

### Abstract

The MIC4807 is an 8 channel, addressable low side driver and is guaranteed to deliver 100mA minimum at up to 80V per channel. This note discusses the operation of the MIC4807 and shows how it can be used as a display driver with dimming for incandescent indicators.

### Introduction

The MIC4807 contains 8 low side drivers that are controlled by addressable latches (see Figure 1). Open-drain, N-channel MOSFETs of approximately  $5.1\Omega$  "on" resistance are used as output devices. The MOSFETs are designed for operation to 80V.

Each output is controlled by its own addressable latch; the latches are selected by a 3-bit parallel address ( $A_{in}$ ,  $B_{in}$ , and  $C_{in}$ ). A "1" at the data input turns the corresponding MOSFET on.

Power ICs demand protection from excessive current and dissipation, and to this end the MIC4807 includes short-circuit current limiting and thermal shutdown. In fact, the chip can withstand a dead short to 80V without damage. The output limits at typically 200mA, and the chip is guaranteed to deliver 100mA minimum over temperature. While current limiting provides short-term protection from load faults, thermal shutdown protects against sustained fault conditions by shutting off all outputs when the die temperature exceeds  $150^{\circ}\text{C}$ . Current limiting and thermal shutdown are indispensable, yet they are sorely lacking in many other functionally similar ICs where the implementation of protection circuits is left as an exercise for the user.

### Incandescent Lamp Characteristics

Owing to their superior light output, incandescent lamps are preferred over other display devices for use in bright environments. Unfortunately, incandescent lamps have a number of characteristics that make them difficult to work with in practical applications. For example, lamps do not lend themselves to multiplexing. It is technically possible to multiplex lamps by a higher-than-rated supply voltage in conjunction with PWM techniques to control filament power dissipation.

A major pitfall of multiplexing is reliability. If the multiplex circuit fails to advance for any reason (power-up phenomenon, slow or stuck oscillator, etc.) the lamps will burn out instantly. In addition, the switched current increases proportionally with the supply voltage, necessitating larger switches.

Since multiplexing is impractical, each lamp must have its own dedicated driver. This adds circuit overhead not only in the number of drivers, but also in terms of communicating with the drivers.

The brightness of an incandescent lamp is an asset in brightly illuminated environments, but what happens at night? Under contrasting conditions of low ambient light levels, the bright display can temporarily blind persons viewing it. Examples of environments with wide-ranging light levels include the cockpit of an airplane, or the operator's cab on farm or construction machinery. A dimming feature is highly desirable for any incandescent display.

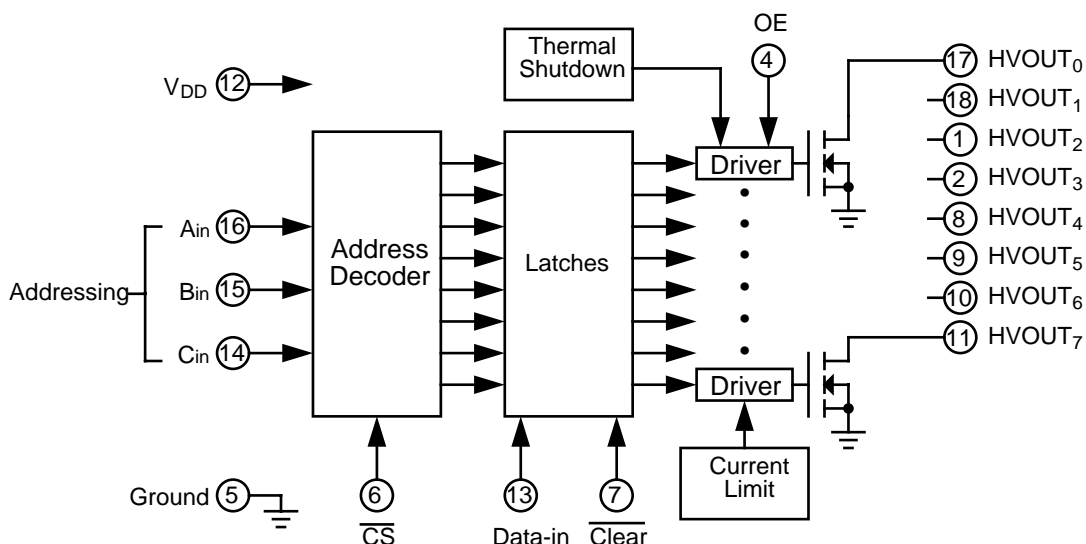


Figure 1. MIC4807 Block Diagram

Unlike LEDs, incandescent lamps require more current and voltage than 5V digital logic circuits can deliver. In particular, lamps draw an appreciable inrush current because the filament resistance is much lower when cold than when hot. Inrush currents of 10 times rated operating current are not uncommon. This impacts both the current rating of the driver and the lifetime of the lamp. Among other contributing factors, lamp lifetime is limited by the severe thermal shock experienced at turn-on.

