Chipsmall

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General Description

The MIC2870 is a high-current, high-efficiency flash LED driver for one or two high-brightness camera flash LEDs.

The LED driver current is generated by an integrated inductive boost converter with 2MHz switching frequency which allows the use of very small inductor and output capacitor. These features make the MIC2870 an ideal solution for high-resolution camera phone LED flash light driver applications.

MIC2870 supports two 750mA white-LEDs (WLEDs) or a single 1.5A WLED configuration. When two WLEDs are connected, their currents are matched automatically.

MIC2870 operates in either flash or torch modes that can be controlled through either I^{2}C interface or external pins. The brightness in the flash and torch mode can be adjusted via two external resistors individually. High-speed mode I^{2}C interface provides a simple control at a clock speed up to 3.4MHz to support most camera functions such as auto-focus, white balance, and image capture.

Datasheets and support documentation are available on Micrel's web site at: www.micrel.com.

Requirements

The MIC2870 evaluation board requires a bench input power source that is adjustable from 2.7V to 5.0V and is able to deliver greater than 4.5A at 2.7V.

Precautions

The evaluation board does not have reverse polarity protection. Applying a negative voltage across the VIN terminal to GND terminal may damage the device. The MIC2870 evaluation board is tailored for a Li-ion range input supply voltage. It should not exceed 5.0V on the input.

Getting Started

1. **Connect external supply to the VIN terminals.**

   Apply desired input voltage to the VIN (J1) and ground (J2) terminals of the evaluation board, paying careful attention to polarity and supply range (2.7V to 5.0V). An ammeter may be placed between the power supply and the input terminal of the evaluation board. Ensure that the supply voltage is monitored at the input terminals. The ammeter and /or power lead resistance can reduce the voltage supplied to the input.

2. **Enable/Disable the MIC2870.**

   The MIC2870 evaluation board has an enable (EN) pin (J5). The MIC2870 is in standby mode when the EN pin is asserted high. Setting a jumper at TP1 can connect the EN pin to VIN through a pull-high resistor. If this pin is driven low for more than 1s, the IC is shutdown. This pin is pulled down by an internal resistor. Alternatively, the IC can be enabled or disabled by software through I^{2}C interface.

3. **Enable/Disable the torch mode.**

   The TEN (J3) is the torch mode enable pin. When this pin is high, the torch mode is initiated. Setting a jumper at TP4 can connect TEN pin to VIN through a resistor. If this pin is left floating, it is pulled-down internally by a built-in 1μA current source when the device is enabled. Alternatively, the torch mode can be enabled or disabled by software through I^{2}C interface.

4. **Enable/Disable the flash mode.**

   The FEN (TP2 upper pin) is the flash mode enable pin. A low-to-high transition at this pin initiates the flash mode and the flash mode timer. Setting a jumper at TP2 can connect FEN to VIN through a resistor. If this pin is left floating, it is pulled-down internally by a built-in 1μA current source when the device is enabled. Alternatively, the flash mode can be enabled or disabled by software through I^{2}C interface.

Ordering Information

Part Number	Description
MIC2870YFT EV	MIC2870 Evaluation Board
MICUSB Dongle EV	I^{2}C Serial Programmer Board

Getting Started (Continued)

5. Enable/Disable flash inhibit.

The FI (TP3 upper pin) is the flash inhibit pin. When this pin is high in flash mode, both LED1 (D1) and LED2 (D2) currents are changed from the flash mode current level to the torch mode current level. When this pin is low, both LED1 (D1) and LED2 (D2) currents are changed from torch mode current level back to the original flash mode current level. Setting a jumper at TP3 can connect FI to VIN through a resistor. If this pin is left floating, it is pulled-down internally by a built-in 1µA current source when the device is enabled.

6. Graphic user interface support.

Graphical user interface software can be used with the MICUSB Dongle EV allowing configuration and testing of the MIC2870 with a standard computer. For more detail, refer to the *Evaluation Software* section.

Evaluation Board Description

Figure 1. MIC2870 Evaluation Board

Flash Mode

The maximum current level in the flash mode is 750mA per channel. This current level can be adjusted through an external resistor connecting to the FRSET pin according to Equation 1:

$$I_{LED(MAX)} = \frac{7500}{R_{FRSET}}$$
                                                                    Eq. 1

Alternatively, the default maximum value of 750mA per channel is used when the FRSET pin is grounded.

