MBI5037 Application Note

Foreword

MBI5037 is an enhanced 16-channel LED constant-current driver with advanced error detection functions and smart power saving mode. MBI5037 succeeds MBI5026 and exploits **PrecisionDrive™** technology to enhance its output characteristics. And it has the extended advanced functions, such as the silent detection of LED open/short circuit, the diagnosis of driver leakage, and temperature warming. MBI5037 also features two power saving modes: Sleep mode and 0-Power mode. These two modes can increase the power efficiency.

This article provides the application note according to the product characteristics or the problem which customers often meet, including the range of precise constant current, the power-on sequence, and initial state recommended for control signal. The functional application note of Sleep mode, 0-Power mode and error detection are mentioned. And the time multiplexing circuit application is explained finally.

Constant Current Range

MBI5037 is an LED constant current driver, and the excellent current accuracy is

- 10mA to 80mA at various V_{DD} ranging of 4.5V to 5.5V, and
- 3mA to 60mA at various V_{DD} ranging of 3.0V to 3.6V.

If output current is out of range, the current accuracy and line regulation will not be guaranteed.

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Power-on Sequence

Figure 1 shows the recommended power-on sequence. The power for MBI5037 (V_{DD}) should be turned on first, and then is the power of control board (V_{CC}). The control signals should be sent out after all the power of V_{DD} and V_{CC} are stable.

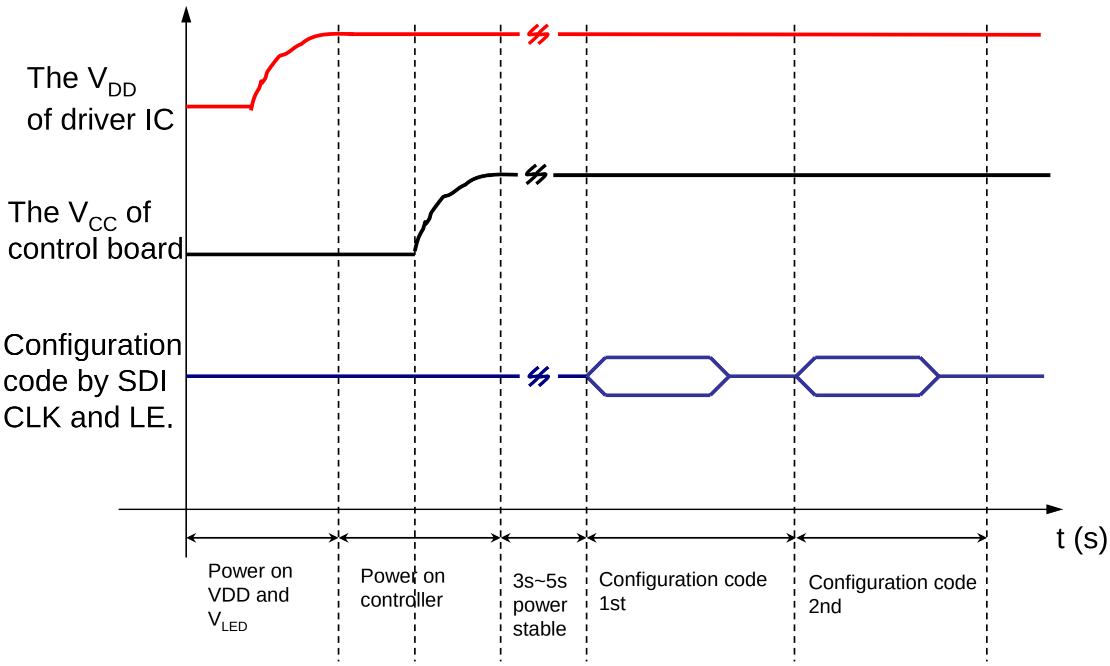

Figure 1. Power on sequence

IC Initial State

To avoid MBI5037 from entering un-expected mode, the CLK, SDI, and LE should keep at low level when power on step. Connecting a pull down resistor with 10kΩ at the output ports of control board is recommended.

