AP-8
Machine Run Control

Introduction

The following application note discusses the use of the APB family of micro PLC's in machine *run time control* applications. The example will illustrate use in a furnace control application although the same techniques may be used in a wide variety of systems.

In many industrial systems, critical sub-systems will have a manufacturer specified service schedule and failure to adhere to regular maintenance may erode the machine performance, drastically reduce the sub-system life time or in extreme situations lead to dangerous or life threatening situations.

In the following application it is assumed that a furnace sub-system within a machine accumulates ash over time and that the furnace must be cleaned based on the number of hours that it is operated. Failure to correctly clean the furnace may lead to 'hot spots' that drastically reduce the over-all lifetime of the containment vessel and can lead to punch thru conditions that pose a severe fire risk. The manufacturer of the machinery provides trained service personal to provide the cleaning and must ensure that the user does not operate the machine beyond the specified time limits.

The furnace portion of the machine is a sub-system that only operates when required. Other portions of the machine handle the processing and loading of the material and provides a control signal to activate the furnace. The furnace control is handled internally to the furnace sub-system. It will be assumed that the furnace control sub-system provides a signal that becomes active (relay closure) when the furnace transitions from the idle to active state.

Run Time Controller

The Run Time Controller must track the number of hours that the *FurnaceActive* contact closure is active. As it approaches the manufacturer's specified *MaxTime* a warning indicator will begin to flash, ensuring that the user has sufficient time to schedule a maintenance call with the manufacturer.

When the running time reaches the *MaxTime* the *FurnaceEnable* output will open, disabling power to the Furnace sub-system and a TimeExpired indicator will be turned on so that the user understands why the furnace is not operating.

The *WarningTime* and *MaxTime* are both set, under password protection, by the manufacturer to meet the requirements of the particular sub-system.

Once the system has reached the MaxTime the timers must be reset. This reset function, which must be password protected, ensures that the operator can not over-ride the forced maintenance schedule.

While resetting the run timers the manufacturer maintenance person may adjust the MaxTime and WarningTime values. For example, in high use applications or if the factory maintenance department is heavily loaded the WarningTime may be increased to allow a greater warning period. As the equipment ages it may be required that the maintenance frequency increases by reducing the MaxTime value.

In addition to monitoring the run time between maintenance the controller will monitor the total run time of the machine and the number of maintenance reset cycles.

AP-8
Machine Run Control

The current running time, the total run time and the number of reset cycles must be retained if the machine is powered down.

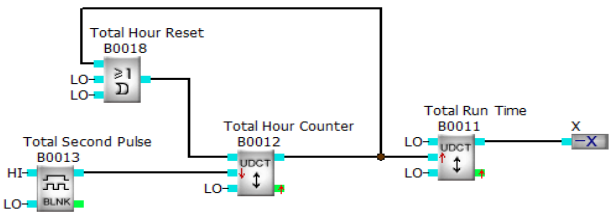
The APB-12MRAL controller provides 8 AC inputs, 4 relay outputs and an integrated HMI display. The application only requires 1 input and 3 outputs.

I/O Assignment

Inputs		
I00	FurnaceActive	ON if furnace is operating.
Outputs		
Q00	Warning Light	Flashes at 1 second rate if RunTime is approaching MaxTime
Q01	MaxTime Light	Turns ON if RunTime equals MaxTime
Q02	Machine Enable	Turns OFF if RunTime equals MaxTime

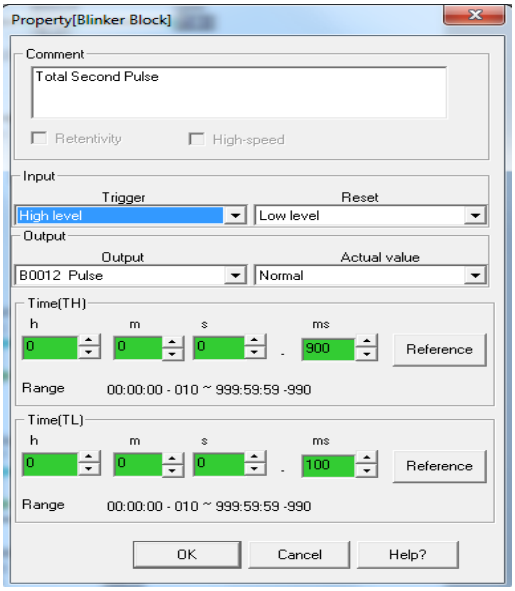
Although the APB controller provides several different timer based function blocks applicable for pulse width control these are not suitable in this application. First, the timer values are limited to 999 hours which may not be sufficient for all applications. The larger issue is that the timers do not offer the ability to be 'paused' when the FurnaceActive signal is removed.

