# Simple equipment for imaging AC

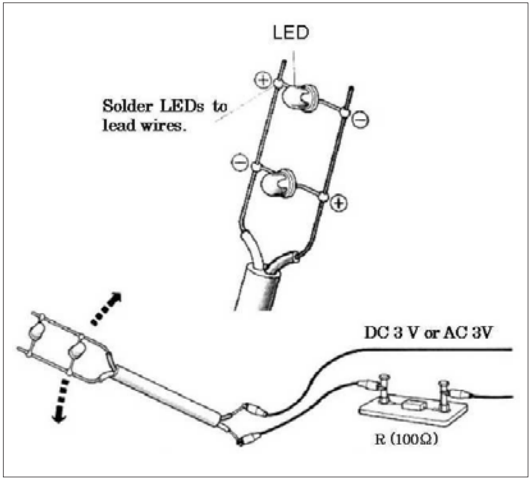


**Figure 1.** *Teaching tool to demonstrate the difference between direct current and alternating current.*

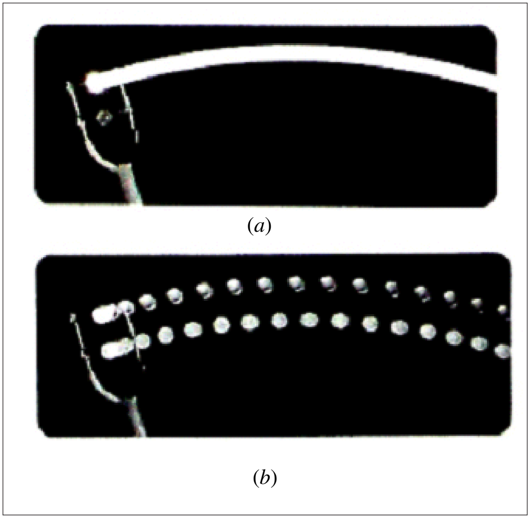


**Figure 2.** *Afterimages of direct current (a) and alternating current (b).*

One very effective way to demonstrate the difference between direct current and alternating current is to use red and green LEDs, as shown in figure 1 [1]. Since the direction of the red diode (LED) is opposite to that of the green one, when a DC voltage is applied, only one of them is constantly switched on. When an AC voltage is applied, the two are switched on and off alternately. This means that if these diodes are swung quickly in front of the student's eyes (or if a student moves their head in front of the equipment) they experience the afterimages shown in figures 2(*a*) and 2(*b*) [1] for direct current and alternating current, respectively.

This tool is easy to make and is used in many schools, but it can only indicate the direction of the electric current, and learners cannot visualize the magnitude of a current or potential difference. Oscilloscopes are fine for showing how voltage changes with time, but they are difficult for young students to set up, and they are expensive, so we have devel-

