DataFilter, and class name must have DataFilter suffix
class HelloWorldDataFilter(DataFilter):
    # Override the receive() method to do something useful with received data
    def receive(self, data):
        # Send modified data to all connected sinks
        self.send(str(data).replace("Hello", "Greetings"))
```

1.2.4 Connecting

To connect the above source, filter and sink to a complete "Hello, World!" data logger, the connection graph could be specified as:

```
digraph {
    source [class=HelloWorldDataSource];
    filter [class=HelloWorldDataFilter];
    sink   [class=ShoutDataSink];
    source -> filter -> sink;
}
```

1.2.5 Running

See the *Command Line Parameters* section for details on specifying configuration from the command line.

```
$ datalogd --plugindir plugin_demos --graph 'digraph{a[class=HelloWorldDataSource];
↪b[class=HelloWorldDataFilter];c[class=ShoutDataSink];a->b->c;}'
```

```
INFO:main:Initialising DataLogDaemon.
INFO:DataLogDaemon:Loaded config from: /etc/xdg/datalogd/datalogd.conf
INFO:pluginlib:Loading plugins from standard library
INFO:pluginlib:Adding plugin_demos as a plugin search path
INFO:DataLogDaemon:Detected source plugins: NullDataSource, LibSensorsDataSource,␣
↪RandomWalkDataSource, SerialDataSource, HelloWorldDataSource
INFO:DataLogDaemon:Detected filter plugins: NullDataFilter, AggregatorDataFilter,␣
↪CSVDataFilter, KeyValDataFilter, TimeStampDataFilter, HelloWorldDataFilter
INFO:DataLogDaemon:Detected sink plugins: NullDataSink, FileDataSink,␣
↪InfluxDBDataSink, LoggingDataSink, MatplotlibDataSink, PrintDataSink, ShoutDataSink
INFO:DataLogDaemon:Initialising node a:HelloWorldDataSource()
INFO:DataLogDaemon:Initialising node b:HelloWorldDataFilter()
INFO:DataLogDaemon:Initialising node c:ShoutDataSink()
INFO:DataLogDaemon:Connecting a:HelloWorldDataSource -> b:HelloWorldDataFilter
INFO:DataLogDaemon:Connecting b:HelloWorldDataFilter -> c:ShoutDataSink
INFO:main:Starting event loop.
GREETINGS, WORLD!
GREETINGS, WORLD!
GREETINGS, WORLD!
^CINFO:main:Stopping event loop.
```

1.3 Connection Graph

Specifying the plugins, their parameters, and the connections between them is performed using the DOT graph description language.

The default connection graph is valid, but not useful, as it simply connects a *NullDataSource* to a *NullDataSink*:

```
1 digraph {
2   source [class=NullDataSource];
3   sink [class=NullDataSink];
4   source -> sink;
5 }
```

The purpose of each line is:

1. `digraph` declares that this is a directed graph. This is required, as the flow of data is not bi-directional.
2. This line declares a *`NullDataSource`* plugin named "source". `source` is a unique label for this node, which can be any string such as "src" or "a". Inside the square brackets are the attributes for the node. The only required attribute is `class`, which specifies the python class name of the plugin to use for the node. Additional attributes are passed to the `__init__()` method of the plugin.
3. This line declares a *`NullDataSink`* plugin named `sink`.
4. This line adds `sink` as a receiver of data from `source`. Connections between nodes are indicated with `->`.

A more complicated (but just as useless!) connection graph is:

```
digraph {
  a [class=NullDataSource];
  b [class=NullDataSource];
  c [class=NullDataFilter];
  d [class=NullDataSink];
  e [class=NullDataSink];
  a -> c -> d;
  b -> c -> e;
}
```

This graph has two data sources and two sinks, connected together with a common filter. Any data produced by either of the sources will be fed to both of the sinks.

1.3.1 Node Attributes

Some plugins may accept (or require) additional parameters during initialisation. These are provided by attributes of the graph node which describe the plugin. The *`RandomWalkDataSource`* is one such plugin. It generates demonstration data using a random walk algorithm, and the parameters of the algorithm can be specified using node attributes.

```
digraph {
  a [class=RandomWalkDataSource, interval=1.5, walkers="[[100, 2.5], [50, 1], [0, 10]]
↪"];
  b [class=LoggingDataSink];
  a -> b;
}
```

The value of `interval` specifies how often the algorithm should run, and the value of `walkers` describes how many random walkers should be used and their starting and increment values.

Any attribute values which contain DOT punctuation (space, comma, [], {} etc) must be enclosed in double quotes, as seen for the `walkers` attribute. The enclosed string will then be interpreted as JSON to determine its type and value, however, any double quotes in the JSON must be replaced with single quotes, so as to not conflict with the double quotes of the DOT language.

Note: To force interpretation of an attribute as a string, enclose the value in an additional set of single quotes. The quotes will be removed during parsing of the DOT. For example, `id="1.23e4"` will be a float, while `id="'1.23e4'"` will be a string.

1.4 Data Logging Recipes

1.4.1 Random Data to CSV File

This generates random data, adds a timestamp, formats as CSV, and writes to a file. The default settings for the *FileDataSink* is to flush out to the file every 10 seconds.

Listing 4: recipes/randomwalk_timestamp_csv_file.config

```
[datalogd]
connection_graph =
  digraph {
    a [class=RandomWalkDataSource];
    b [class=TimeStampDataFilter];
    d [class=CSVDataFilter, labels=None];
    s [class=FileDataSink, filename="randomwalk.csv"];
    a -> b -> d -> s;
  }
```

```
$ datalogd -c recipes/randomwalk_timestamp_csv_file.config
```

```
INFO:main:Initialising DataLogDaemon.
INFO:DataLogDaemon:Loaded config from: /etc/xdg/datalogd/datalogd.conf, recipes/
↪randomwalk_timestamp_csv_file.config
INFO:pluginlib:Loading plugins from standard library
INFO:DataLogDaemon:Detected source plugins: NullDataSource, LibSensorsDataSource,␣
↪RandomWalkDataSource, SerialDataSource
INFO:DataLogDaemon:Detected filter plugins: NullDataFilter, AggregatorDataFilter,␣
↪CSVDataFilter, KeyValDataFilter, TimeStampDataFilter
INFO:DataLogDaemon:Detected sink plugins: NullDataSink, FileDataSink,␣
↪InfluxDBDataSink, LoggingDataSink, MatplotlibDataSink, PrintDataSink
INFO:DataLogDaemon:Initialising node a:RandomWalkDataSource()
INFO:DataLogDaemon:Initialising node b:TimeStampDataFilter()
INFO:DataLogDaemon:Initialising node d:CSVDataFilter(labels=None)
INFO:DataLogDaemon:Initialising node s:FileDataSink(filename=randomwalk.csv)
INFO:DataLogDaemon:Connecting a:RandomWalkDataSource -> b:TimeStampDataFilter
INFO:DataLogDaemon:Connecting b:TimeStampDataFilter -> d:CSVDataFilter
INFO:DataLogDaemon:Connecting d:CSVDataFilter -> s:FileDataSink
INFO:main:Starting event loop.
```

```
$ cat randomwalk.csv
```

```
2020-04-17 22:02:51.887071+09:30,-1.0,2020-04-17 22:02:51.887071+09:30,-2.0
2020-04-17 22:02:52.888208+09:30,0.0,2020-04-17 22:02:52.888208+09:30,0.0
2020-04-17 22:02:53.889423+09:30,-1.0,2020-04-17 22:02:53.889423+09:30,-2.0
2020-04-17 22:02:54.889818+09:30,-1.0,2020-04-17 22:02:54.889818+09:30,-4.0
2020-04-17 22:02:55.891065+09:30,-2.0,2020-04-17 22:02:55.891065+09:30,-6.0
2020-04-17 22:02:56.892261+09:30,-3.0,2020-04-17 22:02:56.892261+09:30,-8.0
2020-04-17 22:02:57.893478+09:30,-4.0,2020-04-17 22:02:57.893478+09:30,-10.0
2020-04-17 22:02:58.894673+09:30,-3.0,2020-04-17 22:02:58.894673+09:30,-12.0
2020-04-17 22:02:59.895897+09:30,-2.0,2020-04-17 22:02:59.895897+09:30,-14.0
...
```

There are no labels for the column headers, and the file will grow infinitely large with time. It might be better to aggregate the data and update the file with only the latest data. Note the use of `mode="w"` and `flush_interval=None`,

which causes the file to be opened, written, and closed on each reciept of data. In this way, each block of aggregated data will overwrite the old one.

Listing 5: recipes/randomwalk_timestamp_aggregator_csv_file.config

```
[datalogd]
connection_graph =
  digraph {
    a [class=RandomWalkDataSource];
    b [class=TimeStampDataFilter];
    c [class=AggregatorDataFilter, buffer_size=3600, send_every=10];
    d [class=CSVDataFilter];
    s [class=FileDataSink, filename="randomwalk.csv", mode="w", flush_interval=None];
    a -> b -> c -> d -> s;
  }
```

```
$ datalogd -c recipes/randomwalk_timestamp_aggregator_csv_file.config
```

```
INFO:main:Initialising DataLogDaemon.
INFO:DataLogDaemon:Loaded config from: /etc/xdg/datalogd/datalogd.conf, recipes/
↪randomwalk_timestamp_aggregator_csv_file.config
INFO:pluginlib:Loading plugins from standard library
INFO:DataLogDaemon:Detected source plugins: NullDataSource, LibSensorsDataSource,␣
↪RandomWalkDataSource, SerialDataSource
INFO:DataLogDaemon:Detected filter plugins: NullDataFilter, AggregatorDataFilter,␣
↪CSVDataFilter, KeyValDataFilter, TimeStampDataFilter
INFO:DataLogDaemon:Detected sink plugins: NullDataSink, FileDataSink,␣
↪InfluxDBDataSink, LoggingDataSink, MatplotlibDataSink, PrintDataSink
INFO:DataLogDaemon:Initialising node a:RandomWalkDataSource()
INFO:DataLogDaemon:Initialising node b:TimeStampDataFilter()
INFO:DataLogDaemon:Initialising node c:AggregatorDataFilter(buffer_size=3600, send_
↪every=30)
INFO:DataLogDaemon:Initialising node d:CSVDataFilter()
INFO:DataLogDaemon:Initialising node s:FileDataSink(filename=randomwalk.csv)
INFO:DataLogDaemon:Connecting a:RandomWalkDataSource -> b:TimeStampDataFilter
INFO:DataLogDaemon:Connecting b:TimeStampDataFilter -> c:AggregatorDataFilter
INFO:DataLogDaemon:Connecting c:AggregatorDataFilter -> d:CSVDataFilter
INFO:DataLogDaemon:Connecting d:CSVDataFilter -> s:FileDataSink
INFO:main:Starting event loop.
```

```
$ cat randomwalk.csv
```

```
timestamp,analog_randomwalk0,timestamp,analog_randomwalk1
2020-04-17 22:27:36.264577+09:30,1.0,2020-04-17 22:27:36.264577+09:30,0.0
2020-04-17 22:27:37.265669+09:30,1.0,2020-04-17 22:27:37.265669+09:30,2.0
2020-04-17 22:27:38.266249+09:30,2.0,2020-04-17 22:27:38.266249+09:30,0.0
2020-04-17 22:27:39.267433+09:30,3.0,2020-04-17 22:27:39.267433+09:30,-2.0
2020-04-17 22:27:40.268600+09:30,2.0,2020-04-17 22:27:40.268600+09:30,0.0
2020-04-17 22:27:41.269554+09:30,2.0,2020-04-17 22:27:41.269554+09:30,0.0
2020-04-17 22:27:42.270715+09:30,3.0,2020-04-17 22:27:42.270715+09:30,-2.0
2020-04-17 22:27:43.271873+09:30,4.0,2020-04-17 22:27:43.271873+09:30,0.0
2020-04-17 22:27:44.272887+09:30,4.0,2020-04-17 22:27:44.272887+09:30,0.0
2020-04-17 22:27:45.274042+09:30,3.0,2020-04-17 22:27:45.274042+09:30,-2.0
2020-04-17 22:27:46.275201+09:30,2.0,2020-04-17 22:27:46.275201+09:30,0.0
2020-04-17 22:27:47.276220+09:30,1.0,2020-04-17 22:27:47.276220+09:30,0.0
```

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```
2020-04-17 22:27:48.277396+09:30,1.0,2020-04-17 22:27:48.277396+09:30,0.0
2020-04-17 22:27:49.278583+09:30,0.0,2020-04-17 22:27:49.278583+09:30,-2.0
2020-04-17 22:27:50.279763+09:30,1.0,2020-04-17 22:27:50.279763+09:30,-2.0
2020-04-17 22:27:51.280956+09:30,0.0,2020-04-17 22:27:51.280956+09:30,-2.0
2020-04-17 22:27:52.282120+09:30,0.0,2020-04-17 22:27:52.282120+09:30,-2.0
2020-04-17 22:27:53.283198+09:30,0.0,2020-04-17 22:27:53.283198+09:30,-2.0
2020-04-17 22:27:54.284388+09:30,1.0,2020-04-17 22:27:54.284388+09:30,-2.0
2020-04-17 22:27:55.285719+09:30,0.0,2020-04-17 22:27:55.285719+09:30,-4.0
2020-04-17 22:27:56.286249+09:30,0.0,2020-04-17 22:27:56.286249+09:30,-4.0
2020-04-17 22:27:57.287438+09:30,-1.0,2020-04-17 22:27:57.287438+09:30,-6.0
2020-04-17 22:27:58.288604+09:30,-2.0,2020-04-17 22:27:58.288604+09:30,-8.0
2020-04-17 22:27:59.289765+09:30,-2.0,2020-04-17 22:27:59.289765+09:30,-10.0
2020-04-17 22:28:00.290927+09:30,-1.0,2020-04-17 22:28:00.290927+09:30,-10.0
2020-04-17 22:28:01.292095+09:30,0.0,2020-04-17 22:28:01.292095+09:30,-12.0
2020-04-17 22:28:02.292911+09:30,0.0,2020-04-17 22:28:02.292911+09:30,-10.0
2020-04-17 22:28:03.294073+09:30,0.0,2020-04-17 22:28:03.294073+09:30,-12.0
2020-04-17 22:28:04.295262+09:30,-1.0,2020-04-17 22:28:04.295262+09:30,-12.0
2020-04-17 22:28:05.296247+09:30,-2.0,2020-04-17 22:28:05.296247+09:30,-10.0
...
```

1.4.2 System Temperatures to Matplotlib Plot

Find available sensor data from libsensors. The `id` field will be a composite of the device and sensor name.

```
$ sensors
```

```
nvme-pci-0100
Adapter: PCI adapter
Composite:    +37.9°C  (low  = -273.1°C, high = +82.8°C)
                       (crit = +84.8°C)
Sensor 1:     +37.9°C  (low  = -273.1°C, high = +65261.8°C)
Sensor 2:     +42.9°C  (low  = -273.1°C, high = +65261.8°C)

k10temp-pci-00c3
Adapter: PCI adapter
Vcore:       969.00 mV
Vsoc:          1.09 V
Tdie:         +40.0°C
Tctl:         +50.0°C
Icore:         5.00 A
Isoc:          8.50 A
```

We will select both the NVME composite (solid-state disk temperature) and k10temp Tdie (AMD CPU core temperature) using a pair of *KeyValDataFilter*s. These make two separate data streams which are re-joined together before being passed on to the aggregator. The aggregator buffers one hour of data, and sends updated data to the *MatplotlibDataSink* once every minute.

Note that with some skilled regular expression use in `val`, it might be possible to use a single *KeyValDataFilter* to select all required sensor data, eliminating the need to rejoin the data streams.

