Application Note

Low Power Operation in TI Programmable Logic Devices (TPLD)

TEXAS INSTRUMENTS

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ABSTRACT

Applications such as remote controls, wearables, robotics, and computer peripherals often require extended battery life, making power conservation a key design consideration. TI Programmable Logic Devices (TPLDs) allow designers to configure the device to dynamically control which device features are actively consuming power at any given time. This application note explores techniques for optimizing power consumption in TPLDs, providing designers with practical guidance on how to achieve extended battery life in TPLD designs.

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1 Introduction to Power Consumption in TPLD

In battery-powered systems, minimizing standby current is a key concern. Standby current is the current drawn by the TPLD from V_{CC} when the device is powered on under static no-load conditions without oscillators, analog comparators, or other power-consuming functions being performed. TI Programmable Logic Devices (TPLDs) offer a significant advantage in this regard, drawing less than 10 microamps of current when in standby. This low standby current can greatly extend battery life when compared to using several discrete components, making TPLDs an attractive choice for low-power designs.

The TPLD component with the most significant power consumption is the oscillator. The key to minimizing the power consumption of the TPLD is to properly manage the operation of the oscillators. For example, a remote control can be designed to only send a signal when a button is pressed. The rest of the time, the remote control needs to consume as little power as possible until the next button press. By dynamically controlling the oscillator, designers can significantly reduce power consumption in designs, leading to an improvement in battery life.

Oscillator selection can make a big difference in the power consumption of a TPLD, with faster frequencies drawing more current than slower frequencies. An oscillator change can drastically affect power consumption. Pre-divider selection plays a smaller but still significant role. Larger pre-dividers reduce the current more than small pre-dividers and can have an effect of reducing the oscillator current consumption by several microamps to a couple hundred microamps. Second stage dividers do not have a significant effect on power consumption. Therefore, selecting the appropriate oscillator and appropriate pre-divider are key to achieving the lowest possible power draw.

Additional TPLD elements that consume a significant amount of power include analog comparators and analog temperature sensors. If a TPLD has features that draw significant current, these elements are listed in the Supply Current Characteristics section of the datasheet. However, the most power-hungry element in the TPLD is the oscillator. A 25MHz oscillator in the TPLD can consume hundreds of microamps while a multi-channel sampling analog comparator can draw only tens of microamps even when four channels are used with continuous sampling. Similarly, a single channel analog comparator in the TPLD can only draw a current of a few microamps. For a complete list of supply current characteristics for any given TPLD, please refer to that device's datasheet.

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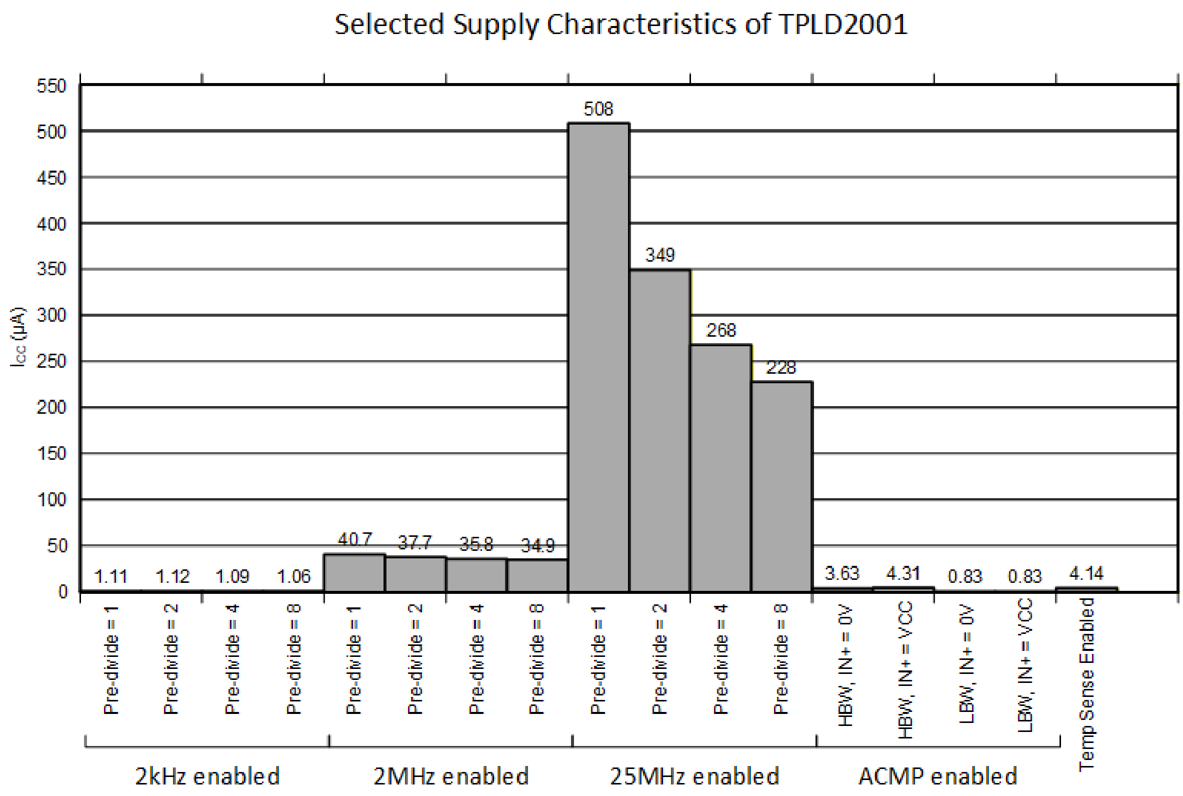