The flash mode current can be initiated at the preset FRSET brightness level by asserting FEN pin high or by setting the I²C flash control register (address 01h) for the desired flash duration, subjected to the flash safety timeout setting. The flash mode current is terminated when the FEN pin is brought low and the I²C flash register is cleared.

Flash mode current can be adjusted to a fraction of the maximum flash mode level (either default or set by the FRSET resistor) by selecting the desired flash current level percentage in the flash control register (Address 01h) through the I²C interface. The flash current is the product of the maximum flash current setting and the percentage selected in the flash register.

The flash safety timeout feature automatically shuts down the flash current if the flash mode is enabled for an extended period of time. Refer to the "Flash Safety Timer" setting in Table 4.

The flash inhibit (FI) pin can be used to synchronize the flash current to a handset GSM pulse event to prevent excessive battery droop. When FEN and FI pins are both high, the flash mode current is limited to the torch mode current setting. The FI Pin is also functional when the flash mode current is enabled through the I²C flash register.

Torch Mode

The maximum torch mode level can be adjusted through an external resistor connecting to the TRSET pin according to Equation 2:

$$I_{LED(MAX)} = \frac{7500}{4R_{TRSET}}$$
                                                                    Eq. 2

Alternatively, the default maximum value of 187.5mA per channel is used when the TRSET pin is grounded. The torch mode operation is activated by asserting the TEN pin high or by setting the I²C torch register (address 02h) for the desired duration. The torch mode current is terminated when the TEN pin is brought low and the I²C torch register is cleared.

Like the flash mode current, the torch mode current can be set to a fraction of the maximum torch mode level (either default or set by the TRSET resistor) by selecting the desired torch current level percentage in the torch register (Address 02h) through the I²C interface. The torch current is the product of the maximum torch current setting and the percentage selected in the torch register.

Overvoltage Protection

When the output voltage rises above the OVP threshold, the MIC2870 is turned off automatically to avoid permanent damage to the IC.

Open Circuit Detection

The open-circuit detector (OCD) is active only when the LED current regulator is turned on. When the external LED is missing or fails open, the LED1/2 pin voltage is pulled to near the ground potential by the internal current sink. If both LEDs are open or missing, the open-circuit detector would force the boost regulator and LED current regulator to turn off. The MIC2870 will try to turn on the boost regulator and LED current regulator again after a 100ms timeout. However, in most practical cases, the boost output voltage would rise above the OVP threshold, when both LED channels have an open fault. The OVP function would cause the MIC2870 to shut down.

Short-Circuit Detection

Like the open-circuit detector, the short-circuit detector is active only when the current regulator is turned on. If either one or both of the external LEDs fail as a short, the short-circuit detector would force the MIC2870 to turn off. The MIC2870 will try to turn on the boost regulator and LED current regulator again after a 100ms timeout. If the short condition persists, the whole cycle repeats again. Prolonged operation in short-circuit condition is not recommended as it may damage the device.

I²C Interface

The timing diagram shows the communications required for write and read operations via the I²C interface. The black lines show master communications and the red lines show the slave communications. During a write operation the master must drive SDA and SCL for all stages except the acknowledgement (A) shown in red, which are provided by the slave (MIC2870).
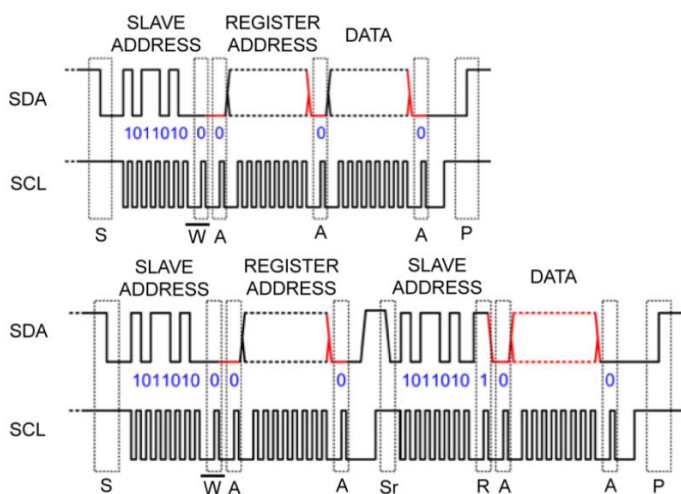

Figure 2. I²C Timing Example

The read operation begins firstly with a data-less write to select the register address from which to read. Then a restart sequence is issued, and then a read command followed by the data read.