The default value of 16-bit shift register is 0xFFFF and SDO is “High” or “1” when MBI5037 is started on.

Power Saving Modes

Sleep mode:

By giving a sleep command, all the output channels of MBI5037 are turned off. The value of 16-bit shift register is cleared to 0x0000, and the latch data is eliminated. During the Sleep mode, MBI5037 cannot execute any action except acknowledging the wake-up command. And users have to send reserved image data after IC is waked up.

0-Power mode:

To follow the two steps to enter 0-Power mode: 1st is to set bit "D" of configuration register, and the 0-Power mode will be enable. 2nd is to send all the output data "0", and then MBI5037 will enter the 0-Power mode automatically. During the 0-Power mode, the I_{DD} down to 1% of original, and MBI5037 does not execute any actions, such as compulsory error detection, configuration register setting, and wake-up mode. In the duration of 0-Power mode, if user executes the compulsory error detection, MBI5037 will always send the error message with 0xFFFF.

To exit 0-Power mode, please follow the steps below:

Step 1: To shift and latch the non-zero data to MBI5039, and during this time, keeps $\overline{OE}$ at high level.

Step 2: To wait for 1ms before execute successive action to make sure MBI5037 has returned to normal mode.

MBI5037 needs 1ms from power saving mode back to normal mode. After giving the wake-up command, please make sure to wait for 1ms before new image data is sent.

The Sequence for Detecting LED Faults

The leakage diagnosis is to detect the leakage problem of MBI5037 output ports, not for the error of LED open-circuit. But when the compulsory open-circuit detection is executed, not only the error of open-circuit will be detected, but also the output channels with leakage problem.

Figure 2 shows the suggested sequence of error detection. The leakage diagnosis should be executed before the open-circuit error detection. Then, take the result of open-circuit detection to calculate with the result of leakage diagnosis by the logic of "Exclusive Nor" to get the correct message of open-circuit detection. If the channel has both leakage and open-circuit problems, through this calculation, the error message will be reported in the results of leakage diagnosis.

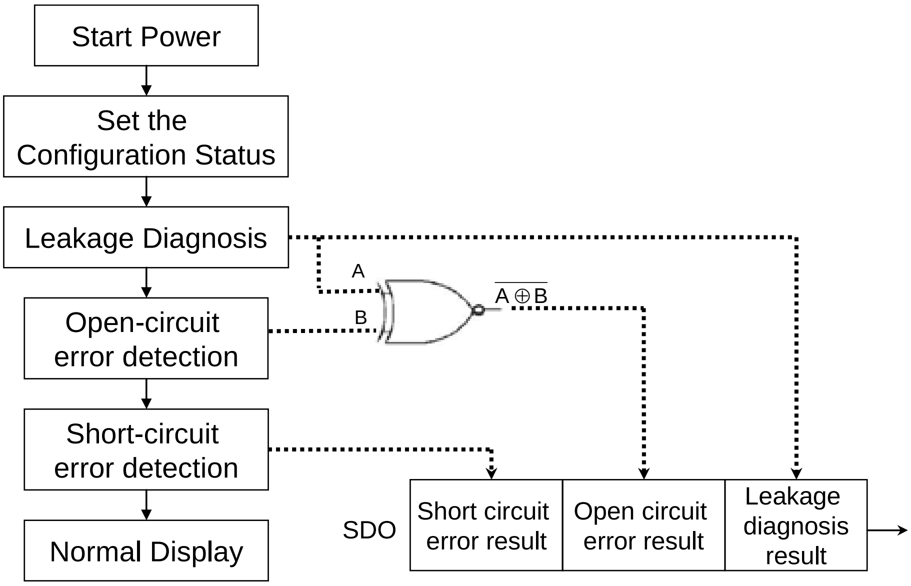

Figure 2. The suggested sequence of error detection

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Setting Parameters for Valid Error Detection

The LED open/short-circuit detection of MBI5037 is achieved by comparing the effective V_{DS} of each output port with the target voltage. The following factors might affect the V_{DS}.