Listing 6: `recipes/temperature_matplotlib.config`

```
[datalogd]
connection_graph =
```

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```
  digraph {
    a  [class=LibSensorsDataSource];
    b  [class=TimeStampDataFilter];
    c  [class=KeyValDataFilter, key="id", val="k10temp.*Tdie"];
    cc [class=KeyValDataFilter, key="id", val="nvme.*Composite"];
    d  [class=JoinDataFilter];
    e  [class=AggregatorDataFilter, buffer_size=3600, send_every=60];
    s  [class=MatplotlibDataSink, filename="temperatures_plot.pdf"];
    a -> b -> c -> d -> e -> s;
    b -> cc -> d;
  }
```

```
$ datalogd -c recipes/temperature_matplotlib.config
```

```
INFO:main:Initialising DataLogDaemon.
INFO:DataLogDaemon:Loaded config from: /etc/xdg/datalogd/datalogd.conf, recipes/
↪temperature_matplotlib.config
INFO:pluginlib:Loading plugins from standard library
INFO:DataLogDaemon:Detected source plugins: NullDataSource, LibSensorsDataSource,␣
↪RandomWalkDataSource, SerialDataSource
INFO:DataLogDaemon:Detected filter plugins: NullDataFilter, AggregatorDataFilter,␣
↪CSVDataFilter, JoinDataFilter, KeyValDataFilter, TimeStampDataFilter
INFO:DataLogDaemon:Detected sink plugins: NullDataSink, FileDataSink,␣
↪InfluxDBDataSink, LoggingDataSink, MatplotlibDataSink, PrintDataSink
INFO:DataLogDaemon:Initialising node a:LibSensorsDataSource()
INFO:DataLogDaemon:Initialising node b:TimeStampDataFilter()
INFO:DataLogDaemon:Initialising node c:KeyValDataFilter(key=id, val=k10temp.*Tdie)
INFO:DataLogDaemon:Initialising node cc:KeyValDataFilter(key=id, val=nvme.*Composite)
INFO:DataLogDaemon:Initialising node d:JoinDataFilter()
INFO:DataLogDaemon:Initialising node e:AggregatorDataFilter(buffer_size=3600, send_
↪every=60)
INFO:DataLogDaemon:Initialising node s:MatplotlibDataSink(filename=temperatures_plot.
↪pdf)
INFO:DataLogDaemon:Connecting a:LibSensorsDataSource -> b:TimeStampDataFilter
INFO:DataLogDaemon:Connecting b:TimeStampDataFilter -> c:KeyValDataFilter
INFO:DataLogDaemon:Connecting c:KeyValDataFilter -> d:JoinDataFilter
INFO:DataLogDaemon:Connecting d:JoinDataFilter -> e:AggregatorDataFilter
INFO:DataLogDaemon:Connecting e:AggregatorDataFilter -> s:MatplotlibDataSink
INFO:DataLogDaemon:Connecting b:TimeStampDataFilter -> cc:KeyValDataFilter
INFO:DataLogDaemon:Connecting cc:KeyValDataFilter -> d:JoinDataFilter
INFO:main:Starting event loop.
```

1.4.3 Realtime Plots with Pyqtgraph

This generates five sets of random data using the *RandomWalkDataSource* and plots them in realtime as traces on a pyqtgraph plot using *PyqtgraphDataSink*.

The `plotlayout` parameter demonstrates setting up two stacked plot panels and styling the five traces.

Listing 7: `recipes/randomwalk_pyqtgraph.config`

```
[datalogd]
connection_graph =
  digraph {
```

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```
    a [class=RandomWalkDataSource, interval=0.03, walkers="[[5.6, 0.10], [7.8, 0.15],␣
↪[9.0, 0.25], [12345, 45], [12345, 67]]"];
    s [class=PyqtgraphDataSink, npoints=1024, title="Pyqtgraph Plots", size="[1000,␣
↪800]", plotlayout="
      [
        {
          'ylabel': 'Temperature (°C)',
          'traces': [
            {
              'name': 'Trace 1',
              'pen': [255, 0, 0],
              'selector': [
                ['type', 'randomwalk'],
                ['id', '0']
              ]
            },
            {
              'name': 'Trace 2',
              'pen': [0, 255, 0],
              'selector': [
                ['type', 'randomwalk'],
                ['id', '1']
              ]
            },
            {
              'name': 'Trace 3',
              'pen': [0, 0, 255],
              'selector': [
                ['type', 'randomwalk'],
                ['id', '2']
              ]
            }
          ]
        },
        {
          'ylabel': 'Pressure (kPa)',
          'traces': [
            {
              'name': 'Trace 4',
              'pen': [255, 255, 0],
              'selector': [
                ['type', 'randomwalk'],
                ['id', '3']
              ]
            },
            {
              'name': 'Trace 5',
              'pen': [255, 0, 255],
              'selector': [
                ['type', 'randomwalk'],
                ['id', '4']
              ]
            }
          ]
        }
      ]
    "];
```

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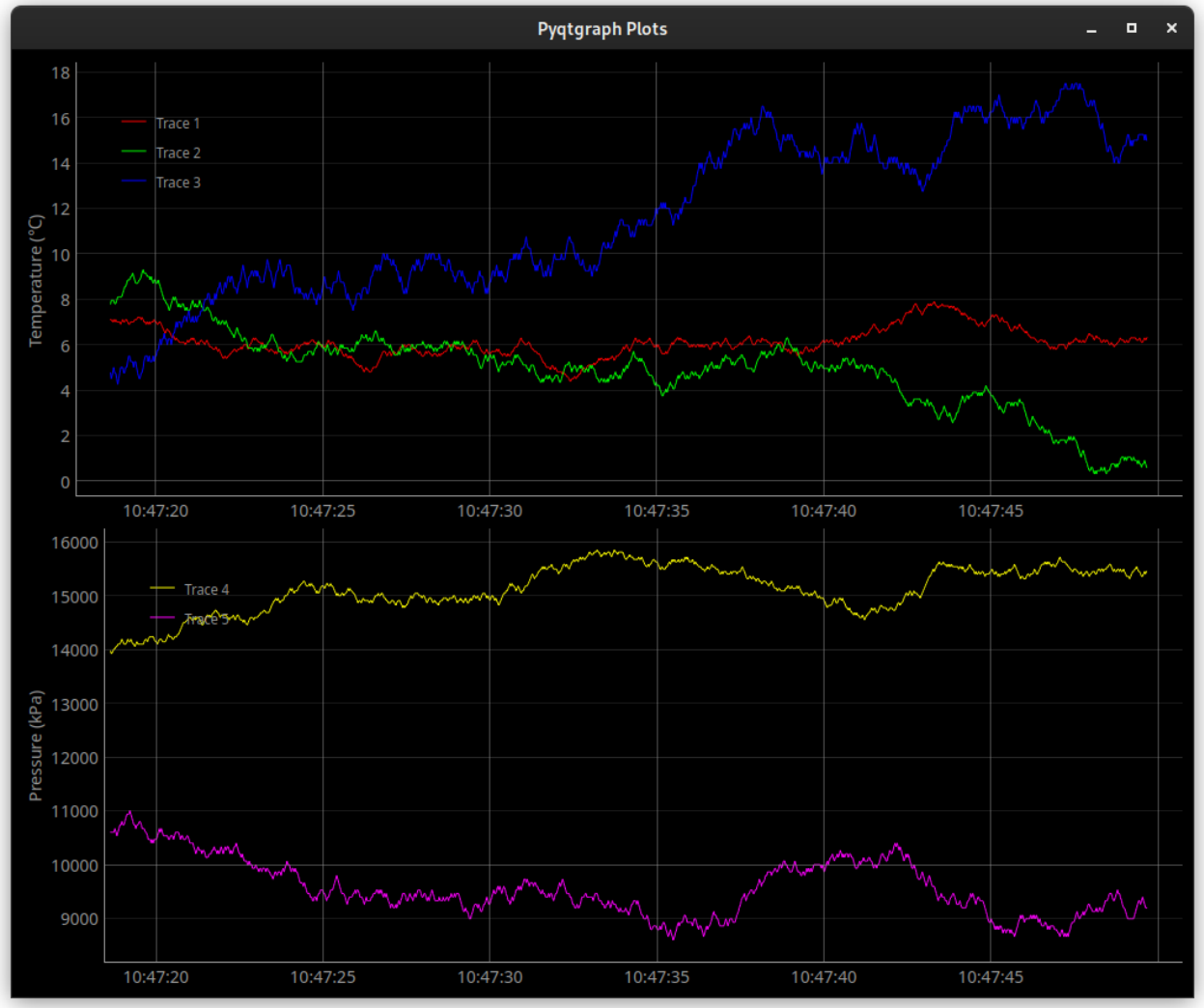
```
    a -> s;
  }
```

```
$ datalogd -c recipes/randomwalk_pyqtgraph.config
```

```
INFO:main:Initialising DataLogDaemon.
INFO:DataLogDaemon:Loaded config from: recipes/randomwalk_pyqtgraph.config
INFO:pluginlib:Loading plugins from standard library
INFO:DataLogDaemon:Detected source plugins: NullDataSource, PicoTC08DataSource,␣
↪RandomWalkDataSource, SerialDataSource
INFO:DataLogDaemon:Detected filter plugins: NullDataFilter, AggregatorDataFilter,␣
↪CoolingPowerDataFilter, CSVDataFilter, FlowSensorCalibrationDataFilter,␣
↪JoinDataFilter, KeyValDataFilter, PolynomialFunctionDataFilter, TimeStampDataFilter
INFO:DataLogDaemon:Detected sink plugins: NullDataSink, FileDataSink,␣
↪InfluxDB2DataSink, LoggingDataSink, MatplotlibDataSink, PrintDataSink,␣
↪PyqtgraphDataSink
INFO:DataLogDaemon:Initialising node a:RandomWalkDataSource(interval=0.03,␣
↪walkers=[[5.6, 0.1], [7.8, 0.15], [9.0, 0.25], [12345, 45], [12345, 67]])
INFO:DataLogDaemon:Initialising node s:PyqtgraphDataSink(npoints=1024,␣
↪title=Pyqtgraph Plots, size=[1000, 800], plotlayout=[{'ylabel': 'Temperature (°C)',
↪'traces': [{'name': 'Trace 1', 'pen': [255, 0, 0], 'selector': [['type', 'randomwalk
↪'], ['id', '0']]}, {'name': 'Trace 2', 'pen': [0, 255, 0], 'selector': [['type',
↪'randomwalk'], ['id', '1']]}, {'name': 'Trace 3', 'pen': [0, 0, 255], 'selector': [[
↪'type', 'randomwalk'], ['id', '2']]}]}, {'ylabel': 'Pressure (kPa)', 'traces': [{
↪'name': 'Trace 4', 'pen': [255, 255, 0], 'selector': [['type', 'randomwalk'], ['id',
↪ '3']]}, {'name': 'Trace 5', 'pen': [255, 0, 255], 'selector': [['type', 'randomwalk
↪'], ['id', '4']]}]}])
INFO:DataLogDaemon:Connecting a:RandomWalkDataSource -> s:PyqtgraphDataSink
INFO:main:Starting event loop.
```



1.4.4 Water Cooling Power Dissipation to CSV File

This recipe outlines connecting commonly available DS18B20 temperature sensors and a fluid flow sensor (such as the YF-S401, YF-S402B etc) to an Arduino, which collects data and sends it via a USB serial connection to the host computer. The data is processed to compute power dissipation into the cooling water, converted to comma-separated values (CSV) and written to a file.

1.4.4.1 Hardware

Two temperature sensors are required, one each for the inlet and outlet water temperatures. The flow sensor should be connected in line, preferably on the cold side. The calculations need to convert the pulse counts from the flow sensor to a fluid flow rate. Combined with the temperature difference of the water, the power dissipated into the liquid can be determined.

Get the Arduino code from GitLab or copy and paste below into a new Arduino sketch. Upload it to your Arduino.

Listing 8: `datalog.ino`

```
#include <Arduino.h>
#include <Wire.h>
#include <SPI.h>

////////////////////////////////////////////////////////////
// Device Configuration Settings
////////////////////////////////////////////////////////////

// An ID string for this Arduino
#define BOARD_ID_STRING "A"

// Interval between reads of devices
#define READ_INTERVAL 2000
// Interval between empty "keep alive" messages to maintain connection
#define KEEPALIVE_INTERVAL 1000

// Select which types of sensors to use
#define USE_DIGITAL_PINS true
#define USE_ANALOG_PINS true
#define USE_DS18B20_TEMPERATURE true
#define USE_BH1750_LUX false
#define USE_COUNTER false

////////////////////////////////////////////////////////////
// Pin Definitions and Sensor Configuration
////////////////////////////////////////////////////////////

#if USE_ANALOG_PINS
  // Set of analog input pins to read
  const int analog_pins[] = {A0, A1, A2, A3, A4, A5};
#endif

#if USE_DIGITAL_PINS
  // Set of digital input pins to read
  const int digital_pins[] = {4, 5, 6};
#endif

#if USE_DS18B20_TEMPERATURE
  // Run the 1-wire bus on pin 12
  const int onewire_pin = 12;
#endif

#if USE_COUNTER
  // Flow sensor pulse pin input, must be interrupt enabled
  // These are pins 0, 1, 2, 3, 7 for a Leonardo board
  // Note that Leonardo needs pins 0+1 for Serial1 and 2+3 for I2C
  const int counter_pin = 7;
  // Pin where an LED is connected, will toggle LED in sync with incoming pulses
  // Set to 0 to disable
  const int led_pin = 13;
#endif

////////////////////////////////////////////////////////////
```

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```
#if USE_DS18B20_TEMPERATURE
  #include <OneWire.h>
  #include <DallasTemperature.h>
  // Initialise the 1-Wire bus
  OneWire oneWire(onewire_pin);
  // Pass our 1-Wire reference to Dallas Temperature
  DallasTemperature thermometers(&oneWire);
#endif

#if USE_BH1750_LUX
  #include <hp_BH1750.h>
  // Reference to the BH1750 light meter module over I2C
  hp_BH1750 luxmeter;
#endif

#if USE_COUNTER
  // Number of pulses read from the flow meter
  volatile unsigned long counter_count = 0;
  // Stored start time and pulse count for flow rate calculation
  unsigned long counter_start_millis = 0;
  unsigned long counter_start_count = 0;
  volatile unsigned int led_state = LOW;
#endif


// Variable to record last data acquisition time
unsigned long measurement_start_millis = 0;
unsigned long keepalive_start_millis = 0;

// Variable to keep track of whether record separators (comma) needs to be prepended␣
↪to output
bool first_measurement = true;


#if USE_DS18B20_TEMPERATURE
  // Format a DS18B20 device address to a 16-char hex string
  String formatAddress(DeviceAddress address) {
    String hex = "";
    for (uint8_t i = 0; i < 8; i++) {
      if (address[i] < 16) hex += "0";
      hex += String(address[i], HEX);
    }
    return hex;
  }
#endif

// Print out a measurement to the serial port
void printMeasurement(String type, String id, String value, String units="") {
  // A comma separator needs to be prepended to measurements other than the first
  if (first_measurement) {
    first_measurement = false;
  } else {
    Serial.print(",");
  }
  Serial.print("{\"type\":\"");
  Serial.print(type);
  Serial.print("\",\"source\":\"");
```

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```
  Serial.print(BOARD_ID_STRING);
  Serial.print("\",\"id\":\"");
  Serial.print(BOARD_ID_STRING);
  Serial.print("_");
  Serial.print(id);
  Serial.print("\",\"value\":\"");
  Serial.print(value);
  if (units.length() > 0) {
    Serial.print("\",\"units\":\"");
    Serial.print(units);
  }
  Serial.print("\"}");
}

#if USE_COUNTER
  // Interrupt handler for a pulse from the flow meter
  void counterIncrement() {
    counter_count++;
    if (led_pin != 0) {
      digitalWrite(led_pin, led_state = !led_state);
    }
  }
#endif

void setup(void)
{
  // Open serial port
  Serial.begin(115200);

  #if USE_DS18B20_TEMPERATURE
    // Initialise I2C bus
    Wire.begin();
    pinMode(onewire_pin, INPUT_PULLUP);
  #endif

  #if USE_DIGITAL_PINS
    // Configure set of digital input pins
    for (uint8_t i = 0; i < uint8_t(sizeof(digital_pins)/sizeof(digital_pins[0]));␣
↪i++) {
      pinMode(digital_pins[i], INPUT);
    }
  #endif

  #if USE_COUNTER
    // Configure the flow meter input pin and interrupt for pulse counting
    pinMode(counter_pin, INPUT_PULLUP);
    attachInterrupt(digitalPinToInterrupt(counter_pin), counterIncrement, RISING);
    // LED to toggle if defined
    if (led_pin != 0) {
      pinMode(led_pin, OUTPUT);
      digitalWrite(led_pin, led_state);
    }
    counter_start_millis = millis();
  #endif
}
```

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```
void loop(void)
{
  // Record current time
  unsigned long current_millis = millis();
  // Check if it's time to take some new measurements
  if (current_millis - measurement_start_millis >= READ_INTERVAL) {
    measurement_start_millis = current_millis;
    // The first measurement in this cycle doesn't need a comma delimiter prepended
    first_measurement = true;

    // Print message start
    Serial.print("{\"board\":\"" + String(BOARD_ID_STRING) + "\",");
    Serial.print("\"timestamp\":\"" + String(measurement_start_millis) + "\",");
    Serial.print("\"message\":\"measurement\",\"data\":[");

    ////////////////////////////////////////////////////////////////////////////
    // Arduino Digital Pins
    ////////////////////////////////////////////////////////////////////////////
    #if USE_DIGITAL_PINS
      // Read digital pins
      unsigned int d = 0;
      for (uint8_t i = 0; i < uint8_t(sizeof(digital_pins)/sizeof(digital_pins[0]));␣
↪i++) {
        d += digitalRead(digital_pins[i]) << i;
      }
      printMeasurement("digital", "0", String(d));
    #endif

