

DiSEqC™ Protocol and Low-Noise Block Voltage Regulator TPS65235 for Satellite – STB/TV

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ABSTRACT

Satellite STB/TV technology allows consumers to receive TV programming through a personal dish installed at their homes or permitted buildings. As the terminal in the signal-channel, the satellite STB/TV receiver consists of a dish antenna, low-noise block downconverters (LNBs) or external switches, and a satellite-TV decoder. A communication protocol the called *Digital Satellite Equipment Control* (DiSEqC™) controls the LNBs or external switches.

This application note focuses on how the DiSEqC protocol and LNB function. In addition, two DiSEqC reference designs, based on the LNB voltage regulator [TPS65235](#) from TI, are also discussed.

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1 DiSEqC™ System

DiSEqC is a communication bus between satellite receivers and peripheral equipment using only the existing coaxial cable. This protocol is an open standard with additions controlled by an industry agreement developed by the European Telecommunications Satellite Organization (EUTELSAT). DiSEqC can be integrated into consumer satellite installations to replace conventional analog switching, and minimize the changes required in the tuner-receiver or integrated receiver decoder (IRD).

A prime function of the DiSEqC system is to remotely select between two or more switchable alternatives, like the polarization of received signals. The purpose of the DiSEqC concept is to fix the pin functions (for example, polarization axis), and also their sense (for example, disabled = vertical polarization).

The DiSEqC system is based on presenting (or not presenting) the 22 kHz tone-signaling method. The amplitude of this 22-kHz tone signal is 650 mV peak-to-peak with ± 250 mV tolerance. To compensate for the voltage drop on the cable and trace, the detector must be able to respond to the amplitude down, to approximately 300 mV with ± 100 mV tolerance. TI recommends that the maximum amplitude applied in the bus is 1 V peak-to-peak.

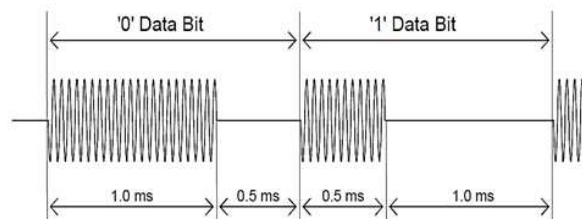


Figure 1. DiSEqC™ Modulation Scheme

With the 22-kHz carrier, the DiSEqC takes a baseband timing of 500 μ s with ± 100 μ s tolerance to transfer a 1/3-bit pulse-width-keying (PWK) coded signal period. In the 22-kHz time envelope, there are nominally 22 cycles for bit 0, and 11 cycles for bit 1 in each transmitted bit.

The full DiSEqC specification allows multiple different levels of application. The implementation level of the DiSEqC is indicated for clear classification between these levels. [Table 1](#) lists the broad levels.

Table 1. Definition of the DiSEqC™ Levels

Level	Control	Product Type
DiSEqC compatible	Tone Burst command	Simple 2-state switches only
DiSEqC 1.0	One-way DiSEqC commands	Receivers only
DiSEqC 2.0	Two-way DiSEqC commands	Receivers and accessories

DiSEqC is a trademark of Eutelsat.

The DiSEqC can support both the receiver implementation and accessories implementation. Table 2 lists the definitions of the different DiSEqC levels employed and proposed for receivers.

Table 2. Proposed Levels of Implementation for Receivers

Level	Directionality	Commands
DiSEqC 1.0	One-way signals	Control of at least four committed switches, capability of one repeat, and Tone Burst command
DiSEqC 1.1	One-way signals	Same commands as level 1.0, capability of the four uncommitted switches, transmission of up to two repeaters, and remote (head-end) tuning mode
DiSEqC 1.2	One-way signals	Same commands as level 1.1, capability of 1-way positioner commands
DiSEqC 2.0	Two-way signals	Control of at least four committed switches, capability of one repeat, Tone Burst command, LNB L.O frequency reading
DiSEqC 2.1	Two-way signals	Same commands as level 2.0, control of the four uncommitted switches, second repeat, and remote tuning mode
DiSEqC 2.2	Two-way signals	Same commands as level 2.1, positioner commands

The DiSEqC specification was added into the Tone Burst command, which can be detected by simple analog hardware. Two types of Tone Burst commands are adopted: the unmodulated to select Satellite A (SA) and the modulated for to select Satellite B (SB). The nominal burst period is 12.5 ms (see Figure 2). For the modulated type, this duration is built up by nine 0.5-ms pulses, and eight 1-ms gaps for bit 1. The modulation tolerances are $\pm 20\%$.