(1). LED forward voltage: LED forward voltage will be changed by the factors such as LED current, LED chip temperature, and so on.

(2). LED turns on/off response time.

(3). Parasitical inductance effect between V_{LED} and LED anode: Parasitical inductance effect will cause the overshoot problem at output port.

(4). The length of the trace between LED cathode and IC's output port: If the PCB trace between LED cathode and IC's output port is too long, the parasitical inductance and resistance will come out, and cause the overshoot problem.

The default value of configuration register is

F	E	D	C	B	A	9	8	7	6	5	4	3	2	1	0
01		0	0	1	0	0	9'b0 0000 0000								

User can follow table 1 to choose a suitable detected parameter in the configuration register of MBI5037.

Table 1. Error detection parameter setting in configuration register

Detected current, bit [B:A] / Detection time, bit [9]	[00, 10]	[10]	[11]
[0]	0.1mA 700ns	0.5mA 700ns	Detection current set by Rext; 700ns
[1]	0.1mA; Detection time control by user	0.5mA; Detection time control by user	Detection current set by Rext; detection time control by user

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Detection Time is set by t_{ERR_C}

If MBI5037's detection time is set by t_{ERR_C}(=700ns), the error detection executes from LE falling edge and keeps the time of t_{ERR_C}, and then the error detection is completed. Figure 3 figures out the relationship between LE, $\overline{OE}$ and output current (I_{OUT}) as configuration register is set with detection current 0.1mA.

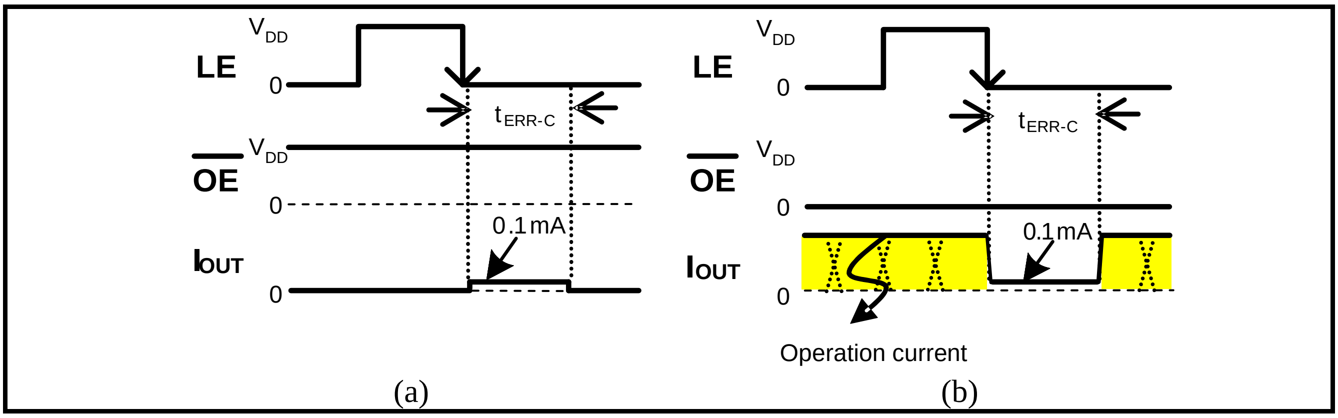

Figure 3. Detection current sets 0.1mA and detection time sets t_{ERR_C} as (a) $\overline{OE}$ keeps at high level, (b) $\overline{OE}$ keeps at low level.

Figure 4 illustrates the relationship between LE, $\overline{OE}$ and output current (I_{OUT}), which detection current is set by R_{ext}.