    ////////////////////////////////////////////////////////////////////////////
    // Arduino Analog Pins
    ////////////////////////////////////////////////////////////////////////////
    #if USE_ANALOG_PINS
      // Read analog pins
      for (uint8_t i = 0; i < uint8_t(sizeof(analog_pins)/sizeof(analog_pins[0]));␣
↪i++) {
        printMeasurement("analog", String(i), String(analogRead(analog_pins[i])));
      }
    #endif

    ////////////////////////////////////////////////////////////////////////////
    // DS18B20 Temperature Probes
    ////////////////////////////////////////////////////////////////////////////
    #if USE_DS18B20_TEMPERATURE
      // We'll reinitialise the temperature probes each time inside the loop so that
      // devices can be connected/disconnected while running
      thermometers.begin();
      // Temporary variable for storing 1-Wire device addresses
      DeviceAddress address;
      // Grab a count of temperature probes on the wire
      unsigned int numberOfDevices = thermometers.getDeviceCount();
      // Loop through each device, set requested precision
      for(unsigned int i = 0; i < numberOfDevices; i++) {
        if(thermometers.getAddress(address, i)) {
          thermometers.setResolution(address, 12);
        }
      }
      // Issue a global temperature request to all devices on the bus
```

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```
      if (numberOfDevices > 0) {
        thermometers.requestTemperatures();
      }
      // Loop through each device, print out temperature data
      for(unsigned int i = 0; i < numberOfDevices; i++) {
        if(thermometers.getAddress(address, i)) {
          printMeasurement("temperature", formatAddress(address), String(thermometers.
↪getTempC(address), 2), "C");
        }
      }
    #endif

    ////////////////////////////////////////////////////////////////////////////
    // BH1750 Lux Meter
    ////////////////////////////////////////////////////////////////////////////
    #if USE_BH1750_LUX
      // Attempt to initialise and read light meter sensor
      if (luxmeter.begin(BH1750_TO_GROUND)) {
        luxmeter.start();
        printMeasurement("lux", "0", String(luxmeter.getLux(), 0), "lux");
      }
    #endif

    ////////////////////////////////////////////////////////////////////////////
    // Fluid Flow Meter
    ////////////////////////////////////////////////////////////////////////////
    #if USE_COUNTER
      unsigned long counter_end_count = counter_count;
      unsigned long counter_end_millis = millis();
      // Total volume in sensor pulses
      printMeasurement("counter_total", "0", String(counter_end_count), "counts");
      // Current flow rate in pulses per minute
      float counter_rate = 1000.0*(counter_end_count - counter_start_count)/(counter_
↪end_millis - counter_start_millis);
      printMeasurement("counter_rate", "0", String(counter_rate, 4), "Hz");
      counter_start_count = counter_end_count;
      counter_start_millis = counter_end_millis;
    #endif

    // Print message end
    Serial.println("]}");
  } else if (current_millis - keepalive_start_millis >= KEEPALIVE_INTERVAL) {
    // Send keepalive packet to maintain serial communications
    keepalive_start_millis = current_millis;
    // Print empty message
    Serial.print("{\"board\":\"" + String(BOARD_ID_STRING) + "\",");
    Serial.print("\"timestamp\":\"" + String(keepalive_start_millis) + "\",");
    Serial.println("\"message\":\"measurement\",\"data\":[]}");
  }
}
```

Ensure the appropriate sensors are selected in the Arduino code using the define statements, for example:

```
#define USE_DIGITAL_PINS false
#define USE_ANALOG_PINS false
#define USE_DS18B20_TEMPERATURE true
#define USE_BH1750_LUX false
```

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```
#define USE_COUNTER true
```

Connect the thermometer's VCC to +5 V, GND to ground, and DATA to pin 12 (or another, to match that specified in the code for the 1-Wire bus). You may need a pullup resistor between the VCC and DATA pins if your thermometer modules don't include one. Connect the flow meter's VCC to +5 V, GND to ground, and sense wire to pin 7 (or another interrupt-enabled pin, to match that specified in the code for the pulse counter). Plug the Arduino into your computer USB cable.

1.4.4.2 Recipe

Listing 9: recipes/serial_coolingpower_csv_file.config

```
[datalogd]

connection_graph =
  digraph {
    arduino [class=SerialDataSource];
    timestamp [class=TimeStampDataFilter];
    flowrate [class=FlowSensorCalibrationDataFilter, a=6011, k=0.15476481, x0=0, b=0.
↪29542879];
    tempcorrect [class=PolynomialFunctionDataFilter, match_keyvals="[['type',
↪'temperature'], ['id', 'A_2827e0853219013e']]", coeffs="[-0.44, 1.0]", rounding=2];
    coolingpower [class=CoolingPowerDataFilter, temperature_id_in="A_28969c7e321901a7
↪", temperature_id_out="A_2827e0853219013e"];

    csv [class=CSVDataFilter, header="once"];
    file [class=FileDataSink, filename="cooling_power.csv", filename_timestamp=True];

    print [class=LoggingDataSink];

    arduino -> timestamp -> flowrate -> tempcorrect -> coolingpower;
    coolingpower -> csv -> file;
    coolingpower -> print;
  }
```

The data input and processing steps are:

- The serial data is read in from the Arduino using the *SerialDataSource* data source. The data contains the temperatures from the thermometers and the pulse counter's number of pulses per second. The IDs of the temperatures correspond to the serial numbers of the thermometer devices.
- The data is fed through a *TimeStampDataFilter* to include timestamps on the data entries.
- Next, the pulse counter's pulses-per-second is converted to a flow rate in litres-per-minute using the *FlowSensorCalibrationDataFilter*. The parameters are used in a calibration curve and have been experimentally determined for a YF-S401 flow sensor.
- A simple offset is applied to one of the thermometers to correct for a slight difference in readings between the two thermometers. This uses a *PolynomialFunctionDataFilter* to subtract 0.44 °C from the reading.

The data flow is then split to two separate paths:

- The data is formatted into a row of comma-separated values and written to a file. This uses a *CSVDataFilter* feeding in to a *FileDataSink*.
- The raw data is also displayed on the console using a *LoggingDataSink*.

1.4.5 Using Multiple Data Sources, Filters, and Sinks

This recipe demonstrates a more complicated scenario where multiple data sources are used. The data is manipulated using filters, and then sent to three different destinations.

A PicoTech TC-08 thermocouple data logger is used to monitor several temperatures. Additionally, an Arduino interfaces with commonly available DS18B20 temperature sensors and a fluid flow sensor (such as the YF-S401, YF-S402B etc). Data filters are used to calibrate/correct the sensor values, and finally to compute power dissipation into the cooling water.

Data is timestamped, converted to CSV, and saved to files. It is also displayed on the console and sent to a remote InfluxDB instance.

1.4.5.1 Hardware

The PicoTech TC-08 is connected via USB. The appropriate drivers and interface library (`libusbtc08.so` on Linux, `libusbtc08.dll` on Windows) must be installed. Six type-K thermocouples are connected to ports 1, 2, 4, 5, 7, 8.

For the Arduino, two temperature sensors are required, one each for the inlet and outlet water temperatures. The flow sensor should be connected in line, preferably on the cold side. The calculations need to convert the pulse counts from the flow sensor to a fluid flow rate. Combined with the temperature difference of the water, the power dissipated into the liquid can be determined.

Get the Arduino code from GitLab or copy and paste below into a new Arduino sketch. Upload it to your Arduino.

Listing 10: `datalog.ino`

```
#include <Arduino.h>
#include <Wire.h>
#include <SPI.h>

////////////////////////////////////////////////////////////
// Device Configuration Settings
////////////////////////////////////////////////////////////

// An ID string for this Arduino
#define BOARD_ID_STRING "A"

// Interval between reads of devices
#define READ_INTERVAL 2000
// Interval between empty "keep alive" messages to maintain connection
#define KEEPALIVE_INTERVAL 1000

// Select which types of sensors to use
#define USE_DIGITAL_PINS true
#define USE_ANALOG_PINS true
#define USE_DS18B20_TEMPERATURE true
#define USE_BH1750_LUX false
#define USE_COUNTER false

////////////////////////////////////////////////////////////
// Pin Definitions and Sensor Configuration
////////////////////////////////////////////////////////////

#if USE_ANALOG_PINS
  // Set of analog input pins to read
```

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```
  const int analog_pins[] = {A0, A1, A2, A3, A4, A5};
#endif

#if USE_DIGITAL_PINS
  // Set of digital input pins to read
  const int digital_pins[] = {4, 5, 6};
#endif

#if USE_DS18B20_TEMPERATURE
  // Run the 1-wire bus on pin 12
  const int onewire_pin = 12;
#endif

#if USE_COUNTER
  // Flow sensor pulse pin input, must be interrupt enabled
  // These are pins 0, 1, 2, 3, 7 for a Leonardo board
  // Note that Leonardo needs pins 0+1 for Serial1 and 2+3 for I2C
  const int counter_pin = 7;
  // Pin where an LED is connected, will toggle LED in sync with incoming pulses
  // Set to 0 to disable
  const int led_pin = 13;
#endif

////////////////////////////////////////////////////////////


#if USE_DS18B20_TEMPERATURE
  #include <OneWire.h>
  #include <DallasTemperature.h>
  // Initialise the 1-Wire bus
  OneWire oneWire(onewire_pin);
  // Pass our 1-Wire reference to Dallas Temperature
  DallasTemperature thermometers(&oneWire);
#endif

#if USE_BH1750_LUX
  #include <hp_BH1750.h>
  // Reference to the BH1750 light meter module over I2C
  hp_BH1750 luxmeter;
#endif

#if USE_COUNTER
  // Number of pulses read from the flow meter
  volatile unsigned long counter_count = 0;
  // Stored start time and pulse count for flow rate calculation
  unsigned long counter_start_millis = 0;
  unsigned long counter_start_count = 0;
  volatile unsigned int led_state = LOW;
#endif


// Variable to record last data acquisition time
unsigned long measurement_start_millis = 0;
unsigned long keepalive_start_millis = 0;

// Variable to keep track of whether record separators (comma) needs to be prepended␣
↪to output
```

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```
bool first_measurement = true;


#if USE_DS18B20_TEMPERATURE
  // Format a DS18B20 device address to a 16-char hex string
  String formatAddress(DeviceAddress address) {
    String hex = "";
    for (uint8_t i = 0; i < 8; i++) {
      if (address[i] < 16) hex += "0";
      hex += String(address[i], HEX);
    }
    return hex;
  }
#endif

// Print out a measurement to the serial port
void printMeasurement(String type, String id, String value, String units="") {
  // A comma separator needs to be prepended to measurements other than the first
  if (first_measurement) {
    first_measurement = false;
  } else {
    Serial.print(",");
  }
  Serial.print("{\"type\":\"");
  Serial.print(type);
  Serial.print("\",\"source\":\"");
  Serial.print(BOARD_ID_STRING);
  Serial.print("\",\"id\":\"");
  Serial.print(BOARD_ID_STRING);
  Serial.print("_");
  Serial.print(id);
  Serial.print("\",\"value\":\"");
  Serial.print(value);
  if (units.length() > 0) {
    Serial.print("\",\"units\":\"");
    Serial.print(units);
  }
  Serial.print("\"}");
}

#if USE_COUNTER
  // Interrupt handler for a pulse from the flow meter
  void counterIncrement() {
    counter_count++;
    if (led_pin != 0) {
      digitalWrite(led_pin, led_state = !led_state);
    }
  }
#endif

void setup(void)
{
  // Open serial port
  Serial.begin(115200);

  #if USE_DS18B20_TEMPERATURE
    // Initialise I2C bus
```

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```
    Wire.begin();
    pinMode(onewire_pin, INPUT_PULLUP);
  #endif

  #if USE_DIGITAL_PINS
    // Configure set of digital input pins
    for (uint8_t i = 0; i < uint8_t(sizeof(digital_pins)/sizeof(digital_pins[0]));␣
↪i++) {
      pinMode(digital_pins[i], INPUT);
    }
  #endif

  #if USE_COUNTER
    // Configure the flow meter input pin and interrupt for pulse counting
    pinMode(counter_pin, INPUT_PULLUP);
    attachInterrupt(digitalPinToInterrupt(counter_pin), counterIncrement, RISING);
    // LED to toggle if defined
    if (led_pin != 0) {
      pinMode(led_pin, OUTPUT);
      digitalWrite(led_pin, led_state);
    }
    counter_start_millis = millis();
  #endif
}


void loop(void)
{
  // Record current time
  unsigned long current_millis = millis();
  // Check if it's time to take some new measurements
  if (current_millis - measurement_start_millis >= READ_INTERVAL) {
    measurement_start_millis = current_millis;
    // The first measurement in this cycle doesn't need a comma delimiter prepended
    first_measurement = true;

    // Print message start
    Serial.print("{\"board\":\"" + String(BOARD_ID_STRING) + "\",");
    Serial.print("\"timestamp\":\"" + String(measurement_start_millis) + "\",");
    Serial.print("\"message\":\"measurement\",\"data\":[");

    ////////////////////////////////////////////////////////////////////////
    // Arduino Digital Pins
    ////////////////////////////////////////////////////////////////////////
    #if USE_DIGITAL_PINS
      // Read digital pins
      unsigned int d = 0;
      for (uint8_t i = 0; i < uint8_t(sizeof(digital_pins)/sizeof(digital_pins[0]));␣
↪i++) {
        d += digitalRead(digital_pins[i]) << i;
      }
      printMeasurement("digital", "0", String(d));
    #endif

    ////////////////////////////////////////////////////////////////////////
    // Arduino Analog Pins
    ////////////////////////////////////////////////////////////////////////
```

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```
    #if USE_ANALOG_PINS
      // Read analog pins
      for (uint8_t i = 0; i < uint8_t(sizeof(analog_pins)/sizeof(analog_pins[0]));␣
↪i++) {
        printMeasurement("analog", String(i), String(analogRead(analog_pins[i])));
      }
    #endif

    ////////////////////////////////////////////////////////////////////////
    // DS18B20 Temperature Probes
    ////////////////////////////////////////////////////////////////////////
    #if USE_DS18B20_TEMPERATURE
      // We'll reinitialise the temperature probes each time inside the loop so that
      // devices can be connected/disconnected while running
      thermometers.begin();
      // Temporary variable for storing 1-Wire device addresses
      DeviceAddress address;
      // Grab a count of temperature probes on the wire
      unsigned int numberOfDevices = thermometers.getDeviceCount();
      // Loop through each device, set requested precision
      for(unsigned int i = 0; i < numberOfDevices; i++) {
        if(thermometers.getAddress(address, i)) {
          thermometers.setResolution(address, 12);
        }
      }
      // Issue a global temperature request to all devices on the bus
      if (numberOfDevices > 0) {
        thermometers.requestTemperatures();
      }
      // Loop through each device, print out temperature data
      for(unsigned int i = 0; i < numberOfDevices; i++) {
        if(thermometers.getAddress(address, i)) {
          printMeasurement("temperature", formatAddress(address), String(thermometers.
↪getTempC(address), 2), "C");
        }
      }
    #endif

    ////////////////////////////////////////////////////////////////////////
    // BH1750 Lux Meter
    ////////////////////////////////////////////////////////////////////////
    #if USE_BH1750_LUX
      // Attempt to initialise and read light meter sensor
      if (luxmeter.begin(BH1750_TO_GROUND)) {
        luxmeter.start();
        printMeasurement("lux", "0", String(luxmeter.getLux(), 0), "lux");
      }
    #endif

    ////////////////////////////////////////////////////////////////////////
    // Fluid Flow Meter
    ////////////////////////////////////////////////////////////////////////
    #if USE_COUNTER
      unsigned long counter_end_count = counter_count;
      unsigned long counter_end_millis = millis();
      // Total volume in sensor pulses
      printMeasurement("counter_total", "0", String(counter_end_count), "counts");
```

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```
      // Current flow rate in pulses per minute
      float counter_rate = 1000.0*(counter_end_count - counter_start_count)/(counter_
↪end_millis - counter_start_millis);
      printMeasurement("counter_rate", "0", String(counter_rate, 4), "Hz");
      counter_start_count = counter_end_count;
      counter_start_millis = counter_end_millis;
    #endif

    // Print message end
    Serial.println("]}");
  } else if (current_millis - keepalive_start_millis >= KEEPALIVE_INTERVAL) {
    // Send keepalive packet to maintain serial communications
    keepalive_start_millis = current_millis;
    // Print empty message
    Serial.print("{\"board\":\"" + String(BOARD_ID_STRING) + "\",");
    Serial.print("\"timestamp\":\"" + String(keepalive_start_millis) + "\",");
    Serial.println("\"message\":\"measurement\",\"data\":[]}");
  }
}
```

Ensure the appropriate sensors are selected in the Arduino code using the define statements, for example:

```
#define USE_DIGITAL_PINS false
#define USE_ANALOG_PINS false
#define USE_DS18B20_TEMPERATURE true
#define USE_BH1750_LUX false
#define USE_COUNTER true
```

Connect the thermometer's VCC to +5 V, GND to ground, and DATA to pin 12 (or another, to match that specified in the code for the 1-Wire bus). You may need a pullup resistor between the VCC and DATA pins if your thermometer modules don't include one. Connect the flow meter's VCC to +5 V, GND to ground, and sense wire to pin 7 (or another interrupt-enabled pin, to match that specified in the code for the pulse counter). Plug the Arduino into your computer USB cable.

