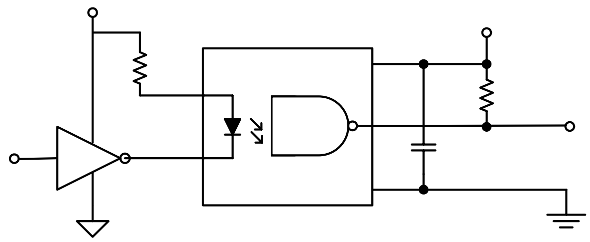
FAQ of High Speed Optocouplers

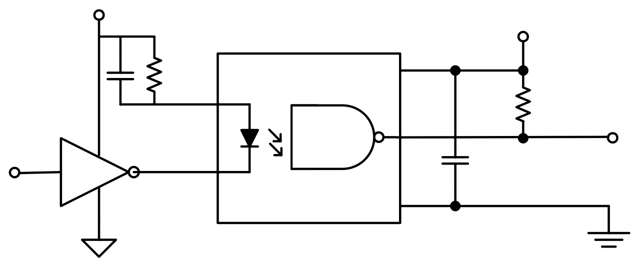
Q: What is the recommended circuit of the 10 Mbd optocoupler?

- Standard



I_F = 9.6 mA, R_L: 350 Ω to 4 K

- With Speeding Capacitor (Cs) to have fast turn-on and keep I_F low



I_F = 7.4 mA, R_L: 350 Ω to 4 K

Q: How much should be the LED forward current (I_F) of the 10 MBd optocouplers?

A: Following issues need to be taken account to define the LED forward current (I_F):

- Input threshold current (I_{TH} or $I_{F(ON)}$)
- Degradation
- Temperature range
- Propagation delay (t_{PHL}, t_{PLH}) vs. I_F

For example, SFH675x, $I_{TH\text{-}max}$ = 5 mA. Suppose:

- its degradation is 30% over 10 Years
  I_{TH1} = 5 * 1.3 = 6.5 mA
- The normalized I_{TH} @100 °C is 113 % (ref. Fig. 8)
  I_{TH2} = 6.5 * 1.13 = 7.35 mA
- The minimum I_F required to get short propagation delay (t_{PHL}) is about 30% more than I_{TH} (ref. Fig.15. Note: the typical I_{TH} is 2.4 mA)
  I_{TH3} = 7.35 * 1.3 = 9.6 mA

So that, the recommended value of I_F is 10 mA, 90% more of Input threshold current ($I_{TH\text{-}max}$).