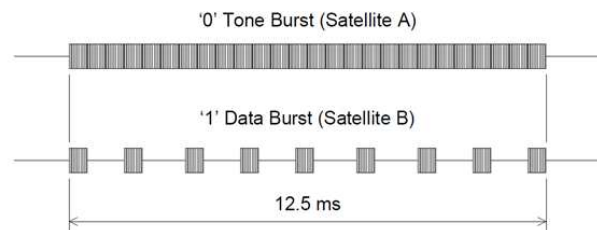


Figure 2. Timing Diagram for Tone Burst Control Signal

The timing request of the DiSEqC 1.x (including DiSEqC 1.0, 1.1, and 1.2) is more complex than the Tone Burst command. For DiSEqC 1.0, after the signal DC-voltage change, a gap of more than 15 ms must be observed to avoid the risk of malfunctions. Another minimum time gap of 15 ms follows the typical full DiSEqC 1.0 message of 54 ms. The SA/SB Tone Burst arrives before another time gap, which is also of a minimum time gap of 15 ms. A complete DiSEqC tone is built up by the full DiSEqC message, SA/SB Tone-Burst, and three time gaps (see Figure 3).

To avoid disturbing the simple analog hardware of the Tone Burst detector, ensure that the DC voltage-signaling step arrives long before the Tone Burst.

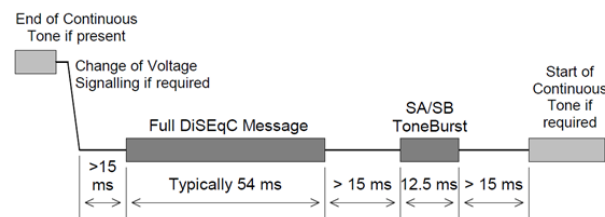


Figure 3. Timing Diagram for DiSEqC™ Level 1.0

The recommended DiSEqC 2.x (including DiSEqC 2.0, 2.1, and 2.2) tone timing is similar to DiSEqC 1.x. The difference is that between the message and the next tone, the master must leave a time gap of at least 150 ms. The DiSEqC command is built up by the master command and the slave reply. The master command is for both the DiSEqC 1.x and the DiSEqC 2.x; the slave reply is for DiSEqC 2.x, or above for the backward signal. The master command consists of the framing byte, address byte, and command byte. Sometimes an additional data byte is also carried in the command. The framing byte includes some high-level control and the slave address is marked in the address byte (see [Figure 4](#)).



Figure 4. DiSEqC™ Master Command Structure

The slave reply starts with the framing byte and the framing byte is followed by 1 or more data bytes (see [Figure 5](#)). The slave reply should take no more than 150 ms from the end of the command message.

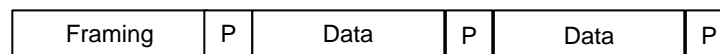


Figure 5. DiSEqC™ Slave Structure

2 Low-Noise Block Downconverter (LNB)

The LNB is a receiving device of satellite TV, which collects the radio waves from the satellite dishes. The LNB carries the signal to the indoor satellite TV receiver using only the coaxial cable, rather than a waveguide line which is relatively expensive and impractical. The LNB is typically built up by the band-pass filter, low-noise amplifier, frequency mixer, local oscillator, and intermediate frequency (IF) amplifier (see [Figure 6](#)).

