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High Speed Optocoupler and its Switching Characteristics H11LxM, H11NxM

Background

In the history of optocouplers, the data speed comparison of the standard phototransistor to the Schmitt trigger output optocoupler is obvious. The H11LxM and H11NxM optocouplers offer vast speed and gain improvements. The H11NxM wins the speed contest given its use of the high speed and high efficiency AlGaAs LED source.

It's been proven that the H11LxM family offers the best value when speed, gain and industrial interface are the criteria. The H11LxM optocoupler uses a low current GaAs IR (950 nm) LED as the source, and a bipolar silicon amplifier as the receiver. The major advantage of this optocoupler is its interface level shifting versatility. The H11LxM device operates over a 3 V to 16 V supply voltage range. Optimum performance is achieved with a supply voltage of 5 V. Attractive timing specifications are possible given the use of a Schmitt trigger detection amplifier and open collector output. The typical output transition times are less than 50 ns. The Schmitt trigger architecture also minimizes output jitter when slow changing LED currents are being monitored.

The H11LxM family members are separated into three LED current threshold bins. The H11L1M holds the spot of most sensitive, offering a threshold equal to or less than 1.6 mA. Coming in second is the H11L3M with a threshold of 5 mA, and lastly the high threshold optocoupler, H11L2M, needing 10 mA or more LED current to guarantee the output is in the low state. These threshold specifications are given as guides. All the parts will switch at current lower than the "maximum" value. However it is recommended that the device be operated a current greater than the "maximum" value. A 10% "guard-banding" compensates for short term temperature and long term LED degradation effects.

Switching Characteristics

The H11LxM family of optocouplers is much faster than the standard phototransistor optocouplers. This improved speed performance is possible given the multistage amplifier and the Schmitt trigger output. The family is presented as having a typical data capability of 1 Mbaud. The key issue here is the term typical. This implies that many parts in the population, but not all parts, are capable of supporting a communication bit time of 1 µs. The definition here is that there is a 1-to-1 relationship of bit time and Baud or signaling rate. Thus a square wave of 50% duty factor with a 2 µs period is composed of a 1010 pattern of 1 µs bit times. Under specific LED operating conditions, each of the three members of the H11LxM family can successfully communicate a 1 MBaud data rate.

Optimum switching is attained by managing the peak LED drive current. Logic switching timing is commonly presented as the time delay for an output transition given a transition of current through the LED. The switching specification is typically given as the propagation delay from output switching from the HIGH state to LOW state, t_{PHL}, and delay from LOW state to HIGH state, t_{PLH}. The switching test circuit and waveforms are illustrated in Figure 2.

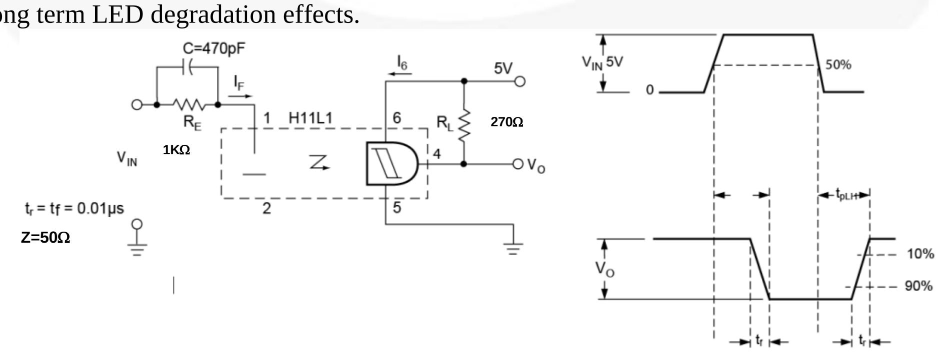

Figure 1. Switching Test Circuit and Waveform

Table 1 illustrates typical performance of each sensitivity bin when operated with a 10% to 25% LED current guardband. The test condition was V_{CC} = 5 V, R_L = 270 Ω. The test data was gathered using a 101010 format of 2 µs ON and 2 µs OFF. The pulse width distortion percentage is based upon a 2 µs bit time.

Table 1. Switching Performance of the Various Current Threshold Bins of H11LxM

Device ID	LED Current, IF (mA)	t_{PHL} (ns)	t_{PLH} (ns)	PWD (ns)	PWD (%)	Date Rate (KBaud)
H11L1M	2	854	1056	202	10	>1000
H11L2M	12	336	1640	1300	63	200
H11L3M	6	555	1600	1045	50	240

The data propagation delay and Pulse Width Distortion (PWD) is data format dependent. This is due to the carrier lifetime of the LED, and the storage time of the output amplifier. The t_{PHL} is peak current dependent, the larger the peak current, the faster the transition time. The H11LxM family is a linear amplifier that is typically driven into saturation. This saturated amplifier is connected to a Schmitt trigger circuit that controls output transistor. As the LED current is increased, the amplifier is driven further into saturation. This overdrive results in excess storage charge in the base emitter junctions of the BJTs found in the circuit. For the amplifier to turn-off, the excess base charge must be dissipated. Given the finite resistances in the integrated circuit - more stored charge means lower turn-off. The data in the table above illustrates the data handling versus LED drive and PWD.

The typical H11L3M is capable of supporting a 1 MBaud serial data clock if one is willing to tune, or adjust the peak LED current. Figure 2 below shows a typical H11L3M operating with a peak LED current of 3 mA.