### Display Driver

Figure 2 shows a practical display driver circuit using the MIC4807. #1835 miniature lamps were selected for use on a loosely regulated "48V" system supply, which normally ran about 110% rated voltage. The #1835 lamp is specified at 55V and 50mA, and it can easily withstand  $\pm 15\%$  varia-

tions in a 48V supply without loss of rated life. The lamps are housed in #31099 (GTE/Sylvania) indicator assemblies. Output current limit precludes the possibility of chip destruction from short circuit conditions such as arise when a lamp socket is "tested" for power with the conductive end of a screwdriver. Long-term short circuits (wiring faults) are handled by the MIC4807's thermal shutdown circuit.

When the MIC4807 cold-starts a #1835 lamp, the output is immediately driven into current limit since it cannot deliver the full inrush current. The cold resistance of a #1835 lamp is approximately  $94\Omega$ ; an initial current of 585mA would flow if connected directly to 55V. The MIC4807 current limit is typically 200mA at room temperature, which reduces the thermal shock at turn-on and increases lamp lifetime. Note that applying 200mA to the cold filament is equivalent to an initial lamp voltage of only 18.8V.

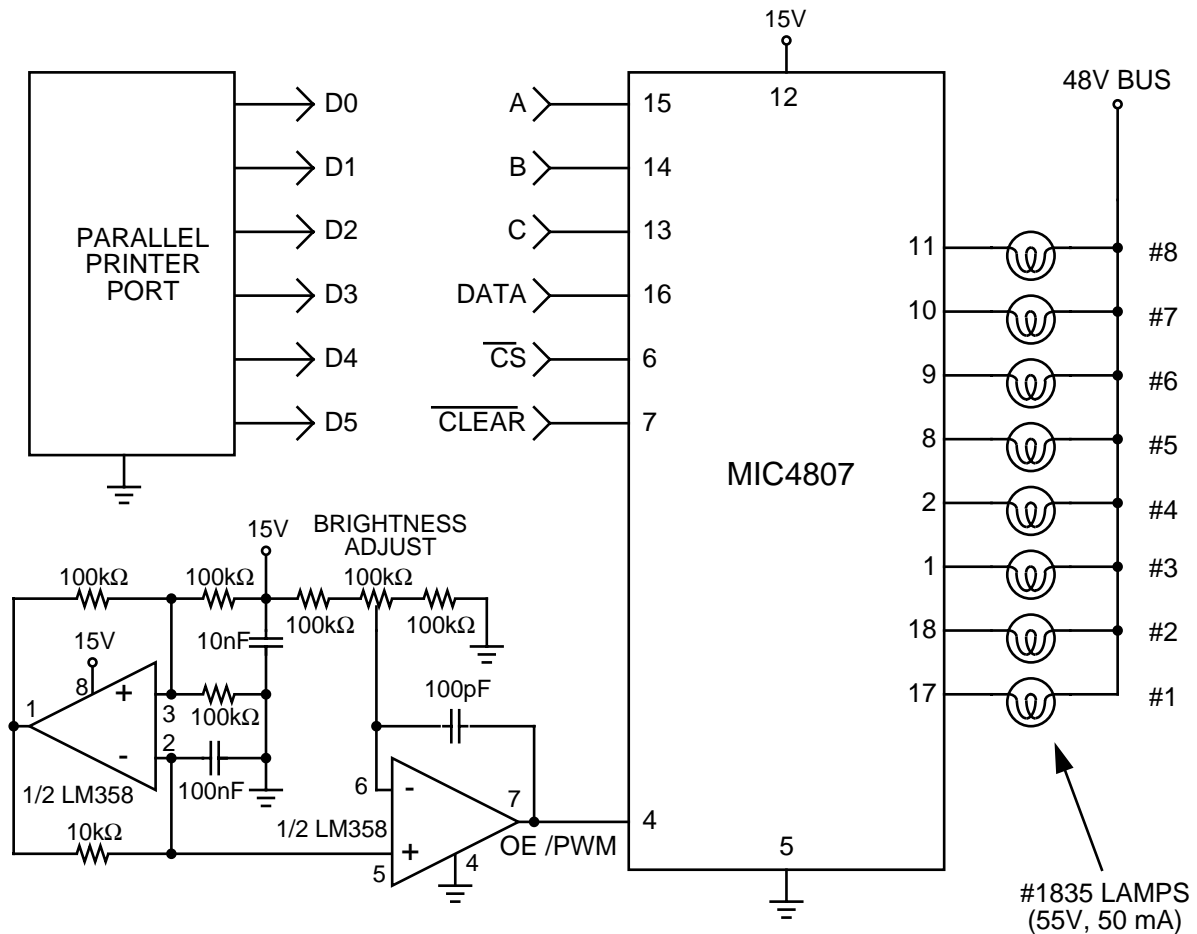


Figure 2. MIC4807 Display Controller with PWM Dimming

## Display Dimming

Dimming is achieved by pulse-width modulation applied to the OUTPUT ENABLE (OE) pin. Since OUTPUT ENABLE acts on all 8 channels, the lamps are simultaneously dimmed by one control signal and maintain equal brightness, regardless of the dimming level.

An LM358 dual op-amp forms the basis of a variable PWM. The control range extends from completely off to completely on, and to any intermediate brightness level.

