

Ultra High Precision MZM Bias Controller

MBC-MZM-01

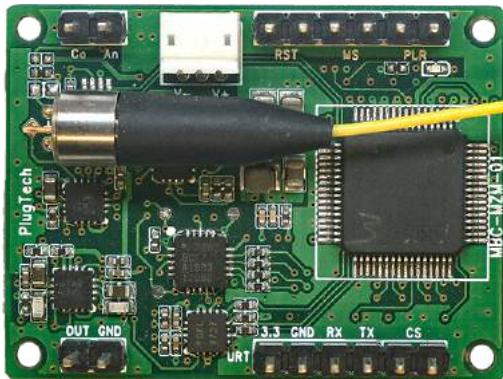


Figure 1. Top view

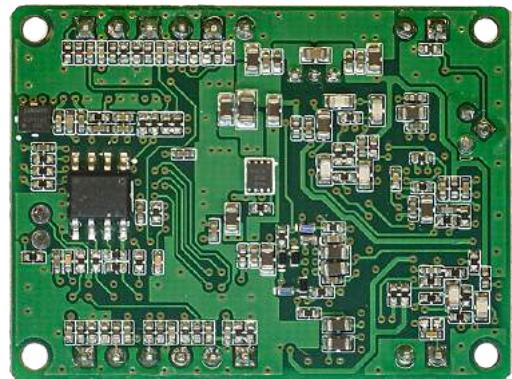


Figure 2. Bottom view

Features

- Bias voltage control on Peak/Null/Q+/Q-
- Bias voltage control on arbitrary point
- Ultra precise control:
50dB maximum¹ extinction ratio on Null mode
 $\pm 0.5^\circ$ accuracy on Q+ and Q- modes
- Low dither amplitude:
0.1% V_π at NULL mode and PEAK mode
2% V_π at Q+ mode and Q- mode
- High stability: with fully digital implementation
- Low profile: 40mm(W) × 30mm(D) × 12mm(H)
- Easy to use:
Manual operation with mini jumper
Flexible OEM operations through MCU UART²
- Two different modes to provide bias voltage:
 - Automatic bias control
 - User defined bias voltage

Applications

- LiNbO₃ and other MZ modulators
- Digital NRZ, RZ
- Pulse applications
- Brillouin scattering system and other optical sensors
- CATV Transmitter

Ordering Information

Part No.: MBC - MZM - 01

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Description

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 bias voltage into the modulator. It keeps reading the output from the modulator and determines the condition of the bias voltage and the related error. A new bias voltage will be applied afterwards according to the previous measurement. In this way, the modulator is ensured to work under proper bias voltage.

¹ The highest extinction ratio depends on and cannot exceed modulator maximum extinction ratio.

² UART operation is only available on some version of the controller.

Performance



Figure 3. Carrier Suppression

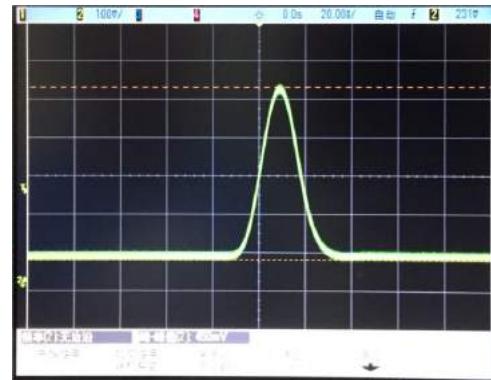


Figure 4. Pulse Generation



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 extinciton 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-MZM-01 bias controllers update the bias voltage every 1 second to ensure fast track response.

MBC-MZM-01

Specifications

Parameter	Min	Typ	Max	Unit	Conditions
Control Performance					
Extinction ratio		MER ¹	50	dB	
CSO ²	-55	-65	-70	dBc	Dither amplitude: $2\%V_{\pi}$
Stablization time		4		s	Tracking points: Null & Peak
		10			Tracking points: Q+ & Q-
Electrical					
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	2		4	mA	
Output voltage range	-9.57		+9.85	V	
Output voltage precision		346		μ V	
Dither frequency	999.95	1000	1000.05	Hz	Version: 1kHz dither signal
Dither amplitude		0.1% V_{π}		V	Tracking points: Null & Peak
		2% V_{π}			Tracking points: Q+ & Q-
Optical					
Input optical power ³	-30		-5	dBm	
Input wavelength	1100		1650	nm	

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

² CSO refers to composite second order. To measure CSO correctly, the linear quality of RF signal, modulators and receivers shall be ensured. In addition, the system CSO readings may vary when running at different RF frequencies.

