DMR4I-Ch

DIGITAL OPTICAL MINISTICK

1. General description

DMR4I-Ch is a multipurpose digital optical ministick, which can be used in a wide range of devices: from housed appliances and reprogrammable switches to robotics control systems.

The ministick has an optical system, which monitors the deflection of the manipulator within ± 5 mm (or ± 55 degrees), and a microcontroller for signal processing.

The ministick produces incrementation signals in two coordinates, X and Y, depending on the angle of the manipulator's deflection in the plane of XY coordinates, which are transmitted via SPI interface. Signal quantity depends on the pressure force and vertical deflection angle - the more pressure is applied, the more the deflection angle and signal quantity become.

DMR4I-Ch is available in six-pin die form

2. Main characteristics

- Operating life – 1.5 million presses
- Dimensions 16x19x13.5 mm
- Manipulator deflection range

+/- 5 mm.

- Power supply voltage 3–5 W.
- Power usage < 3 mA.
- High-speed SPI interface.
- Weight 1.7 g
- Operating temperature from -15 ° C to +60 ° C.

3. Applications

DMR4I-Ch is suitable for a wide range of applications – from small manual input devices such as mobile phones, MP3 players, mice, pendants, PDAs, GPS devices, and video game consoles to polyjoysticks and control sticks for robots, aircrafts, and complex manipulators.

