6. iCE40 UltraLite and iCE40 UltraPlus RGB Driver

iCE40 UltraLite and iCE40 UltraPlus support an RGB DRV hardened IP block that provides high current drive outputs. This allows the iCE40 UltraLite and iCE40 UltraPlus devices to drive Service LED signals directly, reducing the need for an external component. There is one such block per device located at the top I/O bank. The RGB LED driver block provides an open-drain driver for the LED DIODE with constant current from 4 mA to 24 mA in 4 mA step in full current mode or from 2 mA to 12 mA in 2 mA step in half current mode with up to +/-10% accuracy. Each of the steps is controlled by an HDL attribute. The LED driver reference can be enabled within 100 µs time.

Key features of the iCE40 UltraLite and iCE40 UltraPlus RGB Driver:

- Supports three Service LEDs (RGB) with sink current between 4 mA and 24 mA in steps of 4 mA or 2 mA and 12 mA in steps of 2 mA per device ball.
- Supports pins being independently configured as either a high-current sink or an OD GPIO.
- Accuracy of up to ± 10% of the amount of current being sunk at all steps when the voltage at the device pin is at least 0.5 V. Current matching within ± 5% across all three Service LEDs for the same current sink setting (for example, if all three LED pins are programmed to sink 12 mA, their actual sink current is within 5% of each other in the worst case.)
- Consumes ≤ 0.5 µA typical static current (typical, 1.2 V, 25 °C) and ≤ 1 µA max static leakage current per device ball when operating in standby mode (LED off). Consumes ≤ 1.0 mA of current (typical, 1.2 V, 25 °C) per device ball associated with the support circuitry (excluding the actual current being sunk) when operating in LED on mode.
- Wakeup time (from off to on -- fully functional) ≤ 100 µsec.