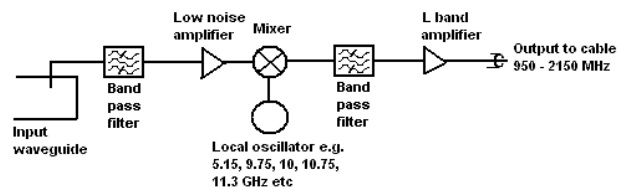


Figure 6. LNB Block Diagram

Because the TV signals are transmitted at radio frequency (microwaves) through satellites, based on the super-heterodyne principle, the LNB converts the captured high-frequency signals to similar ones at a much lower frequency, IF. IF in the LNB block, a fixed frequency generated by the local oscillator, is mixed with the incoming signal to produce two signals equal to the sum of their frequencies and the difference, then the frequency sum signal is filtered out and the frequency difference signal (the IF) is amplified and sent to the receiver through the cable. The band-pass filter only lets the intended frequency bandpass through it to the low-noise amplifier in the following stage. Normally a universal LNB can receive signals from two separate frequency bands (the low band and the high band). Band selection is made by the control signal sent from the associated satellite receiver.

As long as the satellite TV signals are polarized, more TV channels can be transmitted at a given frequency band, but this method requests the receiving terminal filter incoming signals based on their polarizations. To achieve better performance, normally two satellite TV signals are transmitted on the same frequency or some closely adjacent frequency. Two different polarization methods are widely adopted in the satellite TV transmission; one is the linear polarization and the other is the circular polarization. The linear polarization defines the wave by the direction, vertical or horizontal. The transmitted wave passing through the circular polarization does not change its strength but it does change its direction in a rotary manner. Depending on the direction in which the electric field vector rotates, the circular polarization can be referred to as right-handed (right) or left-handed (left).

In universal LNB, the band selection (high and low band) is controlled by presenting the 22-kHz tone with specific definition of the DiSeQc protocol. The polarization is decided by the receiver through two different DC signal levels, normally a 13-V signal and a 18-V signal (Table 3).

Table 3. Universal LNB Control Manner

Power	Band	Polarization
13 V	Low	Vertical, right
18 V	Low	Horizontal, left
13 V + 22 kHz	High	Vertical, right
18 V + 22 kHz	High	Horizontal, left

3 LNB Voltage Regulator TPS65235 Implementation

3.1 Brief Introduction

Because the universal LNB is controlled by DC signal levels and 22-kHz tone presentation, a monolithic semiconductor IC, which can provide both 13-V and 18-V DC signal and the 22-kHz tone, is ideal for the design of the LNB and minimizes the total BOM size. The TPS65235 device from TI is the voltage regulator supporting both DiSEqC 1.x and DiSEqC 2.x, and offers a complete solution for the LNB with simple design and I²C standard interface. For more details, see the [TPS65235 data sheet](#).

