Using CY7B991 (RoboClock®), CY7B9911 (RoboClock+), and CY7B9910 (Robo Jr.) in 3.3-Volt Environments

Introduction

The RoboClock® family of low skew clock buffers includes six products listed in *Table 1*.

Table 1. RoboClock Family

Cypress Part No.	Features
CY7B991	15–80 MHz outputs with /2, /4, invert and programmable skew. TTL output levels.
CY7B992	15–80 MHz outputs with /2, /4, invert and programmable skew. CMOS output levels.
CY7B9910	15–80 MHz outputs. TTL output levels.
CY7B9920	15–80 MHz outputs. CMOS output levels.
CY7B9911	15–100 MHz outputs with /2, /4, invert and programmable skew. TTL output levels.
CY7B991V	15-80 MHz output with /2, /4, invert and programmable skew. LVTTL output levels. 3.3V V_{CC}.
CY7B9911V	15–110 MHz output with /2, /4, invert and programmable skew. LVTTL output levels. 3.3V V_{CC}.

For 3.3V applications, the CY7B991V (Low-Voltage Programmable Skew Clock Buffer) and the CY7B9911V (Low-Voltage RoboClock+) are ideal. They are true 3.3V devices with all the same functionality of the CY7B991/2. The rest of the RoboClock family is a 5V product line requiring all of the power supply pins to be connected to a single +5V supply. However, the 5V RoboClock family can still operate in mixed 5V/3V applications.

Although the 5V RoboClock is not as ideal as the CY7B991V/11V in 3.3V applications, it is still possible to make the outputs 3.3V-compliant. The voltage levels on RoboClock's 5V TTL outputs may not be tolerable by the inputs of strict 3.3V LVTTL products. However, by using the termination network recommended in the data sheet (see *Figure 4*) it is possible to make the TTL-level RoboClock (CY7B991, CY7B9911 and CY7B9910) outputs 3.3V-compliant. The CMOS-level RoboClocks (CY7B992 and CY7B9920) cannot be made 3.3V-compliant due to their design, which achieves rail-to-rail output swings. All the following sections pertain to the CY7B991, CY7B9910, and CY7B9911.

RoboClock's Power Pins

All RoboClock products have six power supply pins separated into two groups. The first group consists of two pins labeled V_{CCQ}. These pins supply power to the logic and Phase Locked Loop (PLL) circuitry. The second group, labeled V_{CCN}, consists of four pins. Each V_{CCN} is a dedicated power supply pin for a particular clock output pair (1Qx, 2Qx, 3Qx, and 4Qx). Both the V_{CCQ} and V_{CCN} pins *must* be connected to a +5V power supply (except for the CY7B991V/11V). It is *not* possible to operate RoboClock with the V_{CCN} pins at 3.3V in the hopes of limiting the output buffers to 3.3V tolerant operation. Tying the V_{CCN} pins to a voltage other than +5V may damage RoboClock.

RoboClock's Output Buffers

The output buffers on RoboClock can drive transmission lines down to 50Ω. The ability to drive low-impedance transmission lines is a result of RoboClock's high current drive output buffers. The voltage-current relationships (or V-I curves) of RoboClock's outputs are shown in *Figures 1* and *2.* Note in *Figures 1* and *2* current polarity is defined as positive when sinking (i.e., current is flowing into the buffer), and negative when sourcing (i.e., current is flowing out of the buffer).

