Displaying decimal numbers

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With the advent of digital measuring equipment around 1960, the need arose to display decimal numbers on the front panel of instruments. In those years, providing a numeric readout was really a problem requiring much inventiveness from engineers. This article discusses several solutions to the display problem as they have been developed from the very beginning of the technology. The examples given are all available in the Historic Collection of EEMCS in Delft.

Figure 1. *Hycon VTVM 615*

Digital measurement equipment

The first example given here is not a digital meter at all. This Hycon Model 615 VTVM (Vacuum Tube VoltMeter, Figure 1) is an analogue voltmeter equipped with a mechanical counter driven by a servo system. This development shows the need for easy to read digital readouts instead of difficult to read needle pointers on an analogue scale.

Digital counters and digital voltmeters

The first digital voltmeter (DVM) was designed by Andrew Kay in 1954 [1]. The oldest digital frequency counter we have in the Historic Collection is a Hewlett-Packard HP-524A (Figure 2). This 8-digit counter measured frequencies up to 10 MHz; it was introduced in 1952. This impressive machine (55 x 71 x 36 cm) was used for two main purposes: measuring the transmitted frequencies of radio stations, and research in nuclear technology. Regarding the latter, please remember that these were the years during which nuclear energy and atomic bombs were developed.

Figure 2. *HP 524A Electronic counter (detail)*

The digital/counting part of these DVMs and frequency counters always includes a series of decade-counters. Each decade-counter consists of four flip-flops. Figure 5 gives the block diagram of such a frequency counter. Basically, such a counter counts pulses. By providing a time base of one second, the counter will display the frequency of the input signal in Hertz.

Construction of a decade counter unit

In those days decade counters were constructed using four vacuum double triodes (e.g., 5693, ECC82, etc.). These triodes were specially developed for on-off control applications involving long periods of operation under cut-off conditions.

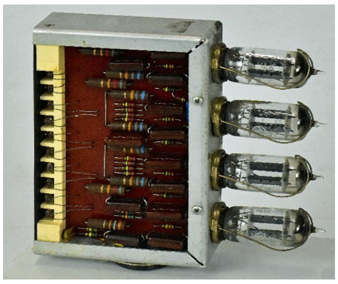

Figure 3. *Decade counter built using four double triodes*

Figure 4. *Front view of that decade counter showing the digits*

A decade counter produces a 4-bit BCD (Binary-Coded Decimal) value. This code has to be converted into signals, suited for the decimal display device. This includes both the signal itself and its voltage level. This latter is relevant, because of the high voltage used in vacuum tube technology and the voltage needed by the display device.

Figures 3 and 4 show a decade counter type HP-AC-4A from Hewlett-Packard with four double triodes. Instead of the usual 1-2-4-8 coding, this counter uses a 1-2-2-4 coding to ease the design of the decoder. The display uses 10 small neon bulbs of type NE-2, one of them being lit. The anode voltage of the triodes is either 70 Volt (logic 0) or about 200 Volt (logic 1). The neon bulbs are so-called cold cathode tubes having a low pressurized gas inside and using an unheated cathode. Electrons are emitted from the cathode and ignite the gas. These tubes require approximately 70 Volt on the anode to ignite. After ignition the voltage over the neon tube drops to about 30 Volt. The current through the neon bulb must be limited by a series resistor, sometimes external to, sometimes built into the bulb.

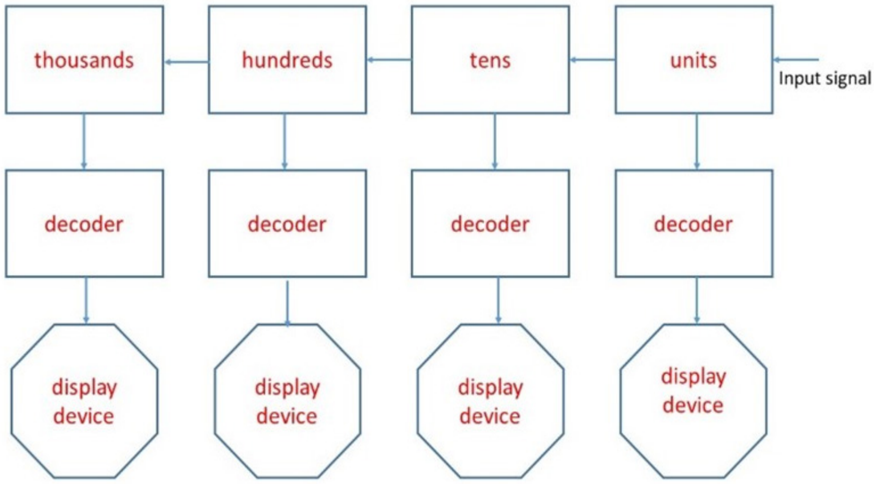

Figure 5. *Block diagram of a frequency counter*

Units like these have been built around 1956 by Hewlett Packard to include in their HP 524A electronic counter (Figure 2) and have also been sold separately [2]. More information regarding this counter can be found in volume 4 of the HP-Journal [3].

The Van Der Heem electronic counter

Regarding display technology an interesting device was produced by the Dutch firm Van der Heem. The electronic counter type 9908 in figure 6 dates back to approximately 1960.