The PWM frequency (400Hz) is considerably higher than the filament's thermal time constant, so the filament's resistance (and temperature) changes very little between "on" and "off" periods. Figure 3 shows the pulsed filament current in a PWM application for a single #1835 lamp as a function of duty cycle. Lamp manufacturers recommend a PWM frequency of at least 400Hz to eliminate aging effects associated with thermal cycling. At an extremely dim 10% duty cycle, a #1835 lamp accepts current pulses of 90mA on a 55V supply, exhibiting a filament resistance of 611 $\Omega$ . At 100% duty cycle the current falls to 50mA, at a resistance of 1100 $\Omega$ . In any dimming circuit the driver circuitry must be sized to deliver the pulsed, low duty cycle current required by the relatively cool filament. This is typically twice the rated (100% duty cycle) lamp current.

## MIC4807 Programming

The MIC4807 programming interface consists of a 3-bit address, a data line, and two control lines (see Figure 2). CLEAR is straightforward; a low on this pin asynchronously

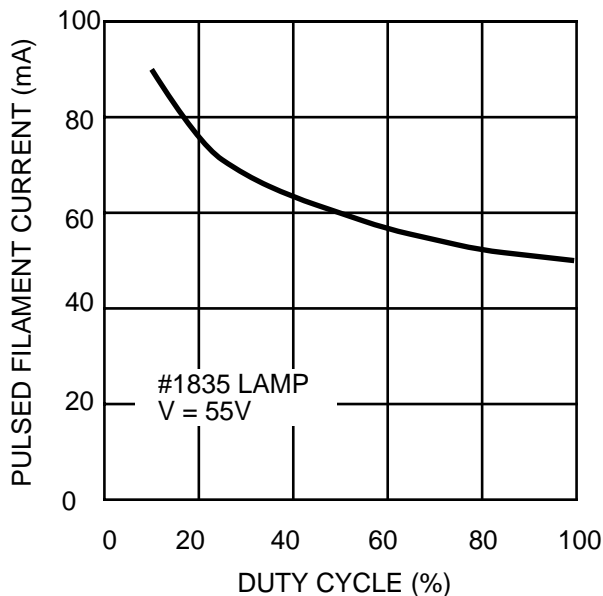


Figure 3. Pulsed Filament Current vs. Duty Cycle

clears the internal latches to turn all outputs off. Programming is accomplished by addressing an output, presenting the desired data (1 = ON, 0 = OFF), and strobing CHIP SELECT with a logic low. DATA is transferred to the addressed output on the falling edge of CHIP SELECT, and is latched in place when CHIP SELECT returns to a high state. In larger displays, CHIP SELECT serves as a means of controlling several MIC4807s while the address, OUTPUT ENABLE, CLEAR, and DATA lines are paralleled.

For bench testing purposes a personal or laptop/portable computer is quite useful. A parallel printer port is commonly available and serves as a convenient means of programming one or more MIC4807s. Software changes can be made quickly and easily and, depending on the programming language used, the program can be stepped manually so that each bit can be checked "on the fly." This presents no problems because the MIC4807 is fully static.

