MCU Car Kit, Ver.5.1

Sensor Board, Ver.5 Assembly Manual

Version 2.00 [ANDTR100]

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Renesas MCU Car Rally Secretariat

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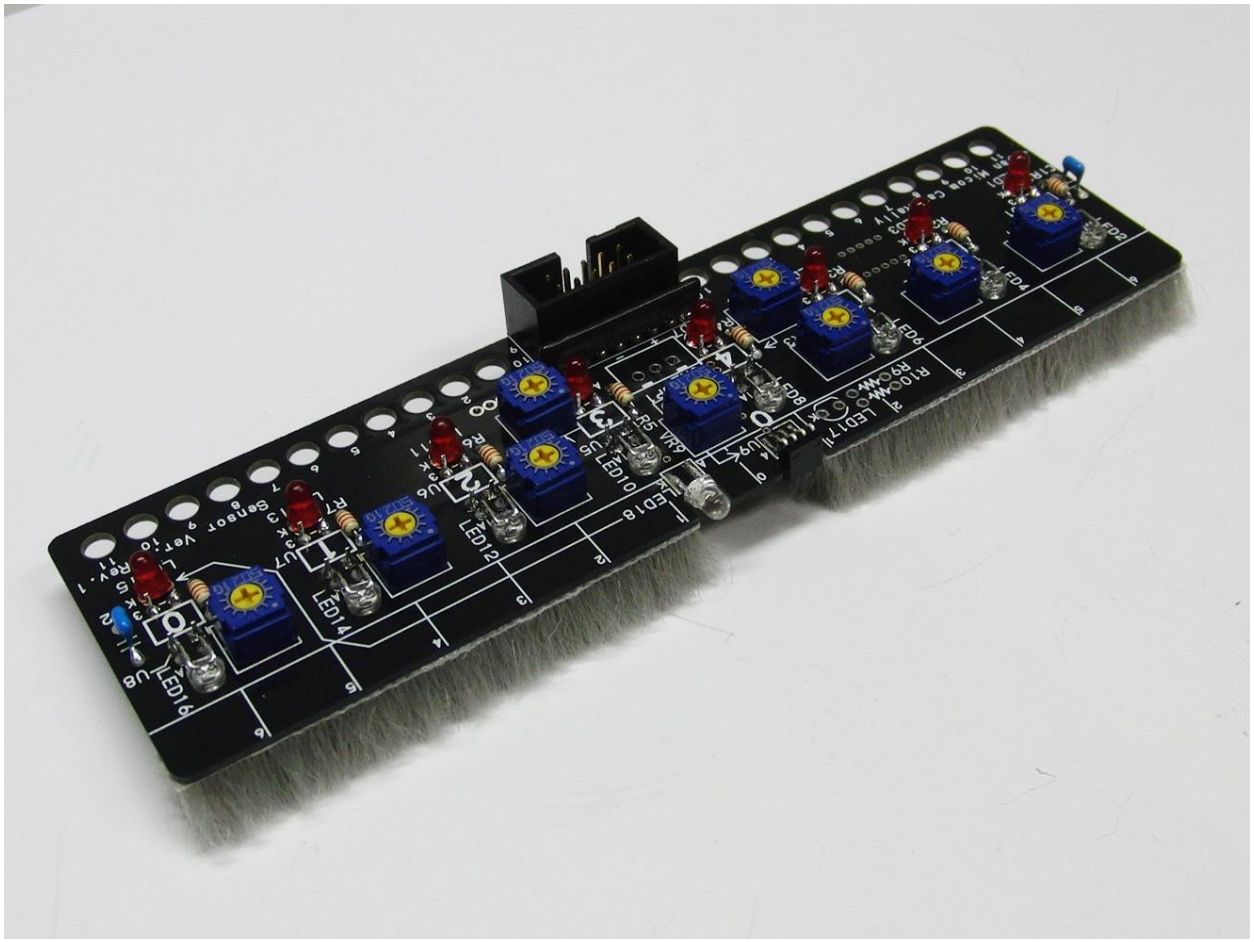
Contents

1. Outline

This is an assembly manual for sensor board ver.5 for MCU car kit ver.5.1.

The sensor board has the following features:

- The board is black to minimize sensor malfunctions.
- It is mounted with eight sensors to detect the white and black portions of the course.
- It is mounted with one sensor to detect when the start bar opens.
- The sensor signal lines are connected directly to the microcontroller (MCU).



▲Sensor Board Ver.5

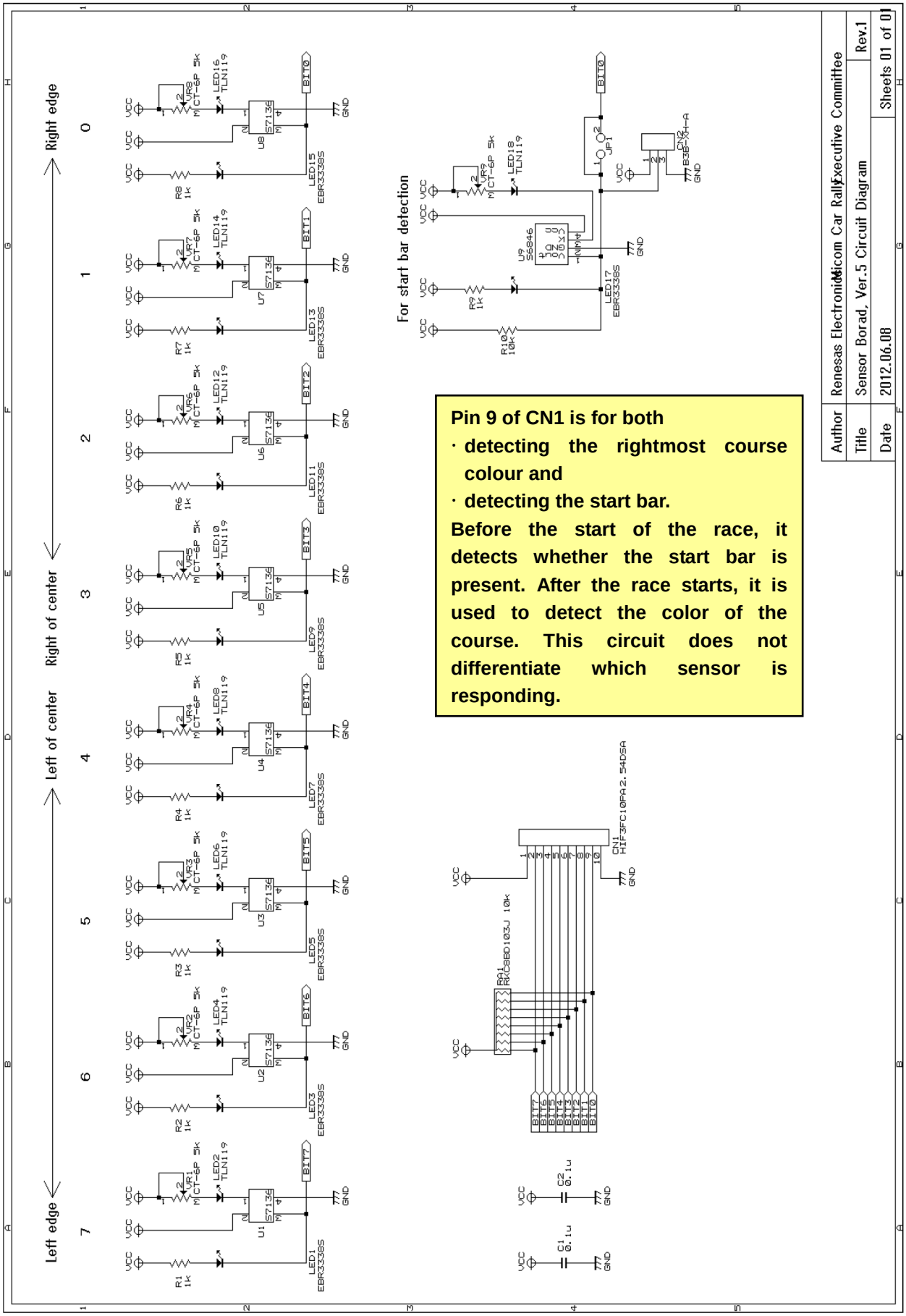
2. Specifications

2.1. Specifications

Name	**Sensor Board Ver.5**
Contained in kit	MCU Car Kit Ver.5.1
Number of boards	1
Number of sensors for monitoring course	8
Number of sensors for monitoring start bar	1
Signal inverter circuit	None (inversion performed by software program)
Connection with the MCU board	RX62T port 4 R8C/38A port 0
Voltage	DC5.0V±10%
Weight actual measured weight of completed board	Approx. 23 g Note: Including polyester pile tape
Resist board colour	Black
Board dimensions	W 140 × D 38 × T 1.2 mm
Dimensions actual measured dimensions	Max. W 140 × D 38 × H 14 mm

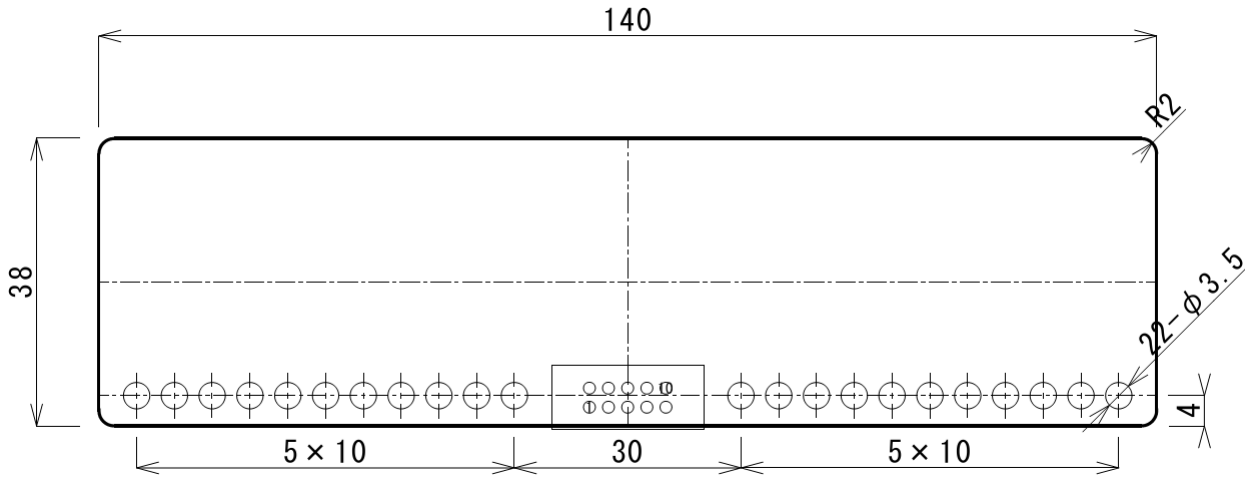
Note: The weight will vary depending on factors such as the length of the lead wires and the amount of solder used.