3.2 Component Selection Guidelines

3.2.1 Reference Design Supporting DiSeqC™1.x Protocol

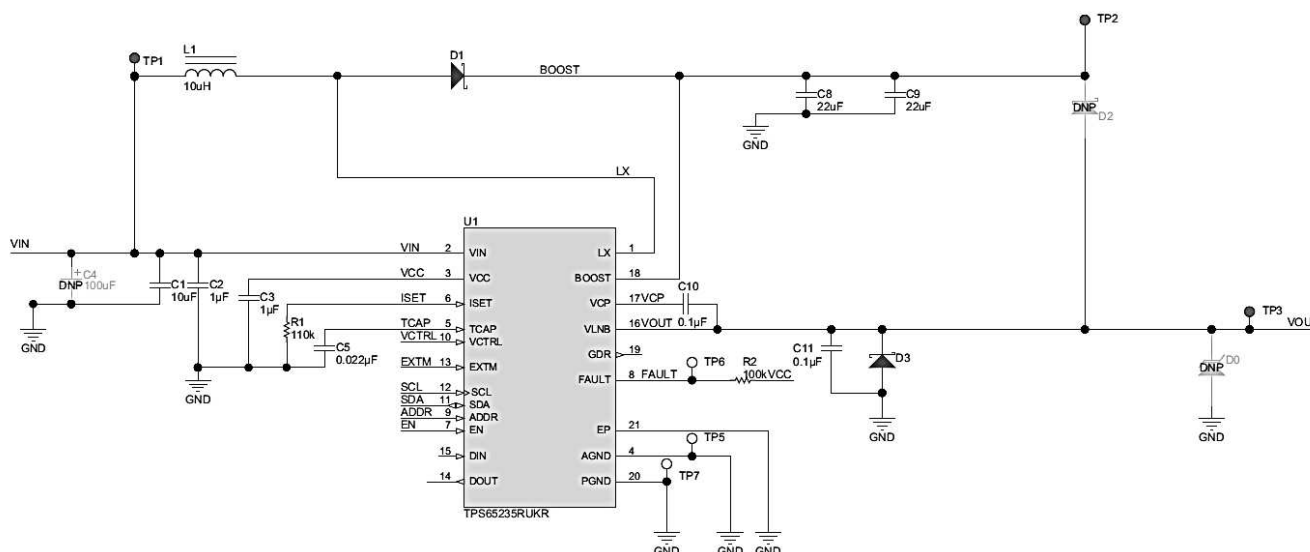


Figure 7. TPS65235 DiSEqC™ 1.x Schematic

Because DiSeqC 1.x supports 1-way communication (receiver only), [Figure 7](#) is only recommended as a reference. Pay special attention to the capacitors; TI highly recommends using at least X7R or X5R rating and 1206 size, if you want to achieve lower LNB output ripple (see [Figure 8](#)). If the surge test is needed for the application, add diodes D0 and D2 as the external protection components. If the application does not require any surge test, D0 and D2 can be removed.

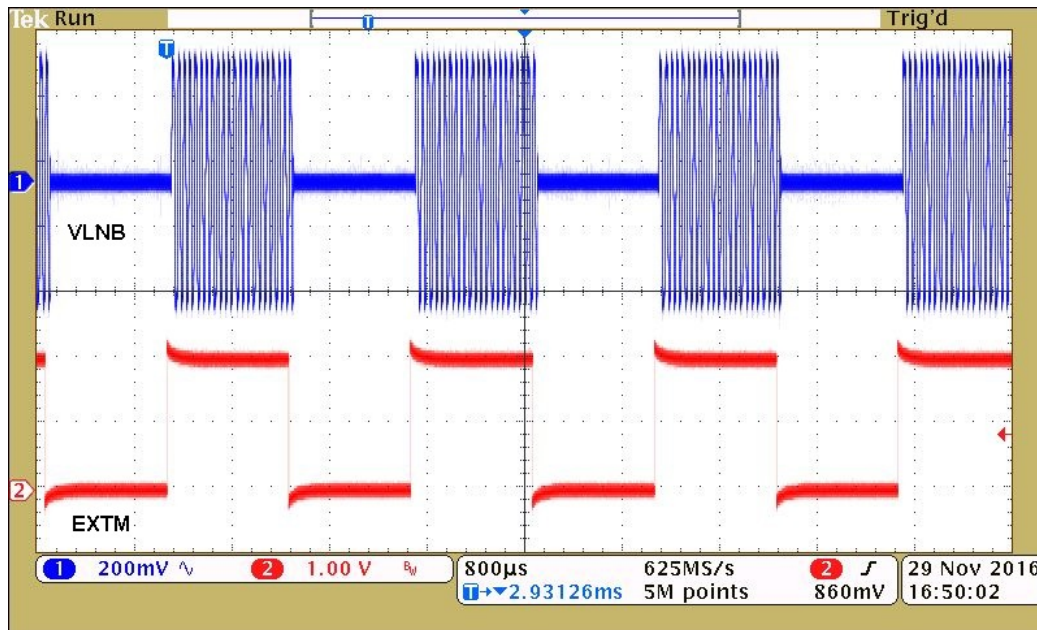


Figure 8. TPS65235 Output VLN

3.2.2 Reference Design Supporting DiSEqC™ 2.x Protocol

DiSEqC 2.x supports 2-way communication, where the LNB can work as a receiver and accessory. The design is slightly different from that for DiSEqC 1.x: the FET switch Q1 and an LRC filter built up by C12 and R0 are placed parallel with inductor L2. The Vout is physically connected to the DIN pin through an RC filter, which includes R8 and C14 (see Figure 9).