³ Please be noted that input optical power does not correspond to the optical power at selected bias point. It refers to the maximum optical power that the modulator can export to controller when bias voltage ranges from $-V_{\pi}$ to $+V_{\pi}$.

MBC-MZM-01

User Interface

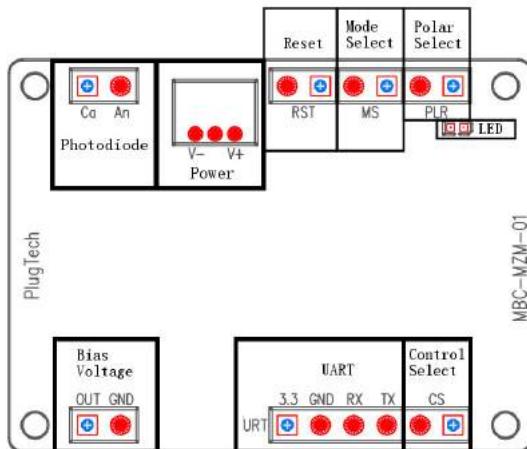


Figure 7. Assembly

Group	Operation	Explanation
Photodiode ¹	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
Reset	Insert jumper and pull out after 1 second	Reset the controller
Mode Select	Insert or pull out the jumper	no jumper: Null mode; with jumper: Quad mode
Polar Select ²	Insert or pull out the jumper	no jumper: Positive Polar; with jumper: Negative Polar
Bias Voltage	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
Control Select	Insert or pull out the jumper	no jumper: jumper control; with jumper: UART control

¹ Some MZ modulators have internal photodiodes. Controller setup should be chosen between using controller's photodiode or using modulator's internal photodiode. It is recommended to use controller's photodiode for Lab experiments for two reasons. Firstly, controller photodiode has ensured quality. 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.

² Polar pin is used to switch the control point between Peak and Null in Null control mode(determined by Mode Select pin) or Quad+ and Quad- in Quad control mode. If jumper of polar pin is not inserted, the control point will be Null in Null mode or Quad+ in Quad mode. Amplitude of RF system will also affect the control point. When there is no RF signal or RF signal amplitude is small, controller is able to lock the work point to correct point as selected by MS and PLR jumper. When the RF signal amplitude exceeds certain threshold, polar of the system will be changed, in this case, the PLR header should be in the opposite state, i.e. the jumper should be inserted if it is not or pulled out if it is inserted.

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-MZM-01A) support UART control.

Description	Command ID ¹	Data Send ¹	Data Received ²	Unit
Get optical power ³	0x67	NA	Current optical power ⁴	μW
Get bias voltage	0x68	NA	Current bias voltage ⁴	V
Get V_π	0x69	NA	Modulator V_π ⁴	V
Set control mode	0x6B	0x01: automative control	0x11: Success; 0x88: Error	
	0x6B	0x02: manually set DAC	0x11: Success; 0x88: Error	
Set output voltage ⁵	0x6C	voltage ⁶	0x11: Success; 0x88: Error	
System reset ⁷	0x6E	NA	NA	
Jump 2 V_π ⁸	0x6F	0x01: Forward ⁹	0x11: Success; 0x88: Error	
	0x6F	0x02: Backward ¹⁰	0x11: Success; 0x88: Error	
Get operating status ¹¹	0x70	NA	0x01: Stabilizing	
	0x70	NA	0x02: Stabilized	
	0x70	NA	0x03: Light too weak	
	0x70	NA	0x04: Light too strong	
	0x70	NA	0x05: Manual state	
Set offset ¹²	0x71	voltage ¹³ +sign ¹⁴	0x11: Success; 0x88: Error	
Set dither amplitude ¹⁵	0x72	Dither Amplitude ¹⁶	NA	
Pause control ¹⁷	0x73	NA	0x11: Success; 0x88: Error	
Resume control ¹⁸	0x74	NA	0x11: Success; 0x88: Error	
Set point ¹⁹	0x76	point info ²⁰	NA	

¹ 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.

² 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.

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

⁴ Data received is 4 byte floating point number(Little Endian).