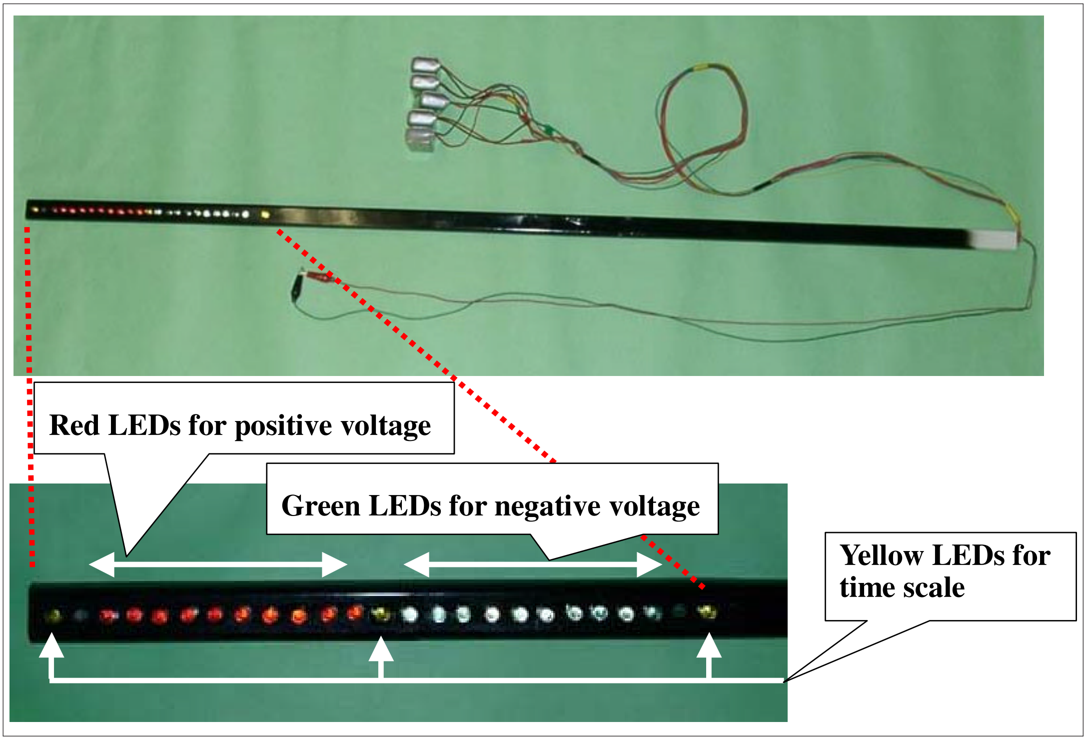


**Figure 3.** *External appearance of our AC display and the LED array on it.*

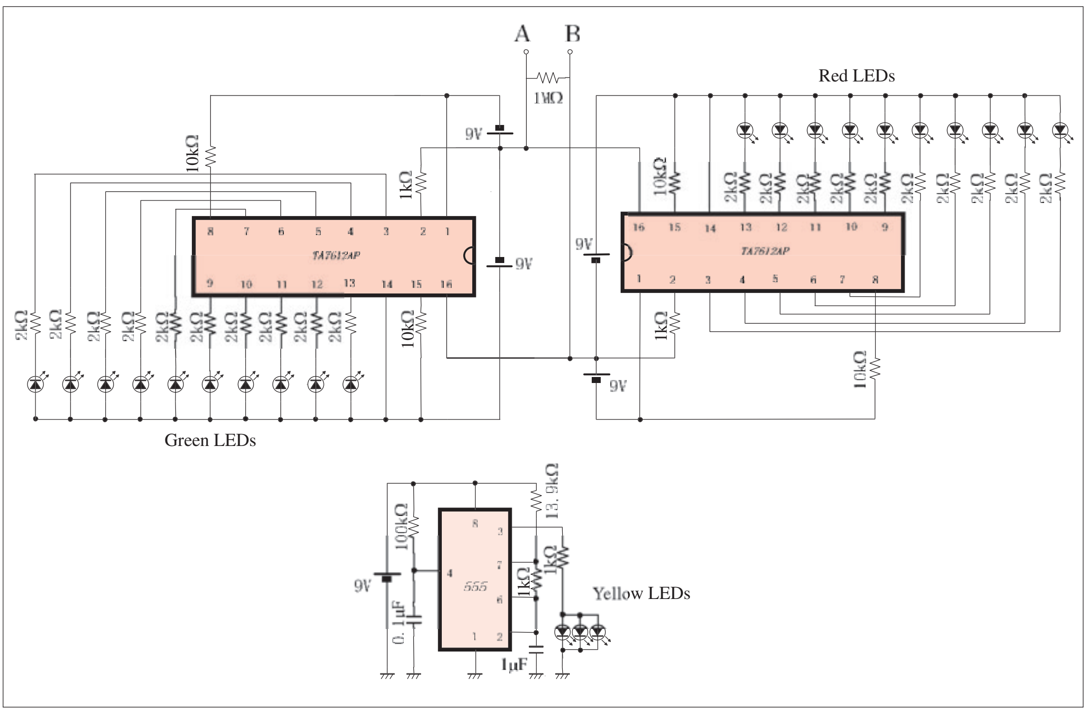


**Figure 4.** *Circuit diagram of the AC display.*

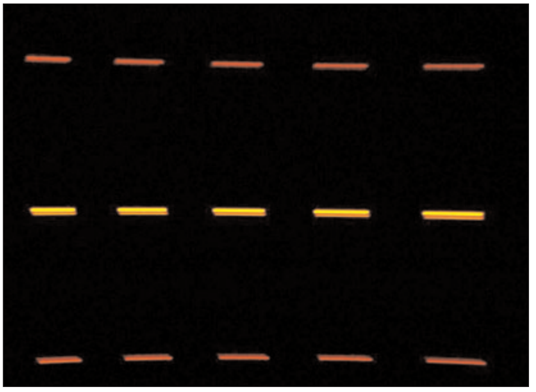

**Figure 5.** *Time scale bars to indicate 50 Hz.*

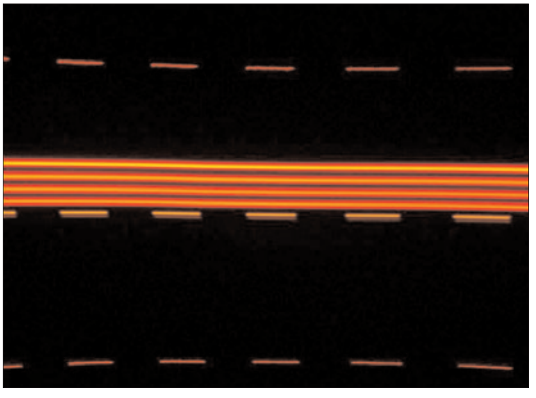

**Figure 6.** *Typical image of the AC display when DC voltage was applied.*

oped a new tool which shows how an AC voltage changes with time, using the afterimage effect of the LEDs.

