

Light-to-Frequency EVM

User's Guide

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LIGHT-TO-FREQUENCY CONVERTER EVALUATION MODULE OVERVIEW

The Light-to-Frequency Converter Evaluation Module facilitates evaluation of the TAOS family of light-to-frequency converter optical sensors through the use of a motherboard and a set of device-specific daughterboards. The EVM is designed to interface via a USB port to a host PC running the Windows-compatible host software application. Several of the daughterboards also feature light-emitting diode (LED) light sources which can be controlled from the host software to allow evaluation of the sensors in a variety of physical sensing arrangements.

GETTING STARTED

On most PCs, installation will automatically start when the CD-ROM is inserted into the drive. If the installation does not begin:

- Click **Start**
- Click **Run**
- Type **D:\setup** and press **Enter**. IMPORTANT: Use the appropriate drive letter in the above command to install the software. CD-ROMs are commonly **D:**
- The installation program will guide you through the product installation

Refer to the ReadMe file on CD for the latest installation instructions.

USB EVM HARDWARE AND DRIVER DESCRIPTION

The specification and system requirements for the hardware portion of the Light-to-Frequency (LTF) EVM USB module follow:

System Requirements: Notebook or Desktop PC running Windows 98, 2000, NT4.0, XP

Host Connection: USB v2.0 using A-type connector

EVM Connection: Mini B-type connector

Software Installation: CD-ROM

The Light-to-Frequency Converter EVM comes assembled and consists of three main parts:

1. A **motherboard**
 2. **Set of Six Daughterboards**, each with a different light-to-frequency converter sensor
 3. A **USB cable**
- **NOTE:** Please leave the LTF EVM installation CD-ROM inserted in the drive. This will simplify the USB Driver Installation steps. The LTF EVM USB driver is located in the D:\FTDI directory on the CD-ROM. This directory can be specified if it is necessary to manually install the driver from a specific location.

Using the enclosed USB cable, plug the mini-B connector into the EVM module. Using the other end of the cable, plug the USB A-connector into a USB port on the computer. A Wizard should appear instructing the user to load a USB driver. See the "Light-to-Frequency EVM Quick Installation" for instructions on loading the USB driver.

See Appendix for schematic diagrams of the LTF EVM motherboard and daughterboards.

Motherboard

The Light-to-Frequency Converter EVM motherboard consists primarily of an integrated BASIC Stamp BS2pe microcontroller, two Atmel ATtiny13 microcontrollers used as coprocessors, and a USB interface. Two sockets, referred to as socket A (J4) and socket B (J7) (see Figure 1) accept any of the six sensor daughterboards. There is a coprocessor associated with each daughterboard, and these are labeled "A" and "B" on the motherboard. Frequency measurements, period measurements and PWM control of the daughterboard LEDs are performed by either the BASIC Stamp or the coprocessors under BASIC Stamp control. The EVM is shipped with an application programmed into the BASIC Stamp which controls the communication between the BASIC Stamp, the sensor coprocessors, and the host PC software application.

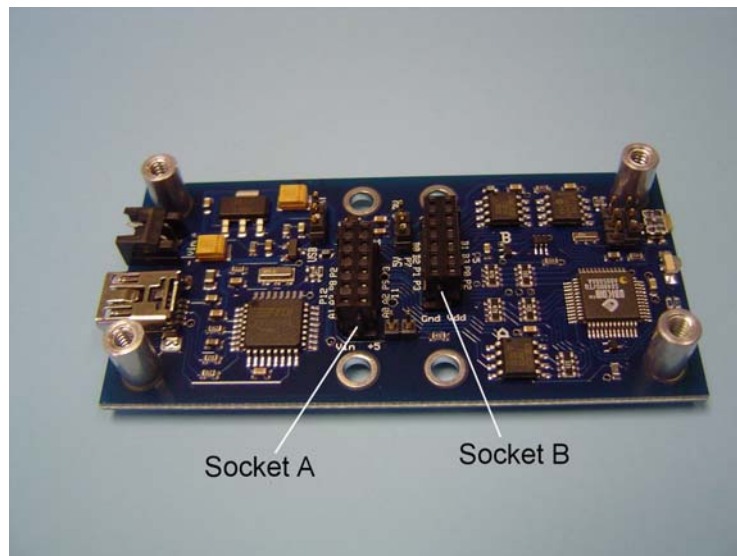


Figure 1 - EVM Motherboard

The EVM daughterboards are hot-pluggable, that is, they may be installed and removed while the EVM and host application is running. The host application will recognize the installed daughterboard(s) and invoke the appropriate daughterboard window(s).