2.2. Circuit Diagram



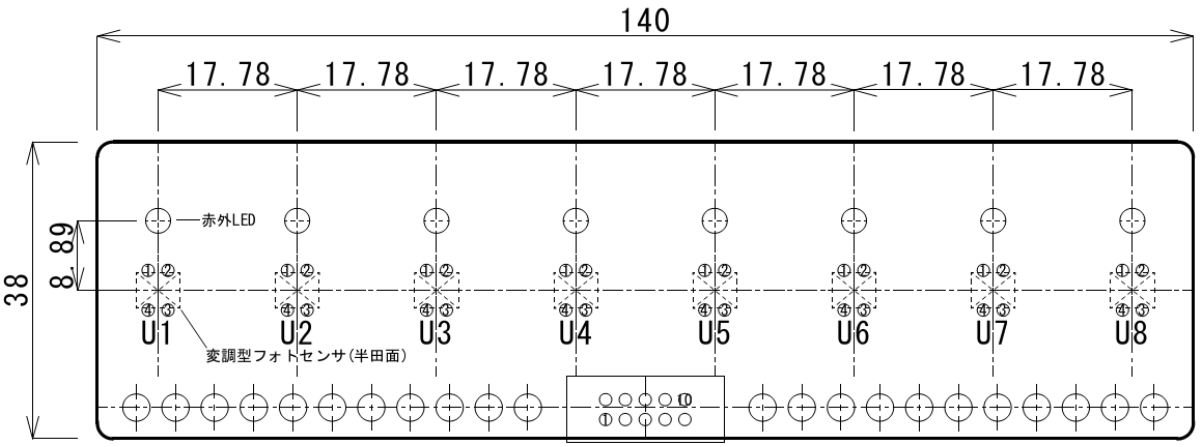
2.3. Board Dimensions

The board has a total of 22 mounting holes, 11 on the right and 11 on the left. These holes are used to secure the sensor board in place.

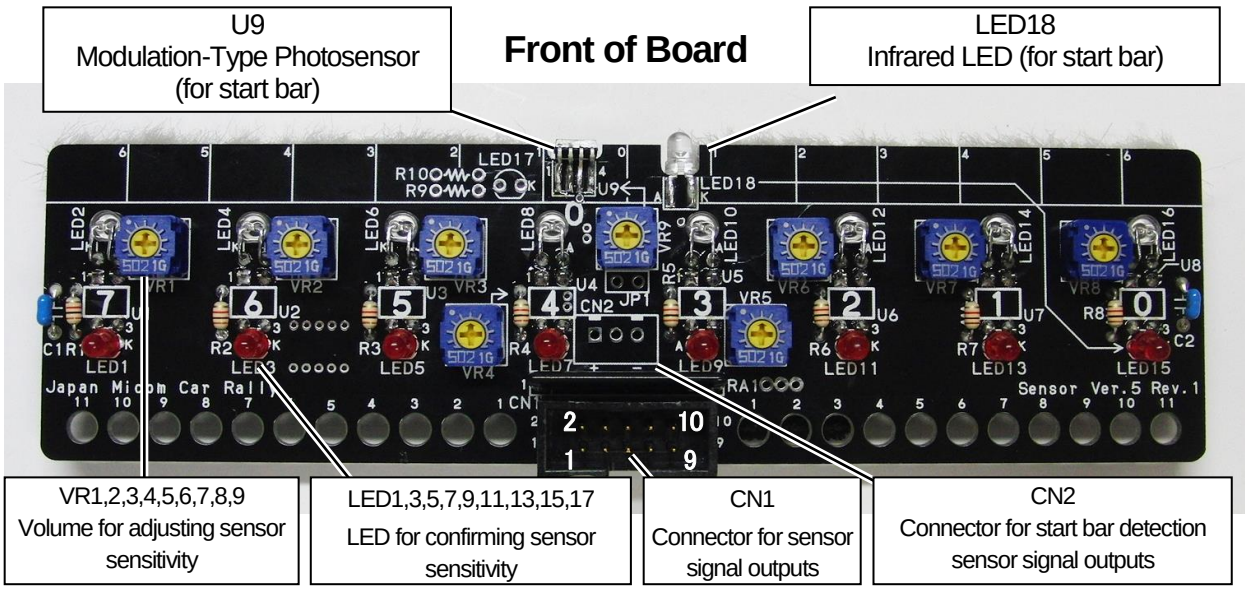


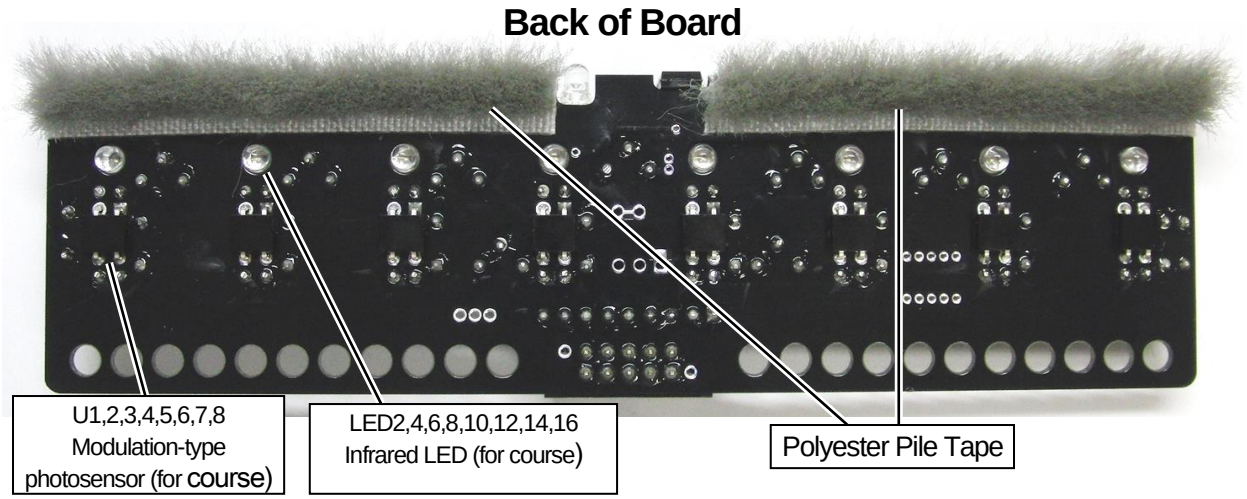
2.4. Fixed Position of the Sensor

There are eight sensors to monitor the black and white portions of a course. These are mounted on the board in the positions indicated below.



2.5. Appearance





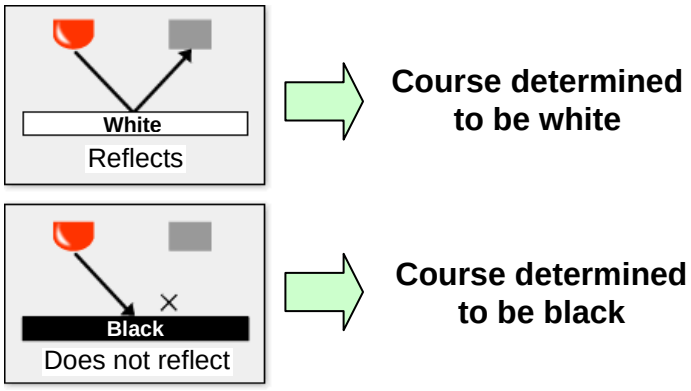
The following shows the connection of connectors and the content of signals:

Part No.	Item	Description
CN1	Connector (connected to MCU board)	Connect to microcontroller board and output sensor information.
LED2,4,6,8, 10,12,14,16	Infrared LED	The TLN119 element is used. It emits infrared light. Since the light emitted is in the infrared range, it is not visible to humans. There are eight infrared LEDs for course detection.
LED18	Infrared LED	The TLN119 element is used. There is an infrared LED for start bar detection.
U1,2,3,4, 5,6,7,8	Modulation-type photosensor	The S7136 element from Hamamatsu Photonics K.K. is used. Light emitted by the infrared LED is picked up by this element. When infrared light is detected, the current portion of the course is determined to be white. When no infrared light is detected, the current portion of the course is determined to be black. There are eight modulation-type photosensors.