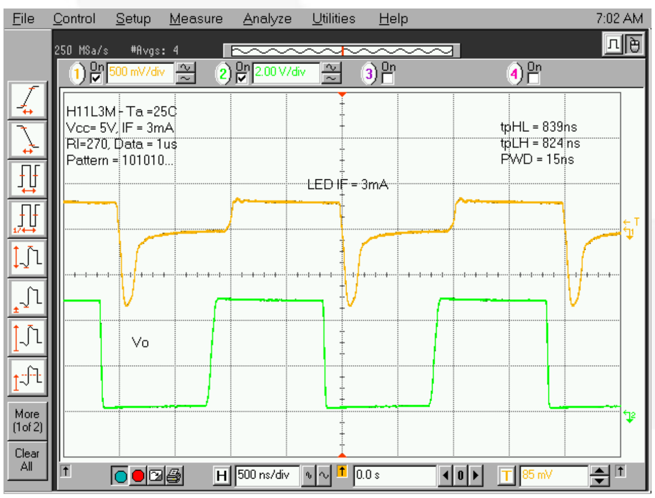

Figure 2. Switching Performance with Peak LED Current at 3 mA

Note that the t_{PHL} = 839 ns, t_{PLH} = 824 ns, and the PWD = 15 ns. The large undershoot of LED current represents the LED's carrier lifetime. In this case, it is between 100 and 150 ns.

Figure 3 illustrates the effect of increasing the LED current and the resulting excess charge, and slower turn-off time. The same H11L3M used in above evaluation is now operated with a peak current of 5 mA. Note that the t_{PHL} has dropped to 191 ns, and the t_{PLH} has extended to 1180 ns.

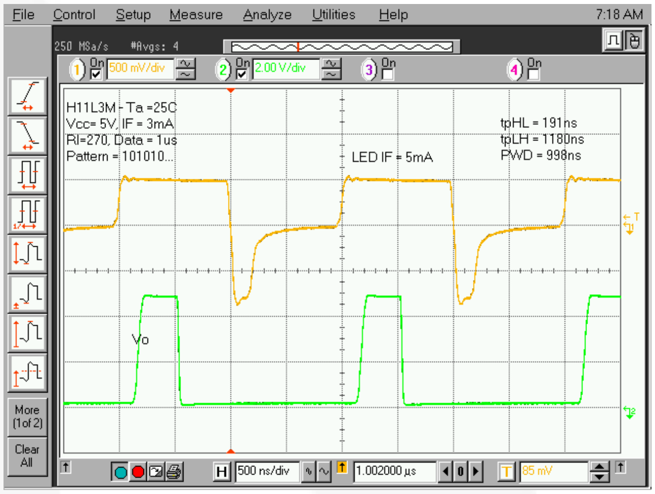

Figure 3. Switching Performance with Peak LED Current at 5 mA

The PWD is greater than the pulse period. This circuit operation would be considered appropriate if 2 µs clock timing is expected. The leading edge repeats about every 2 µs. If the goal is serial data, then the maximum data rate would be 250 KHz (4 µs bit time). This data rate is based on the expected sampling technique of 4 times for either a UART or microprocessor's serial data port.

Figure 4 illustrates the relationship of PWD vs. LED forward current at a data rate of 1 MBaud for the H11L3M optocoupler. A standard test circuit consists of 50 Ω driving circuit and 270 Ω load. The circuit was evaluated with V_{CC} at both 5 V and 10 V. The curve shows very little PWD dependence versus supply voltage. The curve indicates that H11L3M has a "sweet spot" of 4 mA LED forward current versus pulse distortion. The PWD at this current is approximately 200 ns.

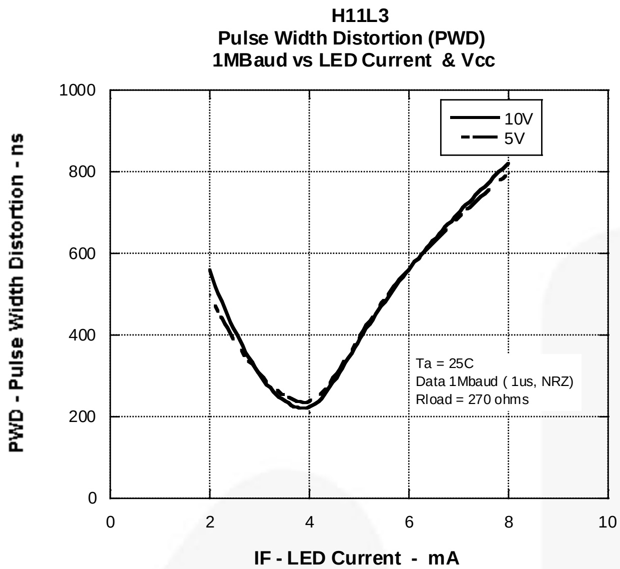

Figure 4. PWD vs. LED Forward Current

Conclusion

The H11L3M's LED forward current can be adjusted to operate the device to transmit a 1 MBaud data signaling rate. The device used in this investigation illustrates the compatibility. Are all H11L3Ms capable of working at 1Mbaud? No. Realistically, under worst-case conditions, the H11L3M's maximum data rate at recommended LED driving conditions of 5 mA is about 200 KBaud. Evaluation indicates that the H11L1M offered the tightest PWD when operated at its recommended LED current. This device with the lowest LED forward current would then be recommended for 1 Mbaud operation.

Recall the H11L3M was developed as an interface to high noise immunity logic (V_{CC} = 15 V). The typical application was transmitting a control pulse between a process controller and an item being controlled.

Today customers use serial and bused data networks where more than control edges are needed. For serial data communication about 1 Mbaud, the higher speed H11NxM family is recommended. This device family uses the high speed and high efficiency AlGaAs LED and a much higher speed trans-impedance driver amplifier.

Related Datasheets

H11L1M Product Information

H11L2M Product Information

H11L3M Product Information

H11N1M Product Information

H11N2M Product Information

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