Using the HLMP-4700/-1700/-7000 Series Low Current Lamps

Application Note 1019

Introduction

The quest for the reduction of power consumption has long been a struggle for design engineers. In many systems, reductions in power requirements mean reductions in driver circuitry and heat dissipation requirements. Individual component power reduction in the telecommunications field adds up to a significant savings in power for large circuits and networks. Reducing power becomes particularly important in the design of portable instruments; the greater the power requirement is, the larger the power supply needs to be and the less portable the instrument becomes.

Avago Technologies has made progress toward LED lamp power reduction by introducing the HLMP-4700/-1700/-7000 series low current lamps. These lamps, available in yellow and high efficiency red, are designed and tested for operation at 2 mA DC. The tinted, diffused packages, available in T-1 3/4, T-1, and subminiature styles, provide the designer a convenient way to reduce power in many applications.

This application note begins by outlining some major characteristics of the low current lamp and compares these characteristics with those of Avago Technologies' standard lamp. Luminous intensity and forward voltage as functions of current, as well as pulsed mode operating efficiency are examined and discussed. Savings in interface techniques employing CMOS, LSTTL, and LTTL logic are covered, and an example analysis of savings in production costs is presented. Also discussed are the ways in which other circuits operating on power supplies greater than 5 volts affect significant power reductions by the reduction in drive requirements. Telecommunications information on current and voltage requirements pertaining specifically to the telephone and typical telephone networks is covered. Finally, battery information on common household cells also is provided. Sizes and capacities are tabled and compared.

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Device Characteristics

The HLMP-4700/-1700/-7000 series lamps were designed specifically with low current DC operation in mind. Avago Technologies' advancements in LED technology and optimization of the chip geometry have increased the light output of the lamp at lower currents. Figure 1 shows typical luminous intensity as a function of forward current for the HLMP-3300/-3301 conventional lamps and the HLMP-4700 low current lamp. From these graphs, it is evident that for currents up to 7 mA DC the low current lamp yields a higher luminous intensity than the conventional lamp shown. For instance, given lamps in identical packages with the same optical characteristics at a forward current of 2 mA, it can be observed that whereas the conventional lamp yields 0.5 mcd, the low current lamp typically yields a luminous intensity of 2.0 mcd.

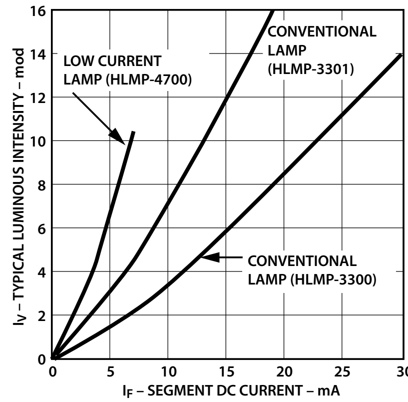

Figure 1. Typical Luminous Intensity vs. Forward Current

The operating forward voltage is directly influenced by the low drive conditions as well. The graph of Figure 2 compares typical forward electrical characteristics of conventional lamps and the low current lamp. It is evident that at any one value of current the forward voltage is higher for the low current lamp than for the conventional lamp. However, since the higher light output at lower current allows the lamp to be driven at lower currents, compare the forward voltage of the conventional lamp at 10 mA to that of the low current lamp at 2 mA. The values, typically 2.2 volts and 1.8 volts, respectively, indicate that the forward voltage is lower for the low current lamp at the respective appropriate drive conditions.

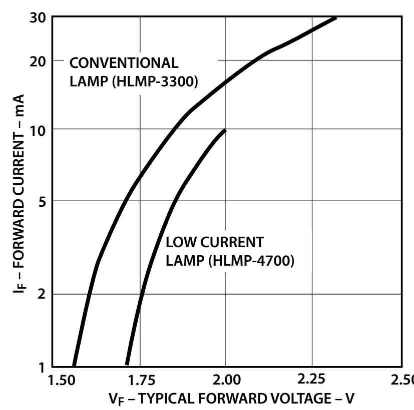

Figure 2. Forward Current vs. Forward Voltage

As mentioned earlier, the low current lamp was optimized specifically for DC operation up to 7 mA. This device is not recommended for operation at high pulsed currents due to increased intensity degradation. The HLMP-3301/-3401 are the respective high efficiency red and yellow lamps in the T-1$^3/_4$ package recommended for high peak pulsed applications. Similar parts exist in T-1 and subminiature packages.

Interface Techniques

One of the prime uses for the low current lamp is in conjunction with CMOS circuitry. Because the lamp requires lower drive current levels, the power and drive circuitry involved in conjunction with CMOS are very often significantly less than the circuitry and power required to drive a conventional lamp. The use of the low current lamp may then result in significant savings in time, materials, and money.

