

# Ultra high precision MZM bias controller on NULL point

## MBC-NULL-03

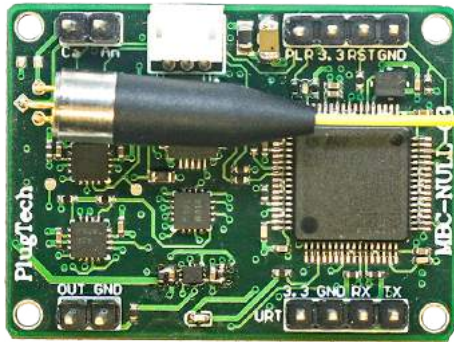


Figure 1. Top View

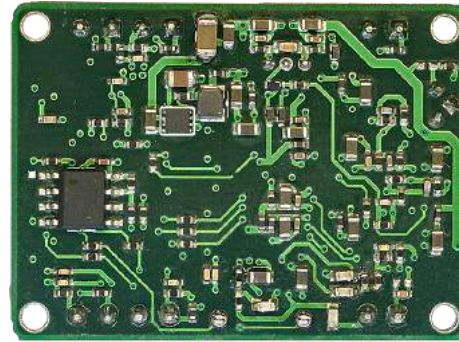


Figure 2. Bottom View

## Feature

- MZM bias control on Null and Peak modes
- Low profile: 38mm(W) × 28mm(D) × 12mm(H)
- High extinction ratio:
  - 53dB Maximum<sup>1</sup>
  - 50.4dB DC extinction ratio lab verified<sup>2</sup>
  - 43dB carrier suppression lab verified
- Low dither amplitude: 0.1%  $V_{\pi}$
- High stability: with fully digital implementation
- Easy to use:
  - Manual operation with mini jumper
  - Flexible OEM operations through UART<sup>3</sup>
- Two different modes to output bias voltage:
  - a. Automatic bias voltage
  - b. User defined bias voltage

## Applications

- LiNbO<sub>3</sub> and other MZ modulators
- Brillouin scattering system and other optical sensors
- Radio over Fiber systems
- Pulse Generation
- Carrier Suppression

## Ordering Information

Part No.: MBC-NULL-03

Contact: info@plugtech.hk

Telephone: +86 13790119725, +852 66459366

## Introduction

PlugTech Precision Systems' modulator bias controller is specially designed for Mach-Zehnder modulators to ensure a stable operation state in various operating environments. Based on its fully digitized signal processing method, the controller can provide ultra stable performance.

The controller injects a low frequency, low amplitude dither signal together with a bias voltage into the modulator. It keeps reading the output from the modulator and determines the condition of the bias voltage and related error. A compensate bias voltage will be applied afterwards according to the previous measurements. In this way, the modulator is ensured to work under a proper bias voltage.

The controller is very compact in volume with high performance. The maximum stable DC extinction ratio measured in Lab is 50.4dB. The highest carrier suppression ratio measured is 43dB.

<sup>1</sup> The highest extinction ratio depends on and cannot exceed the system modulator maximum extinction ratio.

<sup>2</sup> This experiment is conducted by measuring and comparing the power of modulator controlled at Peak and Null respectively.

<sup>3</sup> UART operation is only available on some version of the controller.

## Performance

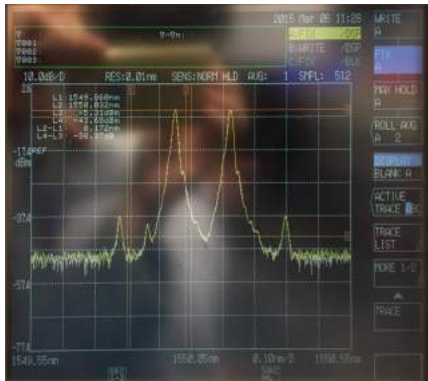


Figure 3. Carrier Suppression

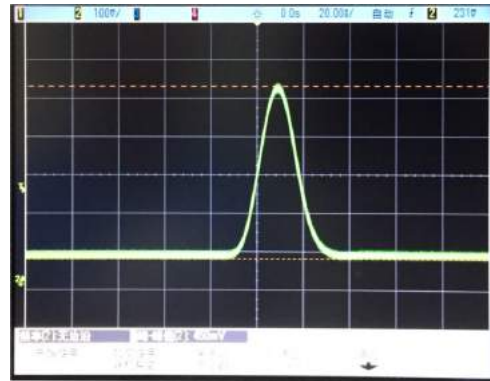


Figure 4. Pulse Generation



Figure 5. Modulator max power



Figure 6. Modulator minimum power

### Maxim DC extinction ratio

In this experiment, no RF signals were applied to the system. Pure DC extinction has been measured.