The MIC2870 responds to a slave address of hex 0xB4 and 0xB5 for write and read operations respectively, or binary 1011010X (where X is the read/write bit).

The register address is eight bits wide and carries the address of the MIC2870 register to be operated upon. Only the lower three bits are used.

I²C Registers

MIC2870 contains three 8-bit read/write registers having an address from 00h to 02h for operation control as shown in Table 1. These registers are reset to their default values in power-on-reset (POR) event. In other words, they hold their previous contents when the chip is shutdown as long as supply voltage is above 1.5V (typical).

Master Control / Status Register [00h]

The master control / status register allows the MIC2870 to be enabled by the I²C interface -- setting the ON [ ] bit high has the same effect as asserting EN pin. The LED short bit, LED_SHT[ ] is set if any or both of the LED is shorted to OUT, while the LED open bit, LED_OP[ ] is asserted only when both LED are open circuit. The thermal shutdown bit, TSD[ ] is set when the junction temperature of the MIC2870 is higher than 160°C. The bit names and assignment of all the bits in the master control / status register and their default values are shown in Table 2.

Flash Control Register [01h]

The flash mode enable, flash safety timer and flash mode current are configurable via the flash control register. The flash control register contains the FTMR[ ] bits, FEN[ ] bit, and FCUR bits. The FTMR[ ] bits set the flash safety timer duration. The FEN[ ] bit has the same function as the FEN pin. When the FEN[ ] is set the flash mode is enabled. The FCUR[ ] bits set the flash mode current in 16 steps from 100% down to 18% of the maximum LED flash current which is set by the FRSET resistor. The detail description of the bit names of all the bits and their assignment in the flash control register and their default values are shown in Table 3. The details of flash timeout duration setting and flash mode current setting can be referred to Table 4 and Table 5.

Torch Control Register [02h]

The torch mode enable, torch mode current, and flash inhibit are configurable via the torch control register. The torch control register contains the TCUR[ ] bits, TEN[ ] bit, and FI[ ] bit. The TCUR[ ] bits set the torch mode current in 16 steps from 100% down to 18% of the maximum LED torch current which is set by the TRSET resistor. The TEN[ ] bit has the same function as the TEN pin. When the TEN[ ] bit is set the torch mode is enabled. The FI[ ] bit has the same function as the FI pin. When the FI[ ] bit is set, the flash mode current is reduced to the torch mode current setting. The detail description of the bit names of all the bits and their assignment in the torch control register and their default values are shown in Table 6. The detail of the torch mode current setting is shown in Table 7.

Table 1. MIC2870 Register Map

Register Address	Register Name	Description
00h	Master Control/ Status	Chip Enable, Control and Status Register
01h	Flash Control	Flash Mode Current, Flash Mode Enable, and Flash Timeout Control Register
02h	Torch Control	Torch Mode Current and Torch Mode Enable Control Register

Table 2. Master Control Register [00h]

	D7	D6	D5	D4	D3	D2	D1	D0
Name	Reserved	Reserved	Reserved	Reserved	ON	LED_SHT	LED_OP	TSD
Access	R	R	R	R	R/W	R	R	R
Default Value	0	0	0	0	0	0	0	0

Table 3. Flash Control Register [01h]

BIT	D7	D6	D5	D4	D3	D2	D1	D0
Name	FTMR	FTMR	FTMR	FEN	FCUR	FCUR	FCUR	FCUR
Access	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
Default Value	111			0	0000			

Table 4. Flash Safety Timer Setting [FTMR]

Register Value [D7:D5] of 01h	Flash Timeout Duration (ms)
111	1250
110	1093.75
101	937.5
100	781.25
011	625
010	468.75
001	312.5
000	156.25

Table 5. Flash Mode Current Setting [FCUR]