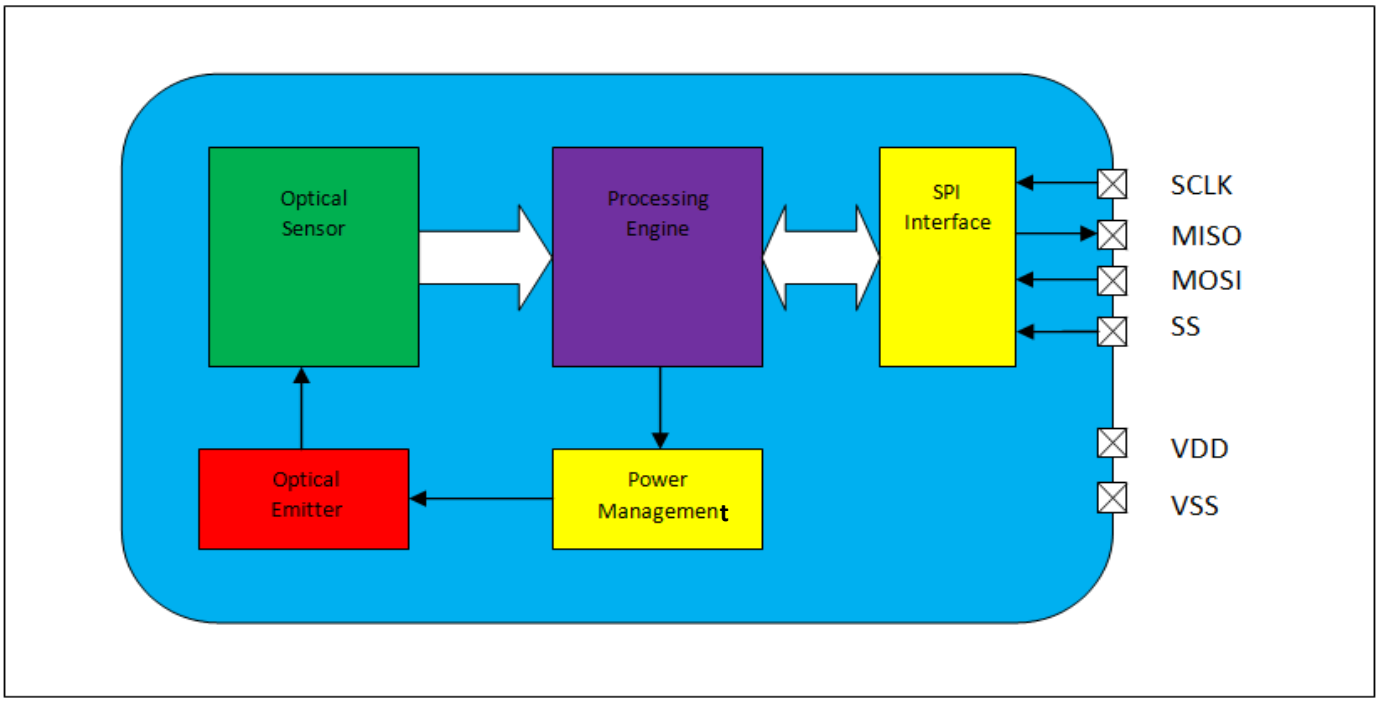


Fig. 1 – Flow chart

4. Pin assignment

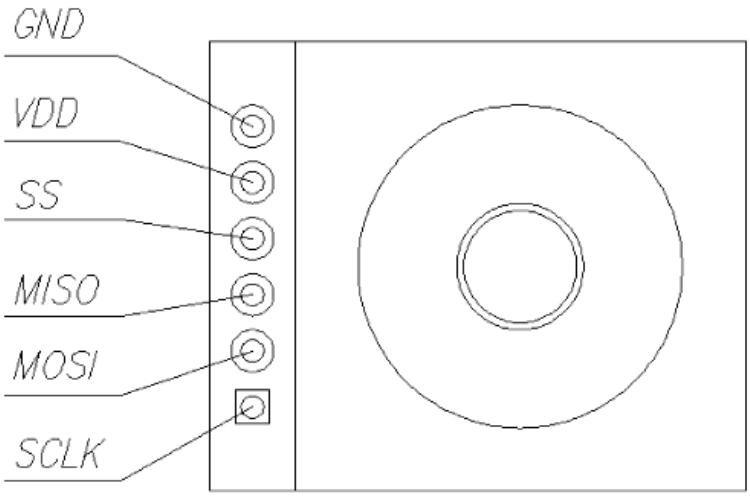


Fig. 2 – Pin assignment (top view)

Table 1. Pin description

Designator	Type	Description
GND	Power supply	Common leg
VDD	Power supply	Device power input
SS	Digital input	Device select input
MISO	Digital output	Interface data output
MOSI	Digital input	Interface data input
SCLK	Digital input	Interface clock signal input

5. Overload capacity

In case the parameters listed in Table 2 exceed tolerability limits, the device can sustain irreparable damage. The table shows critical values that do not guarantee device functioning. Continuous functioning at critical values can compromise device reliability. For the parameters in normal operating conditions, see Section 6.1 of this document.

Table 2. Limiting parameters

Designator	Parameter	Min	Max	Units	Comments
Electrical parameters					
VDD	Power supply voltage	-0.3	6	B	
VIN	Input voltage	-0.3	VDD + 0.3	B	
IOL	Output low-level current	-	100	mA	
IOH	Output high-level current	-100	-	mA	
Temperature characteristics					
TST	Temperature range	-20	+85	° C	

6. Electrical characteristics

T = from -20 ° C to + 80 ° C, VDD = 5 W.

Table 3. Operating conditions

Designator	Parameter	Conditions	Min	Max	Units
VDD	Power supply voltage		3	5.5	V
VIL	Input low-level voltage		0	0.3VDD	V
VIH	Input high-level voltage		0.7VDD	VDD	V
IDD	Useful current		-	3	mA
TCONV	Conversion time	Time from SS link activation to data availability	-	50	ms
DX DY	Deflection		5	8	mm
TAMB	Temperature range		-20	+80	°C
TCLK	Clock cycle		50	-	µs

7. Detailed description

The ministick has an optical system, which monitors the angular deflection of the manipulator within ± 5 mm (or ± 55 degrees), and a microcontroller for signal processing. The functioning of the optical ministick is based on the reflection of light from the surface in a certain direction depending on the manipulator's position. Under the manipulator, there is an infrared photodiode in the middle, which serves as an optical sensor. Around the photodiode, there are infrared LEDs mounted at 90º intervals, which serve as optical emitters.