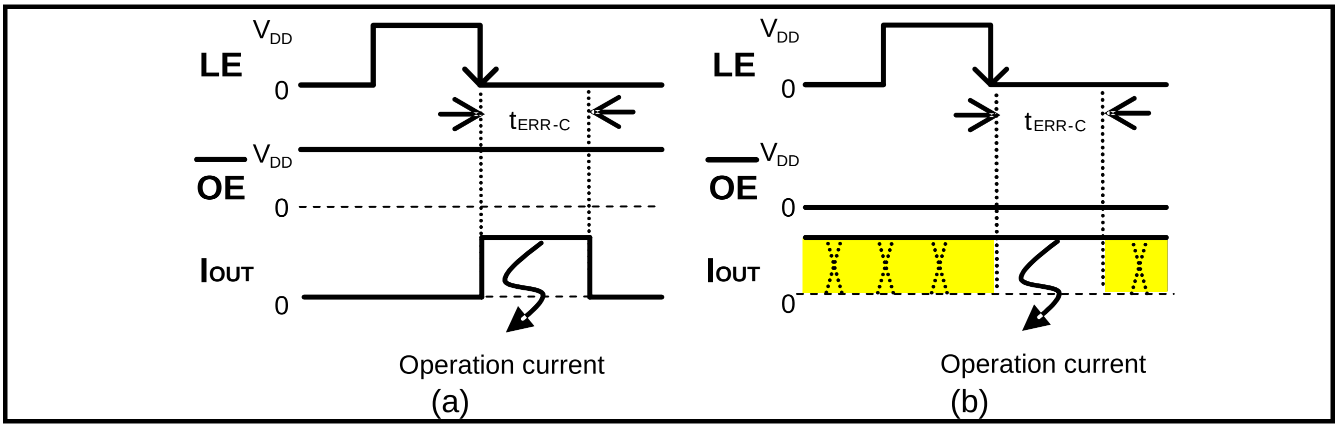

Figure 4. Detection current is set by R_{ext} and detection time sets t_{ERR_C} as (a) $\overline{OE}$ keeps at high level, (b) $\overline{OE}$ keeps at low level.

If $\overline{OE}$ connects to GND directly, to execute the compulsory error detection, user has to follow two steps below:

Step 1: Enter configuration register to change value of bit [B:A] to "11". And then the detection current is set by R_{ext}.

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Step 2: Change the configuration register code, bit [9], to “0” (default). And set the detection time to 700ns.

Detection Time is controlled by User

If the detection time of MBI5037 is controlled by $\overline{OE}$, the error detection executes from the falling edge of LE and completes at the rising edge of $\overline{OE}$. Figure 5 illustrates the relationship between LE, $\overline{OE}$ and output current (I_{OUT}), the detection current is set to 0.1mA.

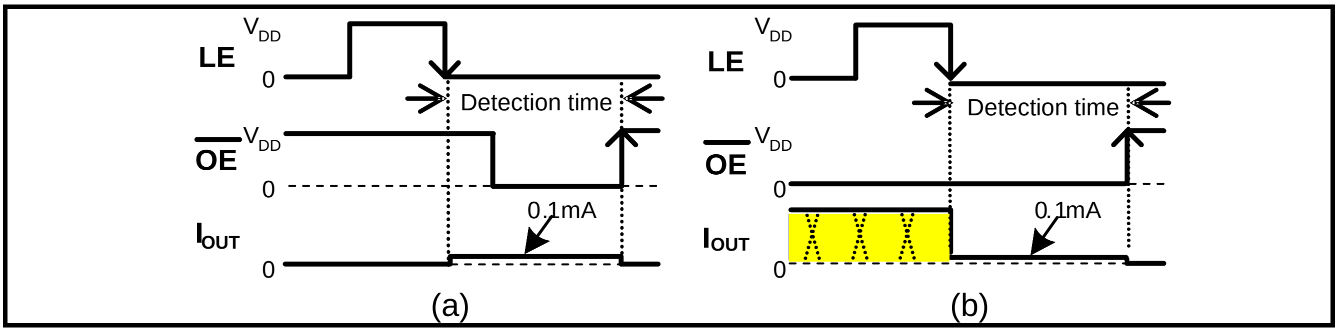

Figure 5. Detection current sets 0.1mA and detection time is controlled by $\overline{OE}$. (a) During error detection, $\overline{OE}$ is from high to low, (b) Before error detection, $\overline{OE}$ is at low level.

