High-Speed PECL and LVPECL Termination

Overview

When high-speed clock and data systems have reached the bandwidth limits of single-ended CMOS/TTL logic, designers are forced to seek other logic alternatives. Today's high-speed emitter coupled logic (ECL), with true differential I/O and superior skew, jitter, and rise/fall times compared to LVTTL logic, provide a compelling alternative. Positive ECL (ECL) is the most common ECL implementation method in today's low-voltage systems. PECL logic levels are referenced to the most positive rail (VCC), thus the translation from ECL-to-PECL is simple. PECL applies to 5V systems, while low-voltage PECL (LVPECL) applies to +2.5V and +3.3V systems. Micrel has an extensive logic and clock synthesis/generation family specified for PECL and LVPECL operation.

Termination

As a result of ECL/PECLs differential, high input impedance, very low output impedance (Open Emitter), and small signal swing (and resulting low EMI), ECL/PECL is ideal for driving 50Ω and 100Ω controlled impedance transmission lines. A signal trace is considered a transmission line, thus requiring termination, when the signal's rise/fall time is faster than a trace's round-trip propagation delay. In some applications, if the distance between two devices is short enough, then termination may not be necessary. Another way to express this is:

If, $t_{RISE(signal)} < 2 \times t_{PD(trace)}$, then the trace is a transmission line and proper termination is required.

And, as with all high-speed transmission lines, to realize all the performance benefits of ECL/PECL, care must be observed when terminating. There are several PECL termination methods. Figures 1 through Figure 6 illustrate the different termination schemes. For optimal performance in high-frequency applications, Micrel recommends parallel termination (shown in Figure 3 and Figure 4). For fanning out to multiple locations, tapping off an existing output (driver) is not recommended because of the signal degradation caused by mismatches in the transmission lines. A better alternative is to use a Micrel fanout buffer such as an SY100EP11U or SY100EP111U. Micrel offers an extensive selection of high-frequency fanout buffers and translators, which can be found at the Micrel web site: www.micrel.com.

Unused I/O and Single-Ended Termination

Many applications will not use all of a device's outputs, such as a fanout buffer or translator. It is a common practice to terminate unused output pairs with a typical 2kΩ–4kΩ resistor to ground (PECL applications). In most cases, an unusual PECL/ECL output pair on a Micrel buffer, translator, or clock generator may be left floating (exceptions are noted in the datasheet).

For single-ended applications that only use one PECL output (Q_{OUT}), the other output ($/Q_{OUT}$) must be terminated properly, as shown in Figure 6.

The circuit should have the same load on both outputs, even with single-ended applications. For single-ended input applications, the unused input must be set to the proper threshold level. The correct level for DC-coupled applications is V_{CC}–2V. The correct value for AC-coupled applications is V_{CC}–1.3V (V_{BB} equivalent). Many of Micrel's devices include a V_{BB} reference voltage pin; proper set-up is shown in Figure 6. If a V_{BB} reference is not available, a simple resistor network, as shown in Figure 6, should be implemented on the unused input. V_{BB} is intended for two applications-unused inputs (shown in Figure 6) and AC-coupled inputs. For AC-coupled inputs, the V_{BB} reference level (V_{CC}–1.3V) is intended to be the termination point via 50Ω resistors on each input.

Summary of Termination Techniques

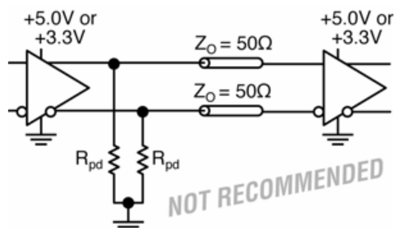

Figure 1. No Termination

- Typically not recommended due to overshoot/ undershoot and reflections
- Only works for very short trace lengths, <<1" and low frequencies <100MHz
- Pull-down resistor (R_{pd}) is required to set current drive for open-emitter outputs
- Pull-down resistor (R_{pd}) is typically 180Ω to 250Ω

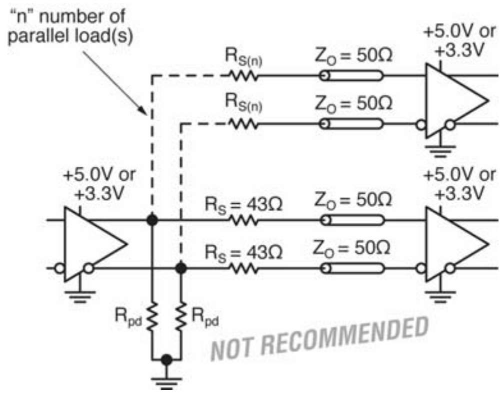

Figure 2. Low-Frequency, Series Termination

- Only for low-frequency applications <100MHz
- For long, uncontrolled impedance traces, R_S acts as series damping resistor
- $R_S \cong Z_O$ – driver output impedance = 50Ω – 7Ω ≅ 43Ω
- P_{pd} (max) = (10 x Z_O – R_S)/n, where n is number of parallel loads
- Parallel loading is <u>not recommended</u> for high-frequency (>100MHz) applications. Instead, use a Micrel fanout buffer such as the SY100EP11U or SY100EP111U