1. Figure 5 demonstrates the optical power of modulator output, when modulator controlled at Peak point. It shows 3.71dBm in the diagram.
2. Figure 6 shows the optical power of modulator output, when modulator controlled at Null point. It shows -46.73dBm in the diagram. In real experiment, the value varies around -47dBm; and -46.73 is a stable value.
3. Therefore, the stable DC extinction ratio measured is 50.4dB.

### Requirements for high extinction ratio

1. System modulator must have high extinction ratio. Characteristic of system modulator decides the maximum extinction ratio can be achieved.
2. Polarization of modulator input light shall be taken care of. Modulators are sensitive to polarization. Proper polarization can improve extinction ratio over 10dB. In lab experiments, usually a polarization controller is needed.
3. Proper bias controllers. In our DC extinction ratio experiment, 50.4dB extinction ratio has been achieved. While the datasheet of the modulator manufacture only lists 40dB. The reason of this improvement is that some modulators drift very fast. Plugtech MBC-NULL-03 bias controllers update the bias voltage every 1 second to ensure fast track response.

## Specifications

Parameter	Min	Typ	Max	Unit
<b>Control Performance</b>				
Extinction Ratio		MER <sup>1</sup>	53	dB
Stabilization time		10		s
<b>Electrical</b>				
Positive power voltage	+14.5	+15	+15.5	V
Positive power current	20		30	mA
Negative power voltage	-15.5	-15	-14.5	V
Negative power current	1.5		4	mA
Output voltage range	-11.34		+11.34	V
Output voltage precision		350		$\mu V$
Dither frequency	999.99	1000	1000.01	Hz
Dither amplitude		$0.1\%V_{\pi}$		V
<b>Optical</b>				
Input optical power <sup>2</sup>	-30		-9	dBm
Input wavelength	1100		1650	nm

<sup>1</sup> MER refers to Modulator Extinction Ratio. The extinction ratio achieved is typically the extinction ratio of the modulator specified in the modulator datasheet.

<sup>2</sup> Please be noted that the input optical power does not correspond to the optical power at the selected bias point. It refers to the maximum optical power that the modulator can export to the controller when the bias voltage ranges from  $-V_{\pi}$  to  $+V_{\pi}$ .



Figure 7. Controller With Adaptor

## User Interface

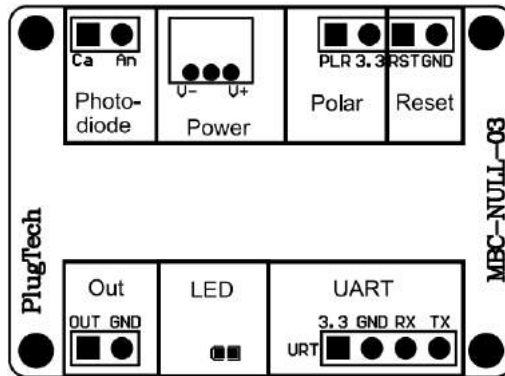


Figure 8. Assembly

Group	Operation	Explanation
Photodiode <sup>1</sup>	PD: Connect MZM photodiode's Cathode	Provide photocurrent feedback
	GND: Connect MZM photodiode's Anode	
Power	Power source for bias controller	V-: connects the negative electrode
		V+: connects the positive electrode
		Middle probe: connects the ground electrode
Polar <sup>2</sup>	Insert or pull out the jumper	no jumper: Null mode; with jumper: Peak mode
Reset	Insert jumper and pull out after 1 second	Reset the controller
Out	Connect with the MZM bias voltage port	OUT and GND provide bias voltages for modulator
LED	Constantly on	Working under stable state
	On-off or off-on every 0.2s	Processing data and searching for controlling point
	On-off or off-on every 1s	Input optical power is too weak
	On-off or off-on every 3s	Input optical power is too strong
UART	Operate controller via UART	3.3: 3.3V reference voltage
		GND: Ground
		RX: Receive of controller
		TX: Transmit of controller

<sup>1</sup> Some MZ modulators have on board photodiodes. Only one choice shall be chosen between using controller photodiode or using modulator photodiode. It is recommended to use controller photodiode for Lab experiments for two reasons. Firstly, controller photodiode has ensured qualities. Secondly, it is easier to adjust the input light intensity. Note: If using modulator's internal photodiode, please make sure that the output current of photodiode is strictly proportional to input power.