1.4.5.2 Recipe

Listing 11: `recipes/serial_tc08_csv_file_influxdb.config`

```
[datalogd]

connection_graph =
  digraph {

    // PicoTech TC08 thermocouples
    tc08 [class=PicoTC08DataSource, interval=1.0, probes="[
      [1, 'Reactor1', 'K', 'C'],
      [2, 'Reactor2', 'K', 'C'],
      [4, 'Radiator', 'K', 'C'],
      [5, 'Waterbath', 'K', 'C'],
      [7, 'Exhaust', 'K', 'C'],
      [8, 'Extraction', 'K', 'C']
    ]"];
    tc08_timestamp [class=TimeStampDataFilter];
    // Save locally to CSV file
```

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```
    tc08_csv [class=CSVDataFilter, header="once"];
    tc08_file [class=FileDataSink, filename="cooling_power_tc08.csv", filename_
↪timestamp=True];

    // Arduino for water temperatures, flow rate, light sensor...
    arduino [class=SerialDataSource];
    // Some processing to compute power dissipated into cooling water
    a_timestamp [class=TimeStampDataFilter];
    // Coffee machine flow meter a=1950, k=0.0965882, x0=0, b=0.721649
    // YF-S401 flow meter a=5975, k=0.173734, x0=0, b=0.284333
    flowrate [class=FlowSensorCalibrationDataFilter, a=1950, k=0.0965882, x0=0, b=0.
↪721649];
    tempcorrect [class=PolynomialFunctionDataFilter, match_keyvals="[['type',
↪'temperature'], ['id', 'A_2827e0853219013e']]", coeffs="[-0.44, 1.0]", rounding=2];
    coolingpower [class=CoolingPowerDataFilter, temperature_id_in="A_28969c7e321901a7
↪", temperature_id_out="A_2827e0853219013e"];
    // Save locally to CSV file
    a_csv [class=CSVDataFilter, header="once"];
    a_file [class=FileDataSink, filename="cooling_power_arduino.csv", filename_
↪timestamp=True];

    // Display in console
    print [class=LoggingDataSink];

    // Save to remote InfluxDB
    influx [class=InfluxDB2DataSink,
      url="http://localhost:8086",
      token="...APITokenWithWriteAccess...",
      org="organisation_name",
      bucket="bucket_name",
      measurement="measurement_name"
    ];

    // Hook everything up
    tc08 -> tc08_timestamp -> tc08_csv -> tc08_file;
    arduino -> a_timestamp -> flowrate -> tempcorrect -> coolingpower -> a_csv -> a_
↪file;

    tc08_timestamp -> print;
    coolingpower -> print;

    tc08_timestamp -> influx;
    coolingpower -> influx;
  }
```

The data input and processing steps are:

- Thermocouple readings are taken from the TC-08 using the *PicoTC08DataSource* data source. The parameters specify the sampling interval (in seconds) and the types of probes attached. Each probe is specified with the channel it is attached to, a label, thermocouple type, and desired units.
- The serial data is read in from the Arduino using the *SerialDataSource* data source. The data contains the temperatures from the thermometers and the pulse counter's number of pulses per second. The IDs of the temperatures correspond to the serial numbers of the thermometer devices.
- Timestamps are added to both sources of data using two instances of *TimeStampDataFilter*.

- Next, the pulse counter's pulses-per-second is converted to a flow rate in litres-per-minute using the *FlowSensorCalibrationDataFilter*. The parameters are used in a calibration curve and have been experimentally determined for a YF-S401 flow sensor.
- A simple offset is applied to one of the thermometers to correct for a slight difference in readings between the two thermometers. This uses a *PolynomialFunctionDataFilter* to subtract 0.44 °C from the reading.

The data flow is then split to several separate destinations:

- The data is formatted into a row of comma-separated values and written to a file. This uses a *CSVDataFilter* feeding in to a *FileDataSink*. There is a separate file for each of the two data sources.
- The raw data is displayed on the console using a *LoggingDataSink*.
- The raw data is sent to a InfluxDB database instance. Example database details have been used here, and will need to be changed to match your specific database.

1.4.6 Temperatures to InfluxDB with Grafana Visualisation on Raspberry Pi

Note: This recipe is outdated. There is a new 2.x version of InfluxDB which integrates a web interface and dashboard (Grafana is not necessary). See the documentation for the v2 *InfluxDB2DataSink* plugin for more information.

This recipe is for running on a Raspberry Pi. It will collect temperature readings from commonly available DS18B20 temperature sensors and log them in an InfluxDB database. Grafana is used display the data over a web interface.

1.4.6.1 Hardware Setup

Any Raspberry Pi should work, this was tested using a Raspberry Pi 3 running Raspbian Buster using a Linux 4.19 kernel.

The DS18B20 temperature sensors require a 4.7 kΩ pullup resistor connected between the VCC and DATA lines. Some integrated modules already include the resistor. Connect the VCC to the RPi GPIO 3.3 V (pin 1), GND to ground (pin 6), and DATA to pin 7.

The 1-Wire bus on the RPi is not enabled by default. The easiest way to enable it is to run `sudo raspi-config` and select 1-Wire from the Interfacing Options. A reboot will be required. After the restart, check the sensor is detected with `ls /sys/bus/w1/devices`, which should list one or more devices starting with `28-` and then a hex serial number. A reading can be obtained by running `cat /sys/bus/w1/devices/28-xxxxxxxxxxxx/w1_slave`, where `xxxxxxxxxxxx` is the serial number of the sensor. The response should include something like `t=22062`, where 22062 indicates 22.062 °C.

The standard Linux libsensors is able to read the temperatures from attached probes:

```
sudo apt install libsensors5 lm-sensors
pip3 install --user PySensors
```

and can be read by running `sensors`.

1.4.6.2 Software Setup

1.4.6.2.1 InfluxDB

Add InfluxDB repository to apt sources (change `buster` to match your raspbian version):

```
wget -qO- https://repos.influxdata.com/influxdb.key | sudo apt-key add -
echo "deb https://repos.influxdata.com/debian buster stable" | sudo tee /etc/apt/
↪sources.list.d/influxdb.list
```

Install InfluxDB, python plugin module, and start the systemd service:

```
sudo apt-get update
sudo apt-get install influxdb
pip3 install --user influxdb
sudo systemctl enable --now influxdb.service
```

The default configuration is probably OK, but can be changed by editing `/etc/influxdb/influxdb.conf`. The database service will be operating on port 8086.

Create a database for datalogd to store its data:

```
influx
create database datalogd
exit
```

1.4.6.2.2 Grafana

Follow instructions on the Grafana website to get latest version for your Raspberry Pi (eg. ARMv7). As of writing, for the Raspberry Pi 3 this is:

The Grafana server should be serving web pages from port 3000, so log into your RPi with a web browser and check that it is working (eg. visit `http://ip_of_your_pi:3000`).

1.4.6.2.3 Recipe

The connection graph can be configured using most defaults as:

Listing 12: `recipes/rpi_temperature_influxdb.config`

```
[datalogd]
connection_graph =
  digraph {
    a [class=LibSensorsDataSource];
    f [class=KeyValDataFilter, key="type", val="temperature"];
    s [class=InfluxDBDataSink];
    a -> f -> s;
  }
```

If you have changed the database configuration, such as usernames or passwords, then these must be set in the attributes for the *InfluxDBDataSink* node.

1.4.6.2.4 Visualisation

Log into your Grafana server (eg. `http://ip_of_your_pi:3000`. Configure an InfluxDB data source, using all default parameters. Configure a Grafana Dashboard as pictured:

1.4.7 Arduino Temperatures to InfluxDB and Grafana Display on Windows

Note: This recipe is outdated. There is a new 2.x version of InfluxDB which integrates a web interface and dashboard (Grafana is not necessary). See the documentation for the v2 `InfluxDB2DataSink` plugin for more information.

This recipe outlines connecting commonly available DS18B20 temperature sensors to an Arduino, which collects data and sends it via a USB serial connection to a Windows machine running InfluxDB database. Grafana is used display

the data over a web interface.

Note: No, I don't know why doing anything on Windows is so difficult.

1.4.7.1 Hardware

Get the Arduino code from GitLab or copy and paste below into a new Arduino sketch. Upload it to your Arduino.

Listing 13: `datalog.ino`

```
#include <Arduino.h>
#include <Wire.h>
#include <SPI.h>

////////////////////////////////////////////////////////////
// Device Configuration Settings
////////////////////////////////////////////////////////////

// An ID string for this Arduino
#define BOARD_ID_STRING "A"

// Interval between reads of devices
#define READ_INTERVAL 2000
// Interval between empty "keep alive" messages to maintain connection
#define KEEPALIVE_INTERVAL 1000

// Select which types of sensors to use
#define USE_DIGITAL_PINS true
#define USE_ANALOG_PINS true
#define USE_DS18B20_TEMPERATURE true
#define USE_BH1750_LUX false
#define USE_COUNTER false

////////////////////////////////////////////////////////////
// Pin Definitions and Sensor Configuration
////////////////////////////////////////////////////////////

#if USE_ANALOG_PINS
  // Set of analog input pins to read
  const int analog_pins[] = {A0, A1, A2, A3, A4, A5};
#endif

#if USE_DIGITAL_PINS
  // Set of digital input pins to read
  const int digital_pins[] = {4, 5, 6};
#endif

#if USE_DS18B20_TEMPERATURE
  // Run the 1-wire bus on pin 12
  const int onewire_pin = 12;
#endif

#if USE_COUNTER
  // Flow sensor pulse pin input, must be interrupt enabled
  // These are pins 0, 1, 2, 3, 7 for a Leonardo board
```

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```
  // Note that Leonardo needs pins 0+1 for Serial1 and 2+3 for I2C
  const int counter_pin = 7;
  // Pin where an LED is connected, will toggle LED in sync with incoming pulses
  // Set to 0 to disable
  const int led_pin = 13;
#endif

////////////////////////////////////////////////////////////


#if USE_DS18B20_TEMPERATURE
  #include <OneWire.h>
  #include <DallasTemperature.h>
  // Initialise the 1-Wire bus
  OneWire oneWire(onewire_pin);
  // Pass our 1-Wire reference to Dallas Temperature
  DallasTemperature thermometers(&oneWire);
#endif

#if USE_BH1750_LUX
  #include <hp_BH1750.h>
  // Reference to the BH1750 light meter module over I2C
  hp_BH1750 luxmeter;
#endif

#if USE_COUNTER
  // Number of pulses read from the flow meter
  volatile unsigned long counter_count = 0;
  // Stored start time and pulse count for flow rate calculation
  unsigned long counter_start_millis = 0;
  unsigned long counter_start_count = 0;
  volatile unsigned int led_state = LOW;
#endif


// Variable to record last data acquisition time
unsigned long measurement_start_millis = 0;
unsigned long keepalive_start_millis = 0;

// Variable to keep track of whether record separators (comma) needs to be prepended␣
↪to output
bool first_measurement = true;


#if USE_DS18B20_TEMPERATURE
  // Format a DS18B20 device address to a 16-char hex string
  String formatAddress(DeviceAddress address) {
    String hex = "";
    for (uint8_t i = 0; i < 8; i++) {
      if (address[i] < 16) hex += "0";
      hex += String(address[i], HEX);
    }
    return hex;
  }
#endif

// Print out a measurement to the serial port
```

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```
void printMeasurement(String type, String id, String value, String units="") {
  // A comma separator needs to be prepended to measurements other than the first
  if (first_measurement) {
    first_measurement = false;
  } else {
    Serial.print(",");
  }
  Serial.print("{\"type\":\"");
  Serial.print(type);
  Serial.print("\",\"source\":\"");
  Serial.print(BOARD_ID_STRING);
  Serial.print("\",\"id\":\"");
  Serial.print(BOARD_ID_STRING);
  Serial.print("_");
  Serial.print(id);
  Serial.print("\",\"value\":\"");
  Serial.print(value);
  if (units.length() > 0) {
    Serial.print("\",\"units\":\"");
    Serial.print(units);
  }
  Serial.print("\"}");
}

#if USE_COUNTER
  // Interrupt handler for a pulse from the flow meter
  void counterIncrement() {
    counter_count++;
    if (led_pin != 0) {
      digitalWrite(led_pin, led_state = !led_state);
    }
  }
#endif

void setup(void)
{
  // Open serial port
  Serial.begin(115200);

  #if USE_DS18B20_TEMPERATURE
    // Initialise I2C bus
    Wire.begin();
    pinMode(onewire_pin, INPUT_PULLUP);
  #endif

  #if USE_DIGITAL_PINS
    // Configure set of digital input pins
    for (uint8_t i = 0; i < uint8_t(sizeof(digital_pins)/sizeof(digital_pins[0]));␣
↪i++) {
      pinMode(digital_pins[i], INPUT);
    }
  #endif

  #if USE_COUNTER
    // Configure the flow meter input pin and interrupt for pulse counting
    pinMode(counter_pin, INPUT_PULLUP);
    attachInterrupt(digitalPinToInterrupt(counter_pin), counterIncrement, RISING);
```

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```
    // LED to toggle if defined
    if (led_pin != 0) {
      pinMode(led_pin, OUTPUT);
      digitalWrite(led_pin, led_state);
    }
    counter_start_millis = millis();
  #endif
}


void loop(void)
{
  // Record current time
  unsigned long current_millis = millis();
  // Check if it's time to take some new measurements
  if (current_millis - measurement_start_millis >= READ_INTERVAL) {
    measurement_start_millis = current_millis;
    // The first measurement in this cycle doesn't need a comma delimiter prepended
    first_measurement = true;

    // Print message start
    Serial.print("{\"board\":\"" + String(BOARD_ID_STRING) + "\",");
    Serial.print("\"timestamp\":\"" + String(measurement_start_millis) + "\",");
    Serial.print("\"message\":\"measurement\",\"data\":[");

    ////////////////////////////////////////////////////////////////////////////
    // Arduino Digital Pins
    ////////////////////////////////////////////////////////////////////////////
    #if USE_DIGITAL_PINS
      // Read digital pins
      unsigned int d = 0;
      for (uint8_t i = 0; i < uint8_t(sizeof(digital_pins)/sizeof(digital_pins[0]));␣
↪i++) {
        d += digitalRead(digital_pins[i]) << i;
      }
      printMeasurement("digital", "0", String(d));
    #endif

    ////////////////////////////////////////////////////////////////////////////
    // Arduino Analog Pins
    ////////////////////////////////////////////////////////////////////////////
    #if USE_ANALOG_PINS
      // Read analog pins
      for (uint8_t i = 0; i < uint8_t(sizeof(analog_pins)/sizeof(analog_pins[0]));␣
↪i++) {
        printMeasurement("analog", String(i), String(analogRead(analog_pins[i])));
      }
    #endif

    ////////////////////////////////////////////////////////////////////////////
    // DS18B20 Temperature Probes
    ////////////////////////////////////////////////////////////////////////////
    #if USE_DS18B20_TEMPERATURE
      // We'll reinitialise the temperature probes each time inside the loop so that
      // devices can be connected/disconnected while running
      thermometers.begin();
      // Temporary variable for storing 1-Wire device addresses
```

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```
      DeviceAddress address;
      // Grab a count of temperature probes on the wire
      unsigned int numberOfDevices = thermometers.getDeviceCount();
      // Loop through each device, set requested precision
      for(unsigned int i = 0; i < numberOfDevices; i++) {
        if(thermometers.getAddress(address, i)) {
          thermometers.setResolution(address, 12);
        }
      }
      // Issue a global temperature request to all devices on the bus
      if (numberOfDevices > 0) {
        thermometers.requestTemperatures();
      }
      // Loop through each device, print out temperature data
      for(unsigned int i = 0; i < numberOfDevices; i++) {
        if(thermometers.getAddress(address, i)) {
          printMeasurement("temperature", formatAddress(address), String(thermometers.
↪getTempC(address), 2), "C");
        }
      }
    #endif

    ////////////////////////////////////////////////////////////////////////////
    // BH1750 Lux Meter
    ////////////////////////////////////////////////////////////////////////////
    #if USE_BH1750_LUX
      // Attempt to initialise and read light meter sensor
      if (luxmeter.begin(BH1750_TO_GROUND)) {
        luxmeter.start();
        printMeasurement("lux", "0", String(luxmeter.getLux(), 0), "lux");
      }
    #endif