During the functioning of the ministick, the microcontroller lights the LEDs one by one. The light emitted by a lit LED reflects from the light-reflecting surface and strikes upon the photodiode, which converts the intensity of the light output into voltage. The voltage comes on the microcontroller AD converter output. The microcontroller measures the voltage at the AD converter input at the moment when each LED is lit. At the request of the head unit, it sends the obtained values to it via SPI interface.

As the manipulator changes its position, the light-reflecting surface is deformed, changing the intensity of the reflected light that strikes upon the photodiode, which leads to changes in the voltage at the microcontroller AD converter input and the output value.

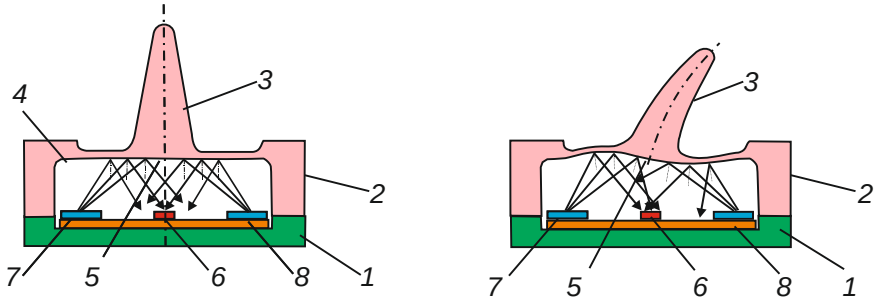


Fig. 3. DMR4I-Ch optical ministick mode of operation

1 – circuit plate; 2 – body; 3 – manipulator; 4 – elastic deformation element, 5 – light-reflecting surface, 6 – photodiode; 7 – light emitting diode.

The ministick produces incrementation signals in two coordinates, X and Y, depending on the angle of the manipulator's deflection in the plane of XY coordinates, which are transmitted via SPI interface. Signal quantity depends on the pressure force and vertical deflection angle - the more pressure is applied, the more the deflection angle and signal quantity become.

DMR4I-Ch has the following advantages:

- simple design;
- high reliability due to low part count and lack of mechanical friction couples;
- versatility;
- multifunctionality and reprogramming capability
- fire and explosion safety due to lack of sparking contacts;
- injury free operation due to the elasticity of the plastic manipulator;
- ergonomics – the size is tailored for human finger reach;
- silent operation;
- low metal and material consumption;
- light weight;
- hermetically sealed version available;
- low energy consumption.

One of the ministick's features is slight non-linearity of the output signal from the manipulator deflection angle due to a slight natural bend in the manipulator when it is deflected. Another feature is slight hysteresis due to the properties of the elastic deformation material.

These features hardly have any impact on the ministick's usability during adaptive control.

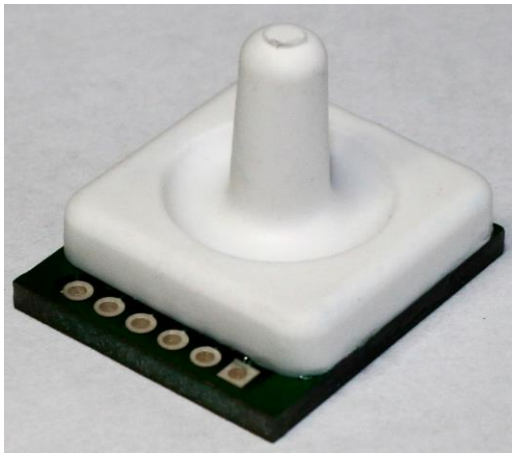


Fig. 4. DMS-13-16-16-SPI-2.0 ministick exterior

8. DMR4I-Ch operation

Typical application:

DMR4I-Ch ministick requires no external components due to its perfection and standard interface. One just needs to connect it to a controller via an SPI bus and energize it. For the possible connection options, see Fig. 5 and 6.