<sup>2</sup> Polar depends on system RF signal. When there is no RF signal in the system, the polar should be positive. When RF signal has amplitude greater than a certain level, the polar will change from positive into negative. At this time, Null point and Peak point will switch with each other. Q+ point and Q- point will switch with each other as well. Polar switch enables user to change the polar directly without changing operation points

## UART Command List

UART of the controller works at TTL(3.3V) level with following parameters: 57600 baud rate, 8 data bits, no parity bit, 1 stop bit.

**Note: UART control is an additional feature for bias controller. Only those model number ended with 'A' (for example, MBC-NULL-03A) support UART control.**

Description	Command ID <sup>1</sup>	Data Send <sup>1</sup>	Data Received <sup>2</sup>	Unit
Get optical power <sup>3</sup>	0x67	NA	Current optical power <sup>4</sup>	$\mu$ W
Get bias voltage	0x68	NA	Current bias voltage <sup>4</sup>	V
Get $V_{\pi}$	0x69	NA	Modulator $V_{\pi}$ <sup>4</sup>	V
Set polar	0x6D	0x1: Positive	0x11:Success; 0x88:Error	
	0x6D	0x2: Negative	0x11:Success; 0x88:Error	
Set control mode	0x6B	0x1: automative control	0x11:Success; 0x88:Error	
	0x6B	0x2: manually set DAC	0x11:Success; 0x88:Error	
Set output voltage <sup>5</sup>	0x6C	voltage <sup>6</sup>	0x11:Success; 0x88:Error	
System Reset <sup>7</sup>	0x6E	NA	NA	
Jump 2 $V_{\pi}$ <sup>8</sup>	0x6F	0x1: Forward <sup>9</sup>	0x11:Success; 0x88:Error	
	0x6F	0x2: Backward <sup>10</sup>	0x11:Success; 0x88:Error	
Set Offset <sup>11</sup>	0x71	voltage <sup>12</sup> +sign <sup>13</sup>	0x11:Success; 0x88:Error	
Set Dither Amplitude <sup>14</sup>	0x72	Dither Amplitude <sup>15</sup>	0x11:Success; 0x88:Error	
Pause Control <sup>16</sup>	0x73	NA	0x11:Success; 0x88:Error	
Resume Control <sup>17</sup>	0x74	NA	0x11:Success; 0x88:Error	

<sup>1</sup> Bias controller can be controlled by a master device, such as a microprocessor, through UART. Command ID and Data Send refer to the data sent by master device. Each command should be send in a frame of 7 bytes following the sequence of Command ID(1 byte) + Data(6 bytes). For data bytes, it should be filled from the first byte and unused data bytes should be zero.

<sup>2</sup> Data received refer to the data received by master device. For data received, it has a frame of 9 bytes following the sequence of Command ID(1 byte)+Data(8 bytes). Similar to data send, received data bytes will be filled from the first byte and unused data bytes will be filled with zero.

<sup>3</sup> The average power corresponds to the optical power which inputs into the controller. The responsivity used in calculation is 0.85A/W.

<sup>4</sup> Data received is 4 byte floating point number(Little Endian).

<sup>5</sup> Set output voltage function can only be used when bias controller is working under manual mode.

<sup>6</sup> Four bytes. Byte one is fixed to 0x00. Calculation of remaining bytes is stated by an example. If 3.215V is required for output, the voltage should be multiplied by 1000 to convert the value to integer, i.e. 3215. Then convert 3215 to hex format. Hex format of 3215 is 0x0C8F. Byte two is the upper half of the final hex result, i.e. 0x0C. Byte three is the lower half, i.e. 0x8F. Byte four is sign of the voltage, 0x00 for positive, 0x01 for negative.

<sup>7</sup> Reset the controller. It will start from initialization.

<sup>8</sup> Modulators may have several working point seperated by 2  $V_{\pi}$ . There may be difference in performance among all the working points. This function is designed to help user select among all the working points to find the best one.

**Note: it may take around 5 seconds for the controller to settle after each jump.**

<sup>9</sup> Suppose current working point at  $V_1$ . After jumping forward, the new working point is set at  $V_1 + 2V_{\pi}$

<sup>10</sup> Suppose current working point at  $V_1$ . After jumping backward, the new working point is set at  $V_1 - 2V_{\pi}$

<sup>11</sup> Sets an offset from Null point of modulator. Suppose current working point is at  $V_1$  and an offset of +0.5V is set. The new working point is  $V_1 + 0.5$ . The offset's factory default value is 0, when user set a new value to the controller, it will be stored in Flash memory and automatically loaded when the controller is turned on or reset.