Percentage of Maximum Current (%)	Register Value [D3:D0] of 01h	Current Per Channel (mA) ($R_{FRSET} = 0\Omega$)	Combined Current (mA) ($R_{FRSET} = 0\Omega$)
100	0000	750.0	1500.0
90	0001	675.0	1350.0
80	0010	600.0	1200.0
70	0011	525.0	1050.0
63	0100	472.5	945.0
56	0101	420.0	840.0
50	0110	375.0	750.0
44.7	0111	335.3	670.5
39.8	1000	298.5	597.0
35.5	1001	266.3	532.5
31.6	1010	237.0	474.0
28.2	1011	211.5	423.0
25.1	1100	188.3	376.5
22.4	1101	168.0	336.0
20	1110	150.0	300.0
18	1111	135.0	270.0

Table 6. Torch Control Register [02h]

BIT	D7	D6	D5	D4	D3	D2	D1	D0
Name	Reserved	Reserved	FI	TEN	TCUR	TCUR	TCUR	TCUR
Access	RO	RO	R/W	R/W	R/W	R/W	R/W	R/W
Default Value	0	0	0	0	0000			

Table 7. Torch Mode Current Setting [TCUR]

Percentage of Maximum Current (%)	Register Value [D3:D0] of 02h	Current Per Channel (mA) ($R_{TRSET} = 0\Omega$)	Combined Current (mA) ($R_{TRSET} = 0\Omega$)
100	0000	187.5	375.0
90	0001	168.8	337.5
80	0010	150.0	300.0
70	0011	131.3	262.5
63	0100	118.1	236.3
56	0101	105.0	210.0
50	0110	93.8	187.5
44.7	0111	83.8	167.6
39.8	1000	74.6	149.3
35.5	1001	66.6	133.1
31.6	1010	59.3	118.5
28.2	1011	52.9	105.8
25.1	1100	47.1	94.1
22.4	1101	42.0	84.0
20	1110	37.5	75.0
18	1111	33.8	67.5

Evaluation Kit Overview

The MIC2870 can be operated as a standalone board or as a modular system where the evaluation board is connected to a PC via an I^{2}C-to-USB interface board (MICUSB Dongle EV).

Connecting the USB-to-I2C Adapter

When interfacing the MIC2870 evaluation board with the MICUSB Dongle, carefully match the GND pin of the evaluation board with the GND pin of the adapter (as shown in Figure 3, the MICUSB Dongle will be upside down). On the MIC2870 evaluation board, the GND pin location is labeled on the left side of the board. It is the first pin of the connecter receptacle JP1. The MICUSB Dongle has GND labeled on both sides of the adapter board.
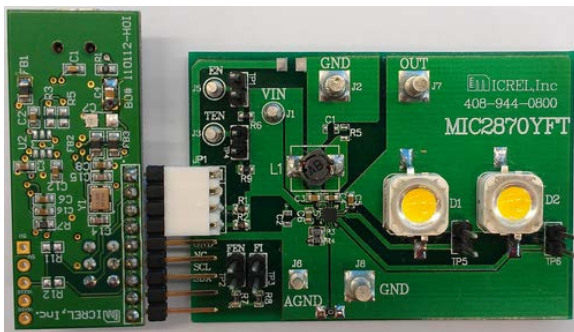
Figure 3. MIC2870 Evaluation Board Interfaces with MICUSB Dongle EV (adapter bottom side faces up)
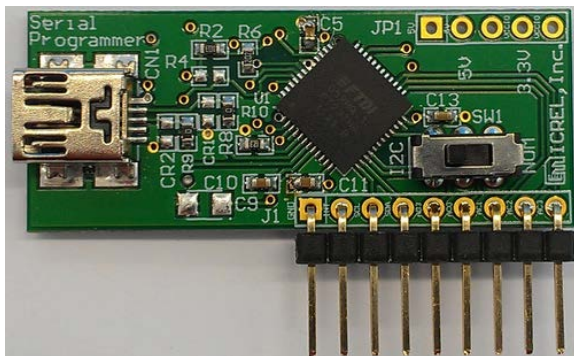
Figure 4. Top Side of the Adapter with the Mini Slide Switch Toggled to I^{2}C Position

MIC2870 Evaluation Software

The MIC2870 evaluation software provides a graphic user interface (GUI) to program the MIC2870 evaluation board. A complete application note on the installation and operation of the evaluation software and the USB adapter user manual can be downloaded from Micrel's web site at www.micrel.com. The evaluation software can read and write to registers inside the MIC2870 IC device via I^{2}C for enabling or disabling the device, torch mode, flash mode, and flash inhibit; changing the WLEDs' brightness in torch mode and flash mode; changing the flash safety timer duration; enabling/disabling breath and strobe special effects; and reporting fault status.