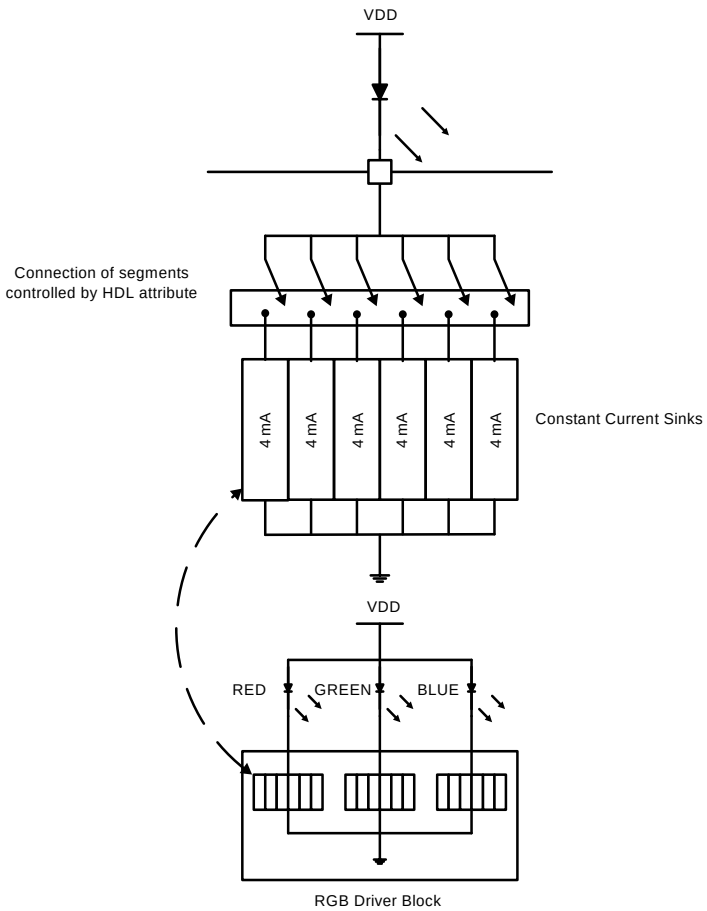

Figure 6.1. iCE40 UltraLite and iCE40 UltraPlus RGB Driver Block Diagram

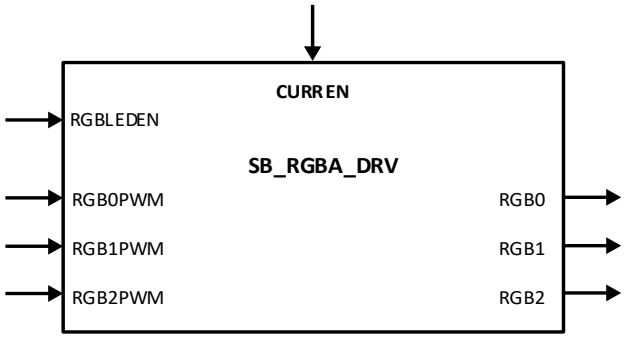

Figure 6.2. iCE40 UltraLite and iCE40 UltraPlus RGB Port Level Diagram

Table 6.1. iCE40 UltraLite and iCE40 UltraPlus RGB Port List

Name	I/O	Level	Description	Notes
RGB0	O	IOPAD	24 mA RGB PAD	64 kHz
RGB1	O	IOPAD	24 mA RGB PAD	64 kHz
RGB2	O	IOPAD	24 mA RGB PAD	64 kHz
RGBLEDEN	I	Digital	Enable Control for RGB LED	Active HIGH
RGB0PWM	I	Digital	Pulse width modulated control signal for RGB_PAD0	64 kHz, Active HIGH
RGB1PWM	I	Digital	Pulse width modulated control signal for RGB_PAD1	64 kHz, Active HIGH
RGB2PWM	I	Digital	Pulse width modulated control signal for RGB_PAD2	64 kHz, Active HIGH
CURREN	I	Digital	Power up	Power up signal, Active HIGH

RGB0

Open-drain output of the RGB Driver connected to the device pin for RED LED

RGB1

Open-drain output of the RGB Driver connected to the device pin for GREEN LED

RGB2

Open-drain output of the RGB Driver connected to the device pin for BLUE LED

RGBLEDEN

Input to the RGB Driver, Enable Control for RGB LED, Active HIGH

RGB0PWM

Input to the RGB Driver, pulse width modulated control signal for controlling RGB0 output. Connects to Embedded PWM IP or FPGA logic, Active HIGH

RGB1PWM

Input to the RGB Driver, pulse width modulated control signal for controlling RGB1 output. Connects to Embedded PWM IP or FPGA logic, Active HIGH

RGB2PWM

Input to the RGB Driver, pulse width modulated control signal for controlling RGB2 output. Connects to Embedded PWM IP or FPGA logic, Active HIGH

CURREN

Input enabling mixed signal control block to supply reference current to RGB driver. Enabling the mixed signal control block takes 100 µs to reach a stable reference current value.

6.1. SB_RGBA_DRV Attribute Description

The SB_RGBA_DRV primitive contains the following parameter and their default values:

```
Parameter CURRENT_MODE = "0b0";
Parameter RGB0_CURRENT = "0b000000";
Parameter RGB1_CURRENT = "0b000000";
Parameter RGB2_CURRENT = "0b000000";
```

Parameter values:

```
"0b0" = Full Current Mode
"0b1" = Half Current Mode
"0b000000" = 0mA. // Set this value to use the associated SB_IO_OD instance at RGB LED
location.
"0b000001" = 4 mA for Full Mode; 2 mA for Half Mode
"0b000011" = 8 mA for Full Mode; 4 mA for Half Mode
"0b000111" = 12 mA for Full Mode; 6mA for Half Mode
"0b001111" = 16 mA for Full Mode; 8 mA for Half Mode
"0b011111" = 20 mA for Full Mode; 10 mA for Half Mode
"0b111111" = 24 mA for Full Mode; 12 mA for Half Mode
```

RGB PAD can also be used as an open-drain GPIO with LVCMOS. These are the differences in characteristic compared to regular iCE40 GPIO.

- No P-channel pull up driver.
- No weak pull up.
- LVCMOS input buffer will be power down when using as RGB Driver.