Figure 6 illustrates the relationship between LE, $\overline{OE}$ and output current (I_{OUT}), which detection current is controlled by R_{ext}.

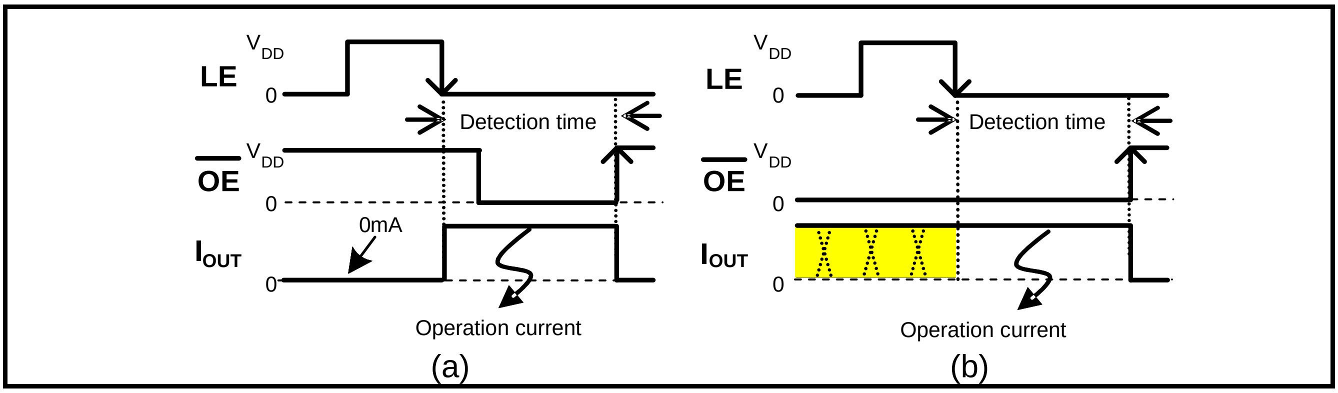

Figure 6. Detection current is controlled by R_{ext} and detection time is controlled by $\overline{OE}$ (a) During error detection, $\overline{OE}$ is from high to low, (b) Before error detection, $\overline{OE}$ is at low level.

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Time-multiplexing Application

Here takes an example in 1/2 duty time-multiplexing application, the circuit is shown as figure 7, two rows of LEDs share an LED supply voltage, V_{LED}. By changing the MOSFET switching, the voltage of V_{LED} lights up two rows of LEDs in turn. Make sure the error detection and error message of first and second row of LEDs are separated.

During the error detection, the power of V_{LED} should keep stable. In addition, the supply voltage of previous LED row should be discharge to 0V completely before short circuit error detection is being processed. Connect resisters, R1 and R2, between V_{LED} and GND to discharge the remaining V_{LED}, as figure 7 shows. The purpose of capacitors, C1 and C2, who are located between Drain and Source of MOSFET, is to reduce the high voltage spike, which is caused by the parasitical effect.