    ////////////////////////////////////////////////////////////////////////////
    // Fluid Flow Meter
    ////////////////////////////////////////////////////////////////////////////
    #if USE_COUNTER
      unsigned long counter_end_count = counter_count;
      unsigned long counter_end_millis = millis();
      // Total volume in sensor pulses
      printMeasurement("counter_total", "0", String(counter_end_count), "counts");
      // Current flow rate in pulses per minute
      float counter_rate = 1000.0*(counter_end_count - counter_start_count)/(counter_
↪end_millis - counter_start_millis);
      printMeasurement("counter_rate", "0", String(counter_rate, 4), "Hz");
      counter_start_count = counter_end_count;
      counter_start_millis = counter_end_millis;
    #endif

    // Print message end
    Serial.println("]}");
  } else if (current_millis - keepalive_start_millis >= KEEPALIVE_INTERVAL) {
    // Send keepalive packet to maintain serial communications
    keepalive_start_millis = current_millis;
    // Print empty message
    Serial.print("{\"board\":\"" + String(BOARD_ID_STRING) + "\",");
    Serial.print("\"timestamp\":\"" + String(keepalive_start_millis) + "\",");
```

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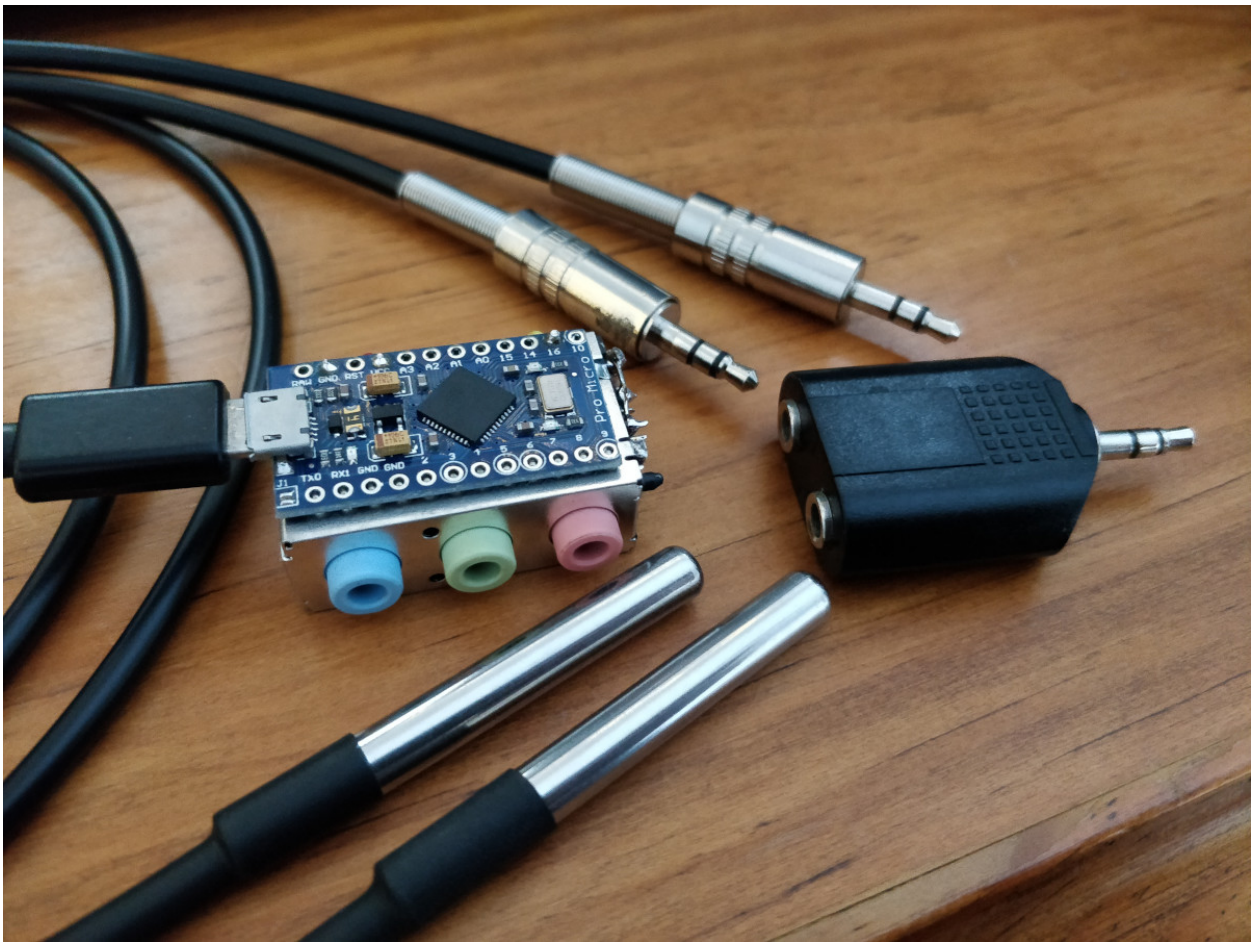
```
    Serial.println("\"message\":\"measurement\",\"data\":[]}");
  }
}
```

Connect VCC to +5 V, GND to ground, and DATA to pin 12 (or another, to match that specified in the code). Plug the Arduino into your Windows machine with a USB cable.

This is a "Pro Micro" Arduino Leonardo compatible board, connected to the DS18B20 sensors using 3.5 mm audio jacks. The benefits of these are that readily available plugs, sockets, splitters and extensions can be used. Don't try plugging headphones in though, they will likely be fried!



1.4.7.2 Recipe

Listing 14: `recipes/serial_temperatures_influxdb.config`

```
[datalogd]
connection_graph =
  digraph {
    a [class=SerialDataSource];
    f [class=KeyValDataFilter, key="type", val="temperature"];
    s [class=InfluxDBDataSink];
```

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```
    a -> f -> s;
  }
```

1.4.7.3 Software

Download and install InfluxDB, and configure it to run at startup:

- Download InfluxDB from https://portal.influxdata.com/downloads/ and unzip to `Program Files`, then rename directory to `InfluxDB`.
- Go the directory and run `influxd.exe`.
- Run `influx.exe`. Type `create database datalogd` then `exit`.
- Hit `Control+C` on the `influxd.exe` window.
- Get the InfluxDB.xml file and save it somewhere.
- Open Task Scheduler (windows key, type `taskschd.msc`, enter). Click `Action->Import Task...`, select the `InfluxDB.xml` file. Click the `Change User or Group...` button, type your user name, click `Check Names`, then `OK`.
- Right click the `datalogd` entry, and select `Run`, then click `OK`.

Download and install Grafana:

- Download Grafana.
- Install.
- Go to `http://localhost:3000`, login with `admin` `admin`, and set a new password.
- Add an InfluxDB data source using default settings.

1.4.8 Bridging Data over Sockets

This example creates two separate instances of the datalogd process, and bridges a data connection between them using *`SocketDataFilter`*s. In this case the running processes are on the same computer, but the connection can be made across a network connection by selecting the correct host addresses.

A socket connection must have one server and at least one client, so one instance is configured to start a server listening on an address (the local loopback address) and port, and the other instance is configured as a client to connect to that port. A

The server configuration is:

Listing 15: `recipes/socket_server.config`

```
[datalogd]
connection_graph =
  digraph {
    r [class=RandomWalkDataSource, walkers="[[100, 10]]"];
    s [class=SocketDataFilter, role="server", host="127.0.0.1", port=4567];
    l [class=LoggingDataSink];
    r -> s -> l;
  }
```

```
$ datalogd -c recipes/socket_server.config
```

```
INFO:main:Initialising DataLogDaemon.
INFO:DataLogDaemon:Loaded config from: recipes/socket_server.config
INFO:pluginlib:Loading plugins from standard library
INFO:DataLogDaemon:Detected source plugins: NullDataSource, PicoTC08DataSource,␣
↪RandomWalkDataSource, SerialDataSource
INFO:DataLogDaemon:Detected filter plugins: NullDataFilter, AggregatorDataFilter,␣
↪CoolingPowerDataFilter, CSVDataFilter, FlowSensorCalibrationDataFilter,␣
↪JoinDataFilter, KeyValDataFilter, PolynomialFunctionDataFilter, SocketDataFilter,␣
↪TimeStampDataFilter
INFO:DataLogDaemon:Detected sink plugins: NullDataSink, FileDataSink,␣
↪InfluxDB2DataSink, LoggingDataSink, MatplotlibDataSink, PrintDataSink,␣
↪PyqtgraphDataSink
INFO:DataLogDaemon:Initialising node r:RandomWalkDataSource(walkers=[[100, 10]])
INFO:DataLogDaemon:Initialising node s:SocketDataFilter(role=server, host=127.0.0.1,␣
↪port=4567)
INFO:DataLogDaemon:Initialising node l:LoggingDataSink()
INFO:DataLogDaemon:Connecting r:RandomWalkDataSource -> s:SocketDataFilter
INFO:DataLogDaemon:Connecting s:SocketDataFilter -> l:LoggingDataSink
INFO:main:Starting event loop.
INFO:SocketDataFilter:Server started on ('127.0.0.1', 4567)
```

At the moment, nothing will happen, as no client(s) have connected. Open another terminal window and start a new instance using the client configuration:

Listing 16: `recipes/socket_client.config`

```
[datalogd]
connection_graph =
  digraph {
    r [class=RandomWalkDataSource, walkers="[[1.0, 0.1]]"];
    s [class=SocketDataFilter, role="client", host="127.0.0.1", port=4567];
    l [class=LoggingDataSink];
    r -> s -> l;
  }
```

```
$ datalogd -c recipes/socket_client.config
```

```
INFO:main:Initialising DataLogDaemon.
INFO:DataLogDaemon:Loaded config from: recipes/socket_client.config
INFO:pluginlib:Loading plugins from standard library
INFO:DataLogDaemon:Detected source plugins: NullDataSource, PicoTC08DataSource,␣
↪RandomWalkDataSource, SerialDataSource
INFO:DataLogDaemon:Detected filter plugins: NullDataFilter, AggregatorDataFilter,␣
↪CoolingPowerDataFilter, CSVDataFilter, FlowSensorCalibrationDataFilter,␣
↪JoinDataFilter, KeyValDataFilter, PolynomialFunctionDataFilter, SocketDataFilter,␣
↪TimeStampDataFilter
INFO:DataLogDaemon:Detected sink plugins: NullDataSink, FileDataSink,␣
↪InfluxDB2DataSink, LoggingDataSink, MatplotlibDataSink, PrintDataSink,␣
↪PyqtgraphDataSink
INFO:DataLogDaemon:Initialising node r:RandomWalkDataSource(walkers=[[1.0, 0.1]])
INFO:DataLogDaemon:Initialising node s:SocketDataFilter(role=client, host=127.0.0.1,␣
↪port=4567)
INFO:DataLogDaemon:Initialising node l:LoggingDataSink()
INFO:DataLogDaemon:Connecting r:RandomWalkDataSource -> s:SocketDataFilter
INFO:DataLogDaemon:Connecting s:SocketDataFilter -> l:LoggingDataSink
INFO:main:Starting event loop.
```

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```
INFO:SocketDataFilter:Connection established to ('127.0.0.1', 4567).
INFO:LoggingDataSink:Data received:
INFO:LoggingDataSink:  {'type': 'randomwalk', 'id': '0', 'value': 40.0}
INFO:LoggingDataSink:Data received:
INFO:LoggingDataSink:  {'type': 'randomwalk', 'id': '0', 'value': 50.0}
INFO:LoggingDataSink:Data received:
INFO:LoggingDataSink:  {'type': 'randomwalk', 'id': '0', 'value': 50.0}
INFO:LoggingDataSink:Data received:
INFO:LoggingDataSink:  {'type': 'randomwalk', 'id': '0', 'value': 40.0}
```

Similarly, on the server instance, you should see the data sent by the client being logged to the terminal window.

CHAPTER 2

API Documentation

2.1 datalogd package

The datalogd package contains the main *DataLogDaemon*, plus the plugin base classes *DataSource*, *DataFilter*, and *DataSink*, which must be extended to provide useful functionality.

The included data source/filter/sink plugins are contained separately in the *plugins* package.

class datalogd.**DataFilter**(*sinks=[]*)
Bases: *datalogd.DataSource*, *datalogd.DataSink*, pluginlib._parent.Plugin

The base class for all data filter plugins.

*DataFilter*s are subclasses of both *DataSource*s and *DataSink*s, thus are capable of both sending and receiving data. Typically, they are used to sit between a *DataSource* and a *DataSink* (or other *DataFilter*s) in order to modify the data flowing between them in some way.

class datalogd.**DataLogDaemon**(*configfile=None*, *plugindirs=[]*, *graph_dot=None*)
Bases: object

The main datalogd class.

The *DataLogDaemon* reads configuration file(s), interprets the connection graph DOT specification, and initialises data source/filter/sink plugins and connections. The asyncio event loop must be started separately. For an example of this, see the *main()* method, which is the typical way the daemon is started.

Parameters

- **configfile** – Path to configuration file to load.
- **plugindirs** – Directory, or list of directories from which to load additional plugins.
- **graph_dot** – Connection graph specified in the DOT graph description language.

close()
Notify nodes that the application is closing so they may shutdown gracefully.

class datalogd.**DataSink**
Bases: pluginlib._parent.Plugin

The base class for all data sink plugins.

*DataSink*s have a *receive()* method which accepts data from connected *DataSource*s.

close()
Perform any cleanup required during application shutdown.

receive(*data*)
Accept the provided `data`.

Parameters **data** – Data received by this sink.

class datalogd.**DataSource**(*sinks=[]*)
Bases: `pluginlib._parent.Plugin`

The base class for all data sink plugins.

DataSource implements methods for connecting or disconnecting sinks, and for sending data to connected sinks. It has no intrinsic functionality (it does not actually produce any data) and is not itself considered a plugin, so can't be instantiated using the connection graph.

Parameters **sinks** – *DataSink* or list of *DataSink*s to receive data produced by this *DataSource*.

close()
Perform any cleanup required during application shutdown.

connect_sinks(*sinks*)
Register the provided *DataSink* as a receiver of data produced by this *DataSource*. A list of sinks may also be provided.

Parameters **sinks** – *DataSink* or list of *DataSink*s.

disconnect_sinks(*sinks*)
Unregister the provided *DataSink* so that it no longer receives data produced by this *DataSource*. A list of sinks may also be provided. It is not an error to provide a sink that is not currently connected.

Parameters **sinks** – *DataSink* or list of *DataSink*s.

send(*data*)
Send the provided `data` to all connected *DataSink*s.

Parameters **data** – Data to send to *DataSink*s.

class datalogd.**NullDataFilter**(*sinks=[]*)
Bases: *datalogd.DataFilter*

A *DataFilter* which accepts data and passes it unchanged to any connected *DataSink*s.

receive(*data*)
Pass `data` unchanged to all connected *DataSink*s.

Parameters **data** – Data received by this filter.

class datalogd.**NullDataSink**
Bases: *datalogd.DataSink*

A *DataSink* which accepts data and does nothing with it.

Unlike the base *DataSink*, this can be instantiated using the connection graph, although it provides no additional functionality.

class datalogd.**NullDataSource**(*sinks=[]*)
Bases: *datalogd.DataSource*

A *DataSource* which produces no data.

Unlike the base *DataSource*, this can be instantiated using the connection graph, although it provides no additional functionality.

datalogd.**listify**(*value*)
Convert value into a list.

Modifies the behaviour of the python builtin list() by accepting all types as value, not just iterables. Additionally, the behaviour of iterables is changed:

- list('str') == ['s', 't', 'r'], while listify('str') == ['str']
- list({'key': 'value'}) == ['key'], while listify({'key': 'value'}) == [{'key': 'value'}]

Parameters **value** – Input value to convert to a list.

Returns value as a list.

datalogd.**main**()
Read command line parameters, instantiate a new *DataLogDaemon* and begin execution of the event loop.

datalogd.**parse_dot_json**(*value*)
Interpret the value of a DOT attribute as JSON data.

DOT syntax requires double quotes around values which contain DOT punctuation (space, comma, {}, [] etc), and, if used, these quotes will also be present in the obtained value string. Unfortunately, JSON also uses double quotes for string values, which are then in conflict. This method will strip any double quotes from the passed value, then will attempt to interpret as JSON after replacing single quotes with double quotes.

Note that the use of this workaround means that single quotes must be used in any JSON data contained in the DOT attribute values.

Although not strictly correct JSON, some special values will be interpreted as their python equivalents. These are:

- None or null (with any capitalisation) will be read as a python None.
- True (with any capitalisation) will be read as a python True.
- False (with any capitalisation) will be read as a python False.
- NotImplemented (with any capitalisation) will be read as a python NotImplemented.
- NaN (with any capitalisation) will be read as the python float nan.
- Inf or Infinity (with any capitalisation) will be read as the python float inf.
- -Inf or -Infinity (with any capitalisation) will be read as the python float -inf.

Parameters **value** – string to interpret.

Returns value, possibly as a new type.

2.1.1 Subpackages

2.1.1.1 datalogd.plugins package

The plugins package contains the included *DataSource*, *DataFilter*, and *DataSink* subclasses. Some plugins will require additional python modules to be installed, or may have other specific requirements (for example, the *LibSensorsDataSource* probably won't work on Windows operating systems).

2.1.1.1.1 Submodules

datalogd.plugins.aggregator_datafilter module

class datalogd.plugins.aggregator_datafilter.**AggregatorDataFilter**(*sinks=[], buffer_size=100, send_every=100, aggregate=['timestamp', 'value']*)

Bases: *datalogd.DataFilter*

Aggregates consecutively received data values into a list and passes the new array(s) on to sinks.

The aggregated data can be sent at different intervals to that which it is received by using the `send_every` parameter. A value of 1 will send the aggregated data every time new data is received. A value of `send_every` equal to `buffer_size` will result in the data being passed on only once the buffer is filled. A typical usage example would be for data which is received once every second, using `buffer_size=86400` and `send_every=60` to store up to 24 hours of data, and update sinks every minute.

Parameters

- **buffer_size** – Maximum length for lists of aggregated data.
- **send_every** – Send data to connected sinks every *n* updates.
- **aggregate** – List of data keys for which the values should be aggregated.

receive(*data*)

Accept `data`, aggregate selected values, and pass on aggregated data to any connected sinks.

Parameters **data** – Data containing values to aggregate.

datalogd.plugins.coolingpower_datafilter module

class datalogd.plugins.coolingpower_datafilter.**CoolingPowerDataFilter**(*sinks=[], temperature_id_in='A_0', temperature_id_out='A_1', flow_rate_id='A_0', heat_capacity=4184, density=1.0, cooling_power_id='A_0'*)

Bases: *datalogd.DataFilter*

Calculate power absorbed by cooling liquid through a system given flow rate and input and output temperatures.

The calculation requires each receipt of data to contain two temperature entries and one flow rate entry. For example:

