Operational Description
P170033; Bluetooth on Flexi-tape

David Geiman

July 3, 2019

The Bluetooth on Flexi-tape product family is a group of flexible light strips consisting of Red-Green-Blue LEDs with an integrated Bluetooth low energy controller, all on the same 10 mm wide tape. Bluetooth low energy is a wireless personal area network technology designed and marketed by the Bluetooth Special Interest Group aimed at novel applications in the healthcare, fitness, beacons, security, and home entertainment industries. By using a smart-phone application, a user can control the intensity and color of the light strip. For this discussion, the product can be divided into two portions – a controller portion and an RGB LED portion.

The LED flexible tape portion is permanently attached to the controller. It consists of RGB LEDs arranged in multiple paralleled banks. Each parallel bank has three LEDs, with all the elements of each color (red, green, blue) connected in series strings, with a current limiting resistor in each string. The positive end of each series string connects to the raw 12-volt power supply bus that runs the length of the tape. The individual negative ends of the series strings connect to a low side bus respective to their color. The controller section can then adjust the light color and intensity of the LEDs using pulse driven low-side switches. LED flexible portion is available in different lengths and in 30 LEDs and 60 LEDs per meter densities.

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The controller is integrated into one end of the Flexi-tape on a 10 mm by 100 mm two-layer ridge board. It is built around a TeLink TLSR8266 programable system on a chip (U2). This device contains an integrated Bluetooth Low Energy transceiver as well as a 32-bit MCU with 16-kilobytes of SRAM and 512-kilobytes of internal flash memory. The Bluetooth transceiver is controlled by the TeLink BLE 4.2 Qualified Stack. The transceiver requires an off-chip antenna which is implemented as a trace antenna (A1) in this design. A network (R2, R6, L1, C6, C7) is placed between the controller and the antenna to match their impedances.

Very little external circuitry is needed for the controller. An external crystal (Y1) is required for its clock. There are tunable internal crystal loading capacitors (discussed in the calibration section) eliminating the need for external crystal load capacitors. The controller's power management section has integrated power-on and brown-out reset functions, requiring only a small amount of capacitance (C4, C12) on the reset pin.

The controller requires a 3.3-volt power supply. This is derived from the 12-volt external supply using a Holtek HT7533 low power, low drop-out regulator (U1). There is some power condition circuitry between the external supply connection and the regulator. Right off the power connections there is a fuse (F1) and a reverse-polarity diode (D1). That is followed by a low-pass RC filter (R1, C1). The regulator requires an input bulk capacitor (C2) and an output filter capacitor (C3). The 3.3-volt supply is connected to the controller's two DVDD pins, and three AVDD pins - each with a bypass capacitor (C5, C8, C9, C10, and C11). There is also a place on the board to install a three-pin header (P1) to use with the single-wire debug interface. This interface is used for programing and firmware debugging. Its only connections are to the 3.3-volt supply, ground, and the SWS pin on the controller.

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The driving of the RGB LEDs on the strip is done with three NPN bipolar transistors (Q1, Q2, Q3). The collector of each transistor connects to one of the low side bus lines for a given color. The base of each transistor connects to a general-purpose output pin of the controller through a base resistor (R3, R4, R5). When the controller sets a general-purpose pin high, the respective transistor is turned on and pulls its color bus line low, lighting that color on all the RGB LEDs. Using the typical pulse width modulation,

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the controller can then set the intensity and color of all the LEDs on the strip based on the settings chosen by the user with the smart phone application.

The RF circuity of the controller requires calibration to meet the performance specifications of Bluetooth devices. There are three settings involved in calibrating the system. One is the crystal loading capacitor value setting. This setting adjusts for the component-to-component differences of the controller's external crystal. The other two settings set the RF modulation level to ensure compliance to the Bluetooth specification. One setting is for the high end of the frequency band and the other is for the low end. These three setting are stored in flash memory and written to internal registers as part of the initialization routine. The calibration is done in accordance to TeLink's calibration procedures, which involve placing the product in a test fixture that measures the RF performance and writes the calibration settings to the flash memory using the single-wire debug interface.

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