U9	Modulation-type photosensor	The S6846 element from Hamamatsu Photonics K.K. is used. Light emitted by the infrared LED is picked up by this element. When infrared light is detected, the start bar is closed. When no infrared light is detected, the start bar is open. There is a modulation-type photosensor.
VR1,2,3,4, 5,6,7,8	Volume for adjusting sensor sensitivity	The amounts of light output from infrared LEDs are adjusted in these volumes. Some portions of the MCU car course are grey. By adjusting the sensitivity with the volume, it is possible to make the grey areas be detected as white or as black. The standard software program assumes that grey areas will be detected as white.
VR9	Volume for adjusting sensor sensitivity	The amount of light output from LED18 is adjusted using in these volumes. If there is a start bar, it becomes white. If there isn't a start bar, there will be no reflection. Please adjust this volume to react (lights to LED15) when there is a start bar.
LED1,3,5,7, 9,11,13,15	LED for confirming sensor sensitivity	The LED lights when white is detected and is dark when black is detected. The LED is used for confirmation when adjusting the sensitivity with the variable resistor.
—	Polyester pile tape	Polyester pile tape is mounted on the solder side of sensor board and is made a constant height so as to not rub the course and the sensor directly and also to allow the sensor to react appropriately.

2.6. Mechanism for Determining White and Black on Course

On the sensor board, there are eight pairs of elements that emit infrared light onto the course and detect infrared light reflected from the course. White reflects light and black absorbs light. Infrared light is shone onto the course using the infrared-light-emitting element. If the infrared-light-detecting element detects infrared light, the colour is determined to be “white”, and if not, it is determined to be “black”.

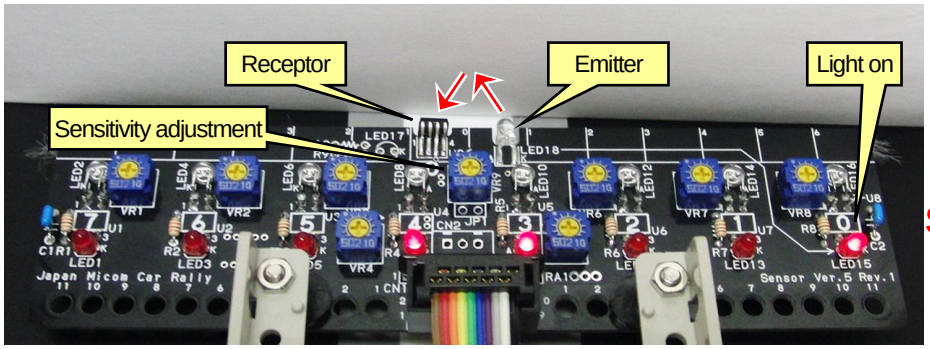


The amount of infrared light emitted can be adjusted using a volume. Some portions of the MCU car course are grey. By adjusting the sensitivity of the volume, it is possible to make the grey areas be detected as white or black. **The standard software program assumes that grey areas will be detected as white.**

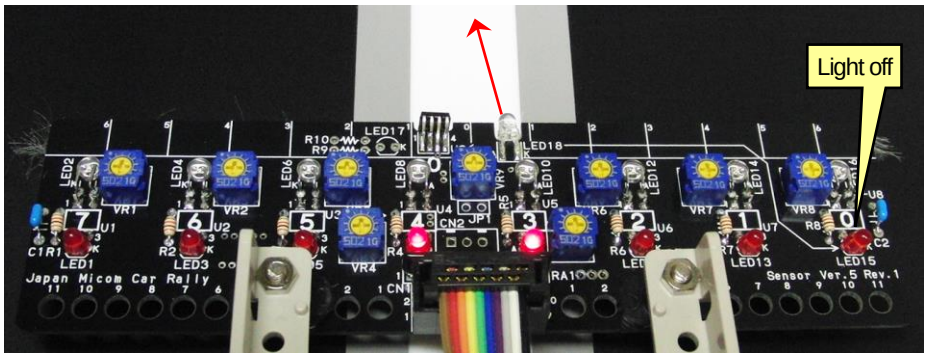
2.7. Mechanism for Determining Whether Start Bar is Open or Closed

At the start of the race, the white start bar is closed. The sensor board has an infrared LED and the S6846 (modulation-type photosensor) on the front. The following states are determined according to the condition of the sensor.

●When the start bar is closed

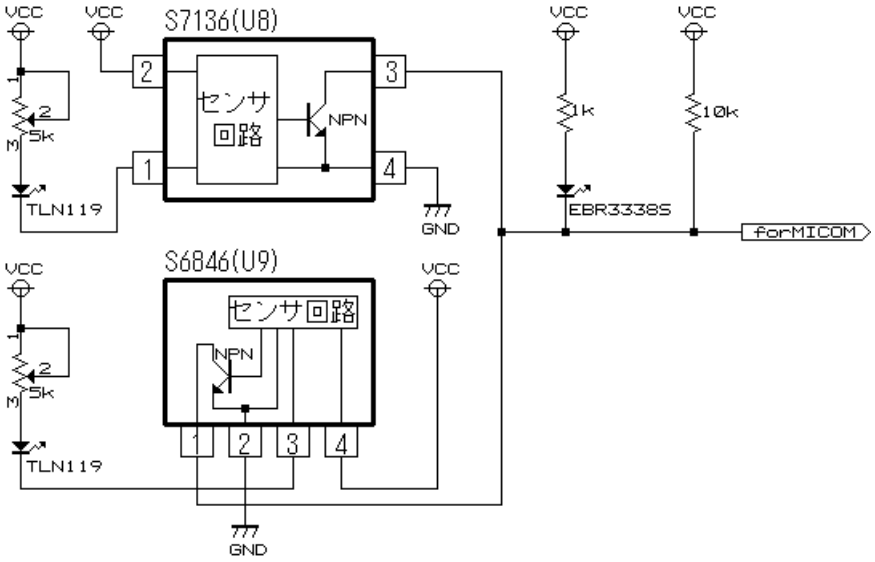


●When the start bar is open

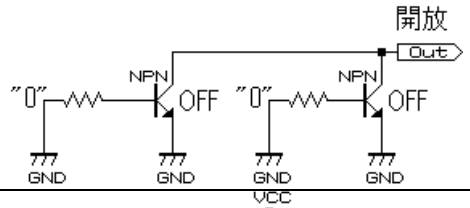
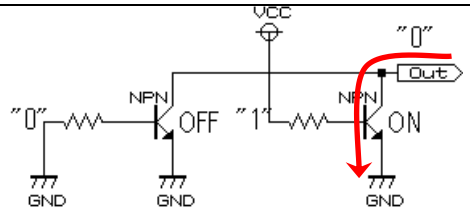
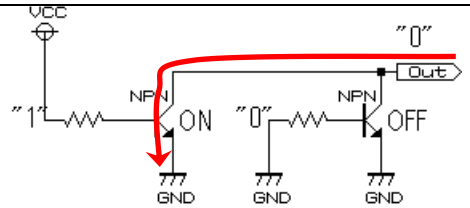
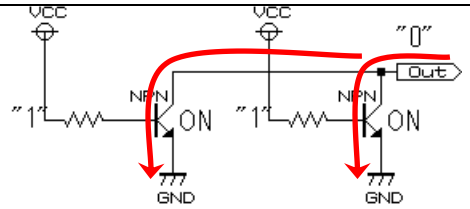


2.8. Output Signals of U8 and U9

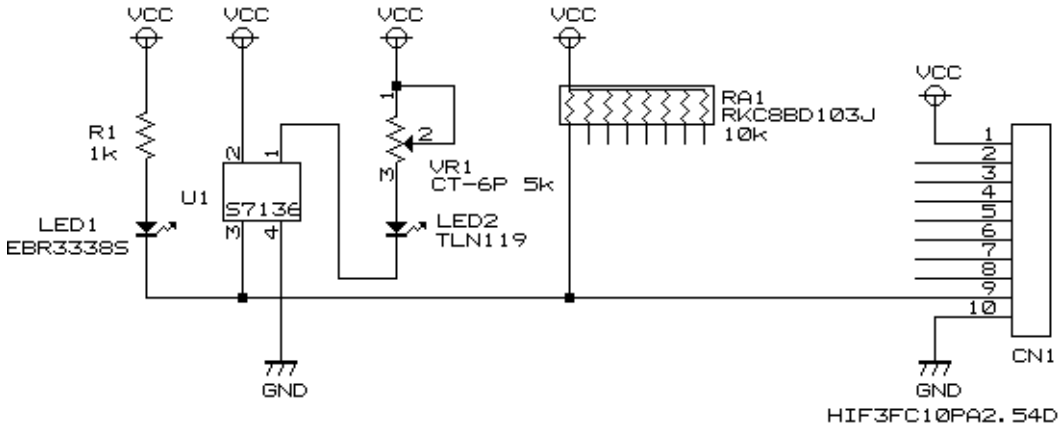
The output of the sensors is open collector output, and an NPN transistor is connected. Pin 9 of CN1 is for both output from the rightmost course detection sensor (U8) and the start bar detection sensor (U9). The circuit is shown below.



The responses from the two sensors and the output signals are shown in the following table.

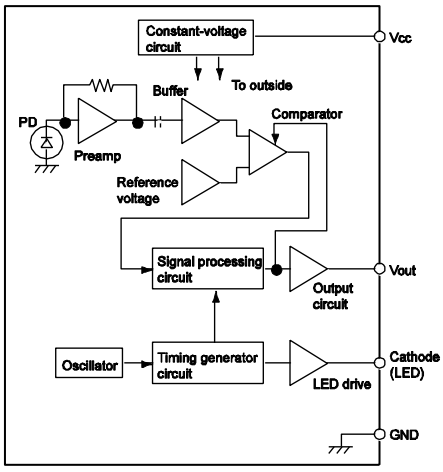
Course detection sensor	Start bar detection sensor	Circuit	Output Explanation
Black	Not detected		Open (high impedance) In fact, a pull-up resistor is attached, so it is 5V output.
Black	**Detected**		0V **When 0V before the start of the race, it determines that the start bar sensor has detected the start bar.**
White	Not detected		0V **When 0V after the race has started, it determines that the course detection sensor has detected white.**
White	**Detected**		0V It shouldn't happen that both are on at the same time.