Daughterboards

Six daughterboards are included with the Light-to-Frequency Converter EVM supporting the evaluation of the following devices: TSL230RD, TSL235R, TSL237S, TSL237T, TSL245R, and TSL238D. Some of the daughterboards contain LEDs in either transmissive or reflective configurations. The daughterboard configurations are summarized below in Table 1.

Table 1 - Daughterboard Configuration and Sensing Geometry

Device	LED	Configuration	Geometry
TSL230RD	N/A	N/A	Vertical
TSL235R	Red	Transmissive	Horizontal
TSL237S	Red	Transmissive	Horizontal
TSL237T	Infrared	Reflective	Vertical
TSL245R	Infrared	Reflective	Horizontal
TSL238D	Infrared	Reflective	Vertical

Any of the six daughterboards may be installed in either of the sockets A or B. To install a daughterboard, align the connector on the bottom of the daughterboard with either of the sockets A or B. Note that the connector is polarized and the daughterboard should be inserted such that the two mounting holes in the corners opposite the side with the connector align over the threaded standoffs on the motherboard. Press firmly over the connector to make sure that the daughterboard is seated firmly in the socket. As explained earlier, the PC host application will recognize which daughterboards are installed and invoke the appropriate windows inside the main application window. Optionally the daughterboards may be held in place with 3/16" 4-40 machine screws inserted through the two mounting holes into the threaded standoffs.

LIGHT-TO-FREQUENCY CONVERTER EVM APPLICATION SOFTWARE

Software Execution

To start the LTF EVM host application, click:

Start -> Programs -> TAOS Light-to-Frequency Converter EVM -> Light-to-Frequency Converter EVM

After the EVM application is executed, a Main dialog window (see below) will appear.

Graphical User Interface (GUI)

The LTF EVM demo application consists of a main window with a control section on the left-hand side, and up to two daughterboard windows depending upon how many daughterboards are installed. Additionally a Strip Chart recorder window can be invoked which displays the data in a graphical representation. Each window is explained in more detail in the following sections.