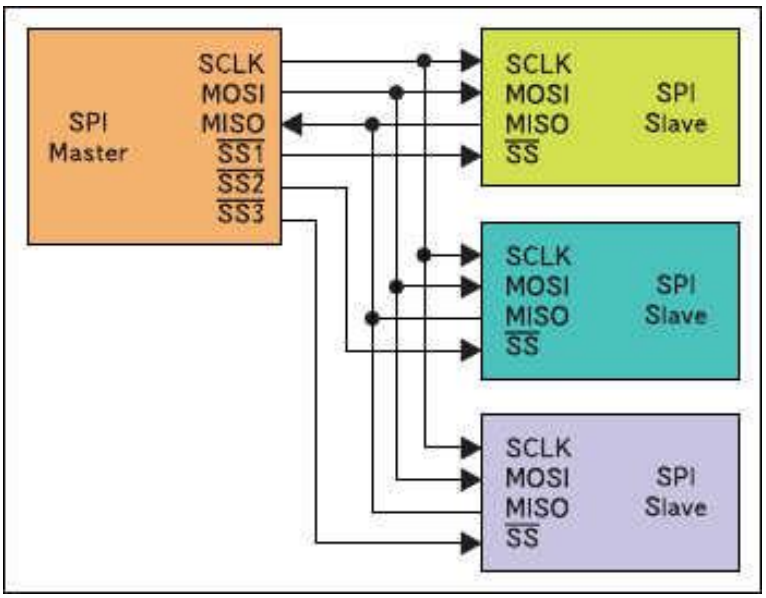


Fig. 5. Radial ministick connection structure

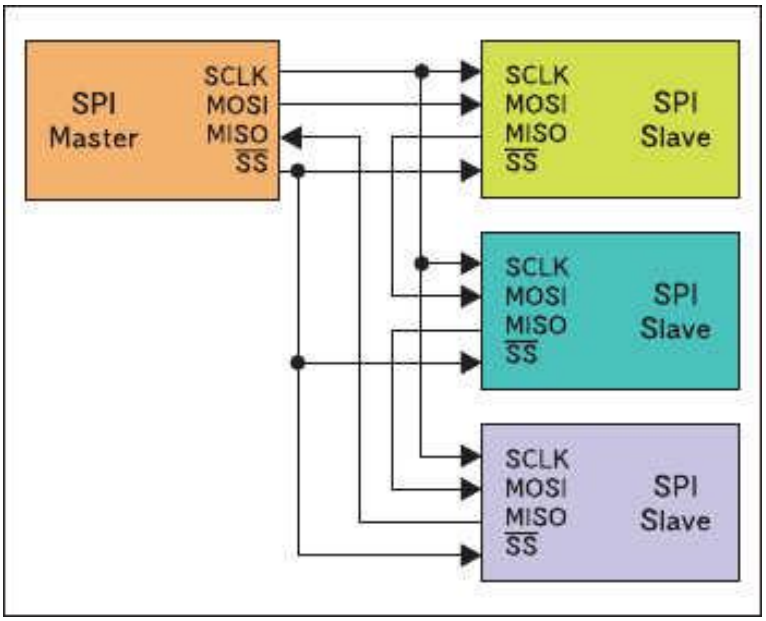


Fig. 6. Circular ministick connection structure

As soon as the ministick is energized and the SS interface line is activated, the microcontroller launches and takes several measurements of the light output. During the measurements, the microcontroller lights each LED one by one and measures the intensity of the reflected light emitted by an LED. The obtained data is then averaged and transmitted to the head unit at its request (see Section 9).

9. XY coordinates interpretation

When the ministick's manipulator is pressed, the intensity of the light output from each LED that strikes upon the photodiode changes. Changes in the intensity of the light output depend on the direction and force of pressure. Pressure force also determines the ministick's deflection angle. Changes in the intensity of the light output from the LEDs result in

changes in the voltage at the microcontroller AD converter output. When the SS interface line is activated, the microcontroller measures current voltage values. The data obtained from the measurements is then uploaded to the interface registers.