2.9. Principles of Sensor Circuit



1. U1 is a photosensor. It has both a receptor and the oscillating circuit of an infrared LED.
2. An infrared LED (LED2) is connected to pin 1 of U1. Light emitted here is received by U1. Volume VR1 is used to adjust the brightness of the infrared LED.
3. Pin 3 of U1 outputs whether or not light was received. An LED (LED1) is connected, so 0 or 1 can be confirmed visually.
4. If light from the infrared LED reaches U1 (course is white), 0 is output. The anode side of the LED becomes positive and the cathode side negative, so the LED lights up.
5. If light from the infrared LED does not reach U1 (course is black), 1 is output (details below). The anode side of the LED becomes positive and the cathode side also positive, so the LED does not light up.
6. Although it was just stated that 1 is output if light does not reach U1, in fact pin 3 of U1 is open collector output. For open collector output, 0 = 0V, and any other value is open, meaning not connected to anything. In the digital world, only values of 0 and 1 are possible. Therefore, a resistor (RA1) is used to pull up the signal to ensure that the value is 1 when the photosensor is open.

Note: Operating Principle of Modulation — Type Photosensor (S7136) for Reference (from the Product Data Sheet)



Truth Value Table

Input	Output Level
LED on	LOW
LED off	OFF

(a) Oscillator and Timing Signal Generator Circuit
The reference oscillator output is obtained by charging and discharging the built-in capacitor with a constant current. The oscillator output is input to the timing signal generator circuit, which produces the LED drive pulses and the timing pulses used for digital signal processing.

(b) LED Drive Circuit
This circuit uses the LED drive pulses produced by the timing signal generator circuit to drive a light emitting diode. The drive duty ratio is 1/16.

(c) Photodiode and Preamp Circuit
The photodiode is of the on-chip type. The photoelectric current from the photodiode is converted into a voltage by the preamp circuit. An independent AC amplifier circuit is used as the preamp circuit. In addition to expanding the dynamic range through increased tolerance for DC and low-frequency ambient light, it boosts the signal detection sensitivity.

(d) C-Coupling, Buffer Amplifier, and Reference Voltage Circuit
A C-coupling is used to further remove the effects of low-frequency ambient light and to eliminate the DC offset from the preamp. The signal is boosted to the comparator level by the buffer amplifier, and the comparator-level signal is generated by the reference voltage circuit.

(e) Comparator Circuit
The comparator circuit has an added hysteresis function to prevent chattering caused by tiny fluctuations in the input light.

(f) Signal Processing Circuit
The signal processing circuit comprises a gate circuit and a digital integrating circuit. The gate circuit prevents malfunctions due to non-synchronous ambient light by distinguishing the input signal during synchronous detection. Since the gate circuit cannot eliminate synchronous ambient light, the digital integrating circuit does so at a later stage.

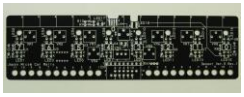
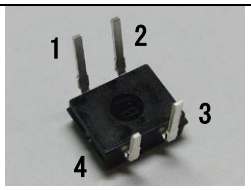
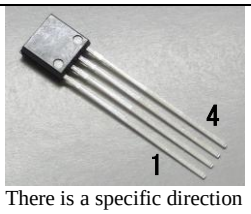
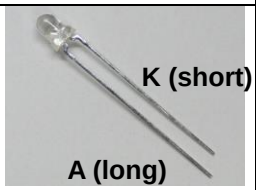
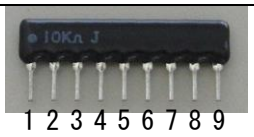
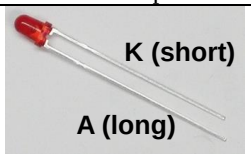
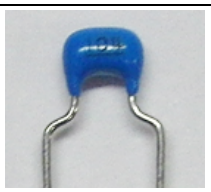
(g) Output Circuit
This circuit buffers the output from the signal processing circuit and outputs it externally.

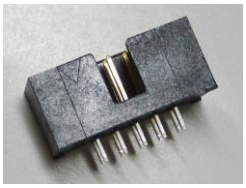
3. Assembling the Board

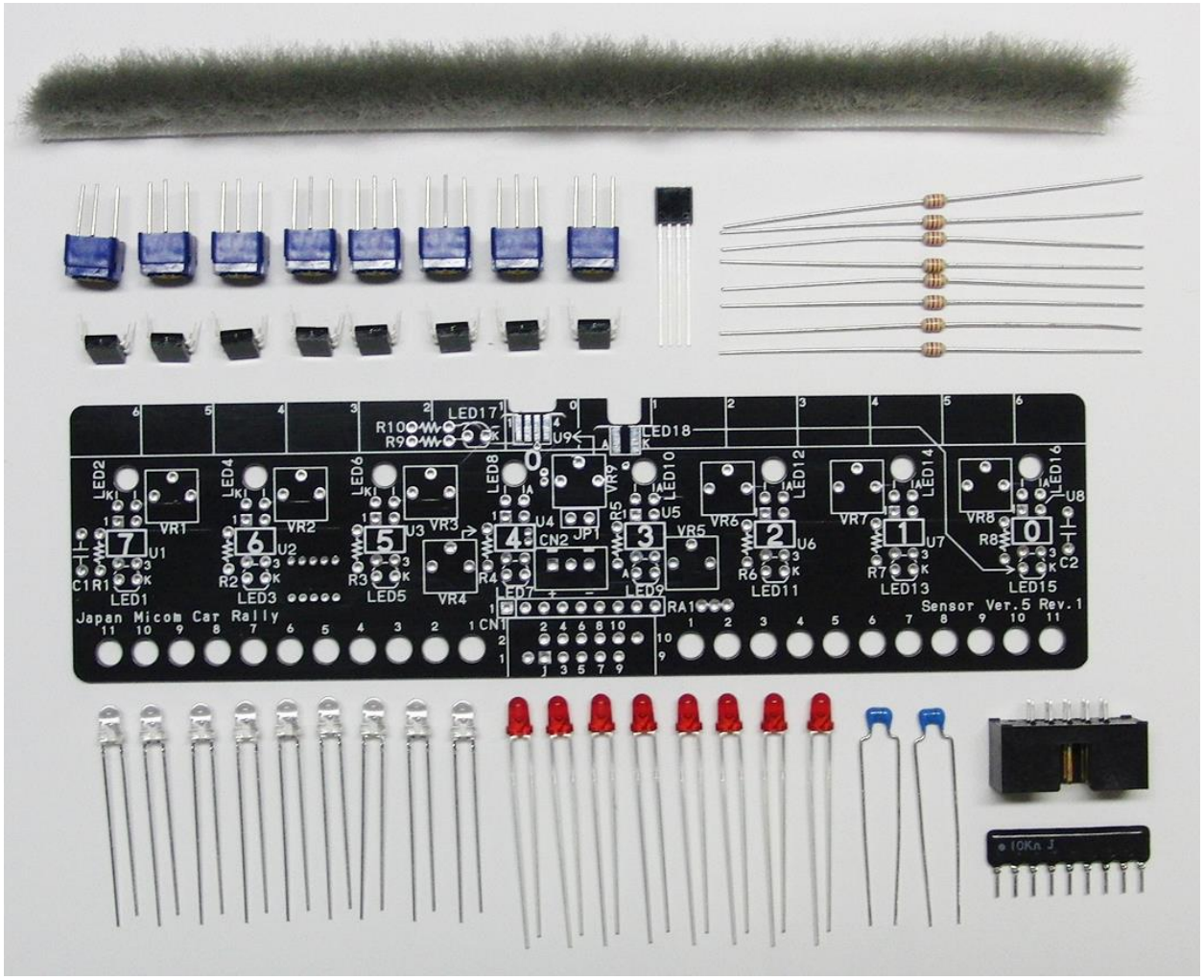
The items required to assemble the sensor board Ver.5 are listed below.

Miniature nippers		Used to cut lead wires.
Miniature cutting pliers		Used to bend lead wires and hold parts in place.
Tweezers		Used to hold parts.
Soldering iron	 	Used to solder parts to the board. A soldering iron rated at about 50～100 watts should be sufficient.
Scissors		Used to cut the bag of the set.
Tester		Used to adjust the servo voltage when added the LM350 additional set.