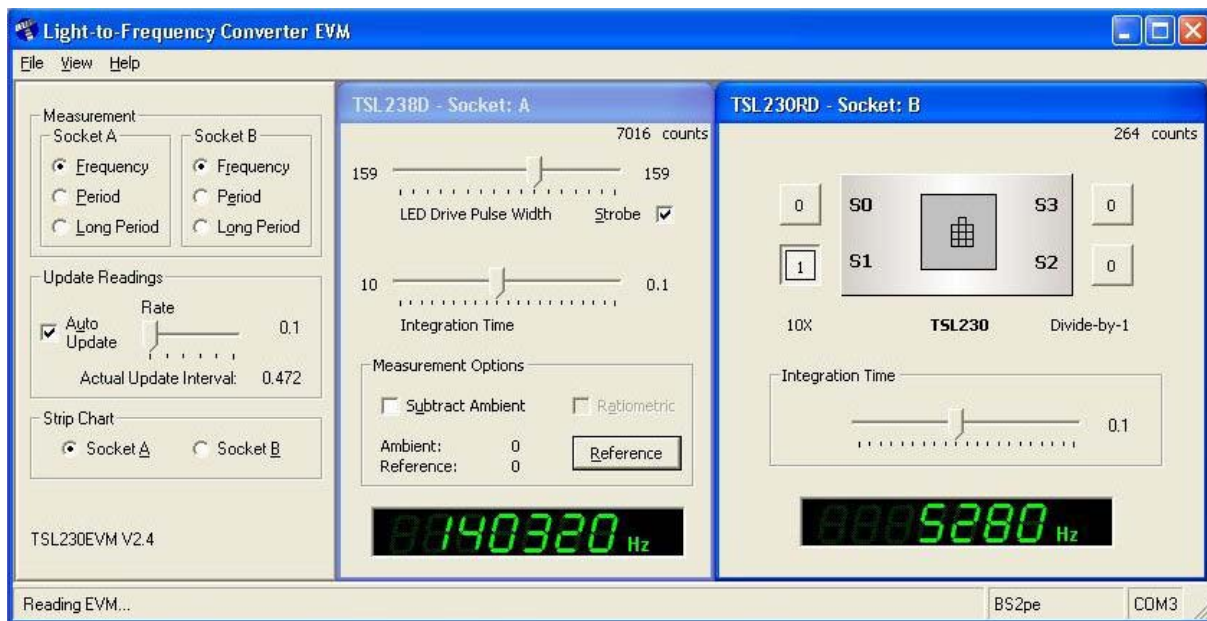


Figure 2 - Light-to-Frequency EVM Main Window

Control Window

The control window appears at the far left of the main application window. It provides control over measurement mode and measurement update rate of both daughterboard windows. Each section is explained in detail below.

Measurement Mode

The Measurement section allows selection of measurement mode of the sensor output frequency. Available options are: Frequency, Period, and Long Period

Frequency measurement uses the technique of counting pulses, or transitions (low-to-high) on the sensor output pin. The counting takes place over a specified measurement time interval, or integration

time. This integration time is controlled independently for each daughterboard. The frequency is then determined by dividing the count value by the integration time to get units of Hz (cycles per second). Since the number of counts obtained during the integration time interval determines the measurement resolution, resolution can be improved by using longer integration times. The maximum count value that can be obtained is 65535 (16-bit), so integration time must be chosen so that this maximum count value is not exceeded.

Period measurement uses the technique of measuring the time between pulses (i.e. low-to-high transitions) on the sensor output pin. The EVM uses an internal hardware-based timer to measure this time interval. The measurement resolution is $2\mu\text{s}$ with a maximum count value of 65535, therefore the maximum time interval (period) that can be measured is 0.131s.

Long period measurement uses a software loop to measure the time interval rather than a hardware-based timer. After establishing an initial condition (such as a high-to-low or low-to-high transition) this technique samples the output state from the sensor and increments a value used as a counter. This process repeats until the state changes from the initial condition. The period is then proportional to the number of counts obtained. Actual time is calculated by multiplying the count value by the time it takes to execute a single pass through the loop. On the BS2pe used on the EVM, this loop time is 0.00119s, or 1.19ms, and the maximum count value is 65535. Therefore the maximum time interval (period) that can be measured is about 78s.

Each of the above three measurement techniques can give different resolution for a given frequency. In general, for high frequencies it is best to use the Frequency measurement mode since this gives a relatively high count value in a reasonable amount of time (integration time). For lower frequencies, a longer integration time is required to get a high count value (high resolution). In this case Period measurement mode can be used, which will result in a higher count value in a shorter amount of time, since only the measurement of one period, or cycle, is required. For very low frequencies (less than about 8Hz, or $1/0.131\text{s}$), the maximum count of the Period measurement mode can be exceeded. In this case the Long Period measurement mode can be used, allowing periods up to 78s (about 0.01Hz) to be measured, although measurement times of this length are not practical in most cases.

Measurement mode can be selected independently for the daughterboards in sockets A and B.

Update Readings

The host software application periodically polls the EVM automatically and requests a measurement. This polling, or update, interval can be adjusted in several steps between 0.1s and 10s using the Rate slider. Note that this update rate is independent of the integration time used to measure frequency. Therefore if the selected integration time exceeds the selected update rate, the update rate will be decreased to allow the frequency measurement to be made. Additionally, if two daughterboards are installed and measuring frequency, both integration times must be accommodated. Therefore the actual update rate may be much slower than the rate selected. The actual update interval is shown below the Rate slider. Automatic measurement update can be disabled and enabled using the Auto Update check box.

