Operational Description
P18060; Vista BT in Aftermarket Channel

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The Bluetooth in Aftermarket Channel is a Bluetooth Low Energy Controller for RGB lights. It consists of a rigid circuit board in a potted channel with lead wires for connection to a low side driven Red-Green-Blue light and 12-volt DC power. It has an integrated Bluetooth low energy controller for user interface using a smart phone application. Bluetooth low energy is a wireless personal area network technology designed and marketed by the Bluetooth Special Interest Group. By using a smart-phone application, a user can control the intensity and color of the attached light.

The controller is contained on a 13 mm by 100 mm two-layer rigid 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). A tuning network (C7, L2, C6, L3, L1) is placed between the controller and the antenna for impedance matching.

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 conditioning 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, 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.

The driving of the attached RGB light is done with three N-Channel MOSFETs (Q1, Q2, Q3). The drain of each transistor connects to one of the low side bus lines for a given color. The gate of each MOSFET connects to a general-purpose output pin of the controller through a gate resistor (R3, R4, R5). When the controller sets a general-purpose pin high, the respective MOSFET is turned on and pulls its color bus line low, lighting that color on the attached light. Using pulse width modulation, the controller can then set the intensity of the three colors on the light based on the settings chosen by the user with the smart phone application.

The MOSFETs are short-circuit protected by monitoring their source currents through a common sense resistor (R7). If the sum of the outputs exceeds ~26 amps, the voltage dropped across this sense resistor will be sufficient to turn on the base of an NPN bipolar transistor (Q4) as determined by a voltage divider network (R6, R8). The transistor's collector will then pull its collector low, against the pullup resistor (R9), and trigger an interrupt pin on the controller. The controller's firmware will then disable the outputs until the next power cycle.

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The RF circuitry 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 settings 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 procedure, which involves 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.