When working in receiver mode, Q1 is turned on and the LRC filter is bypassed. V_{out} is connected directly to VLN. The LNB voltage regulator input is through VLN to V_{out}. The way this design works is similar to the DiSEqC 1.x design.

When operated in accessories mode (see Figure 10), Q1 is turned off, and the LRC filter blocks the input signal from the V_{out}. The input signal is transferred through V_{out} to the DIN through the RC filter.

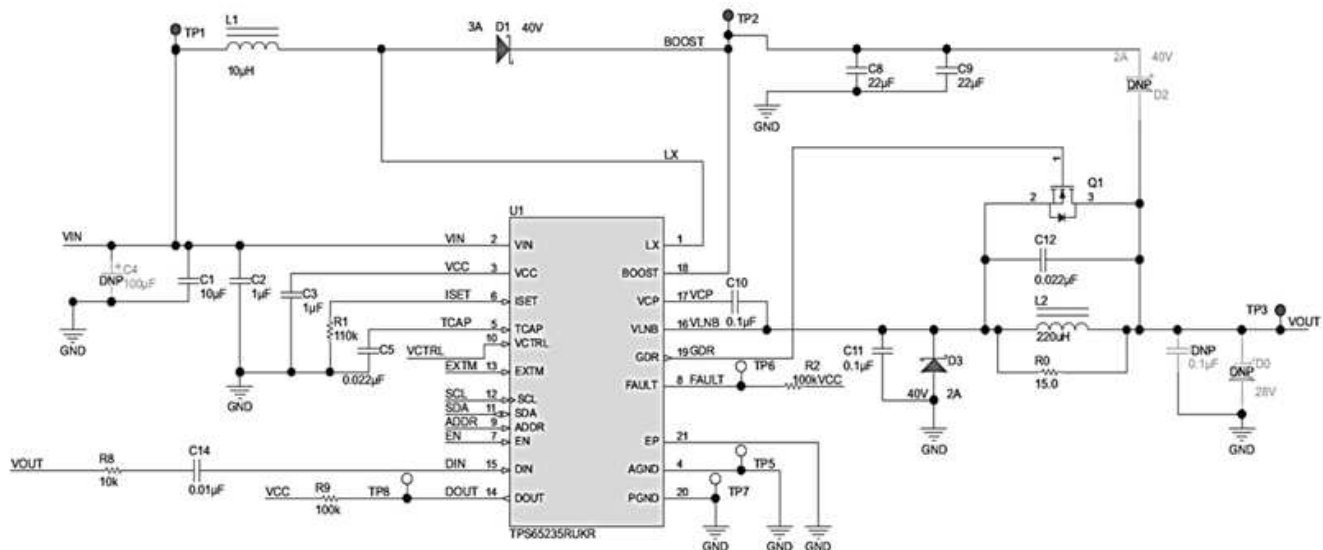


Figure 9. TPS65235 DiSEqC™ 2.x Schematic

As recommended in the design for DiSEqC 1.x, diodes D0 and D2 are optional. If the application does not require any surge test, these two diodes are removable. The 0.1- μ F output capacitor marked DNP in the schematic is the filter capacitor; it can be removed if the system performance is sufficient.