3.1. Table of Parts

Part No.	Name	Model	Photo	Manufacture	Q'ty
	Main Board	140×38×1.2t			1
U1,2,3,4, 5,6,7,8	Modulation-type Photosensor	S7136	 Short pin is 4pin	Hamamatsu Photonics K.K.	8
U9	Modulation-type Photosensor	S6846	 There is a specific direction	Hamamatsu Photonics K.K.	1
LED2,4,6,8,10, 12,14,16,18	Infrared LED	TLN119 or equivalent		Toshiba Corporation	9
R1,2,3,4, 5,6,7,8	Resistor	CFS1/4C 1 kΩ (brown・black・red・gold)		KOA Corporation	8
RA1	Resistor array	RKC8BD103J 8 elements, 1 common, 10kΩ	 There is ● on the side of 1pin	KOA Corporation	1
LED1,3,5,7, 9,11,13,15	LED (red)	EBR3338S or equivalent		Stanley Electric Co.	8
C1,2	Laminated ceramic capacitor	RPEF11H104Z2K1A01B 0.1 μF (104) 5.08 mm pitch		Murata Manufacturin g Co., Ltd.	2
VR1,2,3,4,5,6, 7,8,9	Volume	CT-6P 5kΩ (502)		Nidec Copal Electronics Corporation	9

CN1	10P straight type convex connector	HIF3FC10PA2.54DSA	 ▼mark is 1pin	Hirose Electric Co., Ltd.	
	Polyester Pile Tape	Approx. 150 mm		Available from various manufactures	

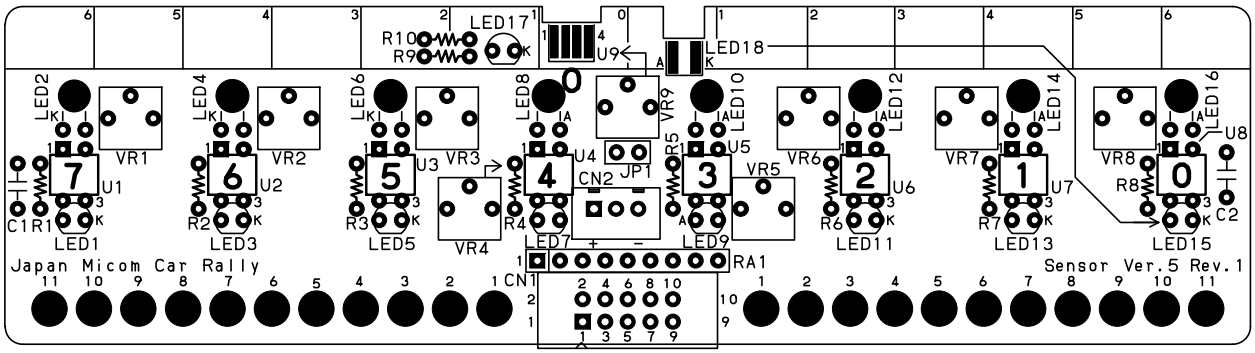


3.2. Other Necessary Parts Besides the Set

Name	Model	Specifics
Solder		The necessary length varies depending on the thickness; if the diameter is 0.6 mm a length of 5 m should be sufficient.

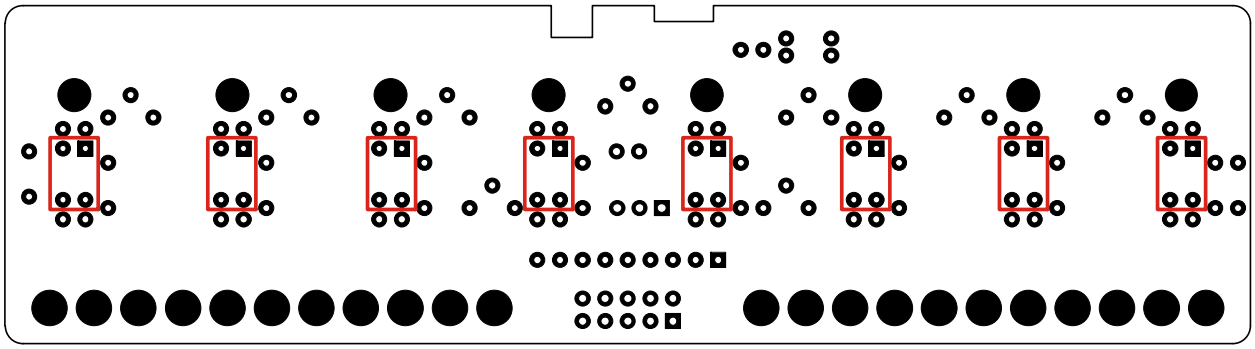
3.3. Part Side

The side with white characters (called silk) is called the **part side** or **component side** (figure below). Parts are mainly mounted to this side. In this manual, there are also parts that are mounted from the solder side, so please read the explanation carefully before mounting.



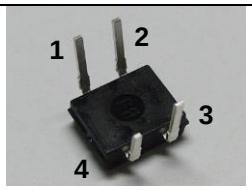
3.4. Solder Side

The side with no silk is called the **solder side** (figure below). Only the S7136 modulation-type photosensors are mounted from the solder side. They are mounted at the eight locations indicated by red rectangles below.

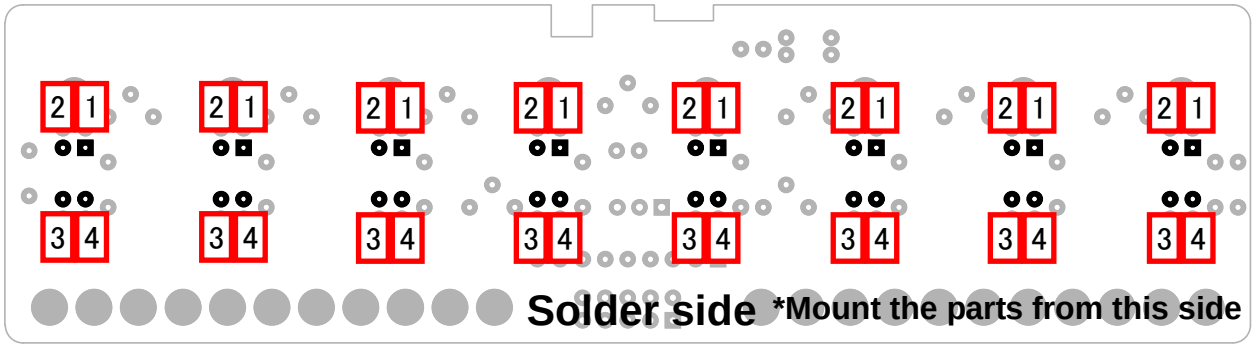


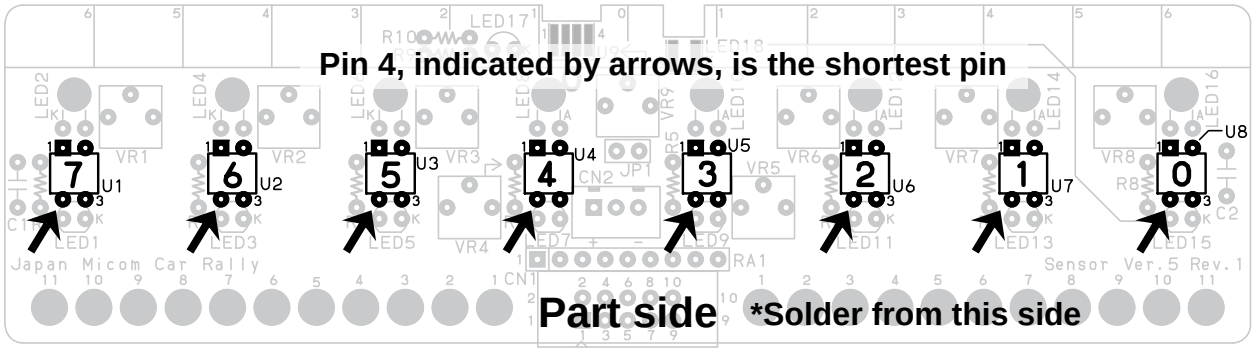
This manual talks about *mounting from the part side*, or *mounting from the solder side*, and so on. Please be careful to use the correct side.

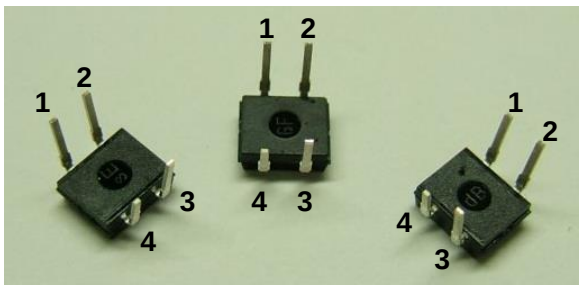
3.5. Mounting the Modulation-Type Photosensor (S7136)

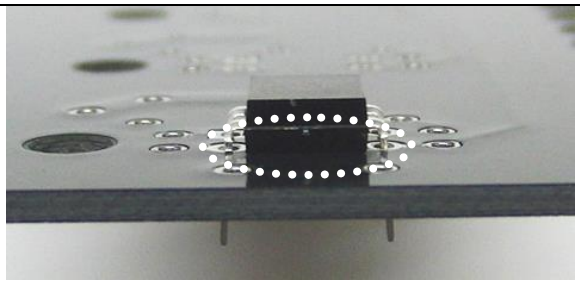
Part No.	Name	Model	Photo	Manufacturer	Q'ty
U1,2,3,4, 5,6,7,8	Modulation-type Photosensor	S7136	 Short pin is 4pin	Hamamatsu Photonics K.K.	8

Mount the eight modulation-type photosensors (S7136) **from the solder side (reverse side of the board), and solder from the part side**. Pay attention to their orientation.

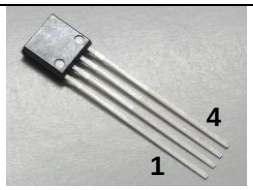




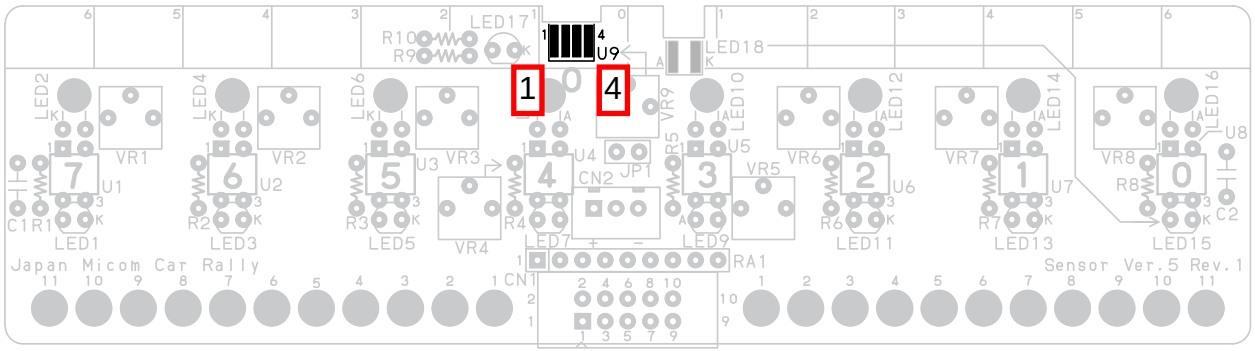
1		Prepare eight modulation-type photosensors. These are the black elements with four pins. Pin 4 is the shortest pin.