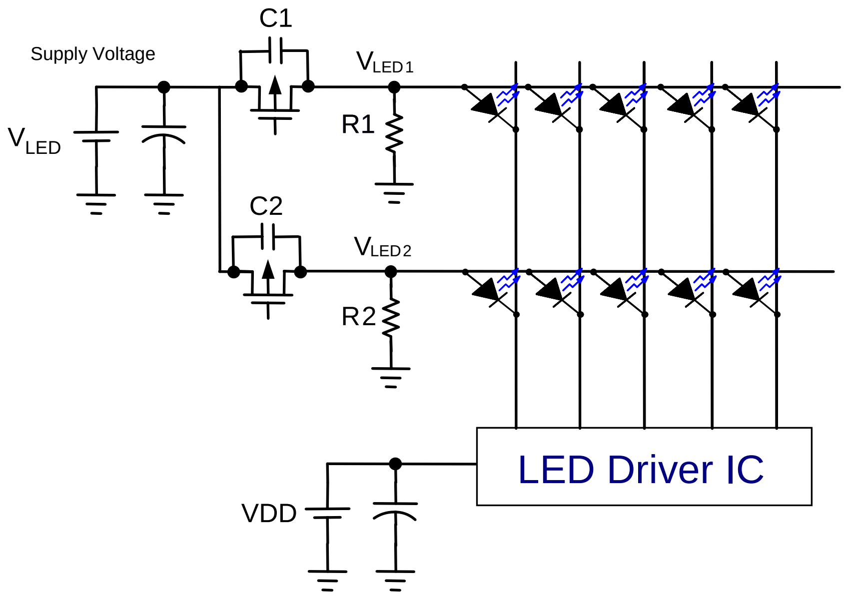

Figure 7. 1/2 duty Time multiplexing circuit.

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The suggested timing diagram of compulsory error detection in time-multiplexing application is shown as figure 8.

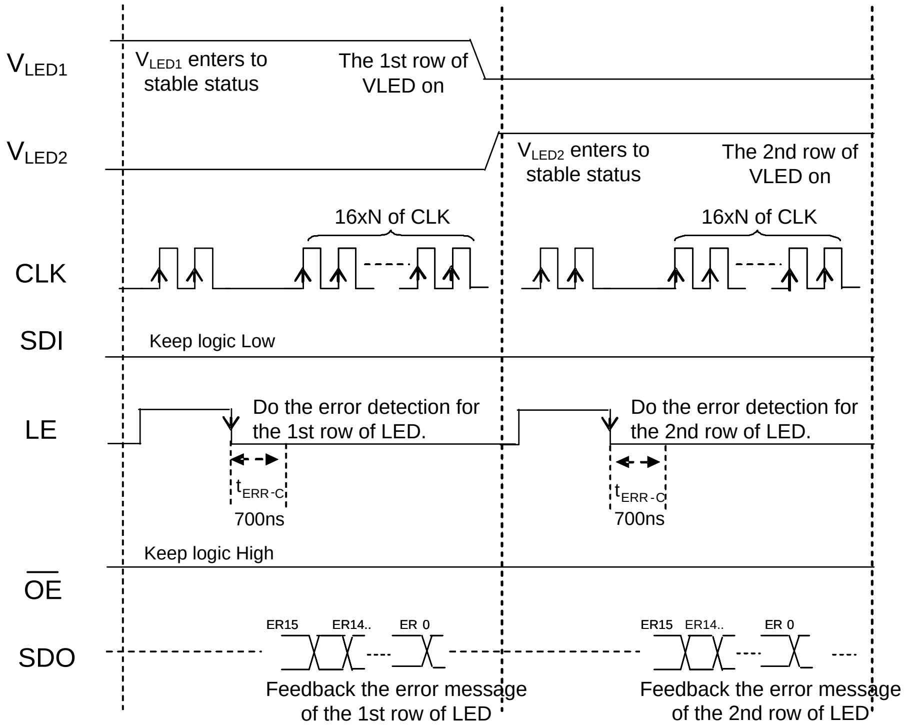

Figure 8. Compulsory error detection timing diagram in 1/2 duty time multiplexing circuit

Conclusion

User can follow this article to make sure MBI5037 works correctly. MBI5037 is an enhanced LED display driver IC with power saving modes and advanced error detection functions. This article describes some application notices. User can follow the article to make sure MBI5037 IC is within the good application characteristic.

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