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

⁶ 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.

⁷ Reset the controller. It will start from initialization.

⁸ Modulators may have several working point separated by 2 V_π . 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.

⁹ Suppose current working point at V_1 . After jumping forward, the new working point is set at $V_1 + 2V_\pi$

¹⁰ Suppose current working point at V_1 . After jumping backward, the new working point is set at $V_1 - 2V_\pi$

¹¹ There might be a delay not exceeding 3s between the controller receives this command and send back data when the controller is in stabilizing status.

¹² Sets an offset from current point of modulator. When the controller locks operating point at Null/Peak point, the offset range is from -70° to +70°. When the controller locks operating point at Quad point, the offset range is from -60° to +60°. The offset's factory default

MBC-MZM-01

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.

¹³ 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 14). This function adds an offset to current lock point, for example, when controller locks modulator at Quad+ point and offset is set to be +1000, then the actual bias voltage will be Quad+ point's bias voltage + an offset voltage. This offset value is proportional to the offset voltage.

¹⁴ 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.

¹⁵ 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 value to the controller, it will be stored in Flash memory and automatically loaded when the controller is turned on or reset.

¹⁶ Format of the data is dither amplitude. Only one byte.

¹⁷ 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.

¹⁸ 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.

¹⁹ This function set the current lock point of controller among Peak/Null/Q+/Q-

²⁰ Point info is two byte long representing the lock point.Peatk: [1 2]; Null: [1 1]; Q+: [2 1]; Q-: [2 2]. For example, to set lock point at Peak, [0x76 0x01 0x02 0 0 0 0] should be sent.

MBC-MZM-01

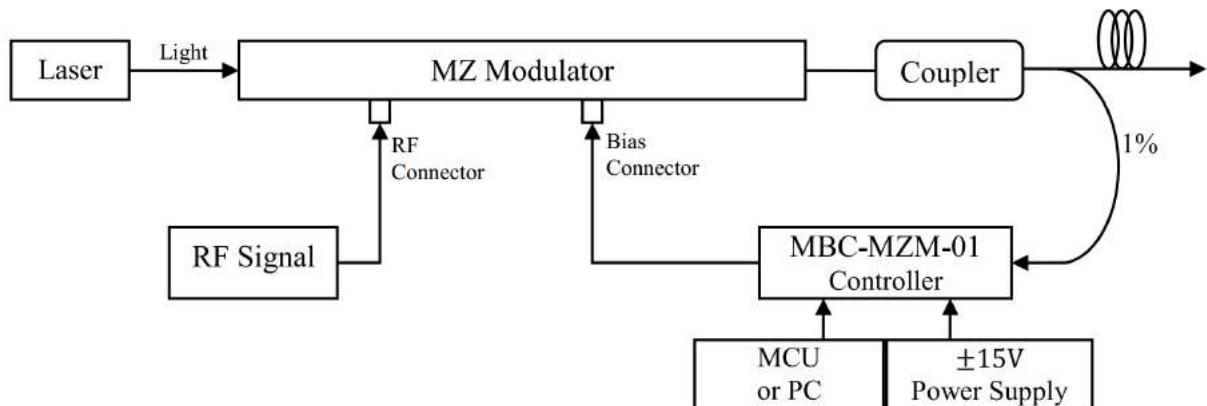
Environmental Characteristics

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

Dimensions

Parameter	Value
Dimensions(W× D× H)	40mm× 30mm × 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 2.54mm 2-pin jumper) with bias port of the modulator.

Step3. Provide controller with +15V and -15V DC voltages. Right after the power is provided, the controller will start to work automatically, LED of the controller will start to blink.

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

Content of the datasheet is subject to modification.

Please send an enquiry email to info@plugtech.hk for latest version of datasheet.

MBC-MZM-01

Revision History

Version	Content	Date
1.0.0	First Release.	2016-Jun
1.0.1	Current on specification table updated.	2016-Sep
1.0.2	Contact updated.	2016-Oct
1.0.3	UART section updated.	2016-Nov
1.0.4	UART section updated.	2017-Mar
1.0.5	Operating wavelength updated.	2017-Jun
1.0.6	UART section updated.	2017-Aug
1.0.7	UART section updated.	2017-Oct
1.0.8	Update UART Note section.	2020-May
1.0.9	Update Dimension Information	2020-Dec