Strip Chart Data Source

A strip chart may be invoked which provides a visual representation of the measurement data (for more information on the Strip Chart see the section entitled Strip Chart). Option buttons select the source of the data for the strip chart from either Socket A or Socket B.

Daughterboard Windows

Daughterboard windows provide control and display measurement results for each daughterboard installed in the EVM motherboard. Although there are six different daughterboards, there are only two

types of daughterboard windows – one for the TSL230RD daughterboard which does not utilize an LED, and one for the other five daughterboards which utilize LEDs.

TSL230RD Daughterboard Window

The TSL230RD daughterboard window provides a graphical representation of the programmable features of the TSL230RD device. The TSL230RD daughterboard window can be seen on the right in Figure 2. Buttons are used to control the state of the sensitivity and output scaling input programming lines on the evaluation device. The pattern of squares in the middle of the picture represents the configuration of active photodiodes in the 100x, 10x, and 1x sensitivity modes. For more information on the TSL230RD please refer to the TAOS TSL230RD Programmable Light-to-Frequency Converter datasheet.

Integration Time

A slider provides adjustment of integration time between 0.01s and 3s for the frequency measurement of the TSL230RD evaluation device. See the section “Measurement Mode” for more information on frequency measurement.

Other Daughterboard Windows

The TSL235R, TSL237S, TSL237T, TSL245R, and TSL238D daughterboards share a common set of features and therefore share a common window format. This daughterboard window format is shown on the left in Figure 2. Controls are provided for LED brightness and sensor integration time, along with several measurement options involving the use of the LED source.

LED Drive Duty Cycle

The EVM uses a pulse width modulation technique to control the brightness of the LED on the daughterboard. Pulse width modulation varies the duty cycle, or percentage of time that the signal is high, of the drive signal to the LED. This drive signal is then low-pass filtered to provide a continuous DC signal. If the duty cycle is low, then the percentage of time that the LED is on is low (near 0%), and the average power, and thus the brightness, is low. If the duty cycle is high (near 100%), then the average power delivered to the LED is nearly maximum level. The duty cycle is controlled by an 8-bit value (0-255) input using the LED Drive Duty Cycle slider.

Strobe

The Strobe option controls whether the LED is turned off after the frequency measurement is made. If the Strobe check box is checked, then the LED will be turned on just before the measurement is made, and turned off after making the measurement. When the LED is turned on, it will be set to the brightness determined by the LED Drive Duty Cycle setting. Turning off the LED between measurements will prevent the light from one daughterboard from affecting the measurements of an adjacent daughterboard, and will minimize heating of the LED at high brightness levels.

Integration Time

A slider provides adjustment of integration time between 0.01s and 3s for the frequency measurement of the TSL230RD evaluation device. See the section “Measurement Mode” for more information on frequency measurement.

Measurement Options

There are two measurement options that may be activated when making measurements with the on-board LED. The ambient subtraction option is activated when the Subtract Ambient check box is checked. When this option is activated, each time the sensor is measured, an extra measurement is made with the LED off. This value is stored and displayed as “Ambient”. This value is then subtracted from the actual frequency measurement and the subtracted value is displayed in the reading window. The calculation used is as follows:

$$\text{Reading} = (\text{Signal} + \text{Ambient}) - \text{Ambient}$$

Ambient subtraction is useful in cases where measurements are being made using the LED in the presence of significant ambient light. Ambient subtraction only works well in situations in which the ambient light is steady or varying slowly. Flickering or rapidly varying ambient light will not be properly subtracted since the measured value may change between the time that the ambient and signal are measured.

