Converter translates Bayer raw data to RGB format

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CMOS image sensors include the color filters of an RGB (red/green/blue) Bayer array, which lets the sensor detect colors. The image data, the output from the image sensor, is Bayer raw data (Figure 1). Unfortunately, most consumer-grade image-displaying devices require an RGB-image-data format with red, green, and blue in each pixel’s data. Therefore, you often need a Bayer-raw-data-to-RGB converter between an image sensor and a displaying device. This Design Idea describes such a converter in Verilog HDL (hardware-description language). Click here to download the code to implement into a CPLD or an FPGA.

![Diagram](image_url)

Figure 2 A CPLD processes Bayer raw data into 24-bit RGB data.

To make the design easy to understand, the RGB data is only 24 bits deep. A 320×240-pixel test-bench pattern verifies the design (Figure 2). The image data for red, green, and blue are 88h, 66h, and 22h, respectively. Figure 3 shows the timing of the converter, and Figure 4 shows the flow...
The LVAL (line-valid) cap signal is the synchronized line-valid signal for reading the data. The process begins when the FVAL (frame-valid)-data signal goes high. When that action occurs, sensor data begins writing to FIFO, FIFO₂, and the data register. After saving the data, FIFO₁ reads out the data. FIFO₂ and the data register read their data at the same time. Those readouts occur one clock cycle after FIFO₁ starts reading. The next 24-bit RGB data remains the same in the data register, and it combines the data from FIFO₁ and FIFO₂, which read out at the same rising edge of the clock. The line-count signal shows whether the data is even or odd, which influences the combinational sequences of the data that reads out from FIFO₁, FIFO₂, and the data register.

Figure 5 is the ModelSim simulation waveform of the converter. The 24-bit RGB output-data values 88h, 66h, and 22h are red, green, and blue data, respectively. The figure shows the 24-bit RGB data as having red, green, and blue values of 88h, 66h, and 22h, respectively, during every line-data period. The line-data period matches the default pixel value in the image data’s test-bench pattern.