Introduction

Load control, also known as demand control is an attempt to keep the maximum demand in a billing month as low as possible. For larger users their electricity bill usually consists of an energy charge as well as a maximum demand charge. For the South African market the maximum demand is defined as the highest average half hour apparent power (kVA) usage in a billing month. The method where demand is calculated over an exact time period is known as block demand.

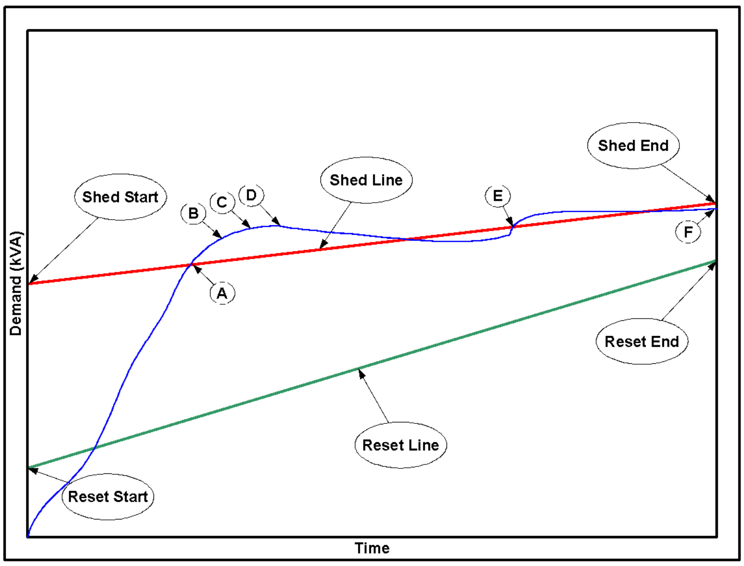
A successful demand control implementation requires a good knowledge of the particular loads and their characteristics. The implementer also needs to know the limitations of each load. Keeping certain loads like geysers and air conditioners off for too long might cause discomfort and cause a negative attitude from the end user.

To summarise there is not really a recipe when it comes to demand control implementation, because each site is unique, in many cases it requires a fair amount of trial and error to find the correct settings for a specific site. Below is a detailed description of the load control algorithm implemented on the PanelTrack to assist the implementer.

Predictive Demand Calculation

The load control algorithm of the PanelTrack is a load shedding algorithm used for limiting peak electrical demand in an electrical system to a programmed target level. PanelTrack utilise a predictive demand calculation to estimate the maximum demand at the end of the half hour period. By knowing what happened up to that point in the half hour and using the current conditions, the PanelTrack can predict what the maximum demand will be. If necessary non-essential loads are selected for shedding until the required target is reached. The switching of the loads is done via 8 onboard open collector outputs which in turn switch external interposing relays that disconnect specified loads from the electrical system via the necessary size contactors.

Control Algorithm



The main elements of the load control strategy are the Shed Line and the Reset Line. Both the start and the end points of these lines are user programmable. The Shed End point represents the target demand in kVA. At the start of a demand block all loads are returned On, assuming that none of the control relays were programmed with a minimum On or Off time. The PanelTrack calculate the predicted demand every second based on the history and the present consumption. In the beginning the predicted demand may exceed the target demand, but loads will only be shed once the accumulative demand exceeds the shed line. In the adjacent figure this condition occurs at point A. At point B it is determined that the predicted demand will exceed the target and the first load with the lowest priority will be shed. This condition occurs at Point C and D. Only after the load shed at point D occurred the predicted demand will not exceed the target. Just before point E a sudden increase in load causes the predicted demand to exceed the target. After point E further loads were turned off to achieve the desired demand below or equal than the set target. The algorithm also makes provision to turn loads on should the accumulated demand drop below the reset line and the predicted demand is below the target.

Programming the Load Control Parameters

The window below shows the parameters that can be programmed via the PanelTrack software. See the descriptions below with a detailed description of each field.