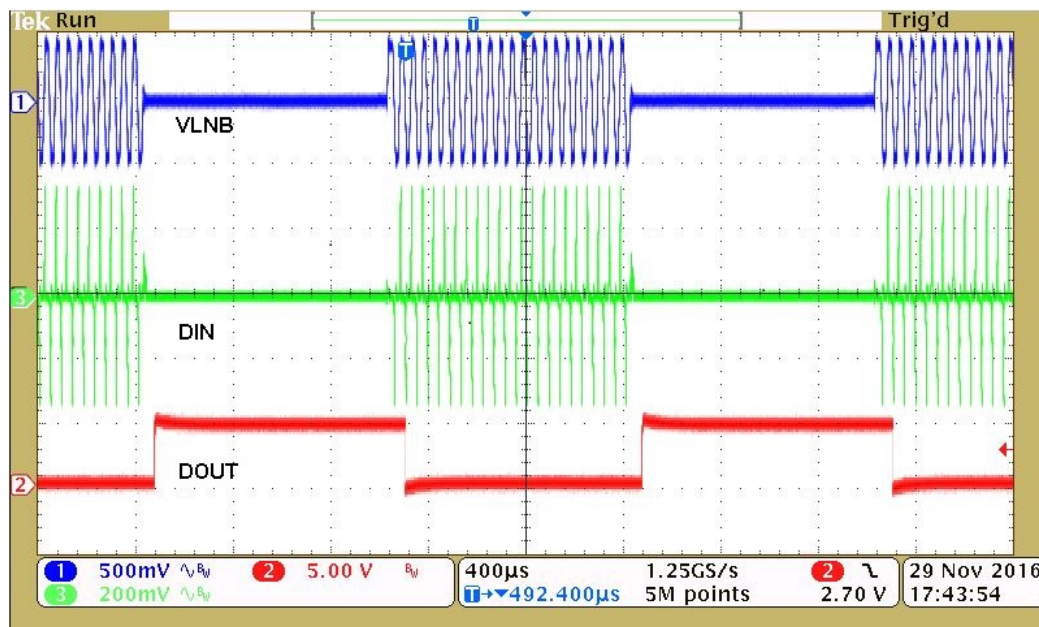


Figure 10. TPS65235 Under Accessories Mode

To achieve lower LNB output ripple, TI highly recommends using capacitors at least X7R or X5R rating and 1206 size.

3.2.3 PC to I2C Application

TI provides software to control the I2C bus from the PC (see Figure 11). The TPS65235 PC-I2C software can be downloaded freely under the TPS65235 product-page of TI.com. To transform the I2C data to USB data, the USB-To-GPIO (USB Interface Adapter EVM) is needed between the PC and TPS65235 EVM.

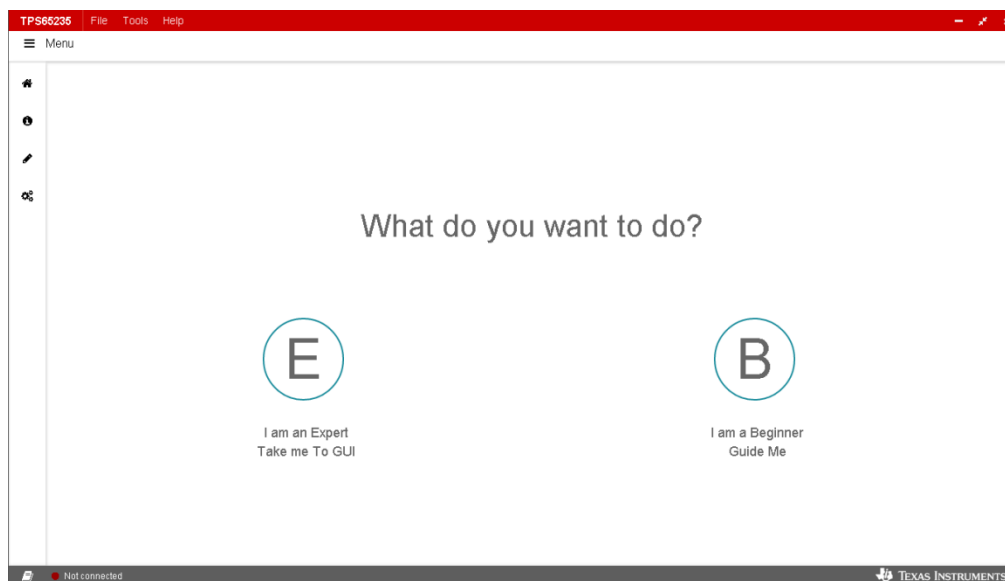


Figure 11. TPS65235 PC-I2C Software Home Page

After opening the TPS65235 PC-I2C software window, the program detects the USB-To-GPIO box first, and initializes the I2C system registers of the TPS65235. The status of the connection is shown by the indicator on the lower right side. If this is the first time you have opened this software, you may need to first select the proper device I2C address based on your design. You can make your I2C address selection in two places (see [Figure 12](#)).