Hour Timer

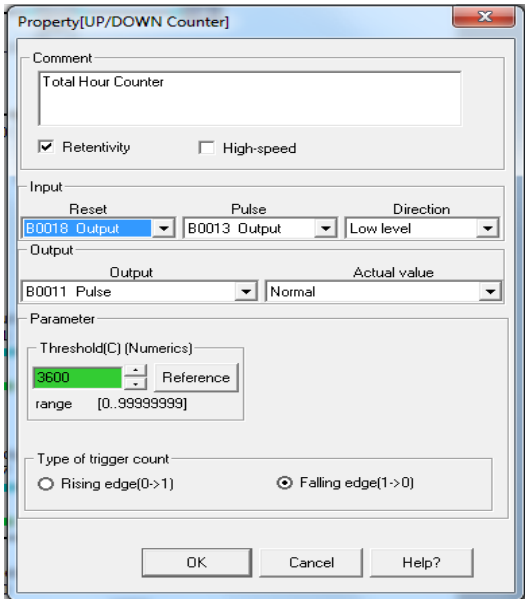


Fortunately, an hour counter is easily implemented using a 1 second 'pulse generator' and a counter that counts to 3600 (number of seconds in 1 hour) and then resets.

The BLNK block B0013 is configured to generate a 900 msec pulse and then delay for 100 msec, resulting in a 1 second pulse train.



The Hour Counter counts 3600 pulses, representing 1 hour and then sets the output active which forces the counter to be reset thru the OR block B0018.

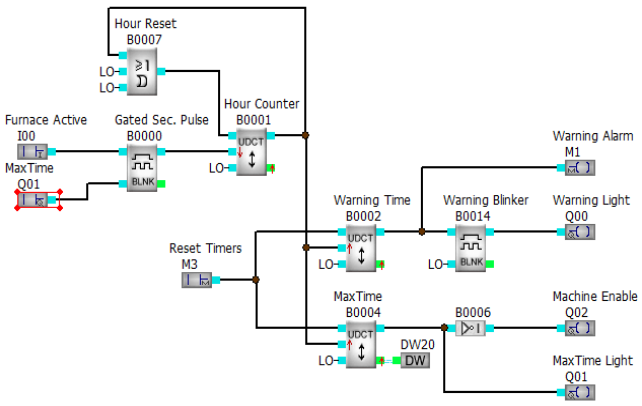


The counter is set to increment on the trailing edge of the pulse and the 'retentivity' flag has been set to ensure the counter value is retained if power is removed.

The signal generated by the hour counter is applied to a second up/down counter UDCT block B0011 which will count the total number of hours that power has been applied to the controller. The digital output is not used (assigned to an 'Open Connection') but the current value of the counter will be used to display the total run time of the machine on the HMI (see below).

Run Control Timer

A similar circuit may be used to track the time that the FurnaceActive signal is applied.



In the circuit shown, the BLNK block B0000 which generates the 1 second pulse has the Furnace Active signal connected to the ENABLE pin. If the signal is not active the BLNK function will not generate any pulses. In addition, the BLNK function RESET input is connected to the MaxTime Light output that will go active when the MaxTime counter reaches the maximum number of hours, disabling further pulses from the BLNK function.

The output from the Gated Hour Counter UDCT Block B0001 is a pulse once every hour and is used to increment two additional UDCT counters, the Warning Time counter B0002 and the Max Time counter B0004.