```
[
    {"type": "temperature", "id": "A_0", "value": 12.34, "units": "C"},
    {"type": "temperature", "id": "A_1", "value": 23.45, "units": "C"},
    {"type": "flow_rate", "id": "A_0", "value": 0.456, "units": "L/min"}
]
```

The IDs used to select the appropriate temperatures and flow rate may be given in the initialisation parameters. Temperatures should be in celsius (or kelvin), and flow rate should be in litres per minute. By default, the heat capacity and density of water will be used for calculations, but alternate values may supplied as a parameters. Heat capacity should be in J/kg/K, and density in g/mL.

If all required data entries are present, a new entry with a `coolingpower` type will be added, and the data will then look like:

```
[
    {"type": "temperature", "id": "A_0", "value": 12.34, "units": "C"},
    {"type": "temperature", "id": "A_1", "value": 23.45, "units": "C"},
    {"type": "flow_rate", "id": "A_0", "value": 0.456, "units": "L/min"},
    {"type": "coolingpower", "id": "A_0", "value": 353.28, "units": "W"}
]
```

The ID used for the `coolingpower` entry may also be specified as an initialisation parameter. If the flow rate entry includes a `"timestamp"` field, its value will be copied to the cooling power entry.

Parameters

- **temperature_id_in** – ID of temperature data for inlet liquid.
- **temperature_id_out** – ID of temperature data for outlet liquid.
- **flow_rate_id** – ID of liquid flow rate data.
- **heatcapacity** – Heat capacity of cooling liquid, in J/kg/K.
- **density** – Density of cooling liquid, in g/mL.
- **coolingpower_id** – ID to use for the calculated cooling power data.

receive(*data*)

Accept the provided `data` and add a `coolingpower` entry calculated from flow rate and input and output temperatures.

Parameters **data** – Data to calculate cooling power from.

datalogd.plugins.csv_datafilter module

class datalogd.plugins.csv_datafilter.**CSVDataFilter**(*sinks=[], keys=['timestamp', 'value'], labels=['timestamp', '{type}_{id}'], header='every'*)

Bases: *datalogd.DataFilter*

Format received data into a table of comma separated values.

The column headers can be formatted using values from the data. For example, for the data:

```
[
    {'type': 'temperature', 'id': '0', 'value': 22.35},
    {'type': 'humidity', 'id': '0', 'value': 55.0},
    {'type': 'temperature', 'id': '1', 'value': 25.80},
]
```

and a node initialised using:

```
sink [class=CSVDataSink keys="['value']", labels="['{type}_{id}'"];
```

the output will be:

```
temperature_0,humidity_0,temperature_1
22.35,55.0,25.80
```

Setting `labels` to `None` will disable the column headers.

By default, the column headers will be generated on every receipt of data. To instead output the column headers only once on the first receipt of data, use the parameter `header="once"`. Setting `header=None` will also disable the headers completely.

Parameters

- **keys** – Name of data keys to format into columns of the CSV.
- **labels** – Labels for the column headers, which may contain mappings to data values.
- **header** – Display the column header `"once"` or `"every"` or `None`.

receive(*data*)

Accept `data` and format into a table of CSV.

Parameters **data** – Data to format as CSV.

datalogd.plugins.file_datasink module

class datalogd.plugins.file_datasink.**FileDataSink**(*filename*, *filename_timestamp=False*, *mode='w'*, *header=''*, *terminator='n'*, *flush_interval=10*)

Bases: *datalogd.DataSink*

Write data to a file.

By default, any existing contents of `filename` will be overwritten without prompting. To instead raise an error if the file exists, set the `mode` parameter to 'x'. The contents of any existing file will be appended to by setting `mode='a'`.

To automatically prepend a date and time stamp to the given filename, set `filename_timestamp=True`. In general, this should create a unique filename and prevent overwriting when `filename` already exists.

The `flush_interval` parameter controls the behaviour of the file writes. It describes how often, in seconds, the operating system's buffers should be flushed to disk, updating the file contents:

- `flush_interval > 0` causes the flush to occur at the given time interval, in seconds. More frequent flushes will keep the contents of the file updated, but put more strain on the machines I/O systems.
- `flush_interval = 0` will flush immediately after each receipt of data.
- `flush_interval < 0` will not automatically flush, leaving this to the operating system. The contents of the file may not update until the program closes.
- `flush_interval == None` will perform a file open, write, and close operation on each receipt of data. This may be desired if the contents of the file should only contain the latest received data (and should be used in conjunction with the `mode='w'` parameter).

Parameters

- **filename** – File name to write data to.
- **filename_timestamp** – Prepend a timestamp to the filename.
- **mode** – Mode in which to open the file. One of 'w' (write), 'a' (append), 'x' (exclusive creation).
- **header** – Header to write to file after plugin initialisation.
- **terminator** – Separator written to file after each receipt of data.
- **flush_interval** – Interval, in seconds, between flushes to disk.

close()
Close the connection to the file.

receive(*data*)
Accept `data` and write it out to the file.

The `terminator` specified in the constructor will be appended to the file after each call of this method.

Parameters **data** – Data to write to file.

datalogd.plugins.flowsensorcalibration_datafilter module

class datalogd.plugins.flowsensorcalibration_datafilter.**FlowSensorCalibrationDataFilter**(*sink*, *cou*, *a=5*, *k=0*, *x0=*, *b=0*)

Bases: *datalogd.DataFilter*

Use a pulse counter's counts per second to compute a liquid flow rate in litres per minute using an experimentally determined calibration function.

A flow sensor has a spinning turbine and outputs pulses due to the flow rate of the liquid. However, the pulse rate will not be directly proportional to the flow rate (each pulse does not correspond to a fixed volume of liquid). A calibration curve can be constructed by measuring the number of pulses emitted over time for a given volume of liquid at a range of different flow rates. A plot of counts per litre versus counts per minute displays the characteristics of the sensor. Fitting the points to a curve of the form $f(x) = a(1 - \exp(-k(x - x_0)^b))$ will provide the required calibration parameters.

The default parameters (`a=5975, k=0.173734, x0=0, b=0.284333`) convert from counts per second to litres per minute for the YF-S401 flow sensor, and may be compatible with models from the same family such as YF-S402 and YF-S402B. A similar, smaller sensor common in automatic coffee machines, model number FM-HL3012C, was found to have parameters of `a=1950, k=0.0965882, x0=0, b=0.721649`.

The original `count_rate` entry in the data will be preserved, with the calculated `flow_rate` being appended as a new data entry.

Parameters

- **counter_rate_id** – ID field to match to the data.
- **a** – Parameter a in calibration function.
- **k** – Parameter k in calibration function.
- **x0** – Parameter x_0 in calibration function.
- **b** – Parameter b in calibration function.

- **units** – New units for the data.

receive(*data*)

Accept the provided `data` and compute a flow rate using the calibration function.

Parameters **data** – Data to calculate flow rate from.

datalogd.plugins.influxdb2_datasink module

class datalogd.plugins.influxdb2_datasink.**InfluxDB2DataSink**(*url='http://localhost:8086'*, *token=''*, *org='default'*, *bucket='default'*, *measurement='measurement'*, *run_id=None*, *field_key=None*, *field_value=None*)

Bases: *datalogd.DataSink*

Connection to a InfluxDB 2.x (or 1.8+) database for storing time-series data.

Note that this doesn't actually run the InfluxDB database service, but simply connects to an existing InfluxDB database via a network (or localhost) connection. See the getting started documentation for details on configuring a new database server.

The `url` parameter should be a string specifying the protocol, server ip or name, and port. For example, `url="http://localhost:8086"`.

The authentication `token` parameter needs to be specified to allow commits to the database. See the token documentation to see how to create and obtain tokens.

Parameters for `org`, `bucket` must correspond to a valid organisation and bucket created in the database for which the authentication token is valid. See the documentation for organisations and buckets for details.

The `measurement` parameter specifies the data point measurement (or "table") the data will be entered into, and does not need to already exist. See the documentation on data elements for details.

A `run_id` parameter may be passed which will be added as a tag to the data points. It may be used to identify data obtained from this particular run of the data logging session. If no value is provided, a value will be generated from a YYYYMMDD-HHMMSS formatted time stamp.

The data point field key will be attempted to be determined automatically from the incoming data dictionaries. If the data dictionary contains a `name` or `label` key, then its value will be used as the database point field key. Alternatively, a field key will be generated from the values of `type` and `id` if present. Finally, a default field key of `data` will be used. To instead specify the data entry which should provide the field key, specify it as the `field_key` parameter. If the field is specified by a parameter or taken from a name or label, then those will not also be included in the entry's database keys. However, if the field name is automatically built from type and id values, these will still be part of the entries keys.

Similarly, the data point field value will use the value from the incoming data dictionary's `value` field if present. To instead specify the data entry which should provide the field value, specify it as the `field_value` parameter. The value won't also appear in the database entry's keys.

Parameters

- **url** – Protocol, host name or IP address, and port number of InfluxDB server.
- **token** – API token used to authenticate with the InfluxDB server.
- **org** – Name of InfluxDB organisation in which to store data.

- **bucket** – Name of InfluxDB bucket in which to store data.
- **measurement** – Name for the InfluxDB measurement session.
- **run_id** – A tag to identify commits from this run.
- **field_key** – A field from the incoming data used to determine the data point field key.
- **field_value** – A field from the incoming data used to determine the data point field value.

close()
Close the connection to the database.

receive(*data*)
Commit data to the InfluxDB database.

Multiple items of data can be submitted at once if `data` is a list. A typical format of `data` would be:

```
[
    {'type': 'temperature', 'id': '0', 'value': 22.35},
    {'type': 'humidity', 'id': '0', 'value': 55.0},
    {'type': 'temperature', 'id': '1', 'value': 25.80},
]
```

In the above case (assuming the `field_key` and `field_value` parameters were not supplied when initialising the plugin), the InfluxDB data point field would be generated as `<type>_<id> = <value>`, and only the global `run_id` parameter would be entered into the data point keys.

If a `name` or `label` field is present, then it will instead be used as the InfluxDB data point field key. For example:

```
[
    {'name': 'Temperature', 'type': 'temperature', 'id': '0', 'value': 22.35},
    {'name': 'Humidity', 'type': 'humidity', 'id': '0', 'value': 55.0},
]
```

In this case, the InfluxDB data point field would be generated as `<name> = <value>`, and the remaining fields (`type` and `id`) would be added as data point field keys, along with the `run_id`.

A timestamp for the commit will be generated using the current system clock if a "timestamp" field does not already exist.

Parameters **data** – Data to commit to the database.

datalogd.plugins.influxdb_datasink module

class datalogd.plugins.influxdb_datasink.**InfluxDBDataSink**(*host='localhost'*, *port=8086*, *user='root'*, *password='root'*, *dbname='datalogd'*, *session='default'*, *run=None*)

Bases: *datalogd.DataSink*

Connection to a InfluxDB database for storing time-series data.

Note: This plugin is outdated. For new InfluxDB 2.x installs, use the *InfluxDB2DataSink* plugin instead.

Note that this doesn't actually run the InfluxDB database service, but simply connects to an existing InfluxDB database via a network (or localhost) connection. See the getting started documentation for details on configuring a new database server.

Parameters

- **host** – Host name or IP address of InfluxDB server.
- **port** – Port used by InfluxDB server.
- **user** – Name of database user.
- **password** – Password for database user.
- **dbname** – Name of database in which to store data.
- **session** – A name for the measurement session.
- **run** – A tag to identify commits from this run. Default of `None` will use a date/time stamp.

close()
Close the connection to the database.

receive(*data*)
Commit data to the InfluxDB database.

Multiple items of data can be submitted at once if `data` is a list. A typical format of `data` would be:

```
[
    {'type': 'temperature', 'id': '0', 'value': 22.35},
    {'type': 'humidity', 'id': '0', 'value': 55.0},
    {'type': 'temperature', 'id': '1', 'value': 25.80},
]
```

The data point will have its data field generated using the form `<type>_<id> = <value>`.

A timestamp for the commit will be generated using the current system clock if a "timestamp" field does not already exist.

Parameters **data** – Data to commit to the database.

datalogd.plugins.join_datafilter module

class datalogd.plugins.join_datafilter.**JoinDataFilter**(*sinks=[]*, *count=2*)
Bases: *datalogd.DataFilter*

Join two or more consecutive receipts of data together into a list.

If the data are already lists, the two lists will be merged.

Parameters **count** – Number of data receipts to join.

receive(*data*)
Accept `data` and join consecutive receipts of data together into a list.

Parameters **data** – data to join.

datalogd.plugins.keyval_datafilter module

class datalogd.plugins.keyval_datafilter.**KeyValDataFilter**(*sinks=[]*, *select=True*, *keyvals=None*, *key='type'*, *val=None*)

Bases: *datalogd.DataFilter*

Select or reject data based on key–value pairs.

Received data items will be inspected to see whether they contain the given keys, and that their values match the given values. The key-value pairs are supplied as a list in the form `[[key, value], [key2, value2]...]`. All key-value pairs must be matched. A value of the python special value of `NotImplemented` will match any value. If both `value` and `data[key]` are strings, matching will be performed using regular expressions (in which case `".*"` will match all strings). If the `select` flag is `True`, only matching data will be passed on to the connected sinks, if it is `False`, only non-matching data (or data that does not contain the given `key`) will be passed on.

If only a single key-value pair needs to be matched, they may alternatively be passed as the `key` and `val` parameters. This is mainly intended for backwards compatibility.

Parameters

- **select** – Pass only matching data, or only non-matching data.
- **keyvals** – List of dictionary key-value pairs to match in incoming data.

receive(*data*)

Accept the provided `data`, and select or reject items before passing on to any connected sinks.

The selection is based upon the parameters provided to the constructor of this *KeyValDataFilter*.

Parameters **data** – Data to filter.

datalogd.plugins.libsensors_datasource module

class datalogd.plugins.libsensors_datasource.**LibSensorsDataSource**(*sinks=[]*, *interval=1.0*)

Bases: *datalogd.DataSource*

Provide data about the running system's hardware obtained using the `libsensors` library.

`libsensors` is present on most Linux systems, or can be installed from the distribution's repositories (`apt install libsensors5` on Debian/Ubuntu, `pacman -S lm_sensors` on Arch etc.). The available sensors will depend on your hardware, Linux kernel, and version of `libsensors`.

Attempting to initialise this plugin on Windows operating systems will almost certianly fail.

Parameters **interval** – How often to poll the sensors, in seconds.

close()

Close the connection to the sensors.

read_sensors()

Read sensors and send data to any connected sinks.

class datalogd.plugins.libsensors_datasource.**LibSensorsFeatureType**

Bases: `enum.Enum`

A utility `Enum` used to interpret integers representing sensor feature types.

BEEP_ENABLE = 24

CURR = 5

ENERGY = 4

FAN = 1

HUMIDITY = 6

IN = 0

INTRUSION = 17

POWER = 3

TEMP = 2

UNKNOWN = 4294967295

VID = 16

type
The name of the type of sensor reading.

units
The units associated with this sensor reading type.

datalogd.plugins.logging_datasink module

class datalogd.plugins.logging_datasink.**LoggingDataSink**(*level=20, header='Data received:', indent=' '*)

Bases: *datalogd.DataSink*

Output data using python's `logging` system.

Each item of data is output in a separate line, and the formatting can be controlled using the `header` and `indent` parameters.

Parameters

- **level** – The logging level to use for the output.
- **header** – Line of header text preceeding the logged data.
- **indent** – Prefix applied to each line of logged data.

receive(*data*)
Accept the provided data and output it using python's `logging` system.

Parameters **data** – Data to log.

datalogd.plugins.matplotlib_datasink module

class datalogd.plugins.matplotlib_datasink.**MatplotlibDataSink**(*filename='plot.pdf', keys=['timestamp', 'value'], labels=['timestamp', '{type}_{id}']*)

Bases: *datalogd.DataSink*

Note: This plugin is still a work in progress, and is really only at the proof-of-concept stage.

receive(*data*)
Accept the provided `data`.

Parameters **data** – Data received by this sink.

datalogd.plugins.picotc08_datasource module

class datalogd.plugins.picotc08_datasource.**PicoTC08DataSource**(*sinks=[], interval=1.0, mains_rejection='50Hz', probes=[[1, 'Channel_1', 'K', 'C'], [2, 'Channel_2', 'K', 'C'], [3, 'Channel_3', 'K', 'C'], [4, 'Channel_4', 'K', 'C'], [5, 'Channel_5', 'K', 'C'], [6, 'Channel_6', 'K', 'C'], [7, 'Channel_7', 'K', 'C'], [8, 'Channel_8', 'K', 'C']]*)

Bases: *datalogd.DataSource*

Obtain readings from a Pico Technologies TC-08 USB data logging device.

The drivers and libraries (such as libusbtc08.so on Linux, usbtc08.dll on Windows) from PicoTech must be installed into a system library directory, and the `picosdk` python wrappers package must be on the system (with `pip install picosdk` or similar).

On Linux, read/write permissions to the USB device must be granted. This can be done with a udev rule such as:

Listing 1: `/etc/udev/rules.d/51-picotc08.rules`