References

- Figures from SFH675x datasheet

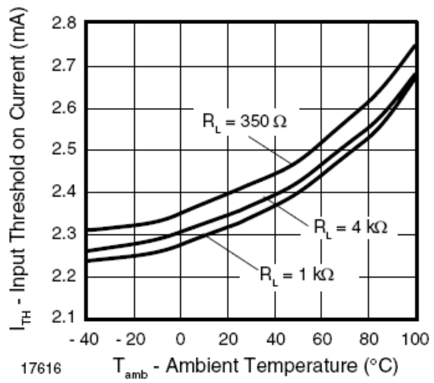


Fig. 8 - Input Threshold on Current vs. Ambient Temperature

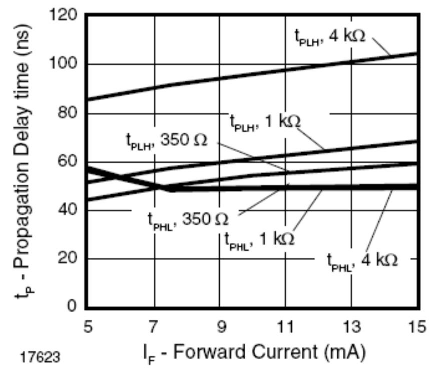
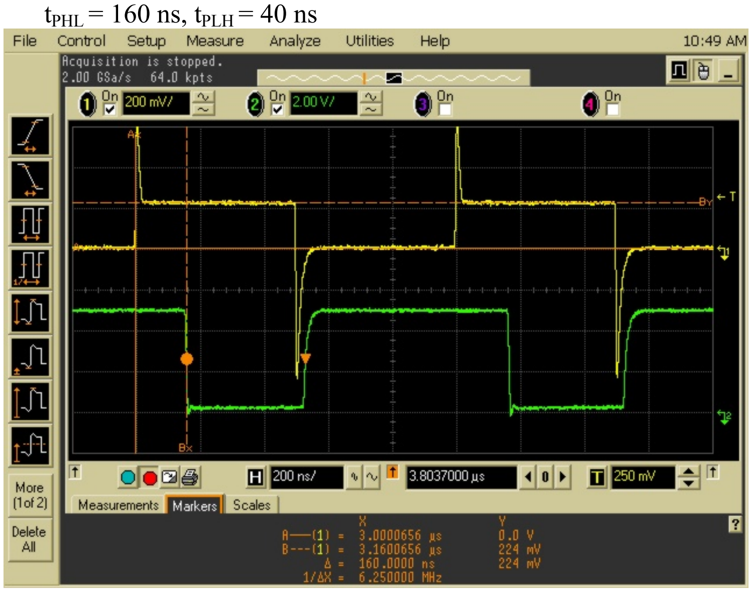


Fig. 15 - Propagation Delay vs. Forward Current

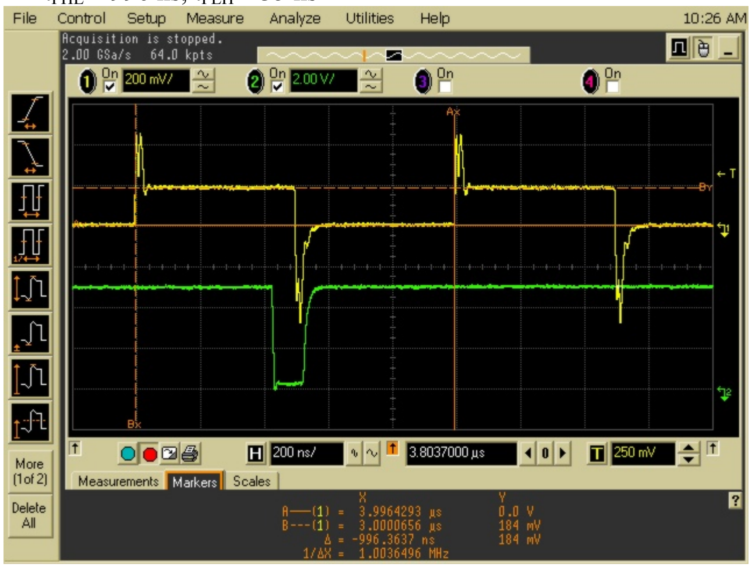
- Test Results of Propagation delay vs. I_F

(1) $I_F = I_{TH} = 2.24$ mA ($R_L = 350$ Ohm)