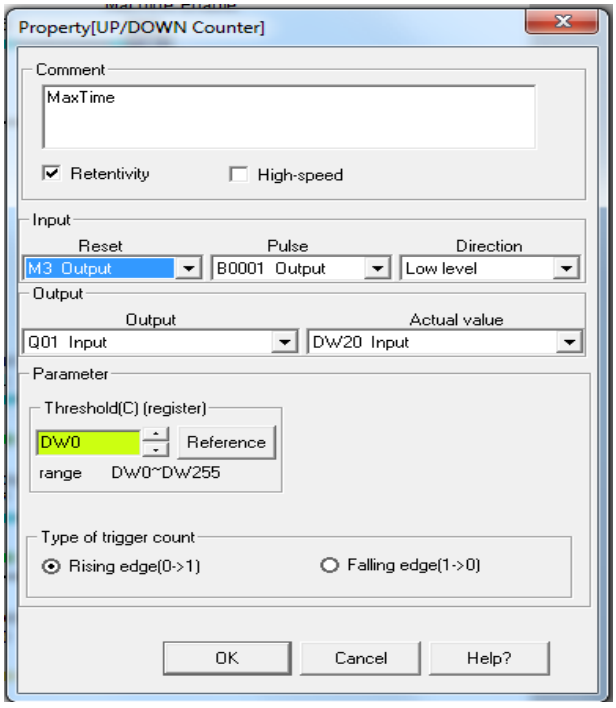
When the Warning Time counter output goes active it enables BLNK block B0014 that generates a 1 second ON and 1 second OFF pulse train driving the Warning light output. The Warning Time Counter output is also used to activate an internal control relay M1 used to trigger an alarm function on the HMI display (see below).

When the Max Time counter reaches it's preset value it will activate the Max Time Light output, which will force the Gated Second pulse generator B0000 (see above) off, disabling further counts. This signal is complemented by the NOT block B0006 which causes the Machine Enable output to be turned off.

Data Registers

The Warning Time and Max Time counters use data registers to set the preset values. *Data Registers* (DW) store variables which may be set using the HMI interface, set to Function Block internal values or be used as presets within function blocks. Data registers 0..12 are retained during power cycles.

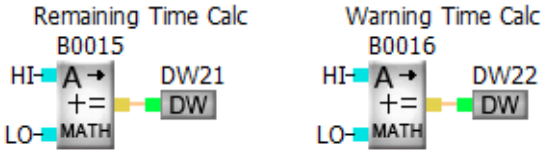
Data Register	Usage
DW0	Max Time (hours), entered by Tech
DW1	Warning Time (hours), entered by Tech
DW20	Run Time
DW21	Remaining Time (Max Time – Run Time)
DW22	Time to Warning (Max Time – Warning Time)