Ratiometric measurements represent the measured value as a ratio between the most recent measurement and a previous reference measurement. Making a ratiometric measurement is a two-step process. First a reference value must be recorded. This is accomplished by setting up the desired reference condition, then clicking the Reference button. This reference value is then stored and displayed as "Reference". This value is used as the standard for subsequent measurements. The ratiometric measurement is calculated as follows:

$$\text{Reading} = \text{Signal} / \text{Reference}$$

Note that both measurement options can be used together. In this case, the following calculation is used:

$$\text{Reading} = (\text{Signal} + \text{Ambient} - \text{Ambient}) / (\text{Reference} + \text{Ambient} - \text{Ambient})$$

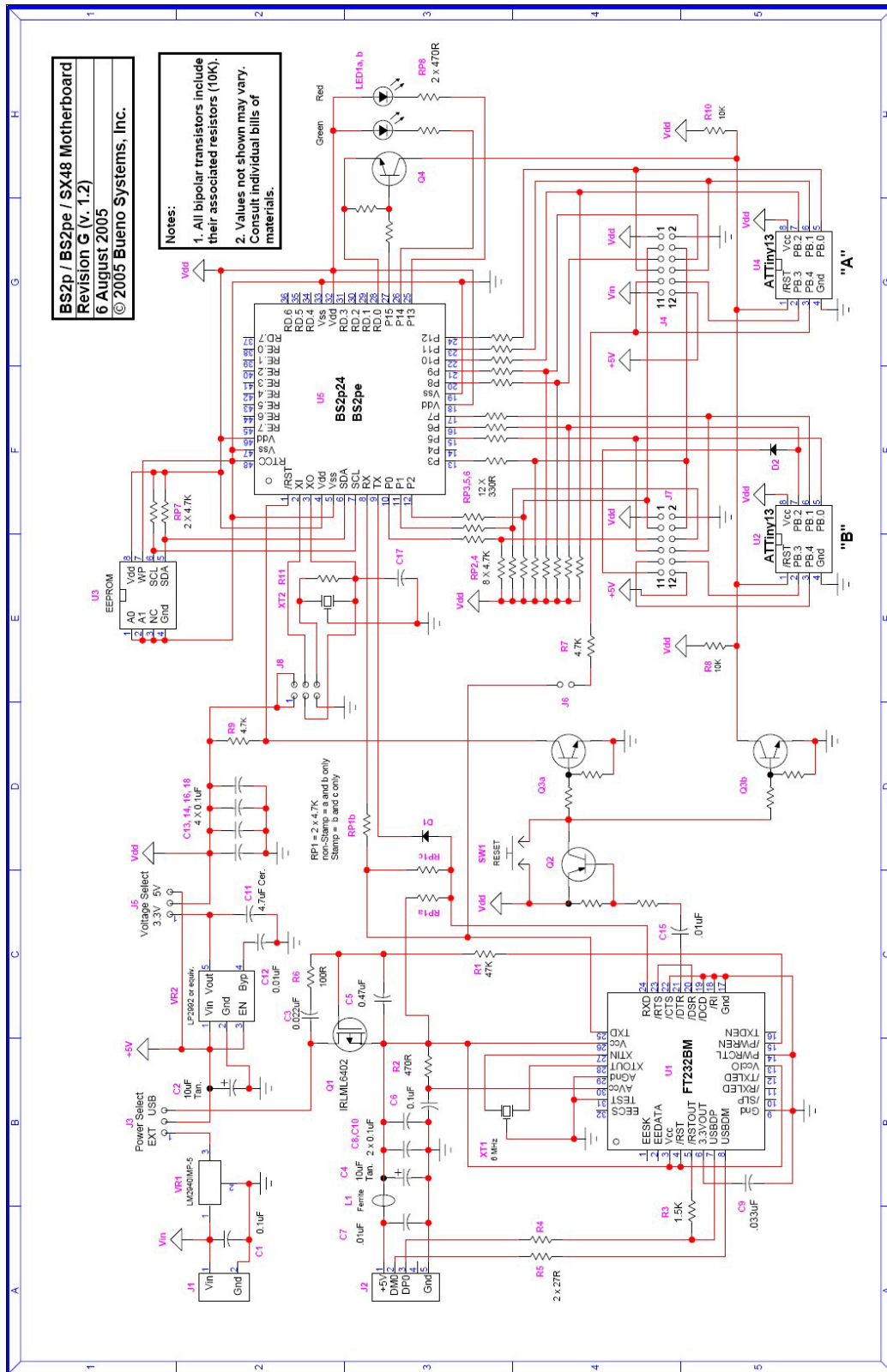
Strip Chart

The Strip Chart window is invoked by selecting menu option View, Strip Chart. The Strip Chart is a graphical representation of the EVM readings as time progressing from left to right. Each time a new reading is taken, the plot moves to the right and the new reading is added at the left. The Strip Chart is useful for visualizing slowly changing lighting conditions. The vertical scale may be set automatically or manually. The vertical scale is set automatically when the Auto check box is checked. When Auto is not checked, the vertical scale may be set using the Vertical Scale drop-down list. Note that if the vertical scale is set too low the plot may not appear (it will be off the top of the chart).