```
# PicoTech TC-08
SUBSYSTEMS=="usb", ACTION=="add", ATTRS{idVendor}=="0ce9, ATTRS{idProduct}=="1000
↪", OWNER="root", GROUP="usbusers", MODE="0664"
```

where the `idVendor` and `idProduct` fields should match that listed from running `lsusb`. The `usbusers` group must be created and the user added to it:

```
groupadd usbusers
usermod -aG usbusers yourusername
```

A reboot will then ensure permissions are set and the user is a part of the group (or use `udevadm control --reload` and re-login). To check the permissions have been set correctly, get the USB bus and device numbers from the output of `lsusb`. For example

Listing 2: `lsusb`

```
Bus 001 Device 009: ID 0ce9:1000 Pico Technology
```

the bus ID is 001 and device ID is 009. Then list the device using `ls -l /dev/bus/usb/[bus ID]/[device ID]`

Listing 3: `ls /dev/bus/usb/001/009 -l`

```
crw-rw-r-- 1 root usbusers 189, 9 Mar 29 13:19 /dev/bus/usb/001/009
```

The middle "rw" and the "usbusers" indicates read-write permissions enabled to any user in the usbusers group. You can check which groups your current user is in using the `groups` command.

Note that you may also allow read-write access to any user (without having to make a usbusers group) by changing the lines in the udev rule to `MODE="0666"` and removing the `GROUP="usbusers"` part.

The `interval` parameter determines how often data will be obtained from the sensors, in seconds. The minimum interval time is about 0.2 s for a single probe and 0.9 s for all eight.

The `mains_rejection` parameter filters out either 50 Hz or 60 Hz interference from mains power. The frequency is selected as either `"50Hz"` or `"60Hz"`.

The `probes` parameter is a list of probe to initialise. Each element is itself a list of the form `[number, label, type, units]`, where probe numbers are unique integers from 1 to 8 corresponding to an input channel on the device. Probe labels can be any valid string. Valid probe thermocouple types are `"B"`, `"E"`, `"J"`, `"K"`, `"N"`, `"R"`, `"S"`, `"T"`, or `"X"`, where `"X""` indicates a raw voltage reading. Units are one of Celsius, Fahrenheit, Kelvin, Rankine specified as `"C"`, `"F"`, `"K"` or `"R"`. For the `"X"` probe type, readings will always be returned in millivolts.

If the device cannot be found or initialised, or the device is unplugged during operation, regular reattempts will be performed. Note that this means that an exception will not be raised if the device cannot be found.

Parameters

- **`interval`** – Time interval between readings, in seconds.
- **`mains_rejection`** – Mains power filter frequency.
- **`probes`** – List of probes and configuration parameters.

`close``()`

Close the connection to the Pico TC-08 device.

datalogd.plugins.polynomialfunction_datafilter module

class datalogd.plugins.polynomialfunction_datafilter.**PolynomialFunctionDataFilter**(*sinks=[], match_keyvals=[['.*', '.*']], value='value', coeffs=[0.0, 1.0], rounding=None, units=None*)

Bases: *datalogd.DataFilter*

Select data based on key–value pairs, then apply a polynomial function to a value.

Any data which matches all of the `match_keyvals` key–value pairs will be processed. The format of the `match_keyvals` parameter is a list in the form `[[key, value], [key2, value2]...]`. For example, `match_keyvals=[["type", "temperature"], ["id", "123"]]` will process any data which has a `"type"` field of `"temperature"` and an `"id"` field of `"123"`. A `value` of the python special `NotImplemented` will match any value for the given key. In the case that values are strings, they will be matched as regular expressions, for example `".*"` will match any string.

Once a data item is matched, a value will be selected to apply the polynomial function to, selected by the `value` parameter. By default this is the value stored under the `"value"` key.

The polynomial function is defined by a set of coefficients, given by the `coeffs` parameter. This is an array of n coefficients, c_n, which forms the function $x' = \sum_n c_n x^{(n-1)} \equiv c_0 + c_1 x + c_2 x^2 \ldots c_n x^n$. For example, `coeffs=[1.23, 1.0]` would add 1.23 to a value, while `coeffs=[0, 10]` would multiply a value by 10. Specifying additional coefficients include quadratic, cubic terms etc.

Rounding may be applied to the result by supplying the number of decimal places in the `rounding` parameter. Rounding behaviour is determined by the numpy `around()` function. Negative numbers specify positions to the left of the decimal point.

The value of the data entry's `"units"` field can be modified or created using the `units` parameter. For example, `units="V"` might be used to indicate that an analogue measurement in arbitrary units now equates to voltage, determined by the polynomial function calibration curve.

Parameters

- **match_keyvals** – Key–value pairs to match to data items.
- **value** – Key from data item containing the value to modify.
- **coeffs** – Coefficients of the polynomial function to apply.
- **rounding** – Number of decimal places to round the result.
- **units** – New value of units field for the modified data item.

receive(*data*)

Accept the provided `data`, select based on key/value pairs, apply function, and pass onto connected sinks.

The selection is based upon the parameters provided to the constructor of this *PolynomialFunctionDataFilter*.

Parameters **data** – Data to correct.

datalogd.plugins.print_datasink module

class datalogd.plugins.print_datasink.**PrintDataSink**(*end='n'*, *stream='stdout'*)
Bases: *datalogd.DataSink*

Output data to standard-out or standard-error streams using the built-in python `print()` method.

Parameters

- **end** – Line terminator.
- **stream** – Output stream to use, either "stdout" or "stderr".

receive(*data*)
Accept `data` and print it out.

Parameters **data** – Data to print.

datalogd.plugins.pyqtgraph_datasink module

class datalogd.plugins.pyqtgraph_datasink.**PlotWindow**(*parent=None*, *data_queue=None*, *npoints=2048*, *plotlayout=None*, *xlink=True*, *crosshair=True*, ***kwargs*)
Bases: `sphinx.ext.autodoc.importer._MockObject`

closeEvent(*event*)

eventFilter(*obj*, *event*)

class datalogd.plugins.pyqtgraph_datasink.**PyqtgraphDataSink**(***kwargs*)
Bases: *datalogd.DataSink*

Plot data in realtime in a pyqtgraph window.

Multiple plot areas may be defined which will be stacked in rows with (by default) linked time axes. Each plot area may itself have multiple traces contained within. The complete plot configuration is defined in the initialisation parameters. The data to use for each trace is selected by matching a series of key-value pairs, in a similar manner to the *KeyValDataFilter*.

A limited number of data points are stored to be plotted, after which the oldest data points will be discarded to make way for incoming data. The number of data points can be specified with the `npoints` parameter, with a default of 2048.

The plot layout is described by the `plotlayout` parameter. As python code:

```
plotlayout = [
    # List of plot panels
    {
        # Plot 1 panel definition
        'ylabel': 'Value (a.u)',
        'traces': [
            # List of trace definitions for this plot panel
            {
                # Trace 1 definition
                'name': 'Trace 1',
                'pen': [255, 255, 0],
                'selector': [
                    # list of key-value pairs to match to data (same as␣
↪KeyValDataFilter)
```

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```
                    ['type', 'analog'],
                    ['id', '.*0']
                ]
            }, # ... possibly more trace definitions
        ]
    }, # ... possibly more plot definitions
]
```

In the connection graph configuration the `plotlayout` data structure must be a string formatted as JSON.

Note that any fields present in a trace definition (such as `'name'` and `'pen'`) are passed to the pyqtgraph `PlotDataItem` initialisation which may be used to customise the trace, such as defining line color or changing to a scatter plot.

Passing the parameter `xlink=False` will unlink the time axes of the plots, so changes to the view of one plot will not affect the others.

By default, a crosshair will be shown under the mouse pointer. Values for each trace at the crosshair x position are shown in the legend, and the y position of the crosshair will be shown to the right of the plot. To disable this functionality, pass `crosshair=False`.

Any additional parameters are passed to the pyqtgraph `GraphicsLayoutWidget` initialisation, which can be used to customise the plot window. For example, changing the window title and size with `title="Plots"` and `size=[1000, 600]`.

Parameters

- **npoints** – Maximum number of data points for a trace.
- **title** – String for title of the plot window.
- **size** – Tuple of (height, width) of the plot window.
- **plotlayout** – Data structure describing the plot layout and traces.
- **xlink** – Boolean, link the time axes of the plots.
- **crosshair** – Boolean, show the crosshair under the mouse pointer.

close()
Signal the pyqtgraph application to close when the application is shutting down.

receive(*data*)
Accept the provided `data` and pass it to the pyqtgraph *PlotWindow* for display.

datalogd.plugins.randomwalk_datasource module

class datalogd.plugins.randomwalk_datasource.**RandomWalkDataSource**(*sinks=[], seed=None, interval=1.0, walkers=[[0.0, 1.0], [0.0, 2.0]]*)

Bases: *datalogd.DataSource*

Generate test or demonstration data using a random walk algorithm.

For each iteration of the algorithm, the output value will either be unchanged, increase, or decrease by a fixed increment. The options are chosen randomly with equal probability.

Multiple walkers can be initialised to produce several sources of random data. The `walkers` parameter is a list, the length of which determines the number of walkers to use. Each item in the list must be a list/tuple of two items: the walker's initial value and increment.

Parameters

- **seed** – Seed used to initialise the random number generator.
- **interval** – How often to run an iteration of the algorithm, in seconds.
- **walkers** – List defining number of walkers and their parameters in the form `[[init, increment], ...]`.

generate_data()
Run one iteration of the random walk algorithm and send the value to any connected sinks.

datalogd.plugins.serial_datasource module

class datalogd.plugins.serial_datasource.**SerialDataSource**(*sinks=[]*, *port=None*, *board_id=None*, *vid=None*, *pid=None*, *serial_number=None*, *location=None*)

Bases: *datalogd.DataSource*

Receive data from an Arduino connected via a serial port device.

See the `datalog_arduino.ino` sketch for matching code to run on a USB-connected Arduino.

Listing 4: `datalog.ino`

```
#include <Arduino.h>
#include <Wire.h>
#include <SPI.h>

////////////////////////////////////////////////////////
// Device Configuration Settings
////////////////////////////////////////////////////////

// An ID string for this Arduino
#define BOARD_ID_STRING "A"

// Interval between reads of devices
#define READ_INTERVAL 2000
// Interval between empty "keep alive" messages to maintain connection
#define KEEPALIVE_INTERVAL 1000

// Select which types of sensors to use
#define USE_DIGITAL_PINS true
#define USE_ANALOG_PINS true
#define USE_DS18B20_TEMPERATURE true
#define USE_BH1750_LUX false
#define USE_COUNTER false

////////////////////////////////////////////////////////
// Pin Definitions and Sensor Configuration
```

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```
////////////////////////////////////////////////////////////

#if USE_ANALOG_PINS
  // Set of analog input pins to read
  const int analog_pins[] = {A0, A1, A2, A3, A4, A5};
#endif

#if USE_DIGITAL_PINS
  // Set of digital input pins to read
  const int digital_pins[] = {4, 5, 6};
#endif

#if USE_DS18B20_TEMPERATURE
  // Run the 1-wire bus on pin 12
  const int onewire_pin = 12;
#endif

#if USE_COUNTER
  // Flow sensor pulse pin input, must be interrupt enabled
  // These are pins 0, 1, 2, 3, 7 for a Leonardo board
  // Note that Leonardo needs pins 0+1 for Serial1 and 2+3 for I2C
  const int counter_pin = 7;
  // Pin where an LED is connected, will toggle LED in sync with incoming pulses
  // Set to 0 to disable
  const int led_pin = 13;
#endif

////////////////////////////////////////////////////////////


#if USE_DS18B20_TEMPERATURE
  #include <OneWire.h>
  #include <DallasTemperature.h>
  // Initialise the 1-Wire bus
  OneWire oneWire(onewire_pin);
  // Pass our 1-Wire reference to Dallas Temperature
  DallasTemperature thermometers(&oneWire);
#endif

#if USE_BH1750_LUX
  #include <hp_BH1750.h>
  // Reference to the BH1750 light meter module over I2C
  hp_BH1750 luxmeter;
#endif

#if USE_COUNTER
  // Number of pulses read from the flow meter
  volatile unsigned long counter_count = 0;
  // Stored start time and pulse count for flow rate calculation
  unsigned long counter_start_millis = 0;
  unsigned long counter_start_count = 0;
  volatile unsigned int led_state = LOW;
#endif


// Variable to record last data acquisition time
unsigned long measurement_start_millis = 0;
```

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```
unsigned long keepalive_start_millis = 0;

// Variable to keep track of whether record separators (comma) needs to be␣
↪prepended to output
bool first_measurement = true;


#if USE_DS18B20_TEMPERATURE
  // Format a DS18B20 device address to a 16-char hex string
  String formatAddress(DeviceAddress address) {
    String hex = "";
    for (uint8_t i = 0; i < 8; i++) {
      if (address[i] < 16) hex += "0";
      hex += String(address[i], HEX);
    }
    return hex;
  }
#endif

// Print out a measurement to the serial port
void printMeasurement(String type, String id, String value, String units="") {
  // A comma separator needs to be prepended to measurements other than the first
  if (first_measurement) {
    first_measurement = false;
  } else {
    Serial.print(",");
  }
  Serial.print("{\"type\":\"");
  Serial.print(type);
  Serial.print("\",\"source\":\"");
  Serial.print(BOARD_ID_STRING);
  Serial.print("\",\"id\":\"");
  Serial.print(BOARD_ID_STRING);
  Serial.print("_");
  Serial.print(id);
  Serial.print("\",\"value\":\"");
  Serial.print(value);
  if (units.length() > 0) {
    Serial.print("\",\"units\":\"");
    Serial.print(units);
  }
  Serial.print("\"}");
}

#if USE_COUNTER
  // Interrupt handler for a pulse from the flow meter
  void counterIncrement() {
    counter_count++;
    if (led_pin != 0) {
      digitalWrite(led_pin, led_state = !led_state);
    }
  }
#endif

void setup(void)
{
  // Open serial port
```

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```
  Serial.begin(115200);

  #if USE_DS18B20_TEMPERATURE
    // Initialise I2C bus
    Wire.begin();
    pinMode(onewire_pin, INPUT_PULLUP);
  #endif

  #if USE_DIGITAL_PINS
    // Configure set of digital input pins
    for (uint8_t i = 0; i < uint8_t(sizeof(digital_pins)/sizeof(digital_pins[0]));
↪ i++) {
      pinMode(digital_pins[i], INPUT);
    }
  #endif