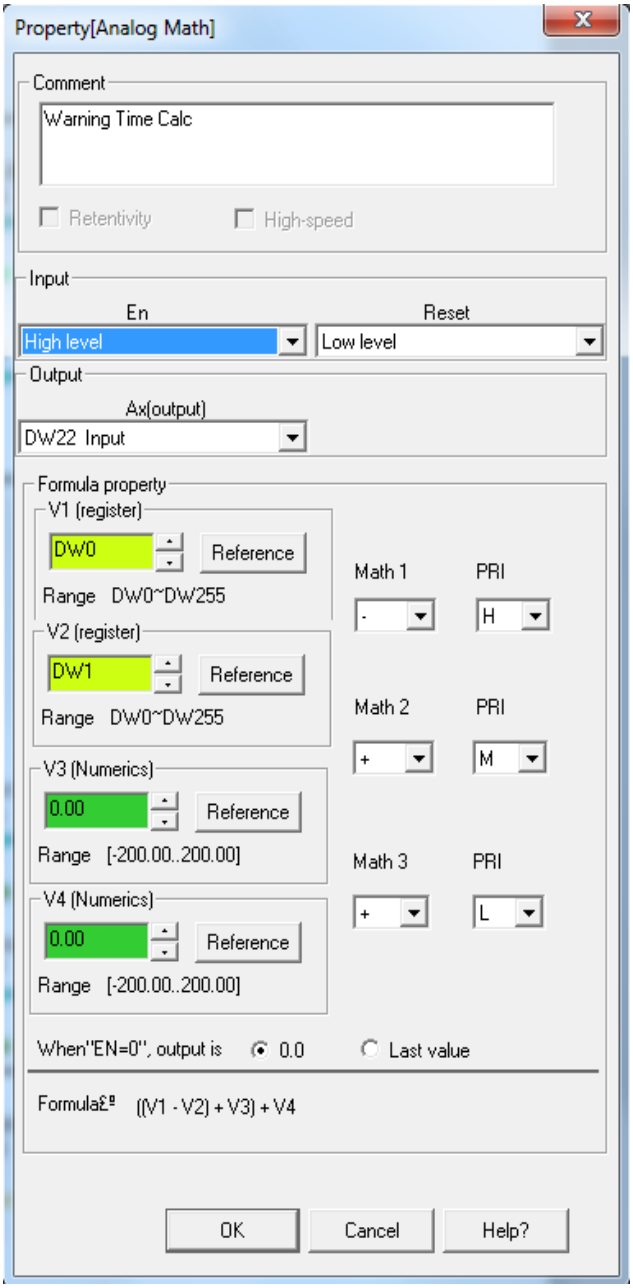


The MaxTime counter will be activated when the count reaches the value defined in DW0. This counter is defined with the 'retentivity' bit set.

The HMI interface (see below) allows setting the DW0 value using the +/- keys and the access may be restricted using the HMI password capability.

The Warning Time, set by the technician as the number of hours before shut-off when the Warning Light is activated. A MATH block B0016 is used to calculate the actual target 'time' as being the Max Time minus the Warning Time (as entered by the technician), eliminating the need to mentally calculate the DW22 Warning Time.



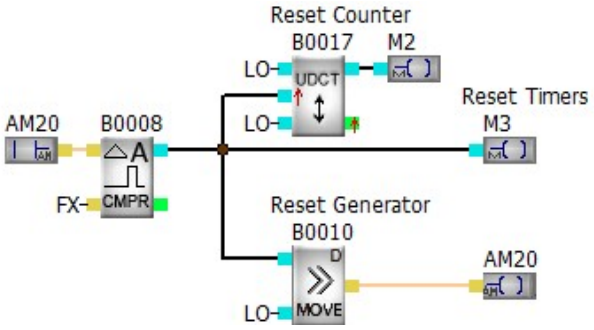


The Remaining Time calculation is similar, but calculates the number of hours remaining before the machine shuts down (Max Time – Run Time) and is used only for the HMI display.

AP-8
Machine Run Control

The last portion of the control logic is used to reset the Max Time and Warning Time counters by the technician. The HMI does not support a mechanism to directly set a digital I/O bit but does allow entering an analog or DW value.

Reset Function



The analog memory value AM20 is applied to a comparator CMPR B0008 and if the value is > 0 the output will be set. As soon as the output goes active the MOVE block B0010 is triggered and it resets the AM20 value to 0, clearing the output. The pulse on the CMPR output is used to increment the Reset Counter, available to the HMI for display and to generate the Reset Timer pulse on the internal digital point M3, used to reset the Warning and Max Time counters.

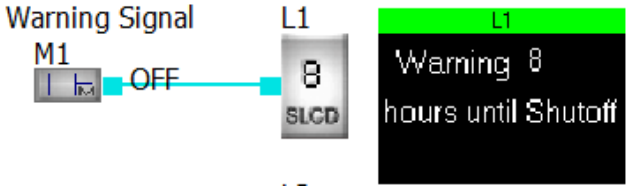
As in the Total Hour Counter, there is no reset available on the Reset Counter and the Reset Counter is configured with the 'retentivity' bit enabled. The output of the counter is not used.