An evaluation program written in BASIC is listed in Figure 4. The program consists of 5 parts. The control/input section is lines 100 through 130. This portion scans the keyboard, and branches to other parts of the program depending on which key is pressed. A "line return" branches to lines 3000 through 3030 where the MIC4807 is cleared and the computer's record of the MIC4807 latch states [8-element array D(A)] is cleared. Execution then returns to lines 100 through 130. A "?" invokes a lamp test function—all of the outputs are turned on by lines 2000 through 2060. Pressing any other key reprograms the MIC4807 with the original data, and returns execution to lines 100 through 130. Pressing any number from 1 to 8 toggles the associated output on or off (lines 1000 through 1020). Lines 4000 through 4020 are accessed from several points in the program; these lines write data to a given address by toggling CHIP SELECT.

The parallel output word is given a value according to which MIC4807 pins should be high or low at any given time.  $A_{in}$  has a numeric (decimal) value of 1,  $B_{in} = 2$ ,  $C_{in} = 4$ , DATA = 8, CHIP SELECT = 16, and CLEAR = 32 to represent a logical "1" at each pin. The port number (8) specified in the "OUT" statements will vary from computer to computer. While final evaluation of data communications must be carried out with the actual host processor, using a computer during the debugging phase of the display design is most helpful.

An equivalent block diagram of the MIC4807 logic circuitry is shown in Figure 5. Note that CHIP SELECT, DATA, CLEAR, AND OUTPUT ENABLE operate on all channels in parallel. The address decoder determines to which latch CHIP SELECT is directed. DATA has no effect on the other latches as their clocking signals remain low.

```

10 REM MIC4807 CONTROL PROGRAM
20 GOSUB 3000
30 REM A=1,B=2,C=4,DATA=8,CS=16,CLR=32
100 A$=INKEY$:IF A$="" THEN GOTO 100 ELSE
    LET A=ASC(A$)-49
110 IF A=-36 THEN GOSUB 3000
120 IF A=14 THEN GOSUB 2000
130 IF A<0 OR A>7 THEN GOTO 100
1000 D(A)=8-D(A)+2*A+96:REM TOGGLE OUTPUT
1010 GOSUB 4000
1020 GOTO 100
2000 REM "?" TURNS ON ALL OUTPUTS FOR TEST
2010 FOR A=0 TO 7
2020 OUT 8,A+56:OUT 8,A+40:OUT 8,A+56
2030 NEXT A
2040 IF INKEY$="" THEN GOTO 2040
2050 FOR A=0 TO 7:GOSUB 4000:NEXT A
2060 RETURN
3000 REM CLEAR DISPLAY AND MEMORY
3010 OUT 8,16:OUT 8,48
3020 FOR A=0 TO 7:D(A)=A+48:NEXT A
3030 RETURN
4000 REM COMMUNICATIONS DRIVER
4010 OUT 8,D(A):OUT 8,D(A)-16:OUT 8,D(A)
4020 RETURN
9999 END

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Figure 4. MIC4807 Control Program Listing

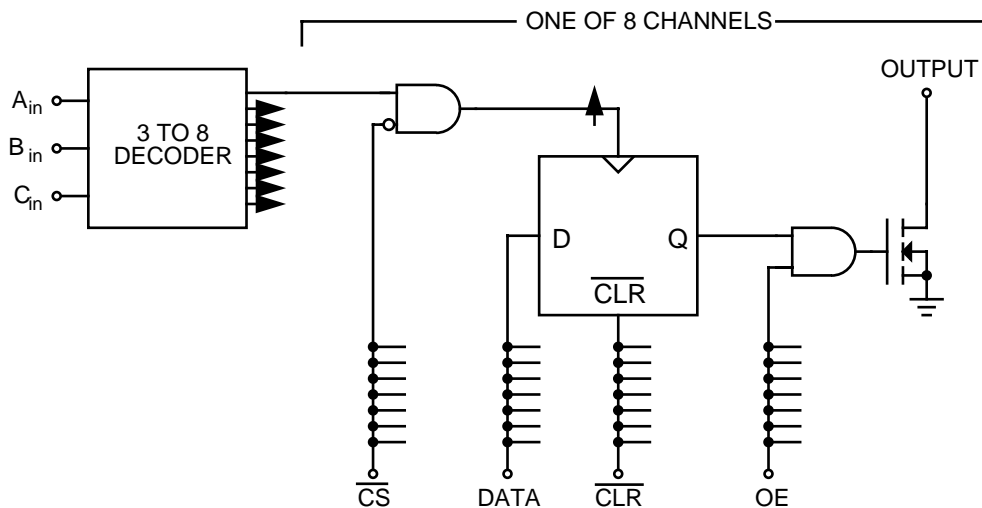


Figure 5. Block Diagram of Logic Circuitry