One major area of savings lies in the number of components used in the drive circuit. Less circuitry allows fewer components to be used. The resulting layout of the schematic takes a smaller area of the PC board to implement and the built-up circuit uses less space (lower volume), leaving room for other components or subassemblies, or for enhancing the overall compactness of the instrument. Thus, direct materials savings are achieved in actual component count and PC board fabrication.

By using less power, the designer can be less concerned about heatsinking and cooling systems. Because the actual power is lessened, less power needs to dissipate through metalized PC boards and heatsinks. Moreover, less power through less circuitry in a given volume decreases the operating ambient temperature inside the case, which is a consideration in deciding whether a given device will require any form of heatsinking. (See Application Note 1005, "Operational Considerations for LED Lamps and Display Devices.")

Figures 3 and 4 illustrate some of these cost savings. Figure 3 shows a drive configuration for a conventional lamp at a typical current of 10 mA. With this drive current, the circuit driven by a CMOS gate requires buffering by some external driver, namely the transistor and current limiting resistor shown. On the other hand, the circuit of Figure 4 shows the drive circuitry from the same CMOS gate supplying 2 mA to the low current lamp in the circuit. Since many CMOS devices are able to sink approximately 2 mA directly, external drivers are no longer necessary to turn the lamp on, and the circuit is simplified to that of Figure 4. The power dissipation for the conventional lamp circuit is calculated to be: Pd = I E = (10 mA) (5 V) = 50 mW

For the low current lamp circuit: Pd = I E = (2 mA) (5V) = 10 mW. The power savings is then 40 mW.

Table 1 lists some CMOS components which sink approximately 2 mA or more to drive the low current lamp with a 5 volt source. There are other CMOS drivers which do so at 10 volts. In the case of LTTL or LSTTL logic families, most components at 5 volts typically sink 4 to 8 mA or more, which is quite sufficient for the lamp to operate.

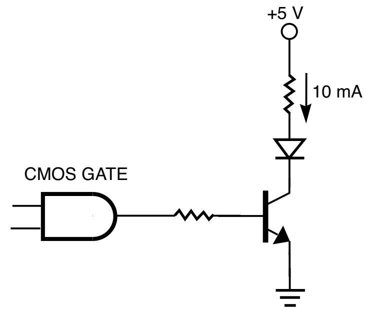

Figure 3. Circuit to Drive a Conventional Lamp

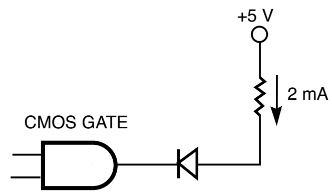

Figure 4. Circuit to Drive a Low Current Lamp

Table 1. CMOS Buffers/Drivers

Vendor	Part Number	I_{OL} (mA) -40°C	25°C		85°C	Description
		Min.	Min.	Typ.	Min.	
Motorola	MC14049UB	3.6	3.2	6.0	2.6	Hex Inverter/Buffer
	MC14050B	3.6	3.2	6.0	2.6	Non-inverting Hex Buffer
	MC14053B	2.3	2.1	2.3	1.3	Non-Inverting 3-State Hex Buffer
RCA	CD4009A/ CD4009UB	3.6	3	4	2.4	Hex Inverting Buffer
	CD4010A/ CD4010B	3.6	3	4	2.4	Non-Inverting Hex Buffer
	CD4041A/ CD4041UB	1.8	1.6	3.2	1.44	Quad/True/Comp. Buffer
	CD4049A/ CD4049UB	3.6	3.0	6.0	2.5	Hex Inverting Buffer
	CD4050A/ CD4050B	3.6	3.0	6.0	2.5	Non-inverting Hex Buffer
National	CD4049C	4.6	4.0	5	3.2	Hex Inverting Buffer
	CD4049M	5.6	4.6	5	3.2	Hex Inverting Buffer
	CD4050BC	4.6	4.0	5	3.2	Non-Inverting Hex Buffer
	CD4050BM	5.6	4.6	5	3.2	Non-Inverting Hex Buffer
	MM70C95/ MM80C95 MM70C97/ MM80C97	4.35	4.35	–	4.35	3-State Hex Buffer
	MM70C96/ MM80C96 MM70C98/ MM80C98	4.35	4.35	–	4.35	3-State Hex Inverter

Higher Voltage Considerations

In circuits where higher voltages are involved, power reductions become even more significant. Figure 5 shows a 12 volt DC supply driving a lamp in series with a current-limiting resistor. The difference in total power in the circuit is significant when the comparison is made between conventional lamps and the low current lamp.