The data read off the ministick is the results of the conversion performed by the AD converter across four channels, two bytes per channel. In order to calculate current coordinates of the ministick's manipulator position, the following formulas must be used:

X = ADC1 – ADC3 – CentreX

Y = ADC2 – ADC4 – CentreY,

where ADC1, ADC2, ADC3, ADC4 are the results of measurements across four channels,

CentreX, CentreY are the results of measurements with the ministick in a neutral position.

10. SPI interface

In order to initiate the data reading procedure, the SS line must be put into active state (0). Then there must be a 50-millisecond delay while the ministick prepares the data on the manipulator's current state for reading. Any data read before the conversion process is finished will be incorrect.

The data on the MISO line are output on the falling edge of the SCLK line. The bytes go with the most significant bit first. For the schematic structure of the package, see Fig. 7.

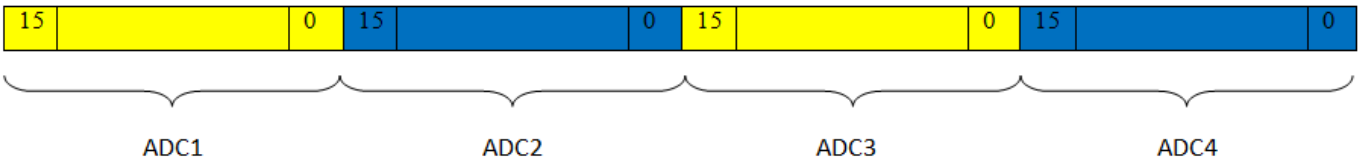
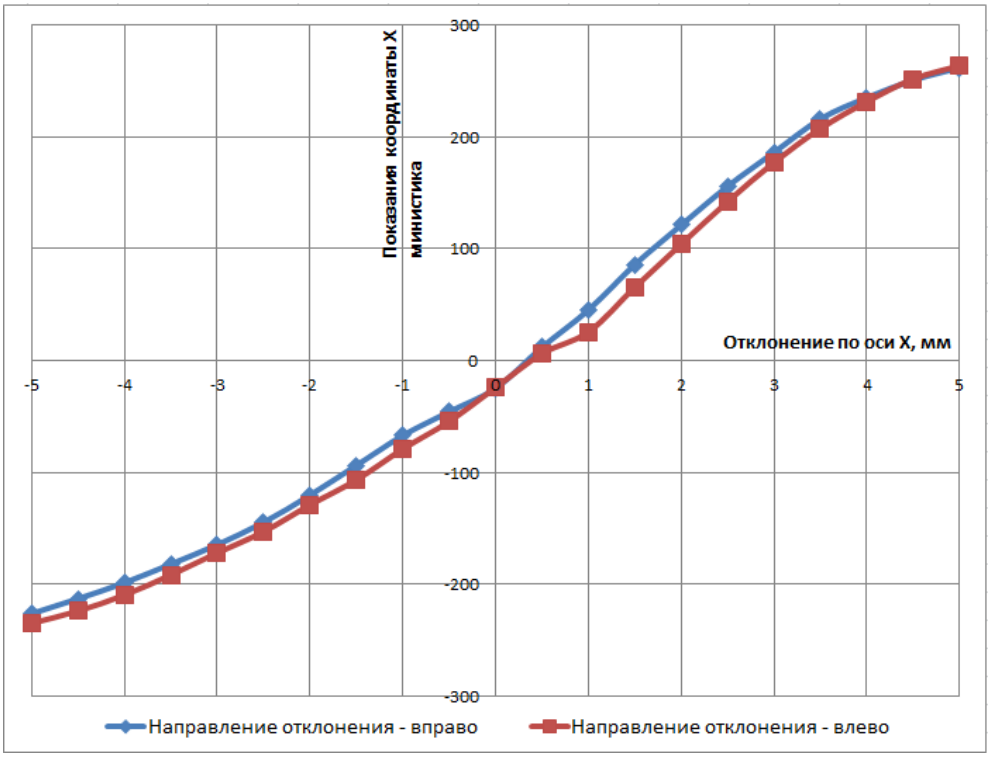


