Capewell Timing Device

ME Team 9

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Project Statement

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The goal of this senior design project is to produce a completely solid-state cycle timer capable of controlling up to 8 separate switches simultaneously. Ideally, the timing device would draw 3W of power or less, be powered by either 120 or 240VAC@60Hz, and cost less than $40 to manufacture. In addition, it must be able to control the timing of each switch with accuracy over a user-defined period (typically 60-120 seconds). Each switch must be capable of controlling a 120VAC, 15A output for a minimum of 100,000 cycles. In addition, both the end-user and factory must have a simple method of setting and changing the timing parameters for each switch. The factory method must be able to lock out end-users from changing the timing parameters of individual switches if desired as well. The intended use of the cycle timer is in industrial dishwashers. The outputs it controls would typically be power to motors pumping water or soap, or other control inputs necessary for dishwasher function.

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| **Requirements** | **Stretch Ideas** (based off each req’t) |
| Control 8 outputs | Modular design to replace switches/relays |
| Quick-disconnect terminals |
| Accept input of 120Vac at 60 Hz | Ability to accept 120 or 240Vac at 60 Hz on same device |
| Operating life of 100,000 cycles min. | Operating life of over 500,000 cycles |
| Match existing cycle timer mounting bolt dimensions |  |
| Target production run cost: $40 per unit |  |
| Timer accuracy within 0.25 seconds |  |
| Power consumption of under 6 W | Power consumption of 3 W or less |
| Timer operation cycles of 60, 90 or 120 seconds |  |
| Manufacturer ability to program and lockout specific timers | Provide USB access for timer programming |
| 3 On/Off swap minimum per switch per cycle |  |
| Capability for customer to program and reprogram timers in the field | Timer ability to resume after manual user interruption (ex: opening dishwasher mid-cycle) |

Task Breakdown (WBS):

The solid-state timing project has been broken down into 5 separate components: the relays, the power supply, the microcontroller (MCU), the user interface, and the enclosure. One member of the team is responsible for each area of the project. The final team member is responsible for making sure all component work in tandem.



*Figure 1: Solid-State Timer Block Diagram*

The team assignments can be viewed in the RACI chart in Figure 3. A brief description of each component follows.

**Relay:**

The relay component is to function as an electrically-controlled version of the previous microswitches. It must be able to switch 120VAC loads at 15A, and it must be switchable with a 3.3VDC logic level signal using less than 7mA of current. In addition, it must last at least 500,000 cycles. Possible substitutions include electromechanical relays, TRIACs, or SCRs.

**Power Supply:**

The power supply is responsible for regulating the 120VAC power input down to DC logic levels. Currently, it appears it will be required to produce regulated output voltages of 3.3VDC, 5VDC, and 10VDC. This, however, is likely to change as the design of the other components is solidified. Possible designs include a step-down transformer coupled with linear regulators or a switching power supply.

**MCU:**

The microcontroller component will function as the brain of the operation. It is responsible for switching on and off the relays at the proper times, and communicating with the user interface to change the timing parameters. It is required to switch up to 8 relays simultaneously over a user-defined cycle period (typically between 60-120 seconds) with timing accuracy of seconds. Three possible microcontrollers were considered: the Atmel ATMEGA328P, the Atmel ATMEGA32U4, and the Atmel ATSAMD21G18A. It has been decided that the SAMD chip will be used, due to its low cost (~$2.80/unit) in bulk and its impressive feature set.

**User Interface:**

The user interface exists to allow both the factory and end-user the ability to edit the timing parameters for each relay. It must be simple to use, and the factory must be able to not only set each relay timing parameters, but also lock-out the end user from editing the parameters of certain relays. Currently, options being considered for the UI include a graphic LCD and buttons, an array of switches, and a USB interface.

**Enclosure:**

The enclosure is the physical component responsible for holding and protecting the delicate electronic components composing the rest of the solid-state timer. It was specified by Capewell that the timer will be located within the control unit of the appliance it is controlling. However, do to the risk that possible water and dust exposure presents to the internal components, it is likely a good idea that the enclosure be IP 65 rated, to protect against dust and splashes. The enclosure must also keep the operating temperature of all components low enough to not degrade operating life.

A tentative WBS is displayed in Figure 2.



*Figure 2: Work Breakdown Structure*

RACI Chart:

*Figure 3: RACI Chart*