TFLN Thermo-optic modulator MZM bias controller on NULL point

TFLN-NULL-01

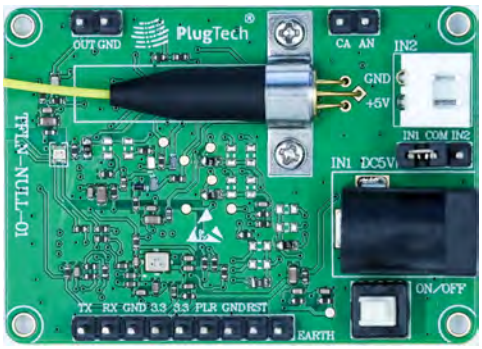

Figure 1. Top View

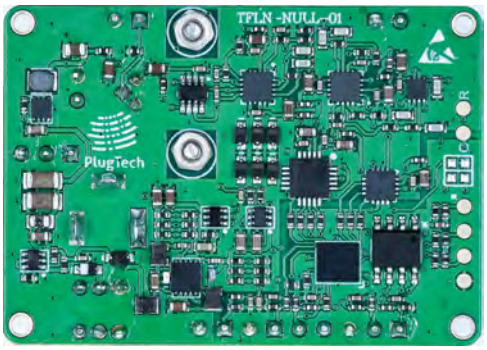

Figure 2. Bottom View

Feature

- MZM bias control on Null and Peak modes
- Low profile: 49mm(W) × 35mm(D) × 14mm(H)
- High extinction ratio[1]
- Low dither amplitude: 0.5% P_π
- High stability: with fully digital implementation
- Easy to use:
  - 5V DC power supply
  - Manual operation with mini jumper
  - Flexible OEM operations through UART
- Two different modes to output bias voltage:
  - a. Automatic bias voltage
  - b. User defined bias voltage
- Flexible working point selection:
  - a. Controller automatically searches locking point
  - b. User defined locking point

Applications

- TFLN and other MZ modulators with bias heater
- Brillouin scattering system and other optical sensors
- Radio over Fiber systems
- Pulse Generation
- Carrier Suppression

Ordering Information

Part No.: TFLN-NULL-01

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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.

Ordering Guide

Model	Output range
TFLN-NULL-01A-040	0-4V
TFLN-NULL-01A-080	0-8V
TFLN-NULL-01A-100	0-10V
TFLN-NULL-01S-***	Custom range

The maximum output voltage of the controller (V_{max}) should not exceed the maximum input voltage of the modulator heater and satisfy the following condition: $(V_{max})^2 > P_\pi \times R_{Heater} \times 0.002$, where P_π is modulator's thermo-optic bias heater P_π value (unit:mW) and R_{Heater} is resistance value (unit:ohm) of modulator's heater.

[1] The highest extinction ratio depends on and cannot exceed the system modulator maximum extinction ratio.

Performance

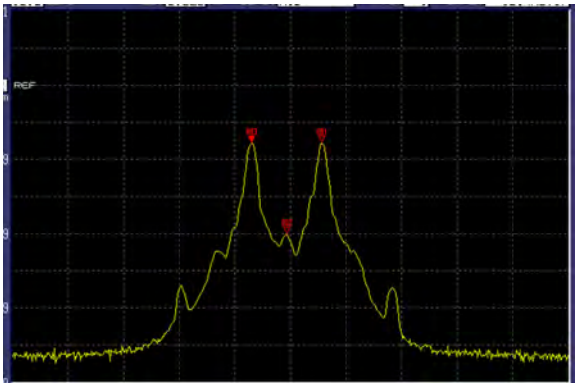


Figure 3. Carrier Supression

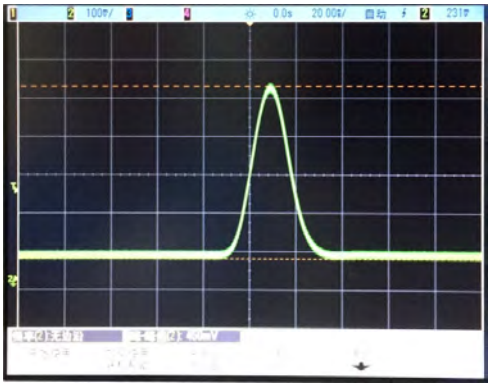


Figure 4. Pulse Generation

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.
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 previous 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 TFLN-NULL-01 bias controllers update the bias voltage every 1 second to ensure fast track response.