<sup>12</sup> Three bytes. The first two bytes are the offset value and the third byte is sign. The first byte is the upper half of offset value in hexadecimal format while the second byte is the lower half. The third byte is the sign of offset value, it can be positive or negative(Refers to Note 13). This function adds an offset to current lock point, for example, when controller locks modulator at Null point and offset is set to be +1000, then the actual bias voltage will be Null point's bias voltage + an offset voltage. This offset value is propotional to the offset voltage.

<sup>13</sup> For the offset value's sign byte content, 1 represent negative sign and 2 represent positive sign. For example, if [0x03 0xE8 0x02] is sent to controller, controller will add 1000 DAC steps to current working point.

<sup>14</sup> Set dither amplitude. It can only be the multiple of 0.1%  $V_{\pi}$  and maximum dither amplitude is 2%. For example, if dither amplitude of arm I is set to be 3. Then dither amplitude on arm I will be 0.3%. The amplitude's factory default value is 1, when user set a new

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value to the controller, it will be stored in Flash memory and automatically loaded when the controller is turned on or reset.

<sup>15</sup> Format of the data is dither amplitude. Only one byte.

<sup>16</sup> This function will pause the controller's automatic control. Dither will be stopped and bias voltage output will remain at the value when the pause command is executed.

<sup>17</sup> This function is used together with Pause Control. When pause control is executed and the automatic control is needed, executing this command will resume automatic control.

# MBC-NULL-03

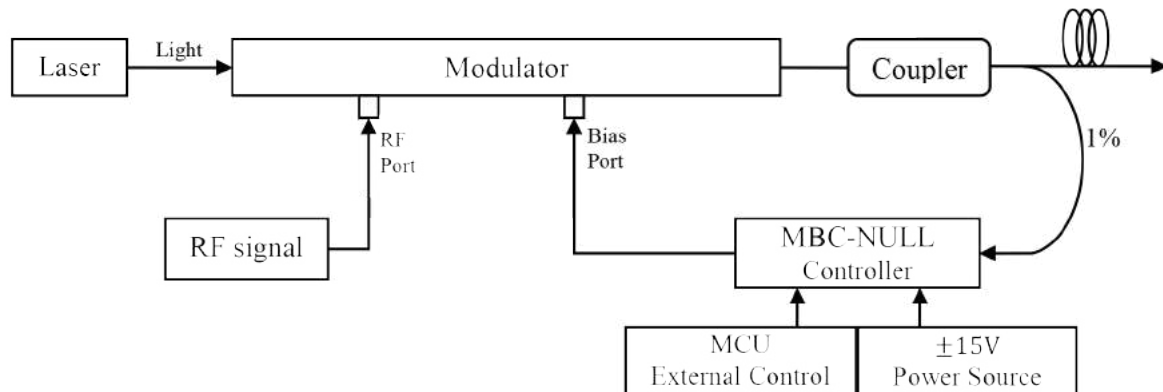
## Environmental Characteristics

Parameter	Min	Typ	Max	Unit
Operating temperature	-10		50	°C
Storage temperature	-20		80	°C

## Dimensions

Parameter	Value
Dimensions(W× D× H)	38mm× 28mm × 12mm
Weight	100g

## Typical Application



The controller is easy to use.

**Step1.** Connect 1% port of the coupler to the photodiode of the controller.

**Step2.** Connect bias voltage output of the controller(through SMA or 2.54mm 2-pin header) with bias port of the modulator.

**Step3.** Provide controller with +15V and -15V DC voltages.

**Step4.** Reset the controller and it will start to work.

**NOTE.** Please be ensured that RF signal of the whole system is on before resetting the controller.



**This is an electrostatic-sensitive device. Please observe precautions for handling**

**Content of the datasheet is subject to modification.  
Please send an enquiry email to [info@plugtech.hk](mailto:info@plugtech.hk) for latest version of datasheet.**



## Revision History

<b>Version</b>	<b>Content</b>	<b>Date</b>
1.0.0	First Release	2015-Apr
1.1.0	Minor modifications. Add performance pictures	2015-May
1.1.1	Modifications in UART section.	2015-Sep
2.0.0	Update for MBC-NULL-02.	2015-Dec
2.0.1	Update UART section.	2015-Dec
2.0.2	Add UART settings description.	2016-Mar
2.0.3	Consolidate UART function description.	2016-May
2.0.4	Current on specification table updated	2016-Sep
2.0.5	Contact and part no. updated	2016-Oct
2.0.6	Add restriction on modulator's internal PD.	2016-Dec
2.0.7	Update UART section	2017-Mar
2.0.8	Update UART section and connection diagram	2017-Aug
2.0.9	Update UART section	2017-Oct
2.1.0	Update User Interface Description	2020-Feb
2.1.1	Update UART note section	2020-May
2.1.2	Update Dimension Information	2020-Dec