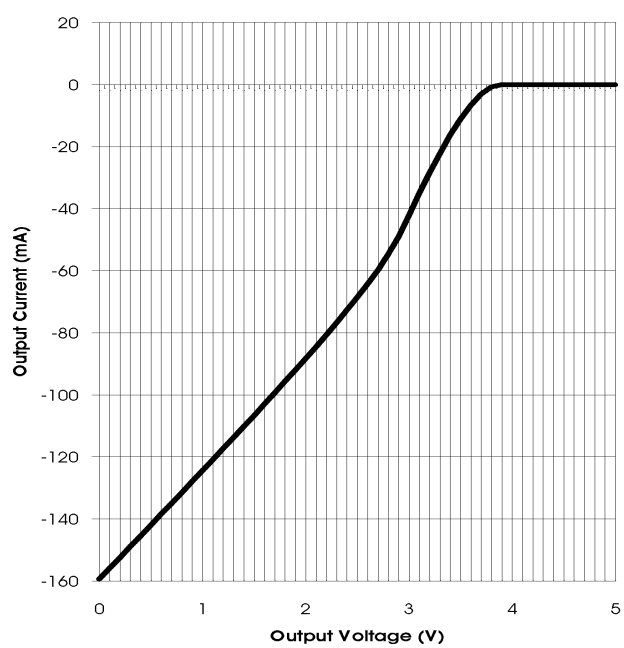


Figure 1. RoboClock Output Buffer V-I Curve, Output = High

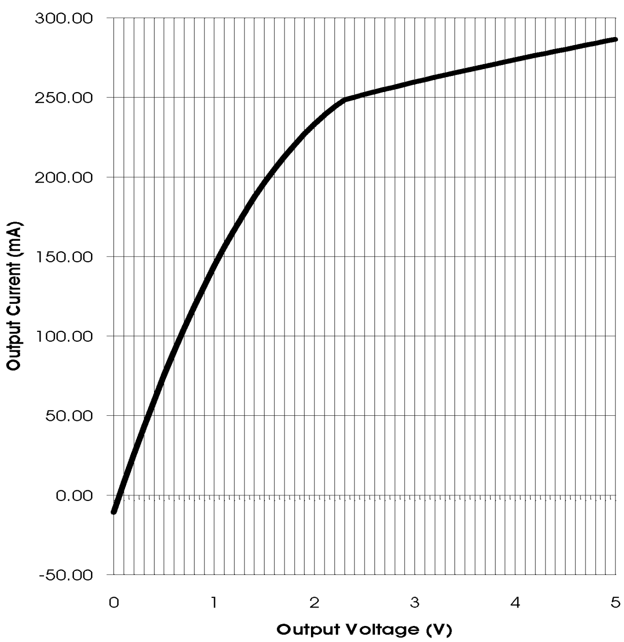


Figure 2. RoboClock Output Buffer V-I Curve, Output = Low

The output buffers are designed to operate in systems with terminated transmission lines. By modifying the termination network, the output buffers can be loaded down (i.e., required to supply more current) resulting in a reduction in their voltage swing. In other words, RoboClock's outputs can be modified for 3.3V-tolerant operation by choosing the correct termination network.

3.3V-Compliant RoboClock Outputs

The JEDEC standard JESD8-A "Interface Standard for Nominal 3V/3.3V Supply Digital Integrated Circuits" defines the voltage levels for 3V- and 3.3V-compliant signaling. For a 3.3V-compliant digital input, the allowable voltage levels, as indicated in JESD8-A, are shown in *Table 2.*

Table 2. JEDEC 3.3V Input Specifications, V_{DD}=3.3V

	Parameter	Min.	Max	Units
V_{IH}	High-Level Input Voltage	2.0	V_{DD}+0.3	V
V_{IL}	Low-Level Input Voltage	–0.3	0.8	V

The outputs of the CY7B991V/11V naturally comply to this standard. To achieve 3.3V compliant output levels, RoboClock's output buffers must be limited to swing no higher than 3.6V (3.3V+0.3V). From the curve trace in *Figure 1*, the output buffers can source 6.63 mA of current at 3.6V. Therefore, the appropriate termination network needed to achieve 3.3V operation is 3.6V/6.63mA≈560Ω. The simplest 3.3V-compliant RoboClock design could use a 560Ω pull-down resistor on the RoboClock outputs.

However, since transmission lines should be terminated to their characteristic impedance, a 560Ω termination resistor on the output of RoboClock would require use of a 560Ω transmission line (uncommon among printed circuit board designs). Most PCB transmission lines are 50Ω, requiring a 50Ω termination.