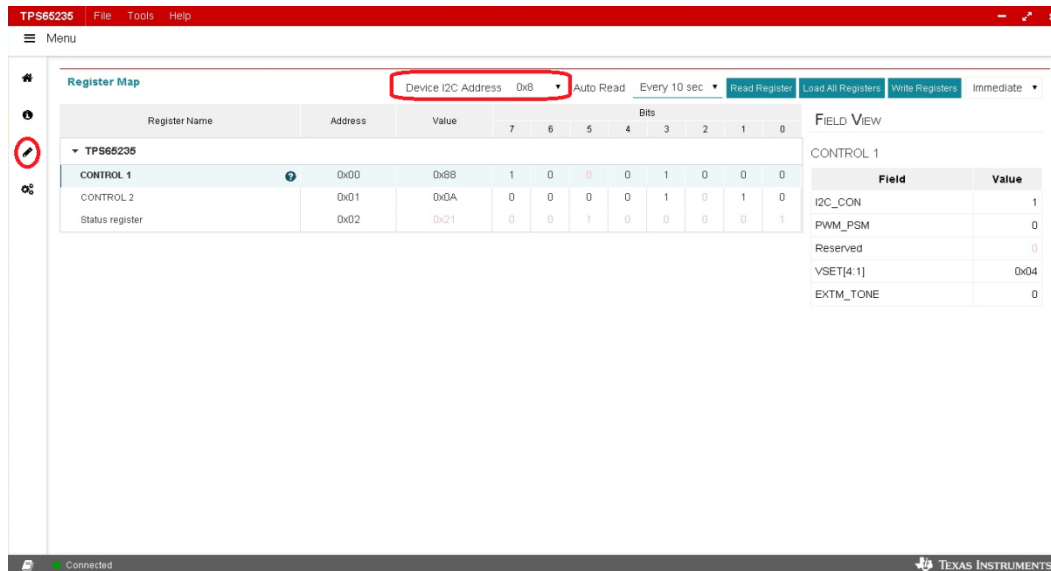


Figure 12. TPS65235 PC-I2C Software Register Map Page

To evaluate the TPS65235 functionality by toggling the system register bits, do the following:

1. Click the Register Map button on the left side of the screen.
2. On the Register Map page, select the I2C address of the design on the top-center of the window.
3. When the software has detected the TPS65235, and indicated the PC is connected to the TPS65235, you can make the register read or write action directly on the software by clicking on the target register bit and read/write register bottom.

This software also provides a practical page for easy changes, by clicking the Basic Settings button on the left side of the software window (Figure 13). On this page, you can also select the device I2C address under the Setting 1 section. To enable the on-time I2C control, click the Enable I2C Control button.