Fig. 7. Data structure



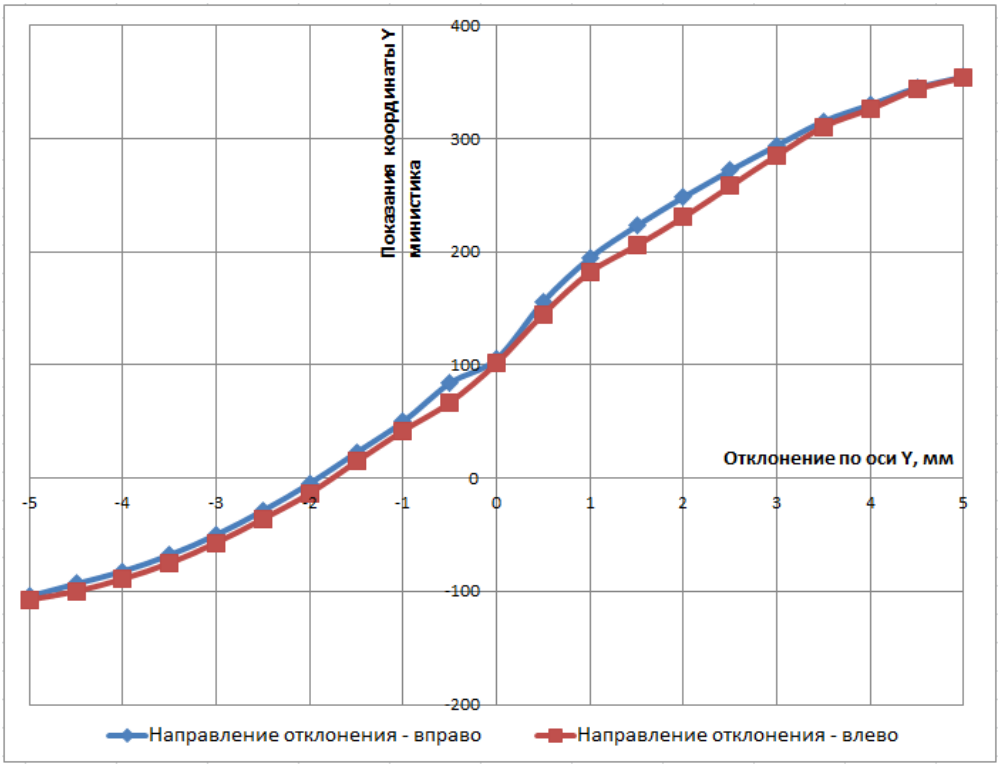


Fig. 8. Dependence of the ministick output signal on the manipulator deflection angle (from the initial middle position to the maximum deflection and back)

Рисунок 8 (слева направо, сверху вниз):