This counter has a freqency range of 10 Hz up to 1 MHz. This counter was already transistorized, but, as the designers had no low voltage display devices available, they used six analog moving coil meters to display the results of the measurements. The decoder they designed was a kind of digital to analog converter. More details of this frequency counter are available in the *Tijdschrift van het Nederlands Radio Genootschap* [4].

Figure 6. *Transistorized counter by Van Der Heem using analogue meters for display*

The Philips E1T electronic counter and display

Around 1953 Philips designed a very ingenious vacuum tube to enable both counting and display of one digit. By electrostatic deflection a small electron beam is projected onto specific locations on one of two horizontal lines of fluorescent material. The number counted is made visible on the outside of the tube. The input to the tube is a negative pulse signal; the tube also provides a carry output to trigger the next decade.

This tube was suitable for applications requiring small dimensions, high counting rates (100 kHz, which was high at the time) and reliability of operations. These tubes have been used extensively in the control console of the former nuclear reactor in Delft (Figure 7). This console is now in our Historic Collection in Delft. Nice demonstrations of this special tube are available on the internet [5] [6]. The design of this very interesting tube as shown in Figure 8 has been described in a Philips Technical Review [7].

Figure 7. *E1T based counter from the console of the former nuclear reactor*

Figure 8. E1T-tube from our collection

The Philps Indicator Tube ZM 550

When counter circuits became transistorized, the low voltage design of the counter did not match with standard neon indicators. Around 1958 Philips therefore developed the ZM 550, (a.k.a. ZM 1050) an integrated counter and indicator tube. In essence, this tube comprises ten neon bulbs in one glass envelope but now running on low voltage. This display device could be developed thanks to the knowledge Philips had on tubes and special gasses. The device has been used in the Philips Scaler PM 4231, a high frequency counter (Figures 9 and 10). A neon glow appears behind the activated digit. This device, sometimes called a Dekatron, is not always easily readable.

A wonderful overview of the research leading to the development of this tube has been given by Ronald Dekker [8]. In particular, the lab reports from Philips Natlab are worth reading (these have been written in Dutch, however).

The Nixie tube

Nixie-tubes have been developed around 1955 by a small firm, later bought by Burroughs. The name “Nixie” was supposedly derived from “NIX I”, an abbreviation of “Numeric Indicator eXperimental No. 1”. Nixie tubes are cold cathode tubes filled with gas; much like the neon bulbs described before. There is one wire mesh anode and there are ten (sometimes more) wire mesh cathodes being shaped as digits [9]. Jelle Boelen, our student member of the Historic Collection, developed a digital clock using old Russian Nixie tubes as shown in Figure 11. The internal design of this clock uses modern digital integrated circuits for the counting and driving the Nixies. It can be easily seen that the designers mounted an upside-down digit of ‘2’ to be used as a ‘5’.

Figure 9. *Philips Scaler 4231 using this special ZM 550 tube*

Figure 10. *One decade of this counter*

Seven segment indicators

Seven segment indicators started appearing already around 1900 [10]. They were first built using filament lamps, but became popular when LED (Light Emitting Diodes) came to the market; later followed by Liquid Crystal Display (LCD) indicators. Figure 12 shows a part of the Casio FR 310 printing calculator. In order to reduce the wiring count between the calulation part of the calculator and the display, the various segments as given in Figure 13 are usually not fully “on”, but are subject to a scanning regime. A particular pass-time in schools was to invent number sequences that showed up as characters when viewed upside down (try 07734 in seven segment form).

A variant of the seven segment indicator was the Hewlett Packard digital numeric indicator using a 4 by 7 dot matrix of leds called the: HP 5082-7300 series (Figure 14). These small (10 x 14 mm) displays were DTL/TTL compatible. This device was somewhat more readable than the seven segment indicator and - depending upon the type - allowed the display of hexadecimal numbers. It could be mounted in a standard DIP-socket. It is worth mentioning, as it was used in the authors' thesis work back in 1976 [11].

Figure 11. *Electronic clock, which uses Nixie-tubes, displaying '19:00:50'*

A modern digital clock

Ronnald Lokker from the Historic Collection was so kind to show us a much more modern kind of digital clock. This clock uses LED´s with programmable colors to create digital numbers on ten layers of polycarbonate. The clock is driven by a programmable microprocessor and is able to display not only time but a multitude of formats (Figure 15).

Two invitations

This brief overview does not to do justice to all developments and developers of the decimal display technologies. The interested reader is welcome to consult the references below and to visit the Historic Collection to have a look at these and many more intruments. The exposition is opened each Monday from 10 AM in the cellar of the low-rise building of EWI.

Figure 12. *Casio FR 310 Printing Calculator using seven-segment indicators*

Schematics for driving these display devices are available from the internet. The Historic Collection would love to have a demonstration setup where these devices can be shown in working condition. In the past, the volunteers of the Historic Collection enjoyed the cooperation of two students. As these students have now finalized their studies, they will soon leave Delft. New student members are very welcome.

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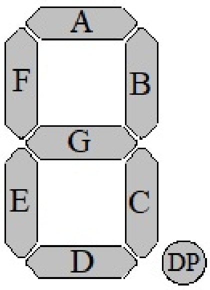

Figure 13. *Standardized ordering of the seven segments and the decimal point*

Figure 14. *HP 5082-7340 4 by 7 led dot hexadecimal indicator (not to scale)*

Figure 15. *Modern numeric display device using LEDs*

References

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