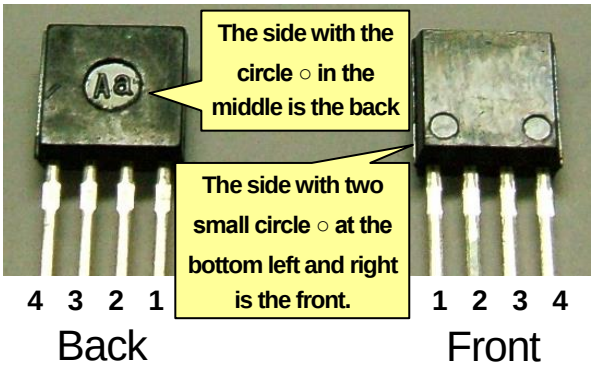
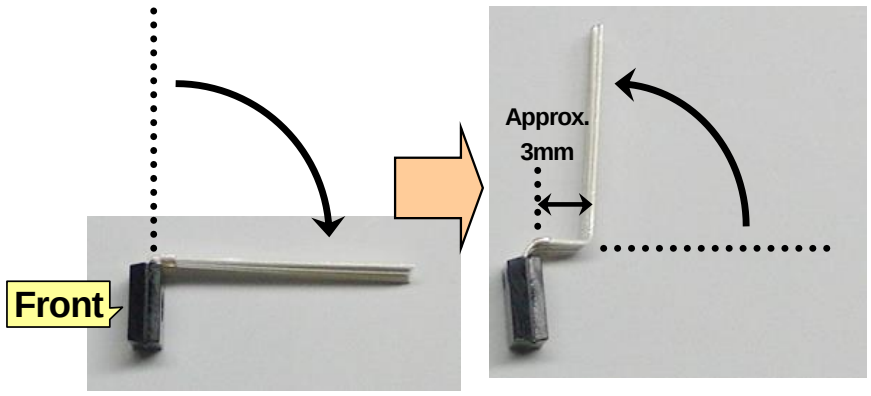
2		Mount the modulation-type photosensors closely, and solder them.

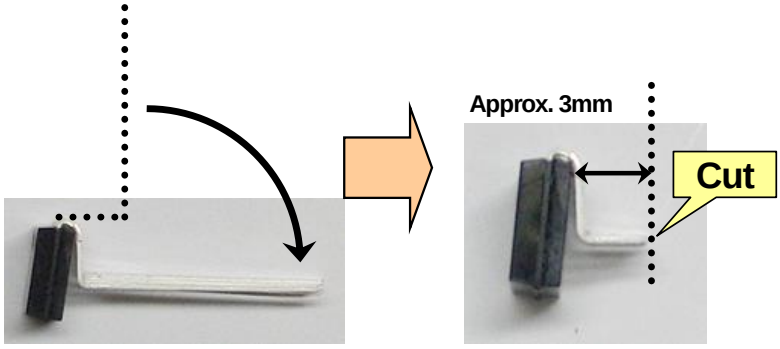
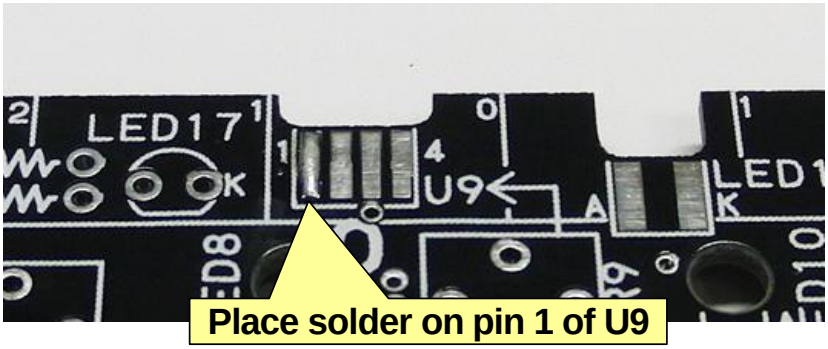
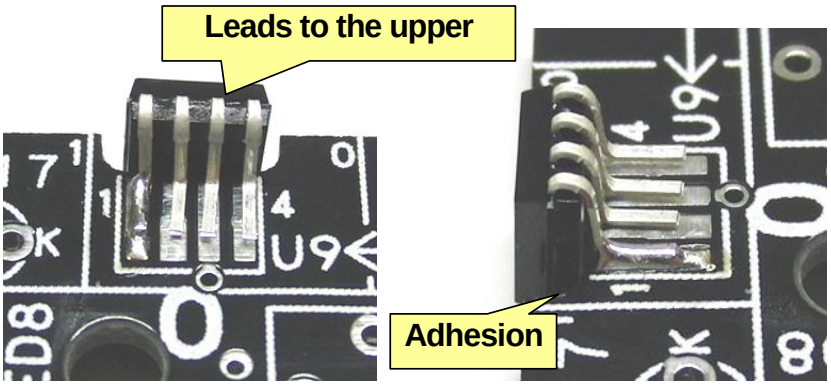
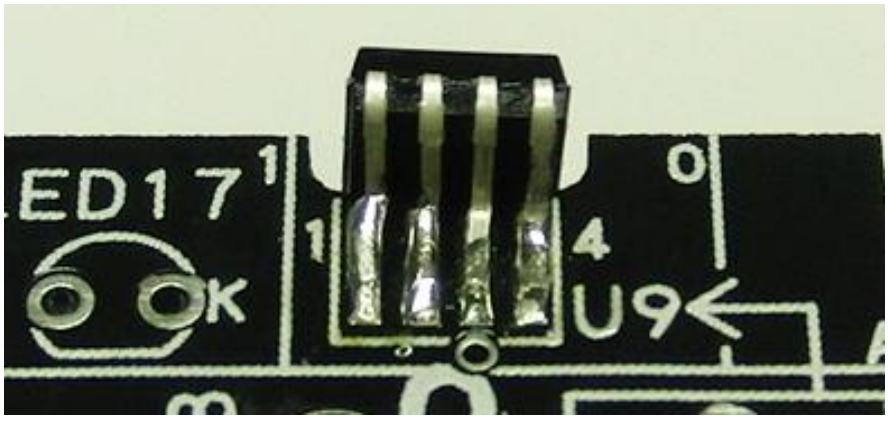
3.6. Mounting the Modulation-Type Photosensor (S6846)

Part No.	Name	Model	Photo	Manufacturer	Q'ty
U9	Modulation-type photosensor	S6846	 There is a specific direction	Hamamatsu Photonics K.K.	1

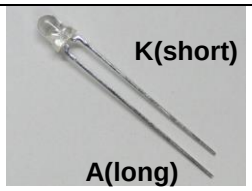
Solder one modulation-type photosensor (S6846). Pay attention to its orientation. The S6846 will be bent.



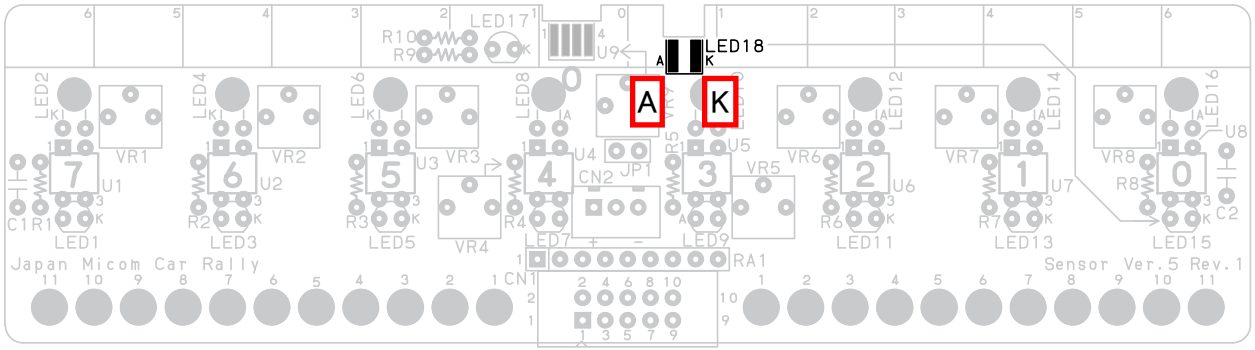
1		There is a back and front as shown in the photo on the left. Please be careful to use the correct side. Pin 1 is on the left and pin 4 is on the right when looked at front side facing up.
2		With the front side on the left, bend four lead wires to 90 degrees. Then, bend in a right angle to the upper part at approximately around 3mm from the root.