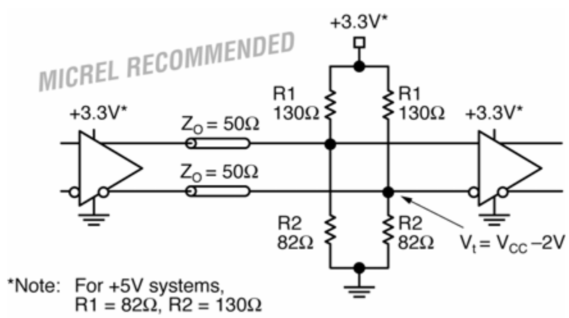

Figure 3. Parallel Termination (Thevenin Equivalent)

- Micrel recommended termination
- Most common PECL/LVPECL termination method
- Resistor divider tracks power-supply fluctuations
- For +3.3V systems, R1 = 2.5 x Z_O, R2 = 1.67 x Z_O
- For +2.5V systems, R1 = 1.67 x Z_O, R2 = 2.5 x Z_O
- Place termination as close to the destination pins as possible
- For parallel loading applications, use Micrel fanout buffer such as SY100EP11U or SY100EP111U

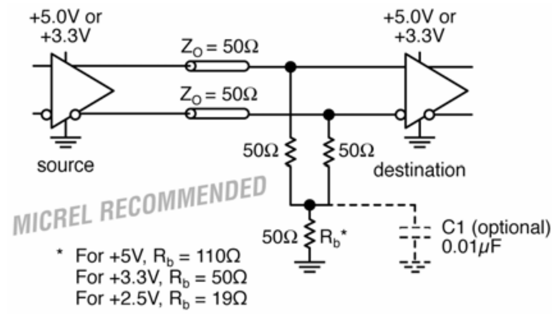

Figure 4. Parallel Termination (3-Resistor)

- Power saving alternative to 4-resistor, Thevenin termination
- Place termination resistors as close to destination inputs as possible
- R_b resistor sets the DC bias voltage, equal to V_t
- 3-resistor networks exist: small package, 1% accuracy, low cost: www.thinfilm.com.

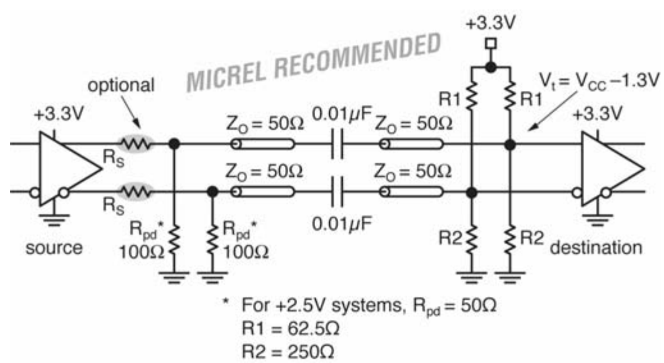

Figure 5. Termination AC-Coupled Transmission Lines

- AC-coupling is only recommended for clock applications (50% duty cycle)
- For best t_r/t_f performance, AC-coupling capacitors should be low ESR, low inductance at targeted clock frequency
- If ringing occurs (overshot/undershoot), adding a series resistor (RS) will dampen the ringing. Typical value is approximately 10Ω. Place resistors as close to source pins as possible.
- Since the AC capacitor blocks the "pull-down" effect of the emitter follower, $V_t \cong V_{CC}$–1.3V
- Typical termination values for +3.3V systems are:
  - R1 = 1kΩ
  - R2 = 1.6kΩ
- If a V_{BB} reference is included, terminate each AC-coupling input with 50Ω to V_{BB}. Bypass the V_{BB} pin with a 0.01µF capacitor to V_{CC}, as PECL is referenced to V_{CC}

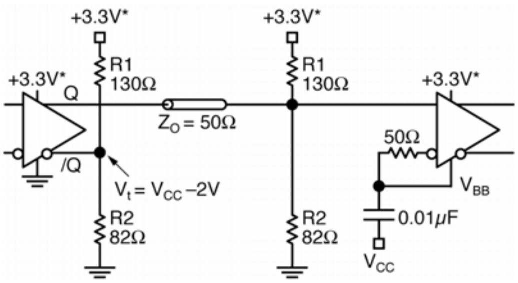

Figure 6. Terminating Unused I/O

- Unused output (/Q) must be terminated to balance output
- Micrel's differential I/O logic devices include a V_{BB} pin $V_{BB} \cong V_{CC}$–1.3V
- Connect unused input through 50Ω to V_{BB}. Bypass with a 0.01µF capacitor to V_{CC}, not GND, as PECL is referenced to V_{CC}.

Datasheets and support documentation can be found on Micrel's web site at: www.micrel.com.

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