Figure 1-1. Selected Supply Characteristics of TPLD2001 at VCC = 5V

Many applications do not require the oscillator to be running at all times. In these situations, turning off the oscillator when not in use can extend battery life significantly. TPLD has two main methods of dynamically controlling the oscillator. One of these is the Auto Power On feature, and the other is the strategic use of the oscillator PDWN input.

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2 Oscillator Auto Power On

By default, a TPLD oscillator is set to Auto Power On mode. In this configuration, the oscillator turns on only when needed by specific TPLD elements. Among these elements are the One Shot, the Counter, and the Delay blocks. In InterConnect Studio, these blocks' ability to turn the oscillator on and off are denoted by a dashed line connecting them to the oscillator. If a block is not connected to the oscillator by a dashed line, the block cannot control the oscillator. The InterConnect Studio design shown in Figure 2-1 shows that the One Shot can turn the oscillator on and off, but the Pattern Generator cannot.

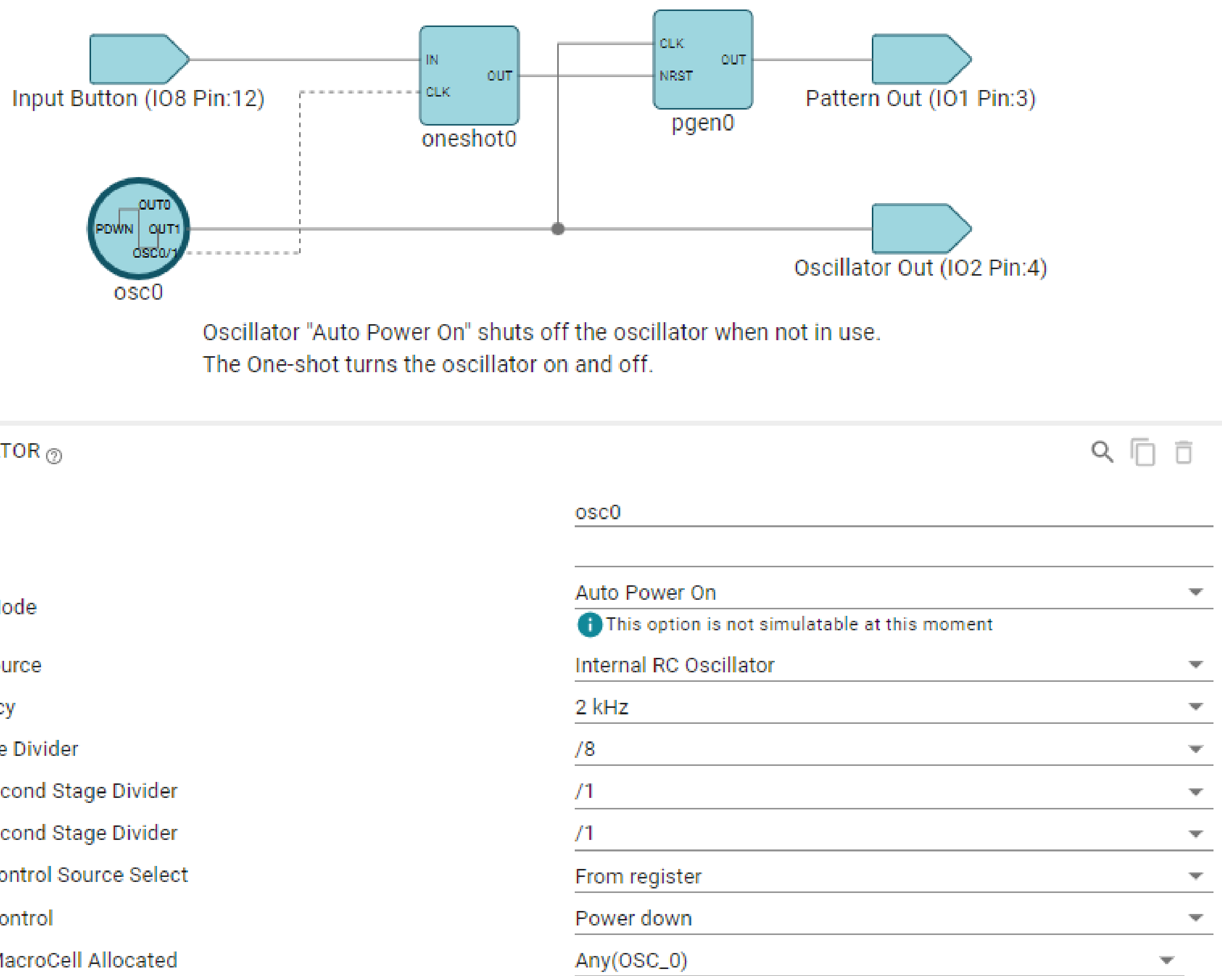

Figure 2-1. InterConnect Studio Block Diagram of a Remote Control Application Utilizing the Auto Power On Feature of the Oscillator

The design shown in Figure 2-1 functions like a remote control. The TPLD waits for the rising edge of an input at IO8 such as a button press then outputs a pre-determined binary pattern at IO1. After the pattern is output a single time, the oscillator turns off and waits for the next button press. The oscillator turns on for exactly 12 clock cycles before turning off again.

This design features a One Shot that controls the oscillator. A Pattern Generator block in InterConnect Studio needs a clock signal to function but cannot control the oscillator, so the One Shot is necessary to turn the oscillator on and off. To maintain that the pattern has time to output, the One Shot is configured to turn on the oscillator for exactly 12 clock cycles before turning back off.

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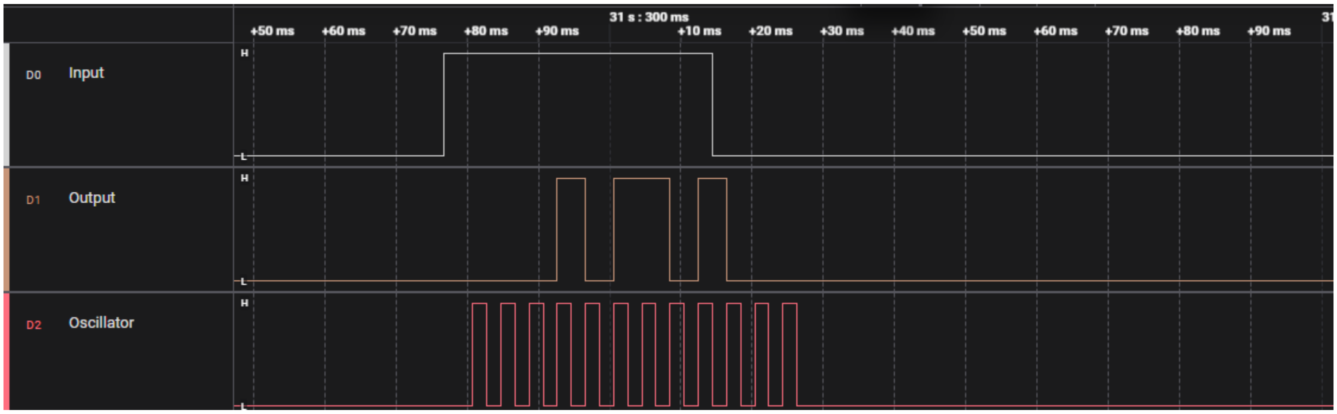