50Ω Load for 3.3V Compliance

A 50Ω characteristic impedance transmission line requires a 50Ω termination in order to prevent voltage reflections. However, the actual termination is not as simple as using a 50Ω pull-down resistor. RoboClock's data sheet switching characteristics (t_{SKEWPR}, $t_{SKEW1–4}$, t_{DEV}, t_{ODCV}, t_{PWH}, t_{PWL}, t_{ORISE}, and t_{OFALL}) are optimized when terminating to a voltage of 2.06V. Therefore, the best RoboClock output termination provides for a 50Ω equivalent load, but also sets the termination voltage to 2.06V.

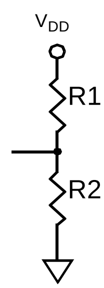
To verify that a RoboClock output terminated to a specific Thevenin resistance and voltage actually meets the JEDEC 3.3V requirements, *Equation 1* must be solved iteratively, with the result compared against the V-I curve of *Figure 1*.

$$\frac{V_{Output} - V_{Termination}}{Z_{Thevenin}} = I_{Output} \quad \text{Eq. 1}$$

$$\frac{V_{Output} - 2.06V}{50\Omega} = I_{Output} \quad \text{Eq. 2}$$

With a 50Ω to 2.06V termination, *Equation 2* can be solved using an iterative process (i.e., choosing a V_{Output} and solving for I_{Output}, until the V_{Output} and I_{Output} results agree with the V-I curve shown in *Figure 1* since we are concerned with limiting the maximum output HIGH voltage) giving a solution of V_{Output}= 3.25V and I_{Output}=23.8 mA.

With the termination chosen to meet 3.3V voltage requirements, the actual resistor values can be found using the circuit and equations shown in *Figure 3*.



$$\frac{1}{R_1} + \frac{1}{R_2} = \frac{1}{50\Omega} \quad \text{Eq. 3}$$

$$\frac{R_2}{R_1 + R_2} \times V_{DD} = 2.06V \quad \text{Eq. 4}$$

Figure 3. Choosing Termination Resistor Values

Solving *Equations 3* and *4* for V_{DD} values of 5V and 3.3V, and choosing standard resistor values, gives the two termination networks shown in *Figure 5*.

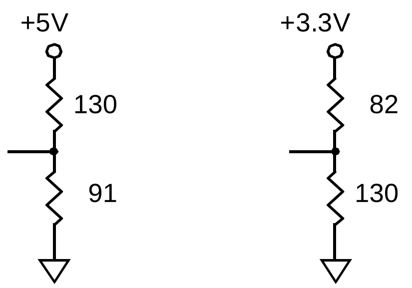


Figure 4. Typical 50Ω Terminations to 5V and 3.3V for 3.3V-Compliant RoboClock Outputs

Note, the termination network for V_{DD}=5V is actually the recommended output load as indicated in the RoboClock data sheet. With these termination networks, the RoboClock output waveform conforms to 3.3V specifications as shown in *Figure 5*.

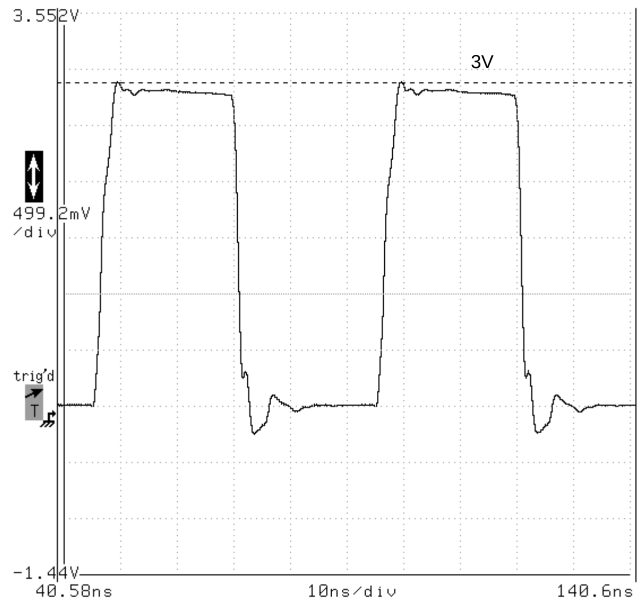


Figure 5. RoboClock Output with 50Ω Load, V_{DD}=5V

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