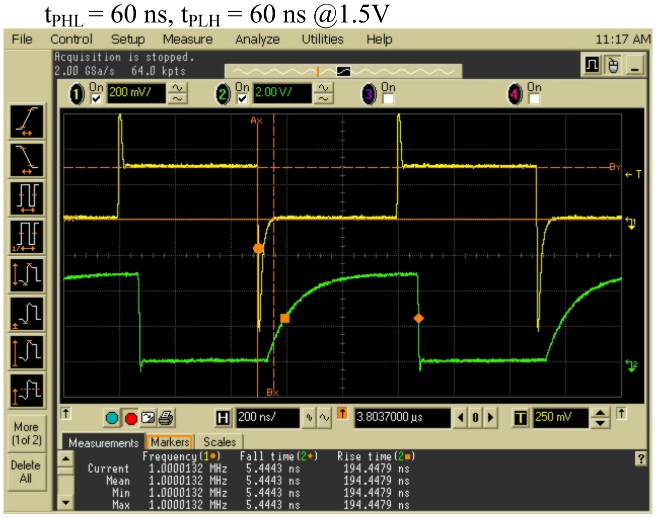
$t_{PHL} = 160$ ns, $t_{PLH} = 40$ ns



(2) I_F = 1.84 mA (R_L = 350 Ohm)
t_{PHL} = 996 ns, t_{PLH} = 35 ns



(3) I_F = 2.9 mA (R_L = 3.3 K)
t_{PHL} = 60 ns, t_{PLH} = 60 ns @1.5V



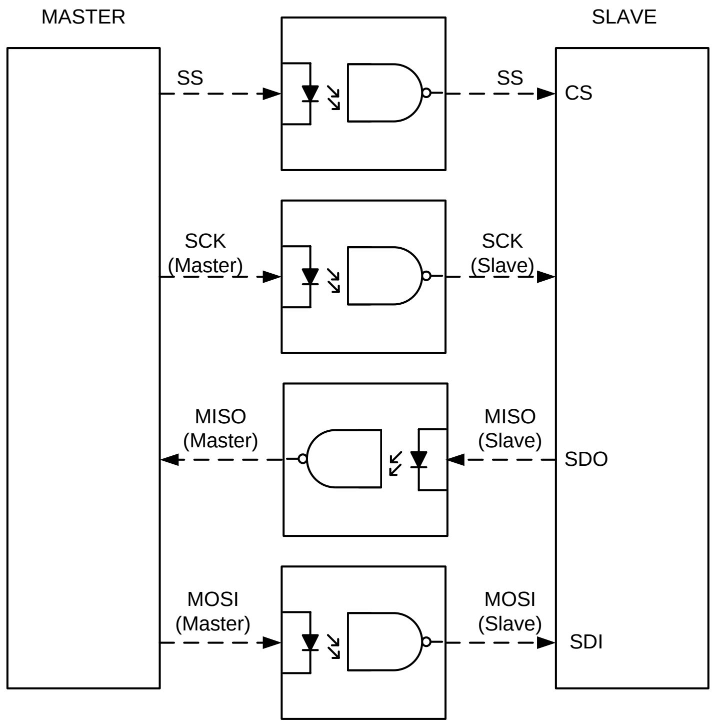
Remarks:

- The I_{TH} (DC) is about 2.24 mA.
- When the I_F = DC I_{TH}, the tp_{HL} = 160 ns (OFF to ON delay), very slow.
- To have short propagation delay the I_F needs to be at least 2.9 mA, 30% higher than DC I_{TH}.
- The I_F value highly affects the t_{PHL} (propagation delay high to low), but not much to the t_{PLH} (propagation delay low to high). This phenomenon is important for serial interfacing, such as SPI bus, etc.

Q: Which switching parameter of the optorcoupler is most important to the SCK rate of SPI bus?

A: The propagation delay time, most critical is the MISO (SDO) related to the initial SCK on the master side.

Both data transfers use SCK to make change and capture. The difference is the master uses its own initial SCK (no time delay) to captures the slave data MISO, which was readout by the SCK on the slave side. So that the final time delay of MISO to the SCK is the two channels' propagation delay time add together.



On the slave side, both signals SCK and MOSI go through all the same paths from the master to the slave. The Propagation delay from master to slave of SCK (t1) and of MOSI (t4) are nearly same if the two channels are well matched, so that the setup time of the data (t5) is still a half period of the SCK.

On the master side, the input data MOSI was read out (changed) by the SCK falling edge on the slave side. The total propagation delay (t2) is the sum of the SCK delay from master to slave and the MISO delay from slave to master. But the master reads (captures) the data on its own un-delayed SCK rising edge. So that, the setup time of the MISO (t3) would be critical if the delay is significant and the SCK rate is high.

For example, SFH675x propagation delay (max) is 100 ns. The delay of other chip in each channel is 20 ns. The total delay of MISO to the initial SCK is (100 + 20) * 2 = 240 ns. The setup time (minimum) is 10 ns. So that, the SCK period (minimum) is (240 + 10) * 2 = 500 ns. The SCK rate (maximum) is 1/0.5 = 2 MHz.