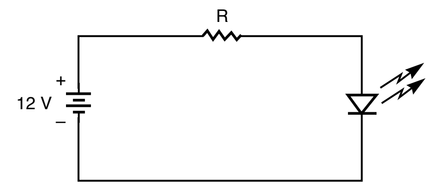

Figure 5. Lamp Circuit Using 12 Volt DC Supply

For standard red lamps:

If $I_f = 20$ mA, then $P_d = I\,E$ (20 mA) (12 V) = 240 mW
for 10 units, P_d = (240 mW) (10 lamps) = 2.4 W

For high efficiency red lamps:

If $I_f = 10$ mA, then $P_d = I\,E$ (10 mA) (12 V) = 120 mW
for 10 units, P_d = (120 mW) (10 lamps) = 1.2 W

For low current lamps:

If $I_f = 2$ mA, then $P_d = I\,E$ (2 mA) (12 V) = 24 mW
for 10 units, P_d = (24 mW) (10 lamps) = 240 mW

As shown in the preceding example, the power consumption is reduced by a factor of 5 to 10 simply by the substitution of the low current lamps for the conventional lamps.

In the circuit of Figure 6, the lamp is driven by 110 volts AC. A current-limiting resistor and a silicon diode for protection are included. Power dissipated by the resistor, the major power-using component, can be calculated assuming the voltage drops across the lamp and the silicon diode are insignificant relative to the 110 volt supply:

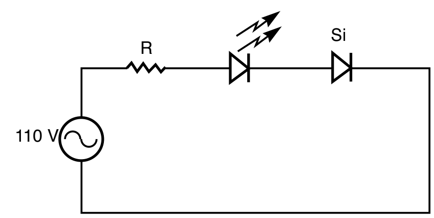

Figure 6. Lamp Circuit Using 110 Volt AC Supply

$$R = \frac{V_{PEAK} - V_f - V_{Si}}{I_{PEAK}} \approx \frac{V_{PEAK}}{I_{PEAK}}$$

Then

$$P_R = I_{RMS}^2 R = \frac{I_{PEAK}^2}{4} R$$

The calculations for all three lamps are tabulated in Table 2. It can be seen that by reducing power, the low current lamp allows the use of smaller, lower wattage resistors to save space and money.

Table 2. Power Calculations for AC Circuit

Lamp	I_{PEAK} (mA)	I_{RMS} (mA)	R (kΩ)	P_R (W)
Standard Red (HLMP-3000)	20	14.1	7.8	0.75
High Efficiency Red (HLMP-3300)	10	7.1	15.0	0.04
Low Current (HLMP-4700)	2	1.4	7.8	0.08

Telecommunications

In telecommunications applications there are only limited amounts of current available to drive the accessories within a telephone. The reduced power consumption of the low current lamp makes it ideal for telecommunications applications. A simplified diagram, shown in Figure 7, depicts signaling with a conventional telephone. When the telephone is on-hook, the circuit is open and there is no current flow. In this condition, an incoming call triggers the ringing generator to energize the ringer. When the receiver is picked up, the telephone goes into the off-hook condition. At this time current is allowed to flow, allowing the user to connect with the calling party via transmitter and receiver.

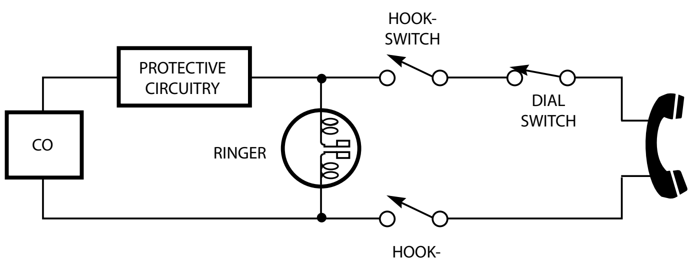

Figure 7. Simplified Telephone Diagram

According to AT&T Technical Publication 48002, the DC supply voltage usually comes from the central office battery, which is nominally 48 volts. In the on-hook condition, the telephone essentially draws no current. Otherwise, the central office senses a trouble condition. When the telephone is off-hook and being used, the telephone must draw a minimum of 20 mA and a maximum of 135 mA. As with the on-hook condition, the central office senses a trouble condition for currents outside this acceptable range. The low current lamp can make efficient use of this limited supply of current in applications such as dial edge lighting, key-pad illumination, or other indicator requirements without the need for an external power source.

In the case of Private Branch Exchange (PBX) systems, it is customary for the manufacturer of the system to provide an additional power supply for functions not already covered by the central office power supply, such as indicators. This supply varies with each manufacturer, but for message indication in the on-hook condition there are typically limited amounts of current available. An ideal application for the low current lamp is line status indication on a system PBX panel. Other applications include message waiting lamps for hotel telephone units, or busy lamp fields at a PBX attendant console. Each lamp in the field is associated with a push button switch by which the attendant may place a call to a particular station. The lamp indicates whether the station is busy or idle.