Getting Started

1. Download the MIC2870 evaluation software and run the setup.exe file. This step may take some time and require an internet connection to update the computer to .NET Framework 3.5.

2. Install the MICUSB Dongle EV driver from FTDI. Double-click on the file CDM20828_Setup.exe. The latest driver can be downloaded from the FTDI website: www.ftdichip.com.

3. After installing the driver, locate the virtual COM port created by the FTDI driver in the Device Manager Menu, under Ports (COM & LPT). The corresponding port will have FTDI listed as the manufacturer.

4. Connect the MIC2870 evaluation board to the PC via the MICUSB Dongle EV. Power the MIC2870 evaluation board VIN input.

5. Set the mini slide switch SW1 on the MICUSB Dongle EV. The SW1 should be toggled to the I^{2}C position as shown in Figure 4.

6. Open the MIC2870 evaluation software in Programs under the Start Menu.

Evaluation Software

The MIC2870 evaluation software graphic user interface (GUI) is shown in Figure 5 and Figure 6. When the evaluation software is just started, it is default in offline mode as shown on the right of the top menu bar in Figure 5. The offline mode is only for running the software without the communication or connection with the MIC2870 evaluation board.

To control the MIC2870 evaluation board with the software GUI, the user firstly has to click the "Test" button. If the connection from the PC to the dongle and then to the MIC2870 EVB is fine as instructed in Connecting the USB-to-I^{2}C Adapter section and in steps 4 and 5 in the *Getting Started* section, the "Target OK" will be shown up at the status bar at the bottom of the GUI as shown Figure 5.

If the connection is not good, the "Target Not Detected" will be shown up at the status bar and the user has to check with the cable connections before proceeding to the next step. When the "Target OK" status is shown, the user can click on the "Offline Mode" at the menu bar to change it to "Direct Editing Mode". When the "Direct Editing Mode" is shown up at the top menu bar and the "Direct Editing Mode Active" is indicated at the status bar as shown in Figure 6, the software GUI allows the user to control the operation of the MIC2870 evaluation board.

Introduction to the GUI Panel

At the left side of the GUI panel, user can check with the MIC2870 registers information and perform read and write operation to the IC registers. At the middle of the GUI panel, user can click the "Enable" option to enable the register polling.

At the right side of the GUI panel which is the MIC2870 Control panel, user can perform the following MIC2870 operation:

1. Check or uncheck the "Enabled" option to enable or disable the MIC2870 device.

2. Change the flash safety timer duration setting from 0 to 7 which corresponding to 8 options from 156ms to 1250ms. Please refer to Table 4 for details.

3. Adjust the flash brightness with the slide bar from 100% to 18% of the maximum LED current in flash mode in 16 steps. The maximum is on the left and the minimum is on the right.

4. Fire flash or reset flash by clicking the flash mode enable button.

5. Check or uncheck flash inhibit option to enable or disable the flash inhibit function.

6. Adjust the torch brightness with the slide bar from 100% to 18% of the maximum LED current in torch mode in 16 steps. The maximum is on the left and the minimum is on the right.

7. Set or reset torch by clicking on the torch mode enable button.

8. Click the "Breath" button, "Strobe" button, and set delay time options for special effects demonstration.

9. Fault indication will be shown at the bottom of the control panel if the register polling is enabled and fault conditions are detected. The current detected fault value can be cleared by clicking the "Clear" button.