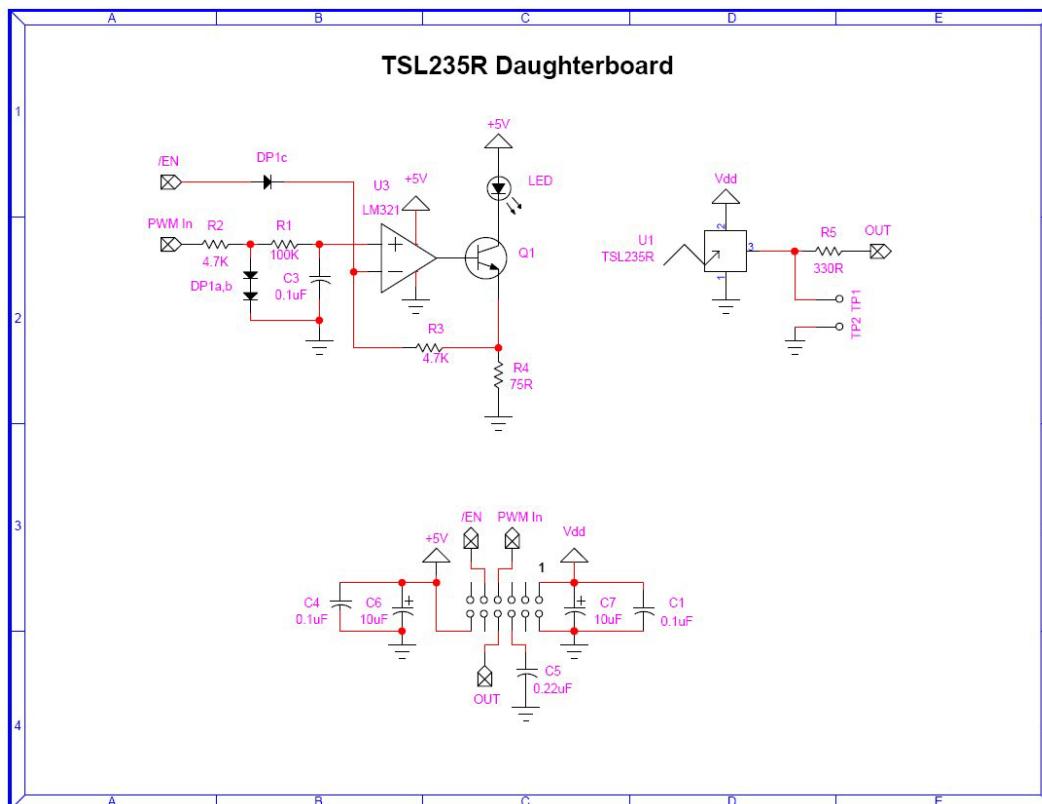
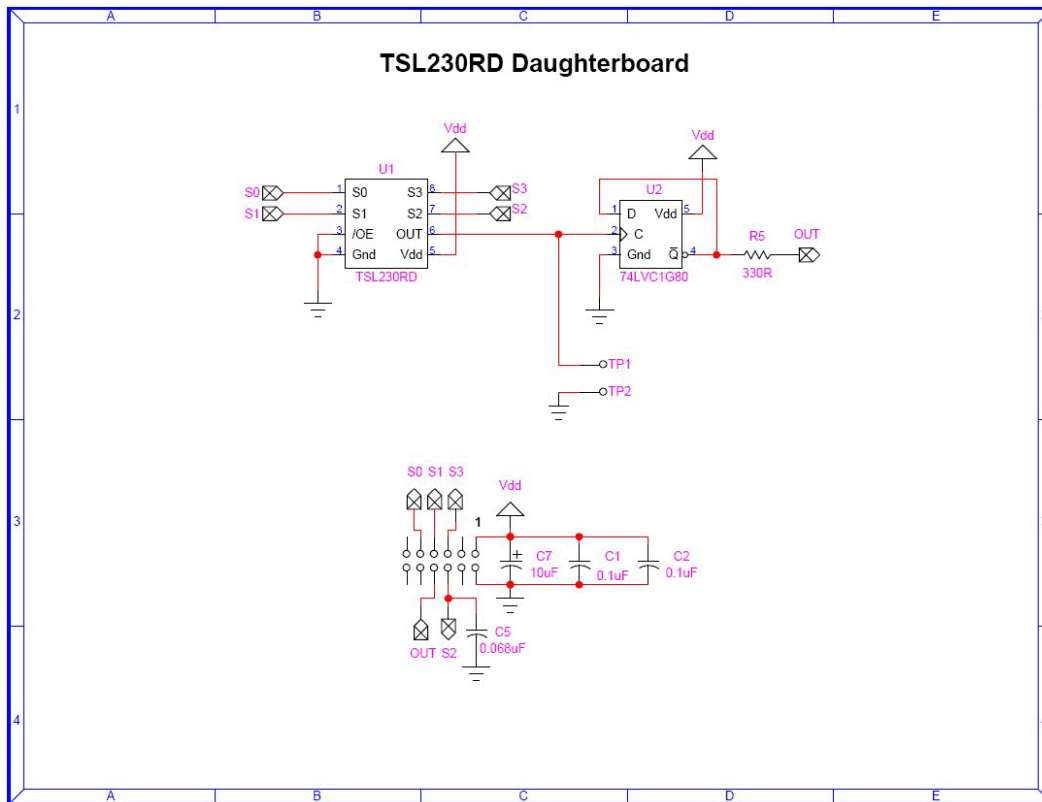
Closing the Application