NOTE: Since a particular central office or interface may vary and therefore change the power supplied, the individual specifications for that system should be consulted. In most countries, the connection of equipment to the telephone network is regulated by a government agency. In the U.S., Part 68 of the FCC Rules and Regulations governs the connection of terminal equipment to the telephone network. There are also Bell System Technical

Publications available which document various aspects of the telephone network. For more specific information, contact:

Division Manager—Information Systems
American Telephone and Telegraph Company
30 Knightsbridge Road
Piscataway, NJ 08854
(201) 966-7111

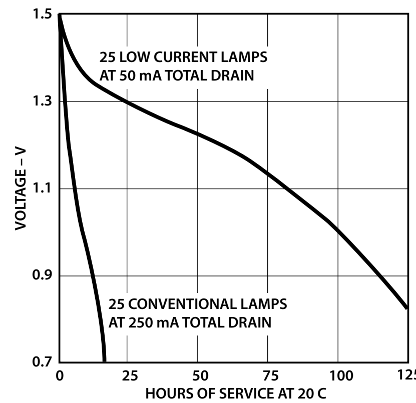

Figure 8. Typical "C" Cell Discharge Characteristics

Batteries

Minimizing size and weight for a power supply has always been an objective for those who design instruments, especially portable equipment. The reduction of drive current required for adequate brightness and visibility means that smaller, lighter power supplies may be used without sacrificing performance, or that a given power supply will not be as heavily loaded, extending the operating life of the supply. Such is the case with the battery, a common portable, lightweight power source. A smaller drain imposed on a given size cell extends the service life of the cells. For example, Figure 8 shows some typical discharge characteristics at several drain values for an alkaline "C" cell. In order to drive 25 conventional lamps, a supply of (25) (10 mA) = 250 mA forward current is required. According to Figure 8, a 250 mA drain would typically exhaust the battery in less than 15 hours. However, 25 low current lamps would need only (25) (2 mA) = 50 mA drive current. The discharge characteristics indicate that the battery would last for 125 hours at 50 mA.

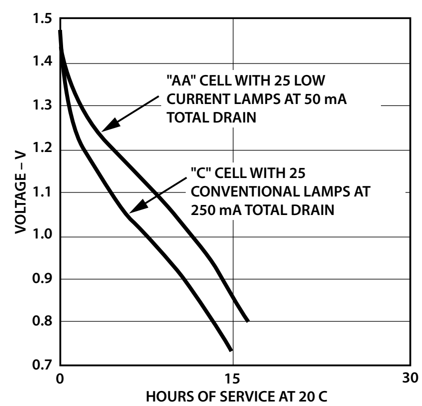

Figure 9. Typical "AA" and "C" Cell Discharge Characteristics

Another possibility is that the decrease in drive requirements may make appropriate the use of "AA" cells instead of the same number of "C" cells without sacrificing performance. A typical drain characteristic for an "AA" cell is graphed in Figure 9. From the previous example, 15 hours of service life can be obtained from the "C" cell to drive the 25 regular lamps. If 25 low current lamps are used, the current decreases to 50 mA. From Figure 9, it can be seen that a drain of 50 mA would yield approximately 15 hours as well. The same amount of service is obtained with a set of batteries which are not only physically smaller by about 80%, but are also typically less expensive.

Table 3 lists the typical household alkaline cells according to ANSI specification C18.1979. The table, restricted to the common household cells only, charts approximate voltages and dimensions. In addition to these ANSI specifications, the table also lists comparative capacities and weights.

Table 3. Alkaline Battery Types, Capacities, and Weights

Cell Type	Voltage (V)	Typical Capacity (mA/hr)	Approximate Volume		Approximate Weight	
			(cu. in.)	(cc)	(oz.)	(gm)
N	1.5	700	0.19	3.1	0.34	9.6
AAA	1.5	800	0.22	3.6	0.42	11.9
AA	1.5	1700	0.48	7.8	0.82	23.3
C	1.5	5000	1.59	26.1	2.28	64.9
D	1.5	10000	3.31	54.3	4.47	127.0
1604	9.0	500	1.26	20.6	1.72	48.9

For further information on selecting the appropriate battery for a given application, the following resources may be contacted:

Duracell International Inc.
Battery Technology Company
So. Broadway
Tarrytown, New York 10591
(914)591-7000

Ray-O-Vac Corporation
101 E. Washington Avenue
Madison, Wisconsin 53703
(608) 252-7400

Union Carbide
Battery Products Division
Old Ridgebury Road
Danbury, Connecticut 06817
(203) 794-2000

For product information and a complete list of distributors, please go to our web site: **www.avagotech.com**

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