Setting of I^{2}C Data Rate

The data rate of the I^{2}C communication can be set at the pull-down menu from the "I^{2}C" menu at the top menu bar as shown in Figure 7. User can set the data rate to 100kbps, 400kbps, or 3.4Mbps from the pull-down menu.
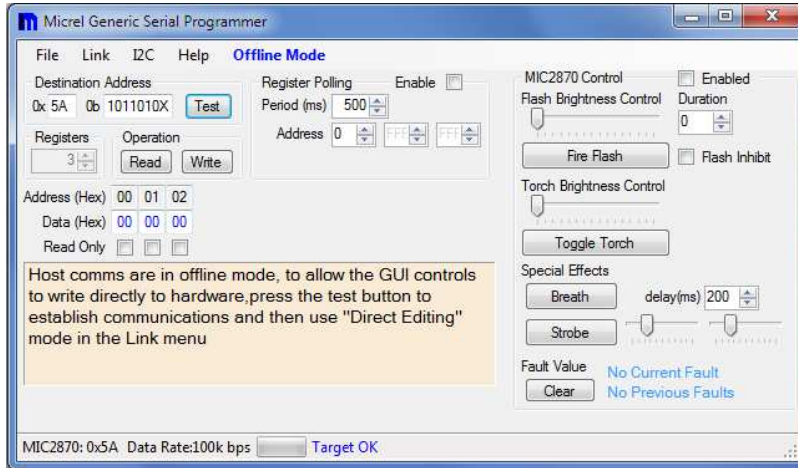
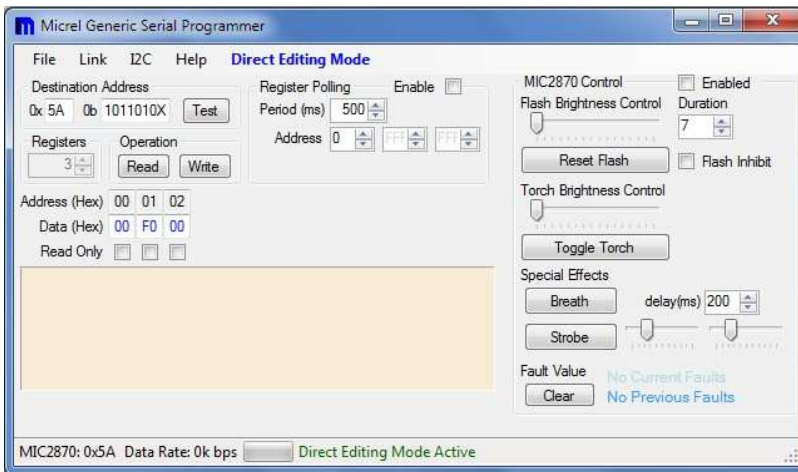**Figure 5. MIC2870 Evaluation Software GUI in Offline Mode**

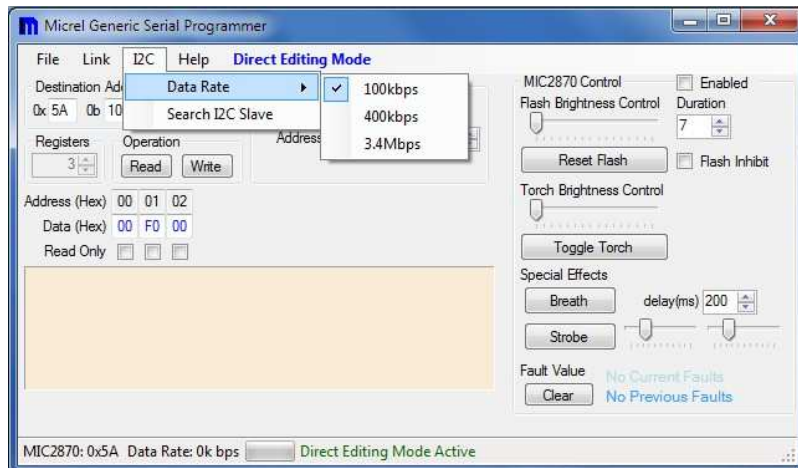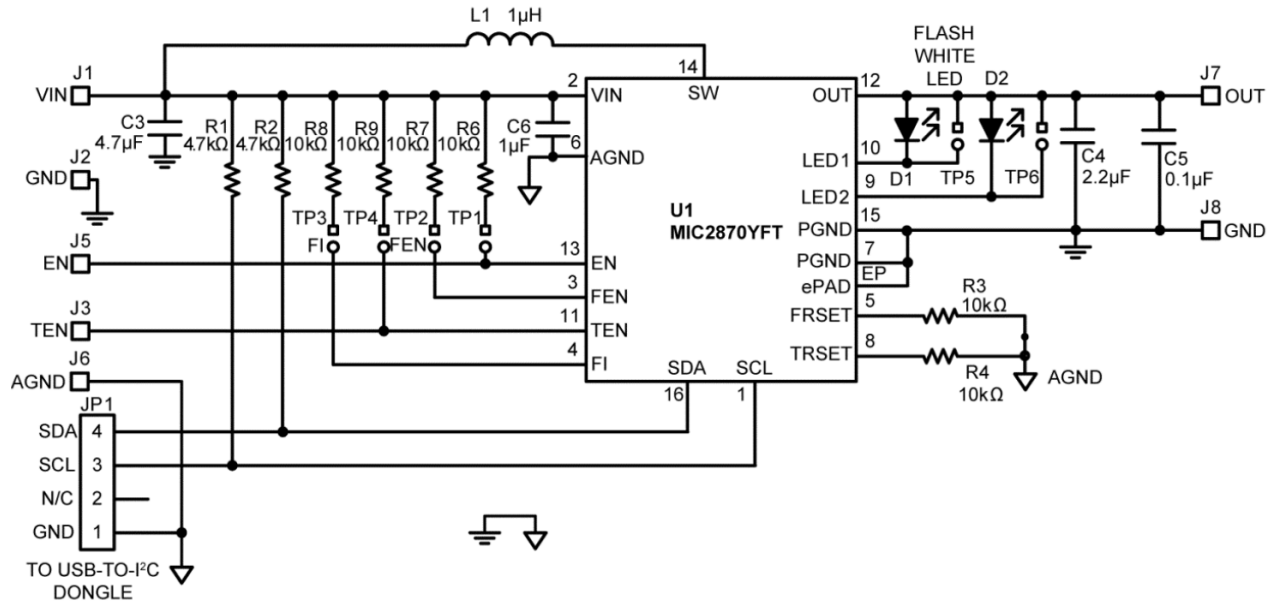**Figure 6. MIC2870 Evaluation Software GUI in Direct Editing Mode**