Ministick X coordinate readings

X-axis deflection, mm

Deflection direction – right

Deflection direction – left

Ministick Y coordinate readings

Y-axis deflection, mm

Deflection direction – right

Deflection direction – left

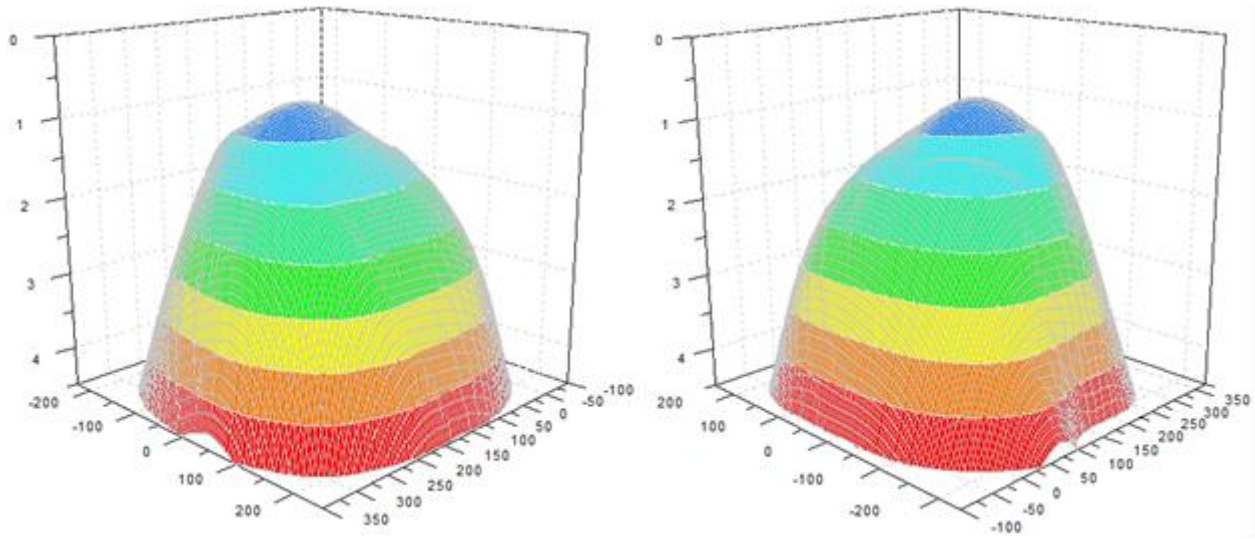


Fig. 9. 3D surface plot of the output signal dependence on the direction of and angle of the ministick deflection

11. Overall and mounting dimensions

The device is available in six-pin die form (16x19x13.5 mm).

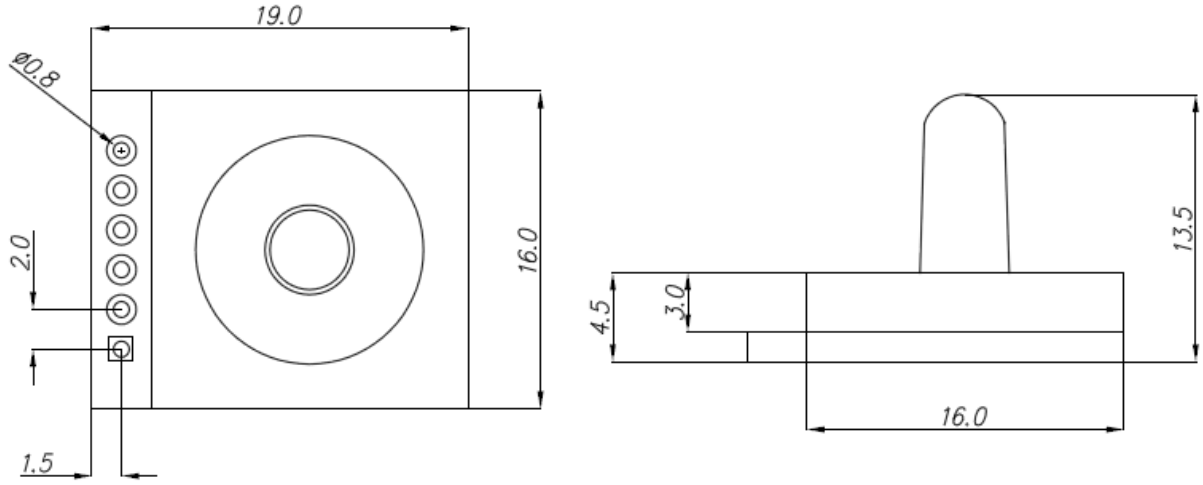


Fig. 10. Optical ministick layout and dimensions