Application Notes/Briefs

HIGH VOLTAGE SHIFT REGISTERS MOVE DISPLAYS

There was a time when one had to go to Times Square or Picadilly Circus to see a moving lamp display. But now they're going into stadium score-boards, stock brokers' offices, waiting rooms and many other places where an attention-getting man-machine interface is wanted.

Naturally, display designers would like to make the control and drive circuitry more compact and less expensive. What's needed to replace the banks of discrete switching devices is storage and switching high-voltage circuits in monolithic form. That's exactly why National developed the MM5081 high-voltage MOS shift register.

This unusual IC is the first MOS device capable of driving gas-discharge tubes and other high-voltage display elements without going through a bipolar buffer such as a transistor or SCR. Moreover, it can "walk" the message around and around the display when operated in a recirculating mode. The latter feature provides a clear-cut division between system functions – the MM5081's take on the responsibility of display operation per se, while the system logic need only format messages and control updating by invading the registers. In other words, the main system logic need pay only intermittent attention to display operation. If the main system is a data-processing computer, for instance, it can handle the display like any other peripheral. Relieved of responsibilities for moving and refreshing the display, the main system can do more data processing between display updates.

REGISTER PLUS SWITCHES

Figure 1 shows in simplified form how one MM5081 would be connected to drive a bank of 10 neon lamps. A data bit stream is entered into the serial input and shifted at the clock rate to the serial output. Then, it can be routed back to the input and recirculated to repeat the display motion.

The states of the data bits circulating through the register control the switching of the MOS output transistors. When a bit in the true state (MOS logical "1") is being stepped down the 10 register stages, the lamps will turn on and off in sequence at the register clock rate. In this mode, the clock rate is the display rate. A typical display rate will move the light along by no more than two or three lamps per second, making any message displayed on parallel rows of lamps easy to follow and read. A latch-type register cell that can shift at frequencies to DC and a single-phase clock input are used in the MM5081 to achieve this effect. However, the logic formatting the data for display will have to run at some higher rate. If the control system has other functions as well, it may be desirable to load the register at a clock rate in the hundreds of kilohertz. At such a high rate, the bit stream flashes by the 10 parallel output switches too rapidly to see the lamps being turned on. After loading, when the main system logic is freed, the clock rate is dropped to the display rate and the message is seen. The message simply recirculates at the display rate until new data is ready for loading.

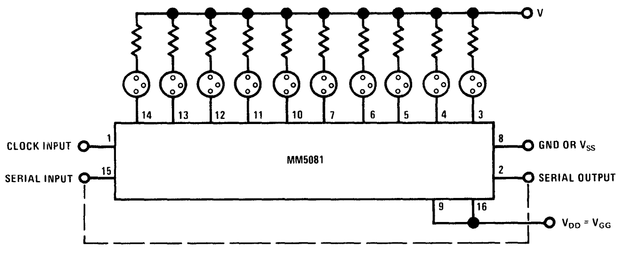

FIGURE 1. Block Diagram

The use of high-speed logic for control is facilitated by making the MM5081 with low-threshold, p-channel, enhancement-mode MOS transistors. As a rule, a low threshold device allows data to be entered at bipolar logic levels.

The output transistors do not need a large gate-voltage change to turn on and off. They are also low-threshold devices in this sense. But they have to withstand transients up to 100 volts and stand off steady state voltages up to 55V to operate lamp-type displays reliably. Adequate gate logic voltages for the output transistors must be ensured to make the lamps glow brightly when they should be on or to make them free of any residual glow due to switch leakage when the switching transistors are turned off. That is, a low R_{ON} and high R_{OFF} must be ensured despite very high voltage on the MOSFET drains. Because a pullup resistor is used, the input gate should be a TTL or DTL device with an uncommitted-collector output able to withstand at least 10V. Among such devices are the DM8810, DM8811 or DM7426 (SN7426) quad NOR-gates, or the DM8812 hex inverter. All these TTL devices will stand off to 14V.