Figure 2-2. Auto Power On Timing Diagram With 40ms Input

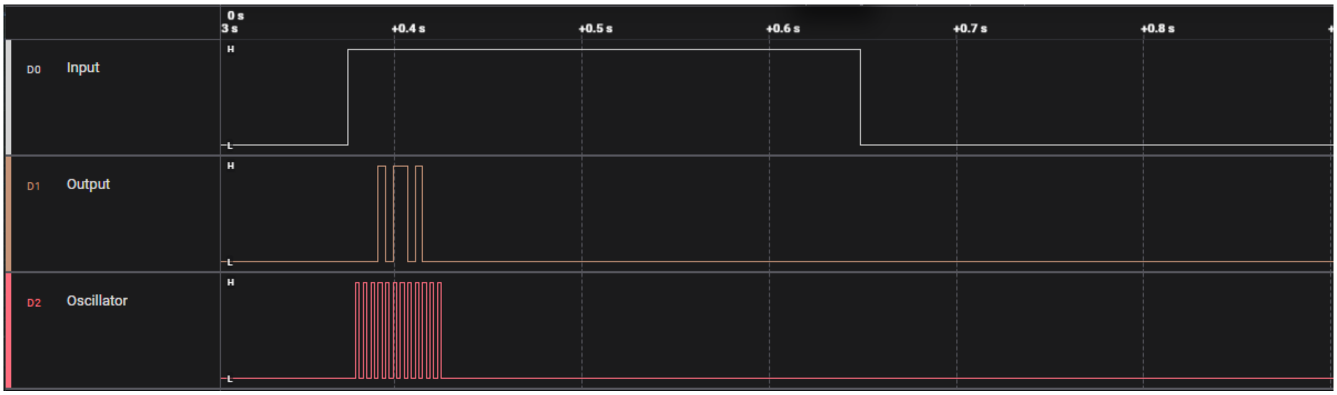

Figure 2-3. Auto Power On Timing Diagram With 250ms Input

The waveform in Figure 2-2 and Figure 2-3 show that after the initial rising edge, the One Shot turns on the oscillator for exactly 12 clock cycles, allowing the Pattern Generator to output its pattern of 0x002D. It does not matter whether the Input remains high or drops before the output is complete. When the TPLD sees a rising edge, the TPLD outputs the pattern a single time.

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3 Utilizing the Oscillator PDWN

The PDWN input to the oscillator forces the oscillator off. When used in combination with the Auto Power On mode, the oscillator ignores a MacroCell's command to turn on. When used with Force Power On mode, the oscillator is always on unless the PDWN oscillator input is utilized.

Figure 3-1 shows an alternative design for a remote control application. In this application, the Pattern Generator continuously outputs the pattern for as long as the NRST input is high and as long as there is a clock signal at the CLK input. However, the Pattern Generator cannot turn the oscillator on and off, but leaving the oscillator on while waiting for an input wastes power.

