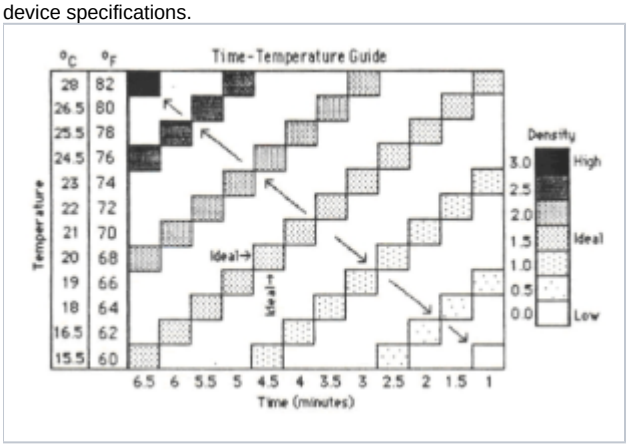
# X-ray development timer

## Background

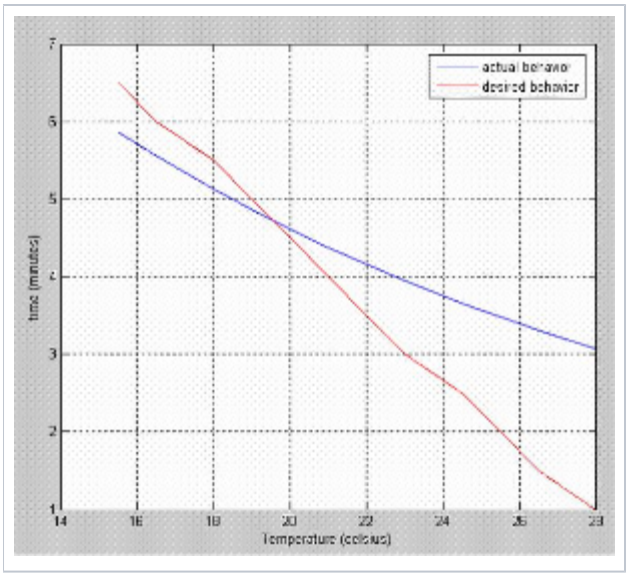
Many hospitals and clinics around the world do not take x-rays digitally; their images are taken on film and manually processed in a chemical bath. A technician must leave the developing film in the bath for a specific amount of time based on the bath's temperature. Often though, floating thermometers and timers are lacking. This leads to poor-quality images and complications in diagnoses. We've been asked to design a device that senses the temperature of the bath, can be activated when the film is placed in the bath, and gives an audible alarm when the appropriate time has been reached. See the attachments section for the WHO's Guidelines to Darkroom Techniques and a question and answer session with a CURES competitor about the device specifications.




## Past work

We've been told of another team that has constructed a prototype using a cell phone charger as a power supply. The device, however was inconsistent in its alarming when under 21 degrees Celsius. Listed below is an email sent from the team, to Billy Teninty, the man who requested the device:

> *Hello Billy,*
> *We are in the final stages of designing the developer timer, and we wanted to get you up to speed on our design and see if we've meets your needs.*
>
> *1)Power supply - We've decided to use a phone charger to regulate the input voltage. Right now we are utilizing a basic European Motorola travel charger, but we think most chargers could be used depending on availability, and we plan on trying the device with a few more to demonstrate this.*
>
> *2)Circuit - Initially we had planned to have a temperature probe to insert into the chemicals, which would be connected to a separate console outside of the bath. In this model, the connection of the thermistor to the circuit by leads would be the most likely source of failure. We then realized we could coat the whole circuit (a roughly 1.5 by 1.5 inch circuit board) in enamel and drop the whole thing in the bath. The cords leading to the charger would be the only part outside the bath. The buzzer is loud enough to be heard when it is submerged. Would this be a suitable alternative?*
>
> *3)Power switch - Dropping the whole circuit in the bath would make it much more difficult to install a switch for the user to turn on and off. The user would simply drop the circuit into the bath, wait a minute or two for the thermistor*
> *to adjust to the temperature, then plug in the phone charger immediately before/after dropping in the film. After the buzzer goes off, the user would unplug the device to turn off the buzzer and then repeat the process. Would this be acceptable? The power switch would also be extra cost (about a dollar) and be a likely point of failure for the device.*
>
> *The price of our current model (not including the charger) is under $10. We think that all of the parts (or comparable parts) could be found in the developing world.*
>
> *Let us know what you think and thanks for your input.*
>
> *-Liz and Frank*




## Current work

The Duke chapter of EWH constructed a breadboard prototype of the timer in the spring of '08 using an RC circuit (see schematic image). The heart of the device is the capacitor which can be used as a timer by letting it slowly discharge. Initially, the capacitor is charged to a certain voltage which is determined by the adjustable voltage divider. Flipping a switch starts timing by allowing the capacitor to start discharging. The voltage across the capacitor is compared with a reference voltage from a second voltage divider with a thermistor in it. The thermistor changes the reference depending on the temperature. When the capacitor voltage drops below the reference, a buzzer or an LED is activated to indicate that the proper time has been reached. However, the amount of time it takes will depend on the reference voltage, and ultimately on the temperature. Using the correct component values leads to a time vs. temperature function which is very close to the one desired.