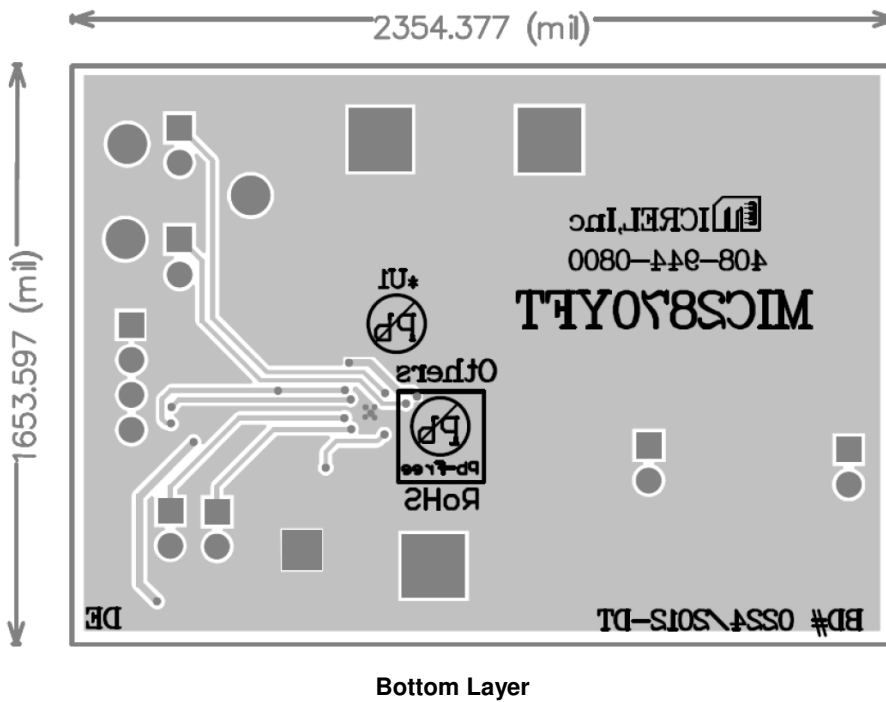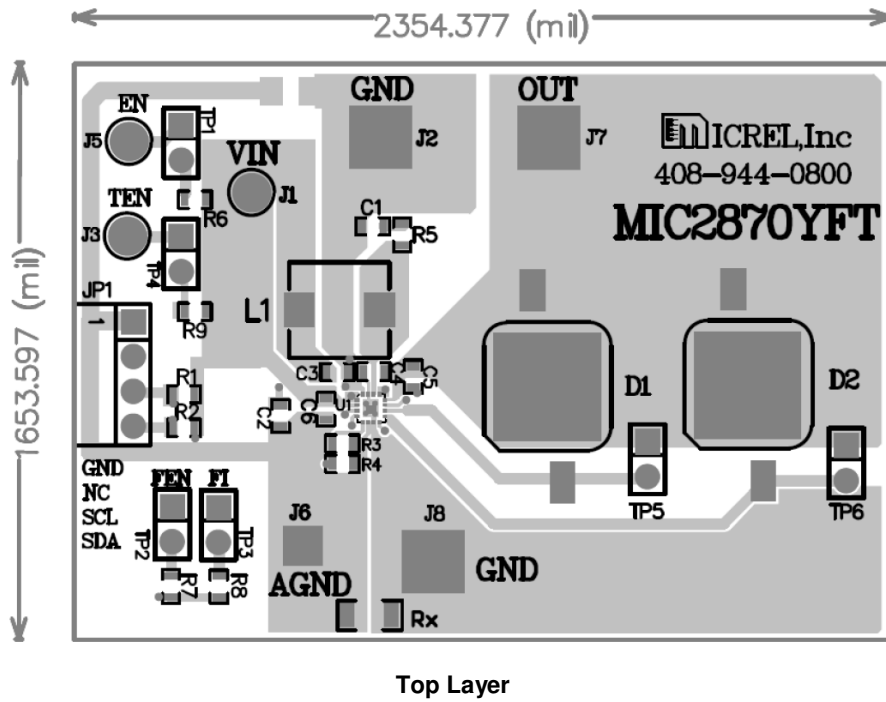**Figure 7. Setting Data Rate from Pulldown Menu**