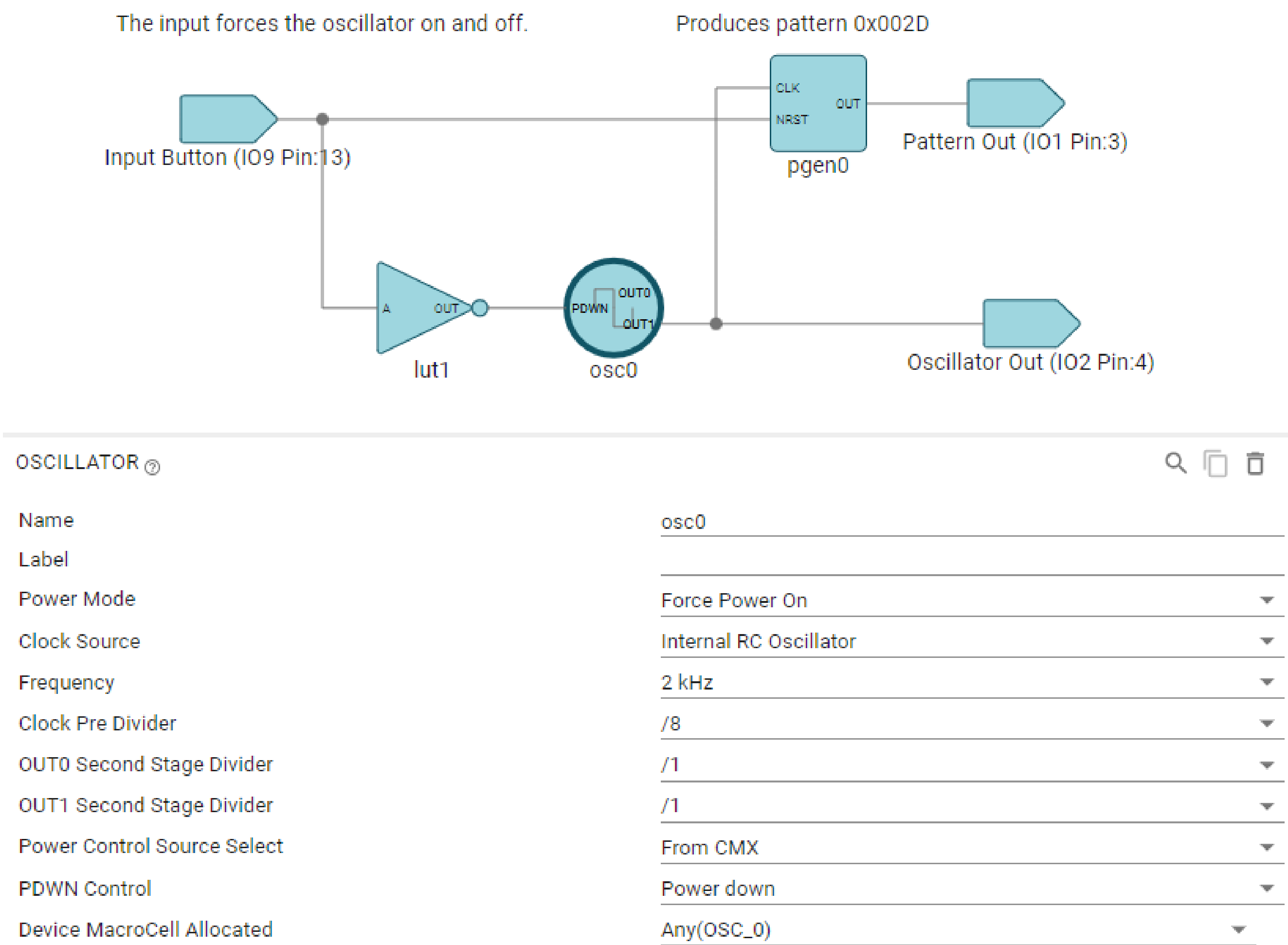

Figure 3-1. InterConnect Studio Block Diagram of a Remote Control Application Utilizing the Oscillator PDWN Pin

To achieve this functionality, the oscillator is set to Force Power On mode, but the oscillator's PDWN input is used to keep the oscillator off when not in use. This significantly reduces the power consumption of the TPLD when on standby when compared to leaving the oscillator always on.

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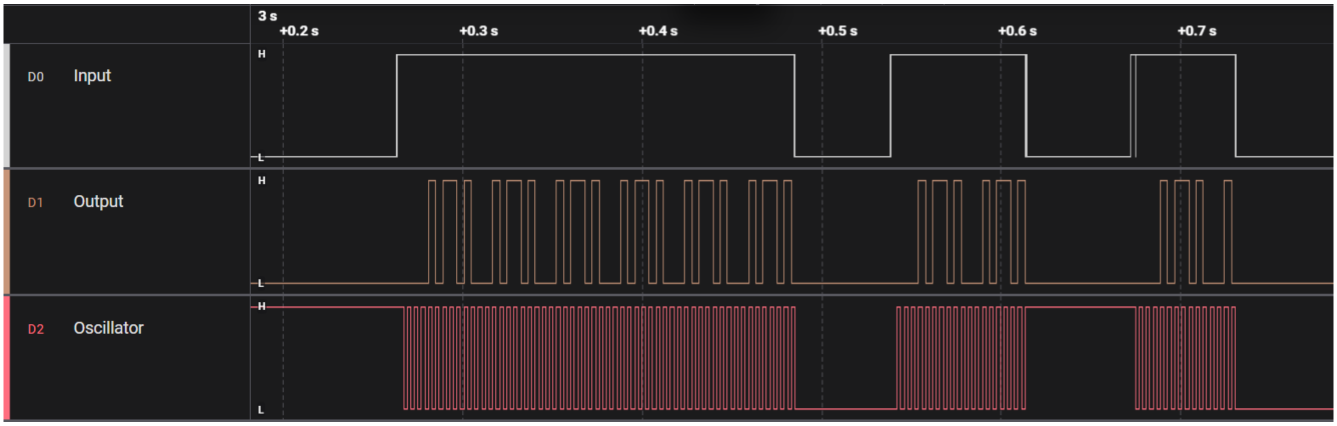

Figure 3-2. Force Power On Timing Diagram

The waveform shown in Figure 3-2 illustrates that for this design, the oscillator is only active while the input is high. Note that if the input falls while the oscillator is high, the oscillator remains high until the oscillator is turned on again. Additionally, the Pattern Generator can be cut off in the middle of a pattern.

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4 Summary

When designing for low-power or battery-operated systems using TPLD, proper utilization is crucial for power optimization. The first is to choose an appropriate oscillator and pre-divider for the design. Next, turn off the oscillator when not actively being used. The method for controlling the oscillator depends on the application and can utilize either the Auto Power On mode or the Force Power On mode. These features make TPLD an attractive option for small, battery-operated applications.

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5 References

- TPLD allows designers to design-in and integrate logic and level translators into a single device, simplifying the BOM and reducing design size. For more information on TPLD, visit the TPLD1202 product page or ask our engineers a question on the TI E2E™ Support Forum. Texas Instruments, *TI Programmable Logic Devices*.

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