I've uploaded a matlab code in the attachments section which simulates the device's output.

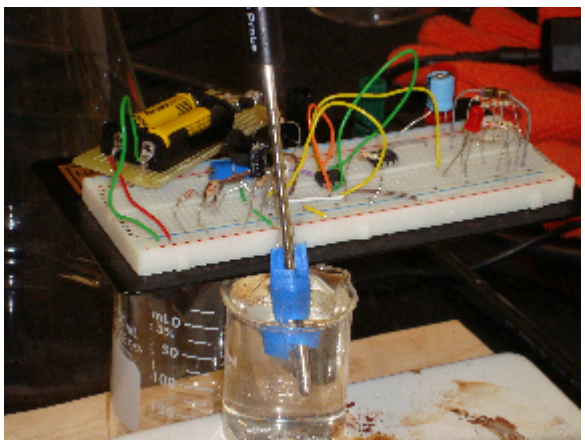
Updates:

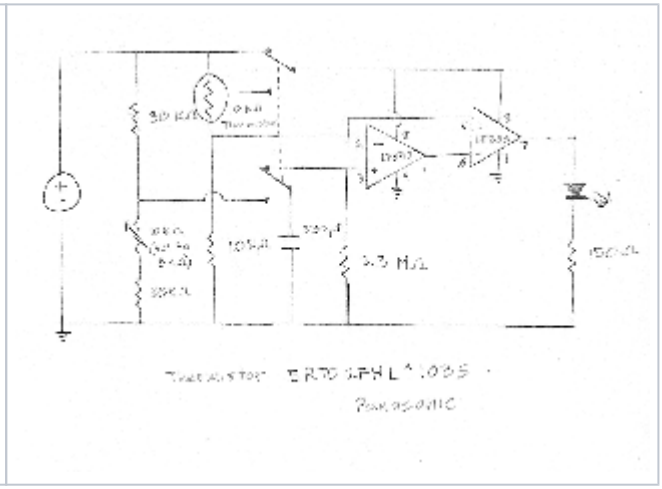
Oct 4, 2008

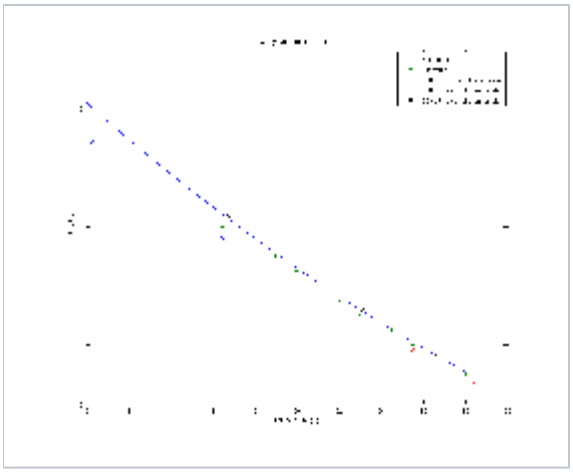
Last week, we finished initial tests at various temperatures. We found that the capacitor, which has a +/- 20% tolerance, seemed to have a value 10% lower than its label. We weren't able to check it directly, but the shape of our time-temperature plot indicated a value around 300 uF. To compensate, a 33 uF capacitor was placed in parallel, and this improved the performance. Slight adjustments are still needed for the potentiometer, but they will depend on the actual values of the components in each device we build.

Oct. 19, 2008

I've uploaded a price list. The device will cost around $14 for an open circuit board. Adding an enclosure with battery pack will add around $10-$12, and adding an external power supply will add around $12 as well. We have also found that the thermistor we were using is now obsolete, so instead we will now use a 220 K thermistor and replace the 10 K resistor with a 220 K resistor. This will lower the current draw during timing. The 3.3 M resistor will be replaced by a 2.7 M resistor in series with a 1 M potentiometer, so that we can adjust for real capacitor values. A three position switch will replace the 2 position switch so that the device can also be turned off. The three switch positions will be off, reset, and time. Finally, a buzzer will replace the LED.







## Contact

If interested, email Stephen DeVience (stephen.devience *at* duke.edu).