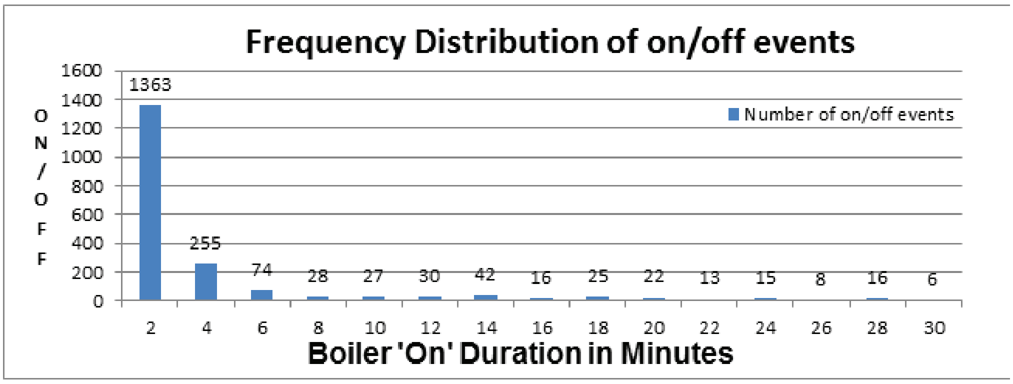
Electrocorder Applicaton Notes: Cycling of closed loop control systems



Data measurement - identify opportunities to save energy

Ongoing data loging - capture your energy profile

Calculate acceptable reduction and savings

Low cost investment for long term energy savings and monitoring

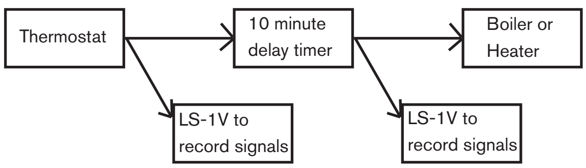
On/off cycling can be a real problem in some closed loop control systems, such as:-
Thermostatically control heating systems.
Pressure controlled compressor systems.
Ambient luminance controlled lighting systems.

As an example, we monitored our thermostatically oil fired central heating system on our office building over a period of about 6 months. We had the following astonishing results.

This shows that over the period there were 1363 times that the boiler came on for 2 minutes or less remember these boiler-on events were requested by the thermostat controller. The boiler came on 255 times for between 2 and 4 minutes etcetera. If you add up all the cumulative time that the boiler was on, you find that for 33% of the time the boiler was on for a period of 10 minutes or less. Also 40% of the time it was on for a period of 15 minutes or less.

For short duration 'on' cycles like those of 10 minutes or less a boiler cannot add very much heat to the building environment, most of the fuel is used to start the boiler and then gets lost in heat losses in the boiler and its surrounding area. If you can eliminate these short duration on cycles, you can reduce the energy consumption by almost the corresponding amount. Analysing the data we estimated a saving of 30% to 40% if we were to eliminate 'on' demands of 15 minutes or less.

Q. How do you solve this problem?
A. Use a delay 'on' timer.
We developed a 10 minute delay timer which take the 'on' signal from the thermostat and when it receives this, which would normally turn the boiler on, it waits for a period (of 10 minutes) before passing on this signal to turn the boiler on, this eliminates all cycling below 10 minutes.



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We used two LS-1V data loggers to monitor the new system over a period and found:-

Cumulative demanded boiler 'On' Time	**21:02 hours**
Cumulative actual boiler 'On' Time	**9:57 hours**
Saving (demanded 'on' time but not given).	**11:05 hours. 52% energy reduction!**
Number of on events demanded	**184 on events**
Actual number of on events	**25 on events**
Saving (demanded 'on' event but not given).	**159 on events. 86% reduction in 'on' cycles.**
Average number of demanded 'on' cycles per year.	**8,375**
Average number of actual 'on' cycles per year.	**1,156**
Saving (demanded 'on' event but not given).	**7,219. 86% reduction in 'on' cycles.**

We achieved a 52% reduction in fuel consumption over the trial period.

It must be noted that the above figures are not theoretical or speculative, they are real figures from a real working heating system servicing our office building. We monitored both the demand 'on' and the actual 'on' signals, these are therefore real savings. As the demand signal was subject to a 10 minute delay, when the demand was a real temperature demand, the temperature would have continued to fall slightly during the 10 minutes delay, that means that when the boiler came on, it would have taken slightly longer to bring the office building up to the set point of 21C, therefore using more energy. **Nonetheless we still achieved a saving of 52%!**

The obvious disadvantage is that the timer introduces a time delay between the demand for hear and the supply of heat, this in turn would have an effect on the controlled internal ambient temperature, which would not be as tightly controlled around the set point of 21C (in our case). The data recorded show that 56% of the demands for energy were not real temperature demands, rather they were the result of the thermostat oscillating (on/off) around the temperature set point. There was not noticeable effect on internal office temperature during the trial of the timer. Basically the timer has the effect of introducing a dead band. The reduction in run time by 52% and the reduction in the number of on cycles by 86% has a significant effect on boiler life.

Compressor cycling can also be an issue in pneumatic compressor systems in industry, where the set point is a pressure level and the system tries to maintain a set point. A better method of control can be to use a dead band system, that is, minimum and maximum pressures are defined separately, the minimum pressure (say 10 bar) activates the on signal and the maximum pressure (say 15 bar) activates the off signal. If you have a system with a single defined pressure, then the introduction of a timer delay can help reduce cycling. For pneumatic systems it is important to look at the minimum working pressures of the items fed from the compressor reservoir also the maximum air demand before setting the delay times. It would be important that the delay not be so long that the air reservoir was depleted by air demand before the timer allowed the compressor to start. With pumps and compressors the reduction of the number on on/off cycles has a major effect on the life of the system.

Controlled Lighting is also prone to cycling, where the set point is a lux level, the system will turn on lighting when that minimum level is observed. Some systems do use a dead band system, that is, a minimum lux level turns the lights on and a greater lux level turns the system off again. Cycling normally only happens at dawn or dusk, due to the low light level, as opposed to throughout the day, to the improvements are limited by the fact that light levels normally continue to increase at dawn and continue reduce at dusk, as opposed to maintain a given level.

The LS-1V was designed for cycle analysis, however Electrosoft lets you perform cycle analysis with other loggers, all you have to do is define an on voltage and an off voltage threshold for voltage loggers and their data and for current data and loggers define an on current and an off current threshold; Electrosoft will do the rest.

LS-1V