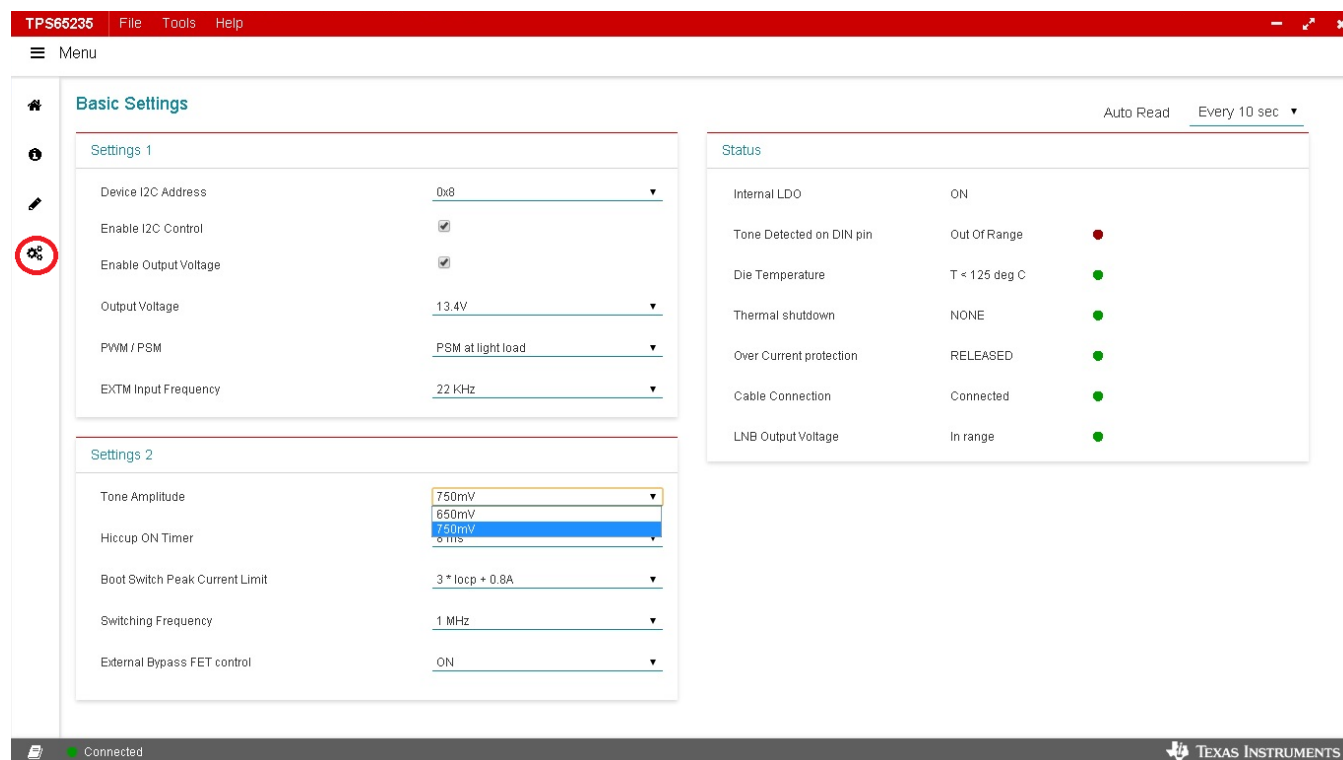


Figure 13. TPS65235 PC-I2C Software Basic Settings Page

After enabling the I2C control, the following items can be controlled by software operation:

- Output enabling
- Output voltage selection
- PWM/PSM mode selection
- EXTM input frequency selection
- Tone amplitude selection
- Hiccup-on-time selection
- Boost switch peak current limit threshold selection
- Switching frequency
- External bypass FET control enabling

Any changes made on this page are automatically updated on the register setup, and you can get their corresponding register on the register map page.

4 Summary

This application note introduces the satellite STB/TV LNB solution with the new TPS65235 device, from TI. The TPS65235 is a full-function, LNB regulator, that can support DiSEqC 1.x and 2.x. The Reference design is listed in Section 3. With this part, users can easily build a satellite STB/TV. For questions or support, you can post on the TI E2E online forum where we can support you directly.

5 References

1. *Digital Satellite Equipment Control Bus Functional Specification Version 4.2*, European Telecommunications Satellite Organization, Feb. 25, 1998
2. *Digital Satellite Equipment Control (DiSEqC™) Update and Recommendations for Implementation Version 2.1*, European Telecommunications Satellite Organization, Feb. 25, 1998
3. *DiSEqC™ 2.0 for Technicians*, Klaus Muller, SPAUN Electronic
4. *TV Explorer and DiSEqC™*, Promax ELECTRONICA, S.A.
5. [Evaluation Module for the TPS65235 LNB Voltage Regulator With I²C Interface](#), User's Guide
6. [TPS65235 EVM User Guide for DiSEqC 2.x Application](#), User's Guide

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