Specifications

Parameter	Min	Typ	Max	Unit	Note
Control Performance					
Extinction Ratio		MER[1]		dB	
Stabilization time		15		s	
Electrical					
Positive power voltage	+4.5	+5	+5.5	V	
No-load current[2]	60		90	mA	
Operating current	70		600	mA	
Output voltage range	0		4	V	TFLN-NULL-01A-040
	0		8	V	TFLN-NULL-01A-080
	0		10	V	TFLN-NULL-01A-100
Dither frequency	999.99	1000	1000.01	Hz	
Dither amplitude		$0.5\%P_{\pi}$		mW	
Feedback input current[3,5]	0.001		0.316	mA	
Optical					
Input optical power[4,5]	-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 the modulator specified in the modulator datasheet.

[2] The working current when the output port of the controller is not connected to the modulator.

[3] Use modulator's built-in PD as feedback input.

[4] Use controller's onboard PD as feedback input.

[5] 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 within the output range of controller.

Figure 7. Controller With Adaptor

User Interface

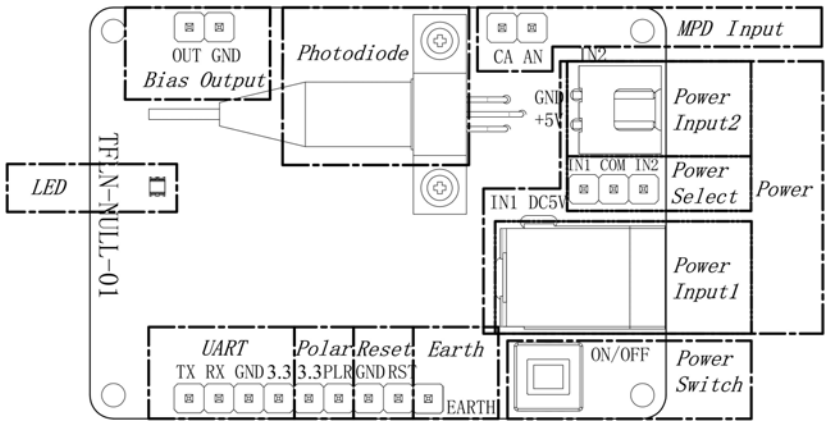


Figure 8. Assembly

Group	Operation	Explanation
Photodiode [1]	Connect with optical coupler at modulator's output	Use controller's onboard PD as feedback input
MPD Input [1]	CA: Connect modulator built-in PD's Cathode	Use modulator's MPD as feedback input
	AN: Connect modulator built-in PD's Anode	
Power	Power Input1: Connect +5V DC adaptor	Use +5V DC power adaptor as power supply
	Power Select: switch power input channel	Example:connect IN1 and COM to active Power Input1
	Power Input2: Connect +5V DC supply	Use other +5V DC source as power supply
Power Switch	Turn on/off bias controller	Press the switch to turn on/off the controller
Polar [2]	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
Earth	Ground pin of bias controller	
Bias Output	Connect with the MZM bias voltage port	OUT and GND provide bias voltages for modulator
LED	Green light constantly on	Working under tracking state
	Green light blinking every 0.2s	Processing data and searching for controlling point
	Green light blinking every 1s	Feedback input is too weak
	Red light blinking every 3s	Feedback input is too strong
	Red light constantly on	Working under PauseControl mode or Manual mode
UART	Operate controller via UART	3.3: 3.3V reference voltage
		GND: Ground
		RX: Receive of controller
		TX: Transmit of controller

[1] Some MZ modulators have built-in photdiodes. Only one choice shall be chosen between using controller's onboard photodiode or using modulator built-in 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.

[2] 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. For detailed instructions on using UART Command, please refer to Operation Guide file.