The waveforms of the three SPI channels (SCK, MISO, MOSI) are shown on the following figure.[1]

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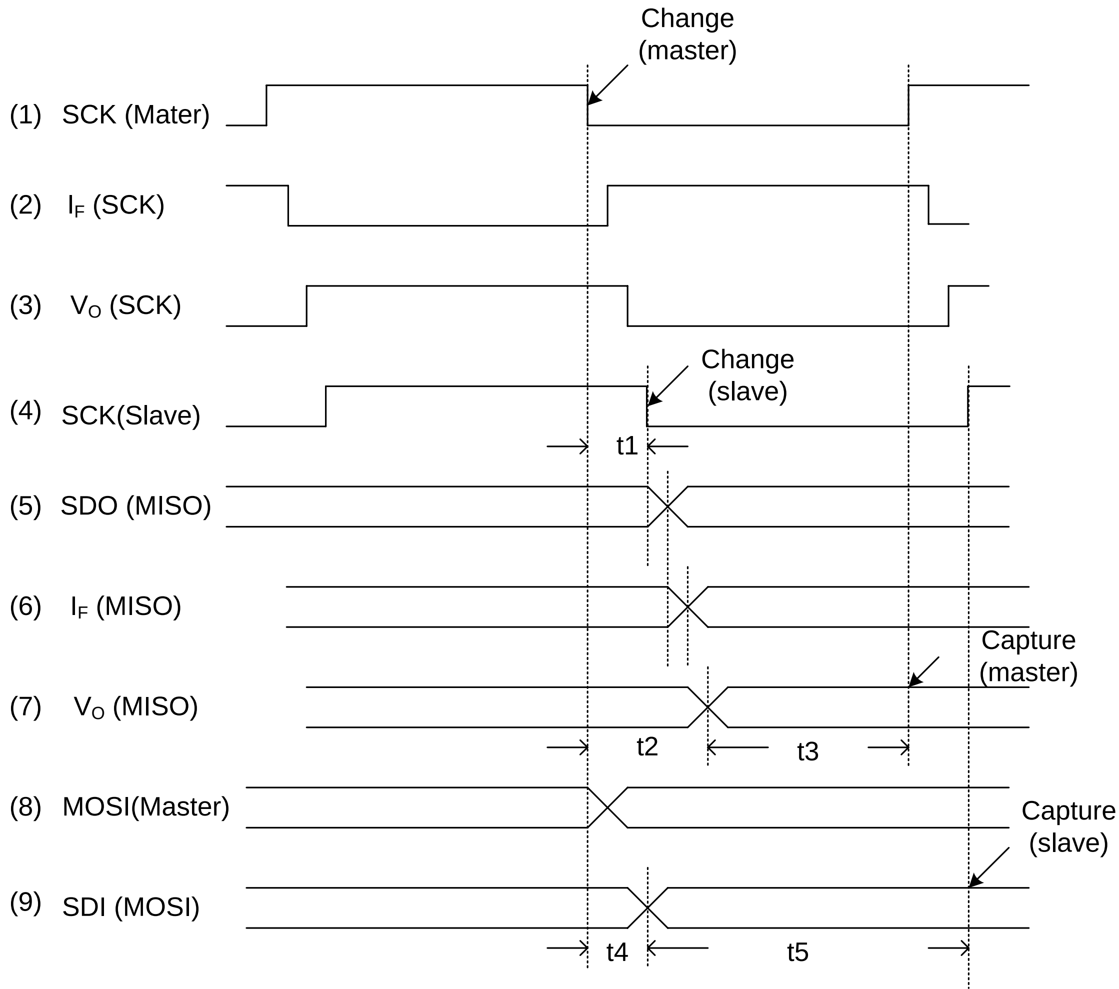
[1] SPI has several different setups. Here is only as an example.



t1: Propagation delay of SCK from master to slave

t2: Total propagation delay of MISO related to the SCK falling edge (change)

t3: Setup time of SDO (MISO) related to the SCK rising edge (capture)

t4: Propagation delay of SDI (MOSI) from master to slave

t5: Setup time of SDI (MOSI) related to the SCK rising edge (capture)