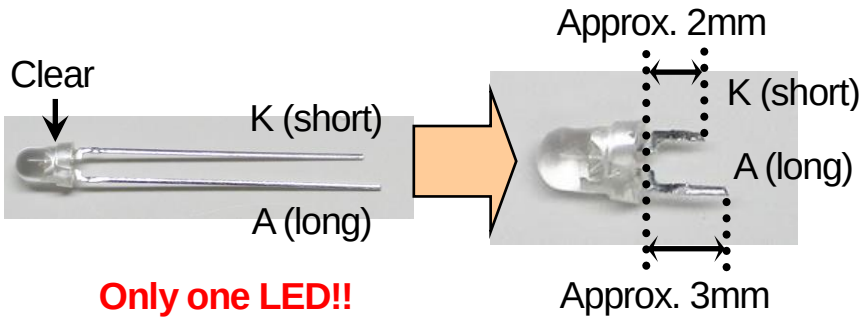
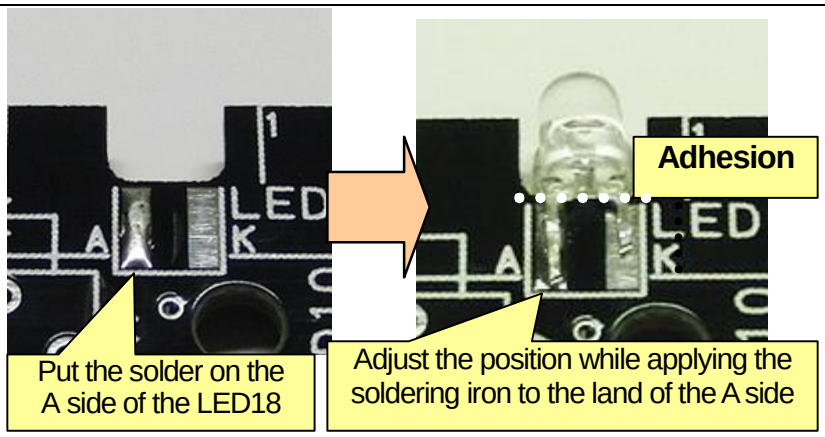
3		Bend the 90 degrees part down into an L-shape. Finally, cut it to approx. 3mm.
4		Place solder on pin 1 of U9 only.
5		Solder pin 1 of the Modulation-type photo sensor (S6846) so that it is flat with the board.
6		Solder pins 2-4 next.

3.7. Mounting the Infrared LEDs（Clear）1

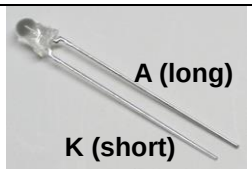
Part No.	Name	Model	Photo	Manufacturer	Q'ty
LED18	Infrared LED	TLN119 or equivalent		Toshiba Corporation	1

Solder one infrared LED (TLN119). Pay attention to its orientation. The remaining eight LEDs will be used in the next step.

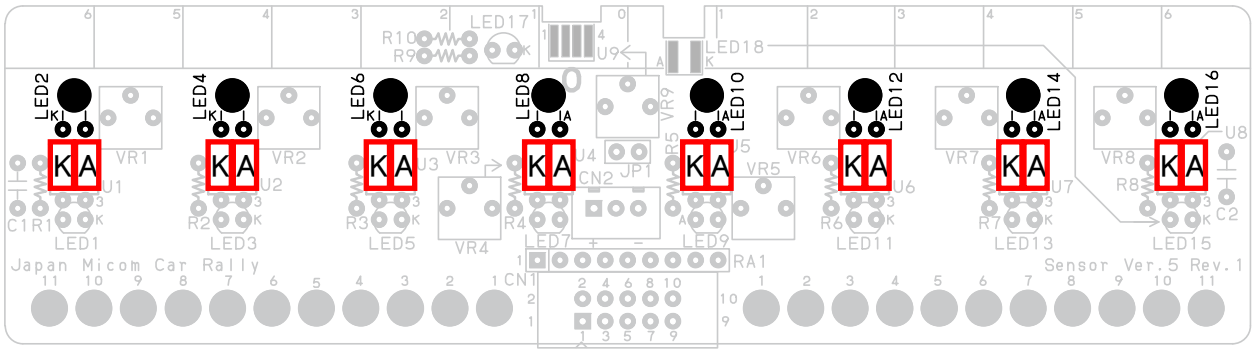


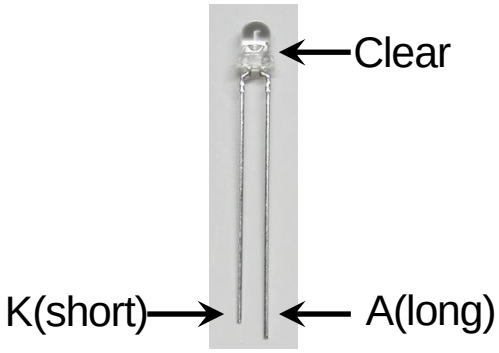
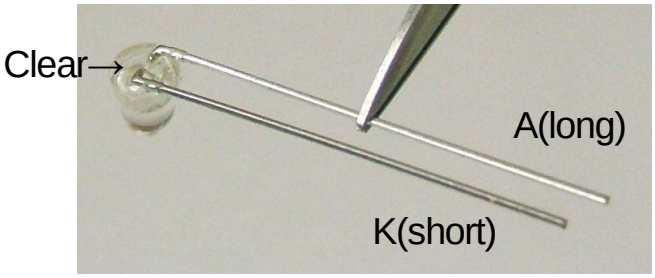
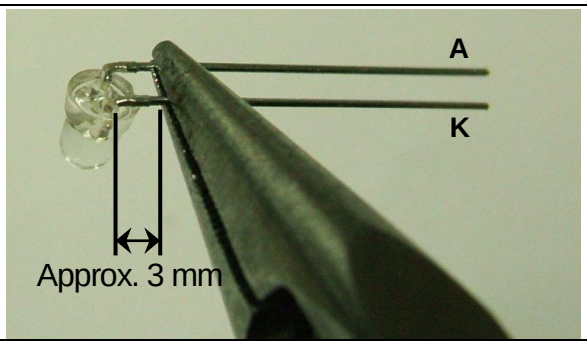
1		The lighting part of infrared LED is clear colour, not red colour. Infrared LED has polarity. The long one is A (Anode), the short one is K (Cathode). Cut off leads to about 2mm on the K side and about 3mm on the A side.
2		Adhere the LED to the board as shown in the photo. Adjust the position whilst putting a solder iron on the leads of the A side. Also solder the K side after adjusting the position.

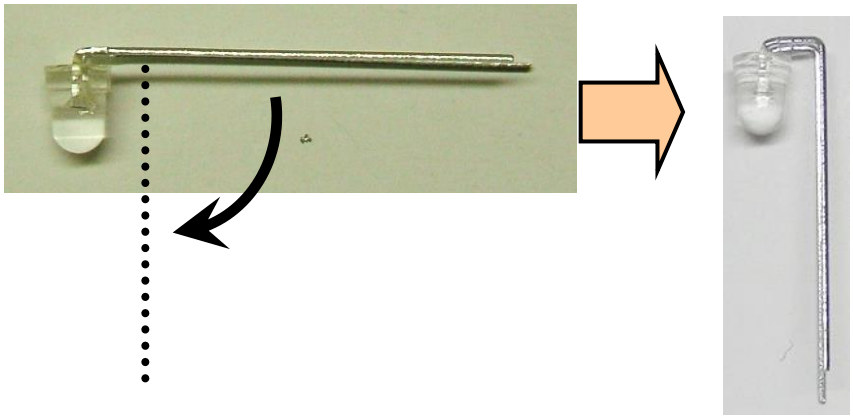
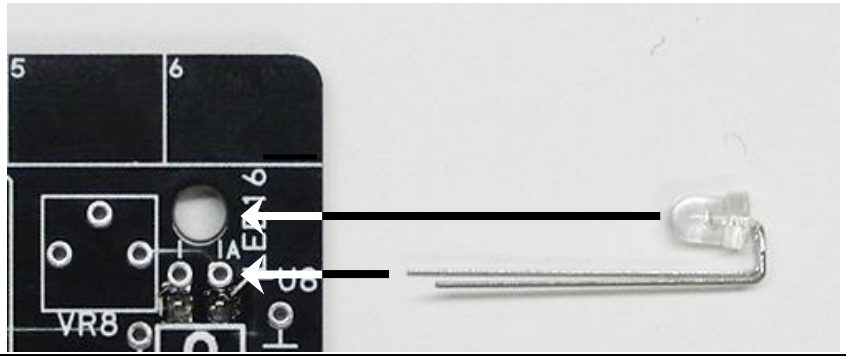
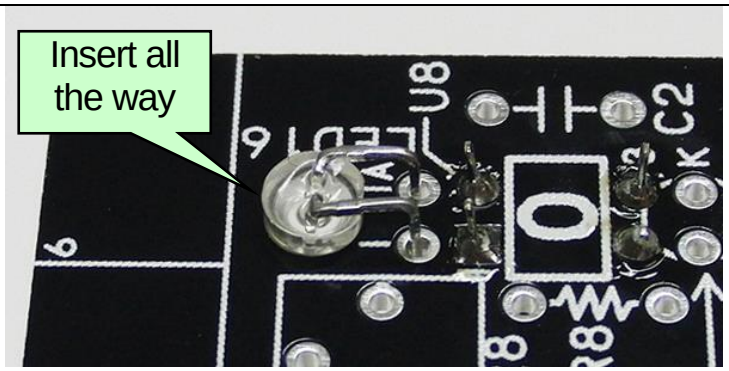
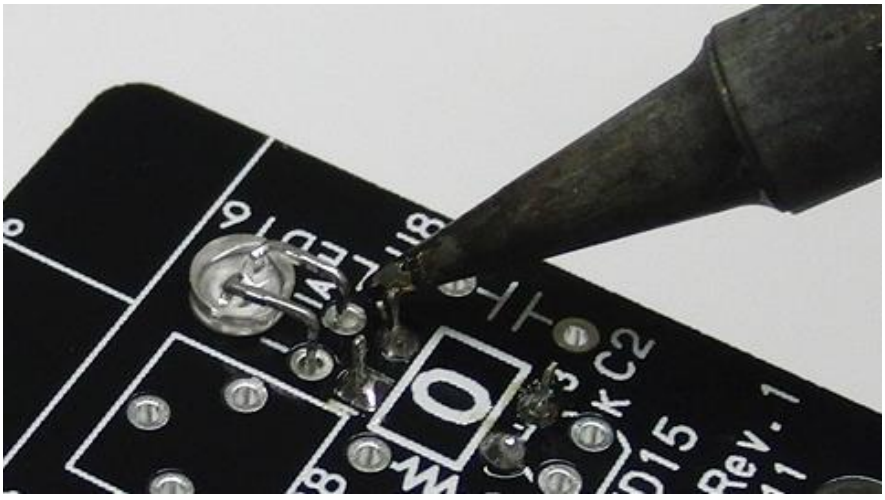
3.8. Mounting the Infrared LEDs (Clear) 2

Part No.	Name	Model	Photo	Manufacturer	Q'ty
LED2,4,6,8, 10,12,14,16	Infrared LED	TLN119 or equivalent		Toshiba Corporation	8

Solder eight infrared LEDs (Clear). Pay attention to its orientation.