Evaluation Board Schematic

Bill of Materials

Item	Part Number	Manufacturer	Description	Qty.
C3	0603ZD475KAT2A	AVX[1]	Ceramic Capacitor 4.7µF, 10V, X5R, 0603	1
	C1608X5R1A475K080AC	TDK[2]		
C4	0603ZD225KAT2A	AVX	Ceramic Capacitor 2.2µF, 10V, X5R, 0603	1
	GRM188R61A225KE34D	Murata[3]		
	C1608X5R1A225K080AC	TDK		
C5	06033D104KAJ2A	AVX	Ceramic Capacitor 0.1µF, 25V, X5R, 0603	1
	GRM188R61C104KA01D	Murata		
	C1608X5R1E104K	TDK		
C6	0603ZD105KAT2A	AVX	Ceramic Capacitor 1µF, 10V, X5R, 0603	1
	GRM188R61A105KA61D	Murata		
	C1608X5R1A105K080AC	TDK		
L1	CDRH4D28CLDNP-1R0PC	Sumida[4]	Inductor 1µH, 3.0A, 14mΩ, L5.1mm x W5.1mm x H3.0mm	1
	LQH44PN1R0NP0L	Murata	Inductor 1µH, 2.45A, 36mΩ, L4.0mm x W4.0mm x H1.65mm	
R1, R2	CRCW06034K70FKEA	Vishay/Dale[5]	Resistor 4.7kΩ, 1%, 1/10W, 0603	2
R3, R4	ERA3AEB103V	Panasonic[6]	Resistor 10kΩ, 0.1%, 1/10W, 0603	2
R6, R7, R8, R9	CRCW060310K0FKEA	Vishay/Dale	Resistor 10kΩ, 1%, 1/10W, 0603	4
D1, D2	SML-LXL99UWC-TR/5	Lumex[7]	LED SQ 5W COOL WHT 6000K SMD, 190lm	2
	2ER103CW06000002	Edison-Opto[8]	LED, 3W, COOL WHT 6000K SMD, 210lm	
U1	**MIC2870YFT**	**Micrel, Inc.[9]**	**1.5A Synchronous Boost Flash LED Driver with I^{2}C Interface**	**1**

Notes:

1. AVX: www.avx.com.
2. TDK: www.tdk.com.
3. Murata: www.murata.com.
4. Sumida: www.sumida.com.
5. Vishay: www.vishay.com.
6. Panasonic: www.panasonic.com
7. Lumex: www.lumex.com.
8. Edison-Opto: www.edison-opto.com
9. **Micrel, Inc.: www.micrel.com.**

PCB Layout Recommendations

Top Layer

Bottom Layer