  #if USE_COUNTER
    // Configure the flow meter input pin and interrupt for pulse counting
    pinMode(counter_pin, INPUT_PULLUP);
    attachInterrupt(digitalPinToInterrupt(counter_pin), counterIncrement, RISING);
    // LED to toggle if defined
    if (led_pin != 0) {
      pinMode(led_pin, OUTPUT);
      digitalWrite(led_pin, led_state);
    }
    counter_start_millis = millis();
  #endif
}


void loop(void)
{
  // Record current time
  unsigned long current_millis = millis();
  // Check if it's time to take some new measurements
  if (current_millis - measurement_start_millis >= READ_INTERVAL) {
    measurement_start_millis = current_millis;
    // The first measurement in this cycle doesn't need a comma delimiter␣
↪prepended
    first_measurement = true;

    // Print message start
    Serial.print("{\"board\":\"" + String(BOARD_ID_STRING) + "\",");
    Serial.print("\"timestamp\":\"" + String(measurement_start_millis) + "\",");
    Serial.print("\"message\":\"measurement\",\"data\":[");

    ////////////////////////////////////////////////////////////////////////
    // Arduino Digital Pins
    ////////////////////////////////////////////////////////////////////////
    #if USE_DIGITAL_PINS
      // Read digital pins
      unsigned int d = 0;
      for (uint8_t i = 0; i < uint8_t(sizeof(digital_pins)/sizeof(digital_
↪pins[0])); i++) {
        d += digitalRead(digital_pins[i]) << i;
      }
      printMeasurement("digital", "0", String(d));
```

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```
    #endif

    ////////////////////////////////////////////////////////////////////////
    // Arduino Analog Pins
    ////////////////////////////////////////////////////////////////////////
    #if USE_ANALOG_PINS
      // Read analog pins
      for (uint8_t i = 0; i < uint8_t(sizeof(analog_pins)/sizeof(analog_pins[0]));
↪ i++) {
        printMeasurement("analog", String(i), String(analogRead(analog_pins[i])));
      }
    #endif

    ////////////////////////////////////////////////////////////////////////
    // DS18B20 Temperature Probes
    ////////////////////////////////////////////////////////////////////////
    #if USE_DS18B20_TEMPERATURE
      // We'll reinitialise the temperature probes each time inside the loop so␣
↪that
      // devices can be connected/disconnected while running
      thermometers.begin();
      // Temporary variable for storing 1-Wire device addresses
      DeviceAddress address;
      // Grab a count of temperature probes on the wire
      unsigned int numberOfDevices = thermometers.getDeviceCount();
      // Loop through each device, set requested precision
      for(unsigned int i = 0; i < numberOfDevices; i++) {
        if(thermometers.getAddress(address, i)) {
          thermometers.setResolution(address, 12);
        }
      }
      // Issue a global temperature request to all devices on the bus
      if (numberOfDevices > 0) {
        thermometers.requestTemperatures();
      }
      // Loop through each device, print out temperature data
      for(unsigned int i = 0; i < numberOfDevices; i++) {
        if(thermometers.getAddress(address, i)) {
          printMeasurement("temperature", formatAddress(address),␣
↪String(thermometers.getTempC(address), 2), "C");
        }
      }
    #endif

    ////////////////////////////////////////////////////////////////////////
    // BH1750 Lux Meter
    ////////////////////////////////////////////////////////////////////////
    #if USE_BH1750_LUX
      // Attempt to initialise and read light meter sensor
      if (luxmeter.begin(BH1750_TO_GROUND)) {
        luxmeter.start();
        printMeasurement("lux", "0", String(luxmeter.getLux(), 0), "lux");
      }
    #endif

    ////////////////////////////////////////////////////////////////////////
    // Fluid Flow Meter
```

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```
    ////////////////////////////////////////////////////////////////////
    #if USE_COUNTER
      unsigned long counter_end_count = counter_count;
      unsigned long counter_end_millis = millis();
      // Total volume in sensor pulses
      printMeasurement("counter_total", "0", String(counter_end_count), "counts");
      // Current flow rate in pulses per minute
      float counter_rate = 1000.0*(counter_end_count - counter_start_count)/
↪(counter_end_millis - counter_start_millis);
      printMeasurement("counter_rate", "0", String(counter_rate, 4), "Hz");
      counter_start_count = counter_end_count;
      counter_start_millis = counter_end_millis;
    #endif

    // Print message end
    Serial.println("]}");
  } else if (current_millis - keepalive_start_millis >= KEEPALIVE_INTERVAL) {
    // Send keepalive packet to maintain serial communications
    keepalive_start_millis = current_millis;
    // Print empty message
    Serial.print("{\"board\":\"" + String(BOARD_ID_STRING) + "\",");
    Serial.print("\"timestamp\":\"" + String(keepalive_start_millis) + "\",");
    Serial.println("\"message\":\"measurement\",\"data\":[]}");
  }
}
```

Other serial-connected devices should work with this class if they conform to the expected communications protocol. Message data should be encoded in a JSON format. For example

which describes a single temperature measurement data point, encapsulated by a message header. Note that the values encoded in the `"value"` field will be attempted to be decoded using the same logic as *parse_dot_json*, so that `"20.25"` will be interpreted as the equivalent python float, and special values such as `None` and `inf` are supported.

If the connection to the serial device cannot be established or is interrupted, regular reattempts will be performed. Note that this means an exception will not be raised if the serial device cannot be found.

Parameters

- **port** – Path of serial device to use. A partial name to match can also be provided, such as "usb".
- **board_id** – ID label provided by the Arduino data logging board, to select a particular device in case multiple boards are connected.

class SerialHandler(*parent*)

Bases: `sphinx.ext.autodoc.importer._MockObject`

A class used as a `asyncio Protocol` to handle lines of text received from the serial device.

Parameters **parent** – The parent *SerialDataSource* class.

connection_lost(*exc*)

handle_line(*line*)

Accept one line of text, parse it to extract data, and pass the data on to any connected sinks.

Parameters **line** – Line of text to process.

close()

Close the serial port connection.

datalogd.plugins.serial_datasource.**find_device**(*vid=None*, *pid=None*, *manufacturer=None*, *product=None*, *serial_number=None*, *location=None*)

Search attached serial ports for a specific device.

The first device found matching the criteria will be returned. Because there is no consistent way to identify serial devices, various parameters are available. The default is to return the first found serial port device. A more specific device can be selected using a unique combination of the parameters.

The USB vendor (`vid`) and product (`pid`) IDs are exact matches to the numerical values, for example `vid=0x2e8a` or `vid=0x000a`. The remaining parameters are strings specifying a regular expression match to the corresponding field. For example `serial_number="83"` would match devices with serial numbers starting with 83, while `serial_number=".*83$"` would match devices ending in 83. A value of `None` means that the parameter should not be considered, however an empty string value (`""`) is subtly different, requiring the field to be present, but then matching any value.

Be aware that different operating systems may return different data for the various fields, which can complicate matching.

To get a list of serial ports and the relevant data fields see the *list_devices* method.

Parameters

- **vid** – Numerical USB vendor ID to match.
- **pid** – Numerical USB product ID to match.
- **manufacturer** – Regular expression to match to a device manufacturer string.
- **product** – Regular expression to match to a device product string.
- **serial_number** – Regular expression to match to a device serial number.
- **location** – Regular expression to match to a device physical location (eg. USB port).

Returns First `ListPortInfo` device which matches given criteria.

datalogd.plugins.serial_datasource.**find_devices**(*vid=None*, *pid=None*, *manufacturer=None*, *product=None*, *serial_number=None*, *location=None*)

Search attached serial ports for specific devices.

Similar to *find_device* exce[pt returns a list of all matching devices. A list is returned even in a single device matches. An empty list is returned if no devices match.

Parameters

- **vid** – Numerical USB vendor ID to match.
- **pid** – Numerical USB product ID to match.
- **manufacturer** – Regular expression to match to a device manufacturer string.
- **product** – Regular expression to match to a device product string.
- **serial_number** – Regular expression to match to a device serial number.
- **location** – Regular expression to match to a device physical location (eg. USB port).

Returns List of `ListPortInfo` devices which match given criteria.

datalogd.plugins.serial_datasource.**list_devices**()

Return a string listing all detected serial devices and any associated identifying properties.

The manufacturer, product, vendor ID (vid), product ID (pid), serial number, and physical device location are provided. These can be used as parameters to *find_device()* or the constructor of a SerialDataSource class to identify and select a specific serial device.

Returns String listing all serial devices and their details.

datalogd.plugins.socket_datafilter module

class datalogd.plugins.socket_datafilter.**SocketDataFilter**(*sinks=[]*, *role='server'*, *host='127.0.0.1'*, *port=45454*, *buffer_size=1048576*, *message_encoding='utf8'*, *message_delimiter='x17'*, *structure_type='json'*)

Bases: *datalogd.DataFilter*

Send and receive data over a network socket.

The SocketDataFilter bridges data over a network socket. The other end of the connection may be another SocketDataFilter, but can be any application that uses the correct message encoding and structure. The connected sockets don't have to be on remote computers, and may be used to perform inter-process communications within a single machine.

The SocketDataFilter can also act as either a socket server, or a client. Connections must involve at least one server and one client. Servers will listen on their given port and accept multiple client connections. Clients will only make a single connection to the given server address and port. If a connection can't be established or is lost, it will be retried indefinitely.

Incoming network data will be forwarded on to all of the SocketDataFilter's *DataSink*s, and input from any connected *DataSource*s will be sent on to any network connections. Note that this behaviour is more like a "bridge" than a "filter".

The network communications protocol is quite basic, but allows some degree of customisation. The defaults are to convert the incoming python data from *DataSource*s to a JSON structure, and encode the resulting string into a byte stream using UTF-8. Network connections are kept open, and messages are separated by an end-of-transmission (EOT, 0x17) byte.

The `role` parameter selects whether the SocketDataFilter acts as a socket server, or socket client. In server mode (default), a server is started bound to the given `host` name or address and `port` number. The server will accept multiple connections, and data will be sent and received from any/all connected clients. If `role="client"`, then the SocketDataFilter will attempt to connect to a server given by the `host` address and `port` number.

The `host` address can be any name or IP address. To only allow connections to/from the local machine, use loopback address of `host="127.0.0.1"` (default). To allow a server to bind to any network interface, use `host=""`.

The `port` can be any unused port number, typically a high number between 1024 and 65535.

The `buffer_size` should be set to the maximum expected size of a data message packet. The default is 1 MiB.

For string (or JSON structured) data, the `message_encoding` determines how it will be converted to or from a byte stream. The default of `"utf8"` is typically fine.

By default, network connections will be kept open, with data message packets separated by a delimiter end-of-transmission (EOT, 0x17) byte. This may be changed to a different byte sequence using the `message_delimiter` parameter. Setting `message_delimiter=None` will mean than the end of a message packet is expected to be followed by the client closing the network connection. Further messages can be sent if the network socket connection is re-established.

To transmit data through the network, it needs to be converted to a stream of bytes. The `structure_type` parameter determines how arbitrary python data should be converted to a structure which can be converted to a byte stream. The default is `structure_type="json"` which will attempt to convert data to or from a JSON object.

Parameters

- **role** – Act as either a `"server"` or `"client"`.
- **host** – Network name or address to bind to (as a server) or connect to (as a client).
- **port** – Network port number to listen on (as a server) or connect to (as a client).
- **buffer_size** – Size of buffer for messages, maximum message size.
- **message_encoding** – Character encoding used for string data (or JSON encoded structures).
- **message_delimiter** – Delimiter byte(s) used to separate message packets.
- **structure_type** – Structure type used to represent data.

receive(*data*)

Accept the provided data and output it to any connected sockets.

Parameters **data** – Data to send to connected sockets.

datalogd.plugins.thorlabspm100_datasource module

class datalogd.plugins.thorlabspm100_datasource.**ThorlabsPM100DataSource**(*sinks=[]*, *serial_number=None*, *interval=1.0*)

Bases: *datalogd.plugins.thorlabspm100_datasource.ThorlabsPMDataSource*

Provide data from a Thorlabs PM100 laser power meter.

This is a wrapper around *ThorlabsPMDataSource* with the appropriate USB PID used as default. See its documentation regarding configuring permissions for accessing the USB device.

Parameters

- **serial_number** – Serial number of power meter to use. If `None`, will use the first device found.
- **interval** – How often to poll the sensors, in seconds.

class datalogd.plugins.thorlabspm100_datasource.**ThorlabsPM16DataSource**(*sinks=[]*, *serial_number=None*, *interval=1.0*)

Bases: *datalogd.plugins.thorlabspm100_datasource.ThorlabsPMDataSource*

Provide data from a Thorlabs PM16 laser power meter.

This is a wrapper around *ThorlabsPMDataSource* with the appropriate USB PID (0x807c) used as default. See its documentation regarding configuring permissions for accessing the USB device.

Parameters

- **serial_number** – Serial number of power meter to use. If `None`, will use the first device found.
- **interval** – How often to poll the sensors, in seconds.

class datalogd.plugins.thorlabspm100_datasource.**ThorlabsPM400DataSource**(*sinks=[]*, *serial_number=None*, *interval=1.0*)

Bases: *datalogd.plugins.thorlabspm100_datasource.ThorlabsPMDataSource*

Provide data from a Thorlabs PM400 laser power meter.

This is a wrapper around *ThorlabsPMDataSource* with the appropriate USB PID used as default. See its documentation regarding configuring permissions for accessing the USB device.

Parameters

- **serial_number** – Serial number of power meter to use. If `None`, will use the first device found.
- **interval** – How often to poll the sensors, in seconds.

class datalogd.plugins.thorlabspm100_datasource.**ThorlabsPMDataSource**(*sinks=[]*, *serial_number=None*, *usb_vid='0x1313'*, *usb_pid='0x8078'*, *interval=1.0*)

Bases: *datalogd.DataSource*

Provide data from a Thorlabs laser power meter.

This uses the VISA protocol over USB. On Linux, read/write permissions to the power meter device must be granted. This can be done with a udev rule such as:

Listing 5: `/etc/udev/rules.d/52-thorlabs-pm.rules`

```
# Thorlabs PM100D
SUBSYSTEMS=="usb", ACTION=="add", ATTRS{idVendor}=="1313", ATTRS{idProduct}=="8078
↪", OWNER="root", GROUP="plugdev", MODE="0664"
# Thorlabs PM400
SUBSYSTEMS=="usb", ACTION=="add", ATTRS{idVendor}=="1313", ATTRS{idProduct}=="8075
↪", OWNER="root", GROUP="plugdev", MODE="0664"
# Thorlabs PM16 Series
SUBSYSTEMS=="usb", ACTION=="add", ATTRS{idVendor}=="1313", ATTRS{idProduct}=="807c
↪", OWNER="root", GROUP="plugdev", MODE="0664"
```

where the `idVendor` and `idProduct` fields should match that listed from running `lsusb`. The `plugdev` group must be created and the user added to it:

```
groupadd plugdev
usermod -aG plugdev yourusername
```

A reboot will then ensure permissions are set and the user is a part of the group (or use `udevadm control --reload` and re-login). To check the permissions have been set correctly, get the USB bus and device numbers from the output of `lsusb`. For example

Listing 6: `lsusb`

```
Bus 001 Device 010: ID 1313:8075 ThorLabs PM400 Handheld Optical Power/Energy␣
↪Meter
```

the bus ID is 001 and device ID is 010. Then list the device using `ls -l /dev/bus/usb/[bus ID]/[device ID]`

Listing 7: `ls /dev/bus/usb/001/010 -l`

```
crw-rw-r-- 1 root plugdev 189, 9 Mar 29 13:19 /dev/bus/usb/001/010
```

The middle "rw" and the "plugdev" indicates read-write permissions enabled to any user in the plugdev group. You can check which groups your current user is in using the `groups` command.

Note that you may also allow read-write access to any user (without having to use/create a plugdev group) by changing the lines in the udev rule to `MODE="0666"` and removing the `GROUP="plugdev"` part.

Parameters

- **serial_number** – Serial number of power meter to use. If `None`, will use the first device found.
- **usb_vid** – USB vendor ID (0x1313 or 4883 for Thorlabs).
- **usb_pid** – USB product ID (0x8078 for PM100D, 0x8075 for PM400).
- **interval** – How often to poll the sensors, in seconds.

close()
Close the connection to the power meter.

datalogd.plugins.timestamp_datafilter module

class datalogd.plugins.timestamp_datafilter.**TimeStampDataFilter**(*sinks=[]*)
Bases: *datalogd.DataFilter*

Add or update a timestamp field to data using the current system clock.

receive(*data*)
Accept the provided `data` and add a timestamp field.

If `data`, or elements in the `data` list are `dicts`, then a "timestamp" field will be added. Otherwise, the data entries will be converted to a `dict` with the old entry stored under a "value" field.

Parameters **data** – Data to add a timestamp to.

CHAPTER 3

Indices and tables

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