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 P_π	0xA4	NA	Modulator P_π [4]	mW
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 output	0x11:Success; 0x88:Error	
Set output voltage[5]	0x6C	voltage[6]	0x11:Success; 0x88:Error	
System reset[7]	0x6E	NA	NA	
Set heater resistance[8]	0xA1	resistance[9]	0x11:Success; 0x88:Error	
Set tracking position[10]	0x9F	target position	0x11:Success; 0x88:Error	
Set offset[11]	0x71	offset[12] +sign[13]	0x11:Success; 0x88:Error	
Set dither amplitude[14]	0x72	Dither amplitude[15]	0x11:Success; 0x88:Error	
Pause control[16]	0x73	NA	0x11:Success; 0x88:Error	
Resume control[17]	0x74	NA	0x11:Success; 0x88:Error	

[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 receiced, 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 0.95A/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] Heater resistance should be calculate when the controller is connected to a different modulator.

[9] The value of the first byte is the first half (0xAB of the heater resistance value converted to hexadecimal (e.g. 0xABCD), and the value of the second byte is the second half (0xCD) of the heater resistance (hexadecimal).

[10] Preset target tracking point. For example, when the position value is set to 2 in Null point mode, the controller will try to lock the 2nd Null point. 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.

[11] Offset compensation power is added to the base power of the current tracking operating point. Offset compensation power = offset compensation amount $\times$ adjust power accuracy, where adjust power accuracy = maximum power value that the controller can output/10000. 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.

[12] 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 to implement a specific working point.

[13] For the offset value's sign byte content, 1 represent negative sign and 2 represent positive sign.

[14] Set dither amplitude parameter. It can only be the multiple of $0.5\%P_\pi$. For example, if dither amplitude parameter is set to 3. Then actual dither amplitude on output port will be 1.5%. 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.

[15] Dither amplitude parameter data = dither amplitude parameter $\times$ 10. Only one byte. For example, when user expect to set the

parameter to 3, the data send to controller should be 30

[16] 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.

[17] 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.

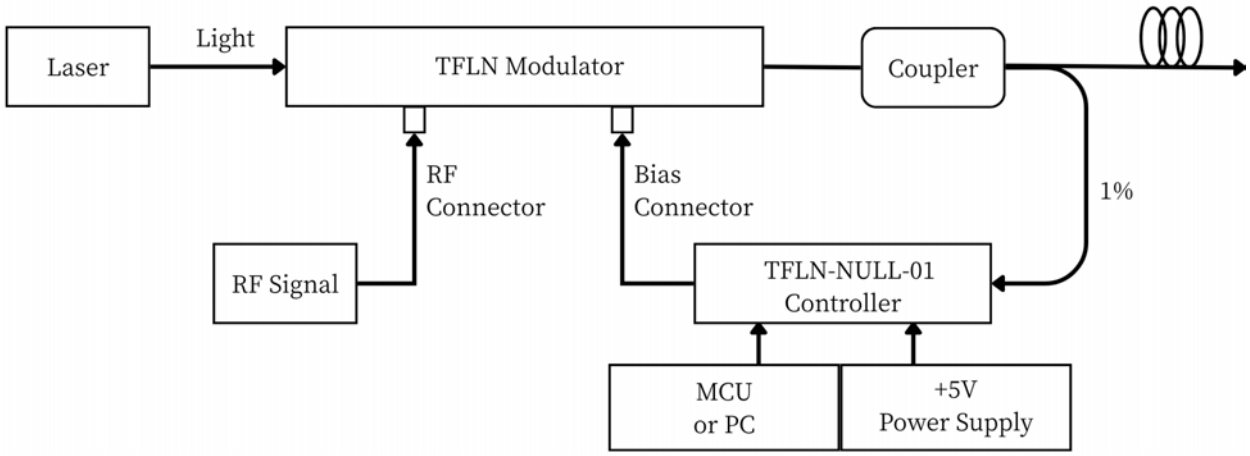
Environmental Characteristics

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

Dimensions

Parameter	Value
Dimensions(W× D× H)	49mm× 35mm × 14mm
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 header) with bias port of the modulator.
Step3. Provide controller with +5V DC voltage.
Step4. Turn on the controller and it will start to work.
NOTE. Please be ensured that RF signal of the whole system is on before turn on/resetting the controller.
NOTE. Please calibrate the modulator heater resistance value via GUI or UART command while the controller is deployed to a different modulator.

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@plugtechmbc.com for latest version of datasheet.

Revision History

Version	Content	Date
1.0.0	First Release	2025-Oct