Load Control Status

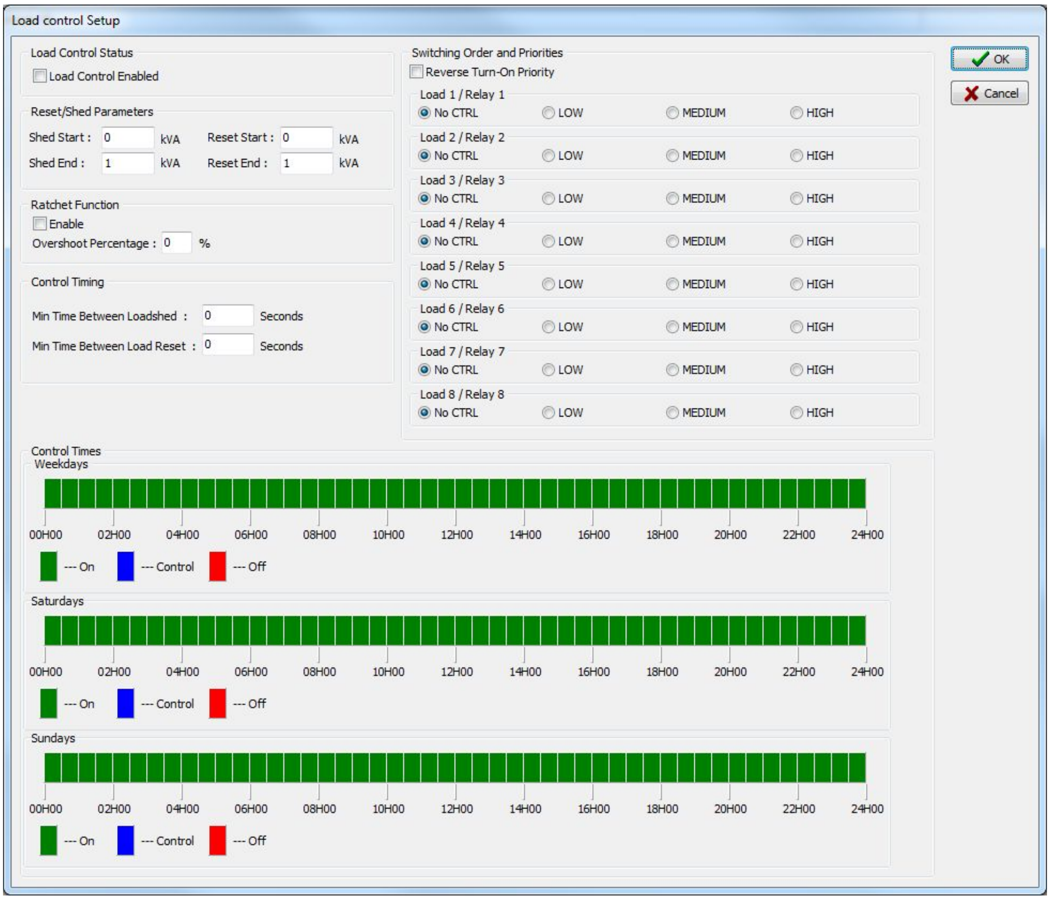
This checkbox enables or disables the load control algorithm. If disabled all 8 loads will be turned on by default.

Reset/Shed Parameters

In this field the user can define the Shed Start, Shed End, Reset Start and Reset End as described in the algorithm above.

Ratchet Function

In this field the user can define whether the ratchet function is enabled or disabled, as well as the percentage that the demand must exceed the original target before the ratchet will move the target. For example if the original target was set to 100kVA and the percentage overshoot is set to 10% the demand must exceed 110kVA before the target will move to the new demand. To prevent target creep the demand must exceed the new target with that percentage before another ratchet will occur. The target will be reset back to 100kVA when a month end event occurs. The ratchet function comes in handy during initial investigations to determine whether a desired target is set to tight. After initial experimentation the user will usually disable the ratchet function.



Load Control Setup Dialog

Control Timing

In this field the user can specify the minimum time between two shed or reset events. It is recommended to give enough time between shed and reset occurrences. During a shed cycle it enables the algorithm to stabilise after a shed event to determine whether another load should be shed. During a return cycle it prevents the simultaneous turn-on of several loads. The minimum timing between shed and reset events is 1 second.

Switching order and priorities

Each of the eight loads can have one of the following priorities. No CTRL, Low, Med and High. If a load is selected as No Ctrl it will always be on regardless of the control times described below. For the rest three conditions Low priority loads will always be turned off first, followed by Medium priority loads and lastly by High priority loads. Loads in the same priority group will be circulated, for example if all eight loads are of the same priority and it were only necessary to turn off three loads in a certain half hour these loads will be kept on if necessary in the next half hour and another three loads will be controlled in the next half hour.

When the Reverse Turn-On Priority checkbox is unchecked the turn off order will be Low first and High last, while the turn-on order will be High first and Low last. If it is checked the turnoff order will be Low first and High last, but the turn-on order will be Low first and High last