## How to make the AC imager

The external appearance of our AC display is shown in figure 3. The main part of this tool is an array of 23 LEDs. Ten red LEDs indicate the magnitude of the voltage applied in the positive direction while ten other green ones indicate that in the negative direction. The other three yellow LEDs are switched on and off every 1/50 second to function as a time scale.

The circuit diagram of this tool is presented in figure 4. The TA7612AP in it is a level meter driver with a linear scale and is usually used for a ten LED bar display. In this work, we used two TA7612APs, one for each direction of the AC voltage. One is connected to ten high luminosity red LEDs (PARA L-513LE1T) and the other to ten green ones (PARA

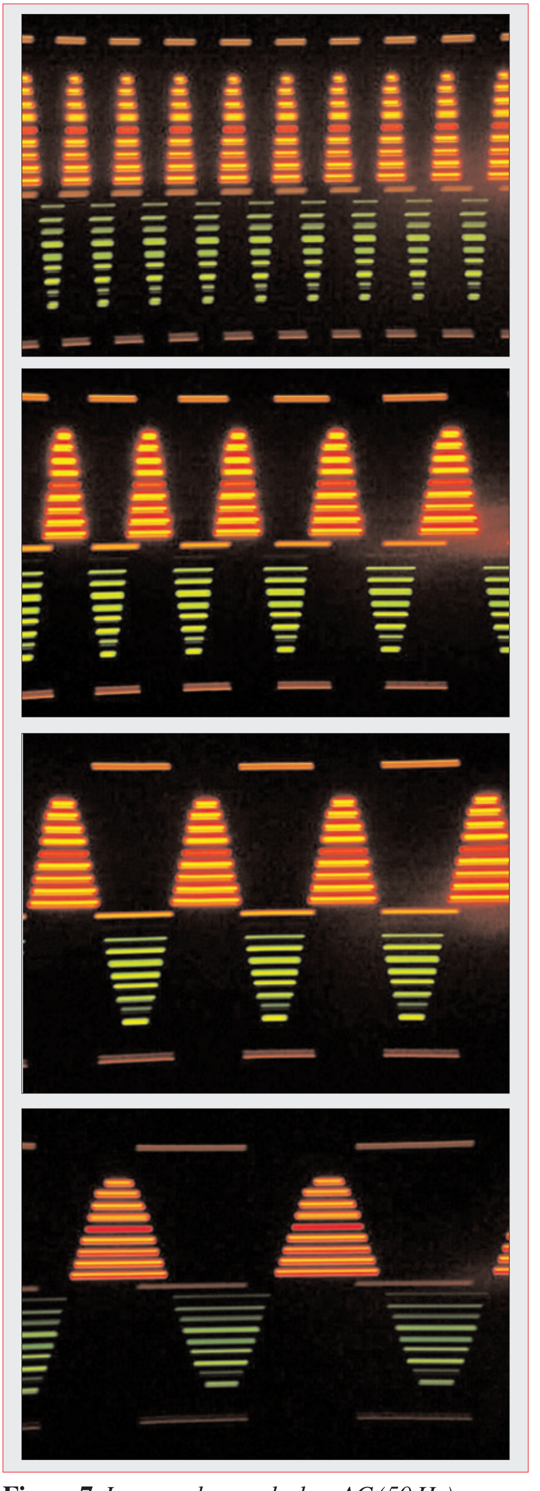

**Figure 7.** *Images observed when AC (50 Hz) voltage was applied. (Swing velocity of the camera increases from top to bottom.)*