The other two gates used in the input switch can be any TTL or DTL types. The arrangement shown brings the serial output back to the serial input through the top gate when the "new data enable" line is low (DTL/TTL logical "0") or permits the registers to be reloaded with new data when the enable line is high. A pull-down resistor is placed on the register output to handle 1.6 mA the current sinking required for operation of the TTL or DTL recirculation control gate.

TICKER-TAPE DISPLAY

A straightforward type of moving lamp display is illustrated in Figures 2 and 3. Simple messages such as CALLING DR. CASEY . . . CALLING DR. CASEY . . . DR. CASEY, PLEASE REPORT TO SURGERY . . . or stock quotes, or a series of instrument readings would be displayed as 7X5 characters by this system. That is, each character would be a lighted lamp pattern selected from a moving matrix seven lamps high by five lamps with a moving column of lamps turned off between characters. The off column is a space bit in each lamp row.

Assume that the display is long enough for 33 characters. Each row requires 33X6 lamps and 198 register stages. Each row is a cascade of 20 MM5081's. The input of the first register and the

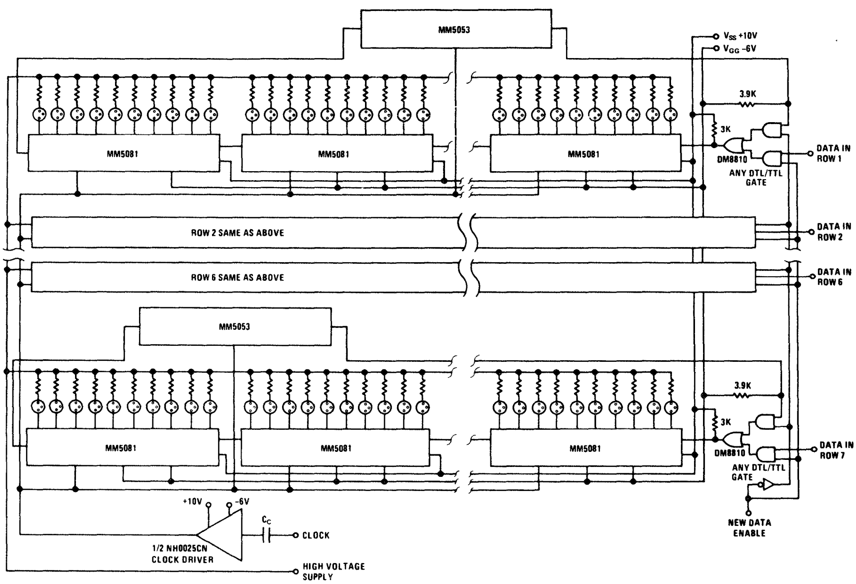

FIGURE 2. 7XN Bit Shift Register and Display

output of the last register are connected as in Figure 1, and the registers in between are simply daisy-chained by connecting each serial output to the next serial input. All seven rows would use 140 register packages.

The character data for this type of system can be formatted by a standard character generator. For instance, the standard ASCII code can address a bipolar compatible read-only memory such as National's MM5241AA, which is programmed to generate 5X7 dot-type characters for CRT display. However, in the lamp display system, the display refresh function is handled without an additional memory. The column bits are entered in each register chain, as before, through the input gating at a rate determined by the clock rate supplied the MH0025C clock driver. The MH0025C is a two-phase driver. However, since the MM5081 takes a single-phase clock input (converted to a two-phase clock inside the register package), only one of the dual drivers in the MH0025C package is shown (the other half can be used to share the clock-drive load).

After the registers are loaded, the clock into the driver is dropped to a frequency of 2 Hz, if the register was loaded at a higher frequency. This rate is stabilized by the coupling capacitor C_C. The coupling capacitor on this type of driver determines the maximum pulse width, but the minimum pulse width is established by the clock signal. So, at the lower frequency, the characters sweep smoothly from right to left across the display lamps. They repeat the message every 100 seconds because 200 register stages are in each of the seven parallel rows.