HMI Interface

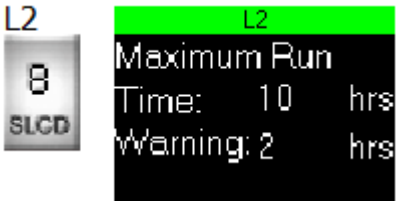
The APB controller will support up to 64 operator screens. The application defines 5 screens, 4 of them as normal operating screens and one as an 'alarm' screen.

L0, the 'Initial Screen', shows the company name, the current number of run time hours, the maximum number of hours allowed, the state of the Warning Light output and the state of the Machine Enable output.

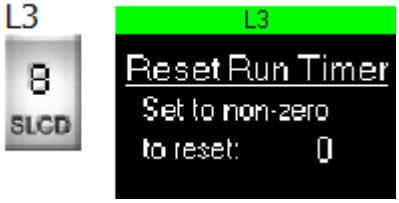
Screen L1 is the alarm screen and the controller will automatically activate this screen when the Warning Signal is generated.



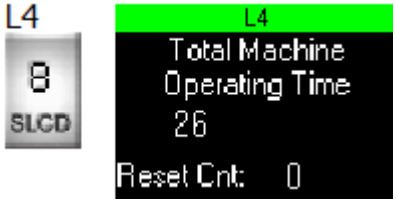
Screen L2 shows the preset MaxTime and WarningTime value (DW0 and DW1). These may be modified by the technician and are password protected.



L3 allows the technician to reset the counters by setting the value to 'non-zero'. The value is mapped to AM20 and will be reset to 0 after the Technician presses the 'OK' key.



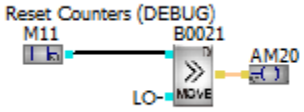
Finally, screen L4 shows the total operating time of the machine and the number of reset cycles. These values can not be reset.



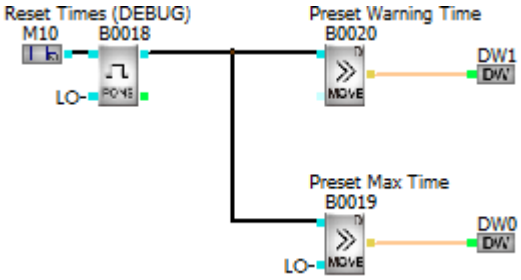
Debugging

Using the integrated APB simulator the application may be loaded into the APBSoftware package and debugged on-screen without any external hardware. Since there is no HMI present two additional circuits have been added that allow resetting the count values and the preset times by clicking the mouse.

The counters may be reset by clicking on the M11 symbol, which causes the MOVE block B0021 to preset AM20 to a non-zero value. After the values have been reset click the M11 again to turn off the input.



The preset values may be reset by clicking M10, which causes the PONS block B0018 to generate a short pulse to MOVE blocks B0020 and B0021 that transfer preset constant values into DW0 and DW1. The values transferred (10 hours Max Time, 2 hours Warning Time) may be changed by modifying the MOVE block parameters.



Debugging any application involving 'hours' would be tedious. By changing the 3600 'second' counters presets (B0011 & B0001) to a low value, for instance 5, the operation is sped up where each 'hour' passes in 5 seconds. These values must be changed back to 3600 before the final application is loaded.