To close the host application select menu option File, Exit, press Ctrl + Q, or click the close button in the main window control box.

Appendix



An Evaluation System for the TAOS Light-to-Frequency Converters



The image contains two circuit diagrams for daughterboards, labeled TSL237S and TSL237T. Both diagrams are presented on a grid with columns A-E and rows 1-4.

TSL237S Daughterboard:

- Input Stage:** A PWM input signal passes through a 4.7K resistor (R2) and a diode (DP1a,b) to a 100K resistor (R1). The signal is then fed into the non-inverting input of an LM321 op-amp (U3). The op-amp is powered by +5V and has its output connected to a transistor (Q1) through a 4.7K resistor (R3). The transistor's emitter is grounded, and its collector is connected to a +5V supply through a 75R resistor (R4). An LED is connected between the +5V supply and the collector of Q1.
- Divider Stage:** The output of the transistor driver is connected to the input of a 74LVC1G80 divider (U2). The divider is powered by Vdd and has its output connected to a 330R resistor (R5) and a test point (TP1). The divider's output is also connected to a test point (TP2).
- Bottom Section:** A multi-channel switcher circuit with a common output (OUT) and a +5V supply. It includes capacitors C4 (0.1uF), C6 (10uF), C7 (10uF), C1 (0.1uF), and C2 (0.1uF). A 0.15uF capacitor (C5) is connected to the output (OUT).

TSL237T Daughterboard:

- Input Stage:** Similar to the TSL237S, but the output of the transistor driver (Q1) is connected to a 22R resistor (R4) instead of a 75R resistor. The LED is labeled IRED.
- Divider Stage:** The output of the transistor driver is connected to the input of a TSL237T divider (U1). The divider is powered by Vdd and has its output connected to a 330R resistor (R5) and a test point (TP1). The divider's output is also connected to a test point (TP2).
- Bottom Section:** Similar to the TSL237S, but the capacitor C5 is 0.33uF instead of 0.15uF.

An Evaluation System for the TAOS Light-to-Frequency Converters