Both the clock driver and the registers operate off the 10V and –6V power supplied.

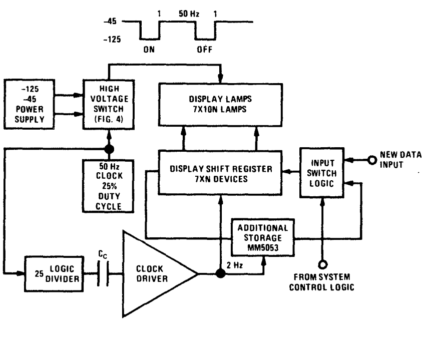

FIGURE 3. System Block Diagram

DISPLAY DRIVE

The high voltage supply (shown in the block diagram in Figure 3) is generated from a high voltage switch. The purpose is to limit the current and voltage across the lamps and the MOS output transistors to ensure that they operate reliably and have long lives. Also, the method reduces power consumption and allows lower power, inexpensive high-voltage power supplies to be used.

The high-voltage switch seen in Figure 3 and detailed in Figure 4 switches at a rate of 50 Hz and a duty cycle of 25%. Thus, when any of the MOS output transistors is on, the lamp that is "on" during that 250 msec display-rate interval (100% duty cycle at 2 Hz) is actually on for only 5 msec at a time. Then it turns off for 15 msec. This refresh rate was chosen because it provides a good lamp intensity with no apparent flicker.

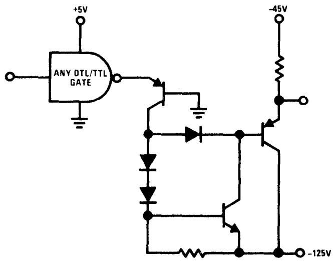

FIGURE 4. High Voltage Switch

The –125V supply turns on the lamps, and the –45V supply turns them off. But what is actually being used is the voltage difference, or bias. Most glow-discharge lamps require a 65V starting voltage and a 60V holding voltage. The switch keeps the lamps alternating between these levels while the MOS transistors are on, but imposes a maximum voltage of only –65V on the MOS transistors (that is, 125–60V) for the 5 msec "on" time. The MM5081 can easily take this – the spec allows –100V at 60 Hz (or 16.66 msec) and they are stress-tested to this level.

INDUSTRIAL DISPLAYS

The characters displayed can be any kind of symbol within the resolution of the lamp array – from letters to cartoon characters – and within the flexibility of the controls. Getting patterns to move back and forth while changing shape is technically feasible, but would require complex clocking techniques to put the bits in the desired location. Static pictorial displays would be fairly simple to implement, merely requiring loading of the registers at a high rate followed by storage at a DC display rate for the desired time. Although the characters would appear static, the high-voltage switch would keep the actual duty rate low.

There are many potential new applications for moving-lamp displays in industrial control systems. Functions such as process flow rates through several feeder pipelines or subassembly line rate in an assembly plant, cannot easily be set up on a CRT display. Complex computer graphic techniques or very expensive multi-gun displays may be needed.

The clock rates and lengths of a number of rows of lamps can readily be adjusted by hand-operated controls, such as voltage-controlled oscillators and gating between registers chosen by selector switches. Any feeder-line display rate that can be represented by the display rate could therefore be varied at a compressed scale of time and distance until the display operator arrived at the optimum balance of rates. This is a visual approach to a problem that generally requires complex mathematics and analog computers to solve.

Nor do the rows of lamps have to be aligned. Individual rows might represent route sections in a transportation network between junctions. By driving each section at a display rate simulating the speed of a particular train, and switching the "train" of moving lights from row to row via switches at the junctions (serial output to serial input register connections), control personnel could simulate system operation. Problems such as tie-ups — or worse — at junctions could be worked out by varying display rates for the trains whose schedules conflicted.