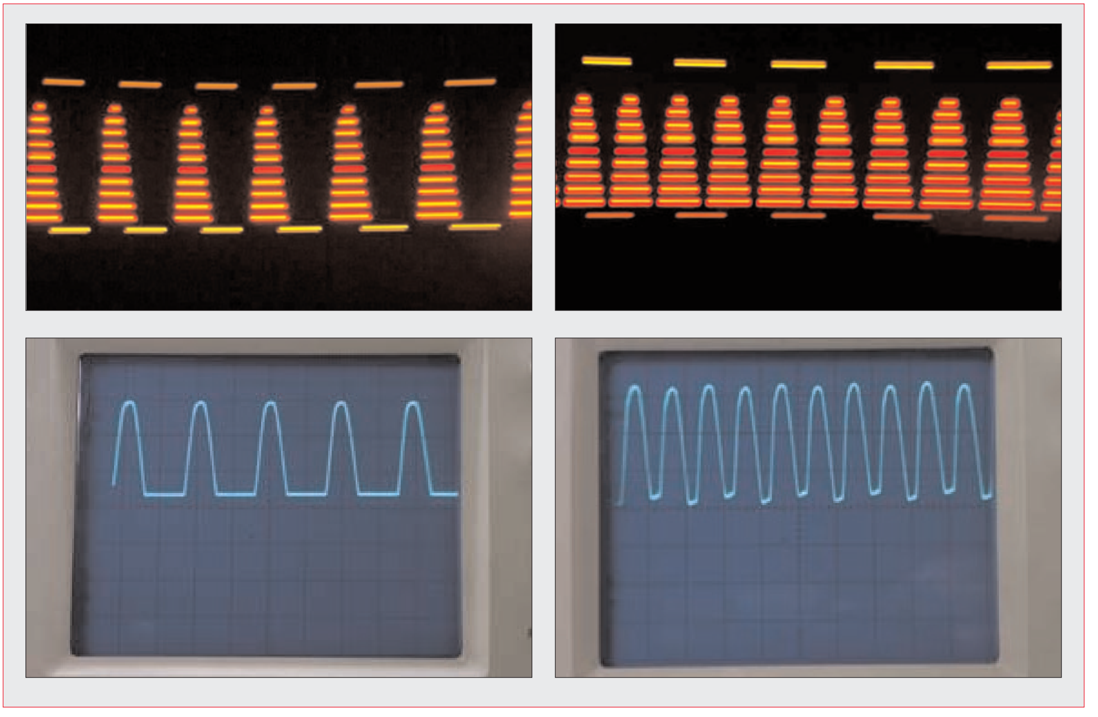

**Figure 8.** *Images of the AC display when half-wave rectified AC (left) and full-wave rectified AC (right) were applied and their images displayed on an oscilloscope.*

L-513SGT3). When a voltage is applied positively between terminals A and B, one or more red LEDs are switched on. The number of diodes switched on is determined by the magnitude of the applied voltage. When the voltage is applied negatively between A and B, one or more green diodes are switched on according to the magnitude of the applied voltage. The range of the applied voltage is 5 V.

The high luminosity yellow LEDs (PARA L-513LY4T) are connected to the 555, which produces accurate timing pulses of 50 Hz. This means that these yellow diodes function as a time scale bar as shown in figure 5 when the display is swung quickly in front of a student's eyes.

## Photographing the image

Two possible methods can be used to take a picture of the image that is the same as the student's afterimage using a digital camera:

1 The AC display is swung in front of the digital camera whose shutter is kept open.
2 The AC display is fixed in front of the digital camera whose shutter is kept open, and the camera is rotated horizontally.

The former corresponds to the afterimage a student can experience when the AC display is swung in front of his eyes and the latter corresponds to that when a student swings his head in front of the AC display. Although we usually swing the display in front of the students, figure 5 and the subsequent pictures were taken by the latter method. There is no significant difference between these two images but the latter is technically superior because the distance between the AC display and the camera can be kept constant more easily.

## Using the equipment

When a DC voltage (+1.5 V) was applied, the image of the AC display was obtained as shown in figure 6. If a student recognizes that the number of switched-on LEDs is constant, they can easily understand that the direction and the magnitude of the voltage are not changing at all. For the yellow diodes, the length of one on–off cycle corresponds to 1/50 s.

The images obtained when the AC voltage (±5 V) was applied are shown in figure 7. In this case, students can easily recognize that not only the direction but also the magnitude of the applied voltage is changing. Besides, using the time scale bars of the yellow diodes, it is easy to recognize that the frequency of the applied AC voltage is equal to 50 Hz.

For half-wave rectification and full-wave rectification, the images obtained are shown in figure 8.

We expect this equipment to be very useful at school because it not only helps to explain AC but it also explains some of the functions of an oscilloscope.

The components to make each AC detector are only about $10 (excluding batteries) so we can prepare many sets for one class, enabling every student to experience it by himself.

## Reference

[1] *Rika 1-bun-ya (lower volume)* 2000 (Japan: Keirinkan) p 19 (Junior high school textbook of Science (Physics and Chemistry) in Japan)

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