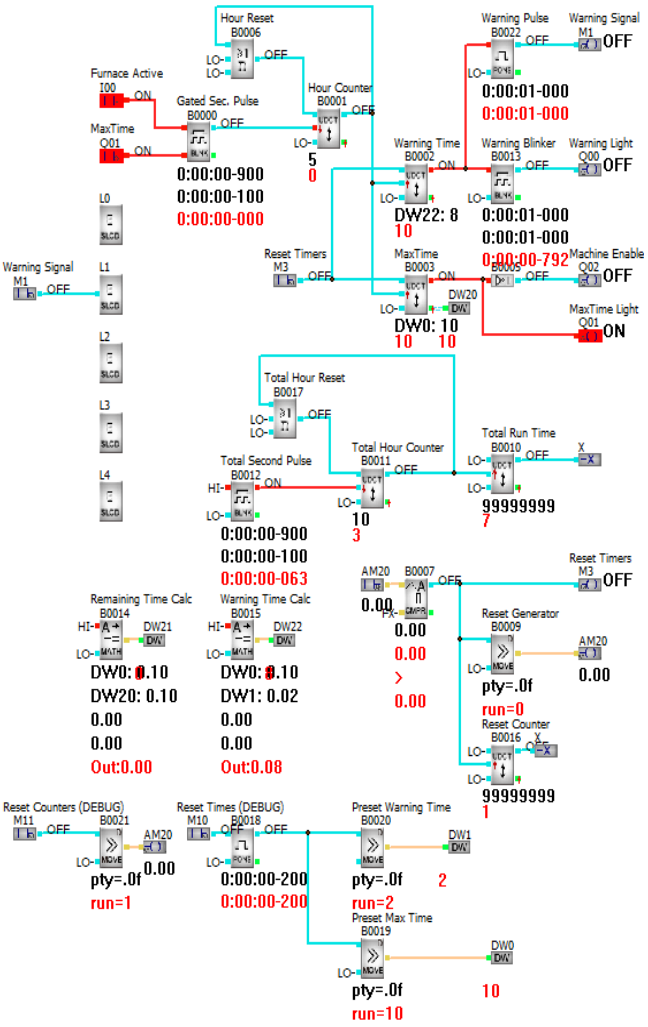
The final application code, shown below, is available as 'AP-8_Machine_Run_Control' and is included as part of the application example zip file available on the on the Ingram Products PLC support page:

www.ingramproducts.com/plcsupport.html

Note: APB applications that include HMI programs consist of two files: programname.aoc and programname.hmi. If moving files ensure that both files are copied.

Note: The AP-8_Machine_Run_Control application code has been saved with the 'hour' counter presets set at 5. These must be set to 3600 to measure 1 hour increments in the final machine.

Note: The AP-8_Machine_Run_Control application code has been saved with the 'debug preset' values set to 8 'hours' MaxTime and 2 'hours' Warning Times. These times may be changed by editing the property blocks associated with B0019 and B0020.



Enhancements

The APB controller implemented the solution using less than 10 percent of the available programming blocks (19 blocks, excluding debug blocks B0018..B0020) out of 320 available). With the power and flexibility of the APB controller numerous enhancements could be offered.

In many applications, auxiliary equipment may require simple time-on and time-off delays. For example, it may be required that ventilation equipment is started 20 seconds before the power is applied to the furnace and the ventilation equipment be held on for a set period of time after the furnace has been turned off.

The FurnaceActive signal could be easily made to toggle the MachineActive output with suitable timers and one of the unused outputs could be used to control the ventilation equipment, again with a suitable 'off' timer.

Often the time performance of the equipment provides a very good indication of the over-all health of the machine. In this example we have used 'running time' as an indirect measurement of the probable ash build up within the furnace. With the addition of a thermostat input that activates at a set temperature the time required for the furnace to reach a defined operating temperature can be used to assess possible degradation of the equipment and could be used to over-ride the preset maintenance times.

If the furnace is equipped with two burners the same temperature/time monitoring information could be used to activate a second set of burners for use with heavy loads while using a single set of burners for light loads.

The standard APB controller is provided with an internal 'retained clock/memory' time of ~ 160 hours (10 days). A low cost 'add-in' battery clip that accepts standard CR1220 lithium batteries is

available (APB-battery_clip) that will extend the data retention time to 1 year.

Summary

The APB microPLC has provided a very low cost alternative for implementing a machine run-time monitor. The proposed solution provides both cycle time and overall machine run time information for long term machine performance monitoring. By providing a lockout of the sensitive equipment based on operating time the manufacturer ensures that factory trained individuals provide periodic required maintenance, extending the machine performance, long term reliability and adherence to safety requirements.

A range of enhancements could be easily introduced that would provide greater energy management and better preventative maintenance.

References

AP-3 APB Process Timing

Ingram Products Inc.,
8725 Youngerman Court
Suite 206
Jacksonville, FL 32244
888-875-2221
West Coast Sales: 951-200-3592
e-mail: sales@ingramproducts.com

Web Site: www.ingramproducts.com