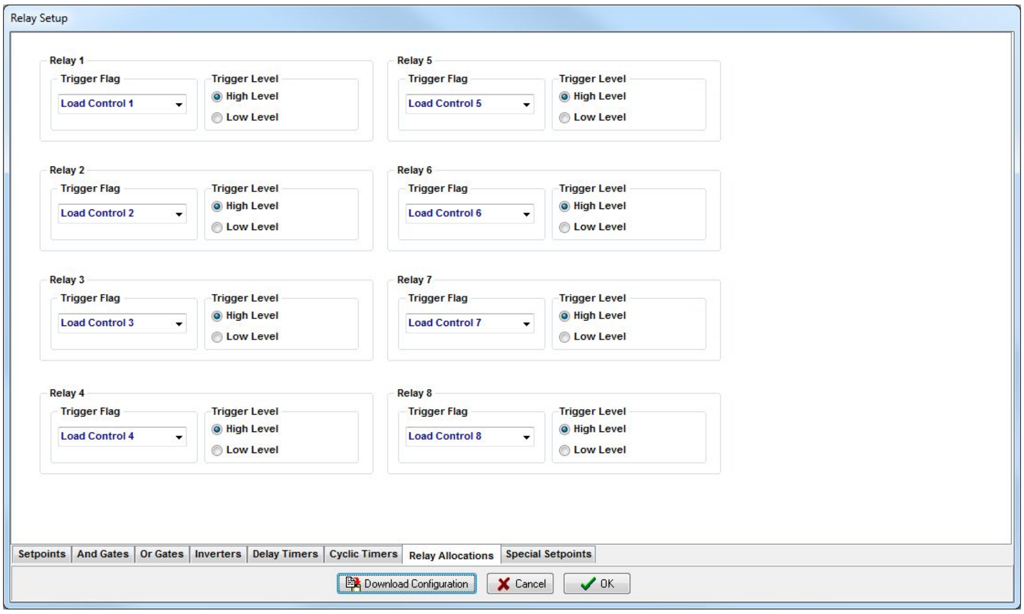
Control Times

This field specify per half hour if the loads should be on, off or controlled. It also makes provision to specify the behaviour of the controller on a Weekday, Saturday or Sunday.

Assigning Relays to the loads

Because the PanelTrack implements other type of control algorithms as well, it is the responsibility of the user to assign to 8 control flags to the external relays. There is nothing that limits the user to rather read the load control flags with via a PLC or SCADA and control external loads independent from the PanelTrack.

To use the 8 onboard digital outputs to control 8 external relays use the Relay Control dialog in the PanelTrack. Go to the Relay Assignment tab and select the 8 Load Control flags 1 for each output.

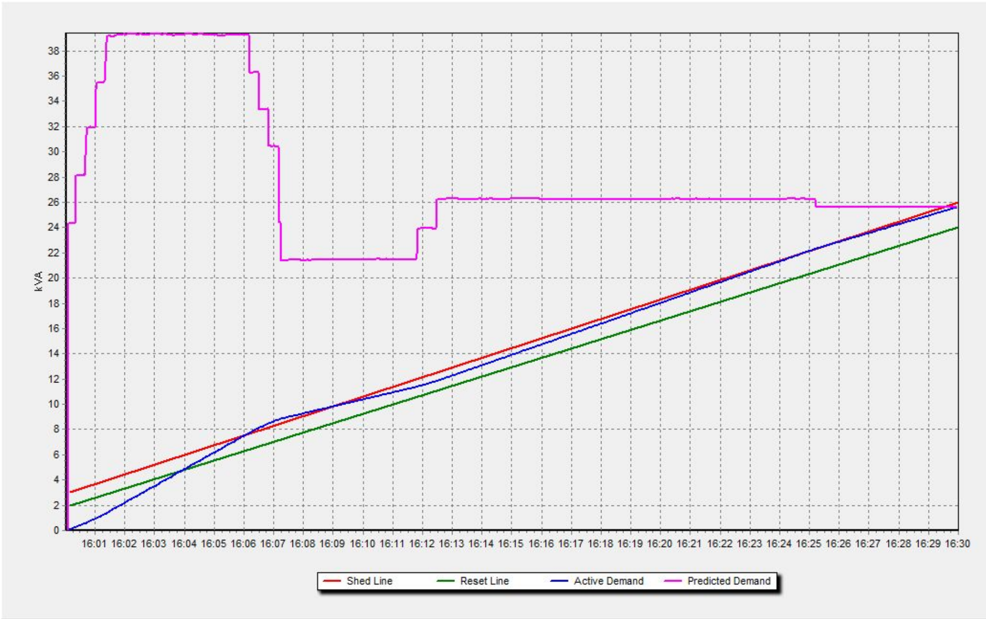


Relay Setup Dialog

Simulated Example

The following examples illustrates a system consisting of 10 loads of about 4kVA each, 8 which are controllable. The system are set to turn loads on and off with a delay of 20 seconds. From the picture below it can be seen that the controller start to turn the loads back in the beginning of the half hour. In the first minute and a half 4 loads are turned back on. Notice how the predicted demand rises after each load is turned on. With all the loads turned on the predicted demand stabilise at about 39kVA about 13kVA above the target of 26kVA. Because the normalised demand is still smaller than the shed line the controller keeps all the loads on.

Only at about 6minutes into the half hour the normalised demand rise above the shed line and the controller start to turn off loads until the predicted demand is below the target. At the 12th minute into the half hour two uncontrollable loads turns on, causing the predicted demand to rise above the target. At this point the normalised demand is below the shed line, therefore no loads are turned off till about the 25th minute when it rises above the shed line. The demand for the half hour ends just below the target.



The simulation below is the same as the above except that the uncontrollable loads did not turn on. Therefore the controller reached the point where the normalised demand dropped below the reset line and starts turning on the loads. Although the predicted demand shot up again above the target it is compensated later at 16:48 when 4 loads are turned off again. Also note that although all the loads are the same size the affect of one load becomes less later into the half hour. The explanation for that are that early in the half hour the future counts more and the past less, but later in the half hour the past counts more and the future less.