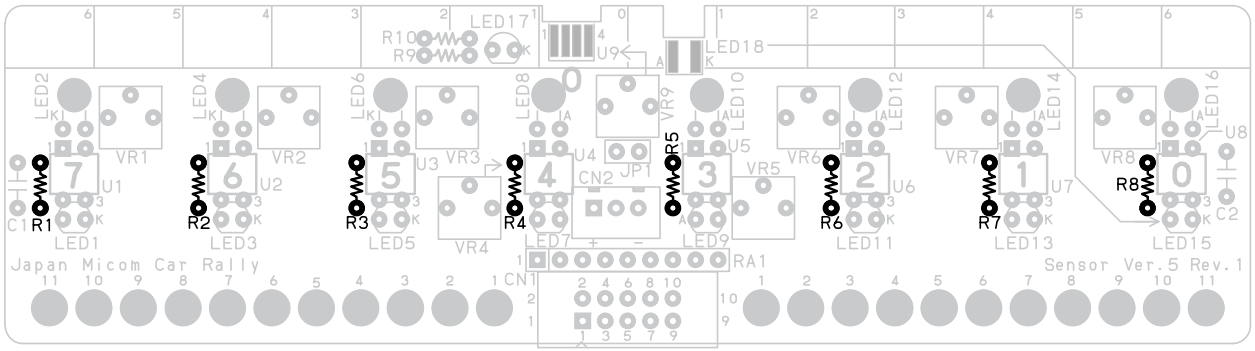
1		**The part of an infrared LED that lights up is a transparent LED. <u>It is not red in colour.</u>** An infrared LED has polarity. The longer lead is the A (anode) side and the shorter lead is the K (cathode) side.
2		Bend the leads 90 degrees at the base. Bend them such that lead A is on the right and lead K is on the left as in the photo. **Note: The base portion of the leads bends easily, so make each bend in a single motion. It is not possible to redo the bend.**
3	**Note:** **Approx. 3 mm is sufficient** 	Grip the leads of the infrared LED with the pliers at a point about 3mm from the base. Grip both leads at once.

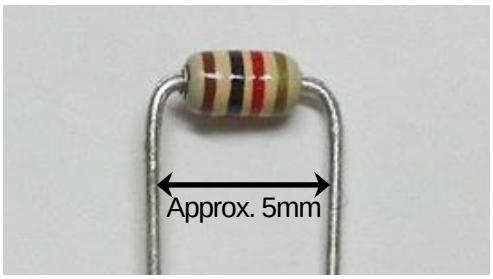
4		As shown in the photo, bend the leads downward 90 degrees. Bend leads A and K at the same time.
5		As shown in the photo, the infrared LED portion fits into the large hole and the leads are inserted through the two lands.
6		Insert the LED all the way and solder it.
7		**Solder the infrared LEDs from the part side.** If soldering is performed from the solder side, the solder iron may come in contact with the modulation-type photosensor and burn it. After the part has been soldered, cut the leads.

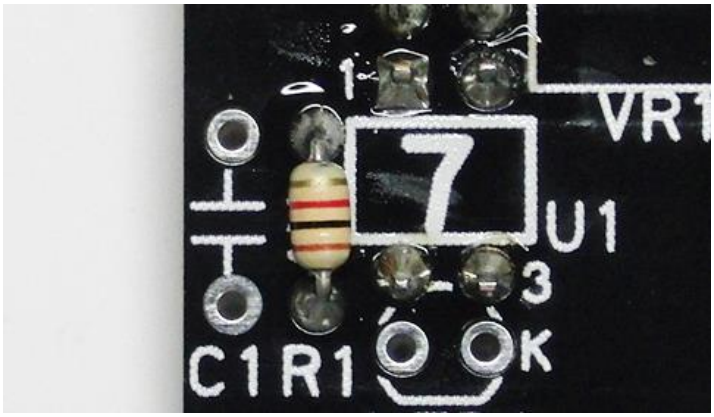
3.9. Mounting the Resistors

Part No.	Name	Model	Photo	Manufacturer	Q'ty
R1,2,3,4, 5,6,7,8	Resistor	CFS1/4C 1 kΩ (brown・black・red・gold)		KOA Corporation	8

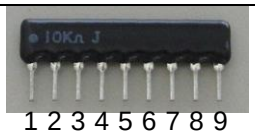
Solder eight resistors.



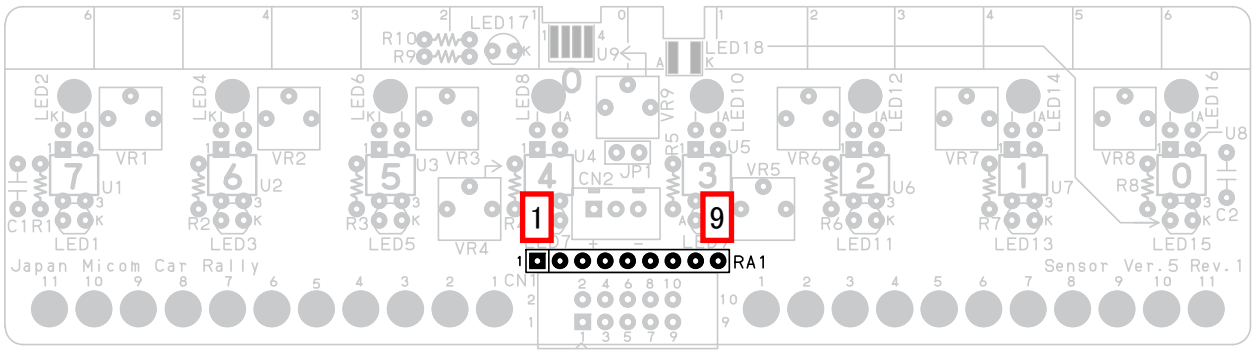
1		Bend the leads so that the width is about 5 mm. If the leads are bent from the base of the resistor the width will be about 5 mm. Be careful not to apply too much force because this would damage the surface of the resistor.

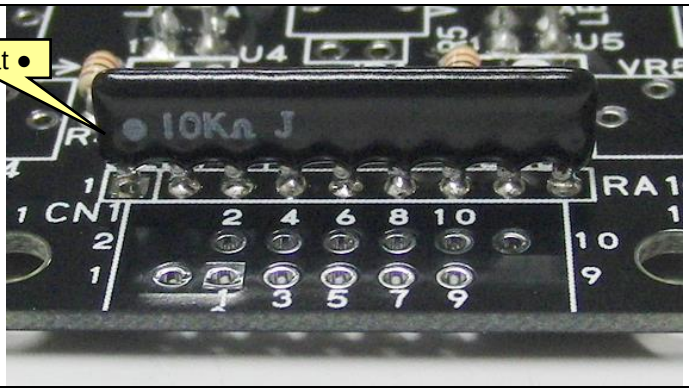
2		The photo shows R1 after it has been soldered.

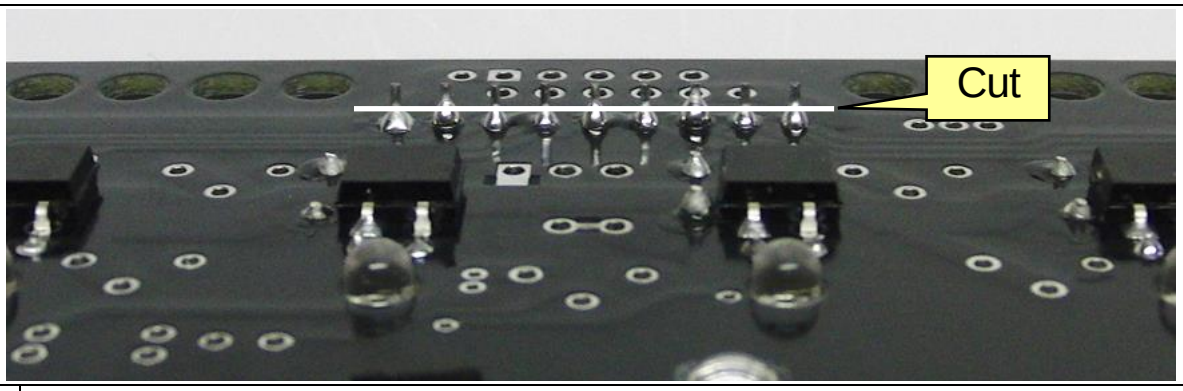
3.10. Mounting the Resistor Array

Part No.	Name	Model	Photo	Manufacturer	Q'ty
RA1	Resistor array	RKC8BD103J 8 elements, 1 common, 10kΩ	 1 2 3 4 5 6 7 8 9 There is ● on the side of 1pin	KOA Corporation	1

Solder one resistor array. The pin 1 side is marked ●.

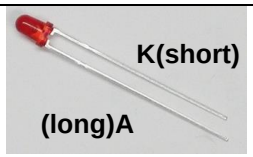


1		Mount the resistor array so that pin 1 lines up with ●.

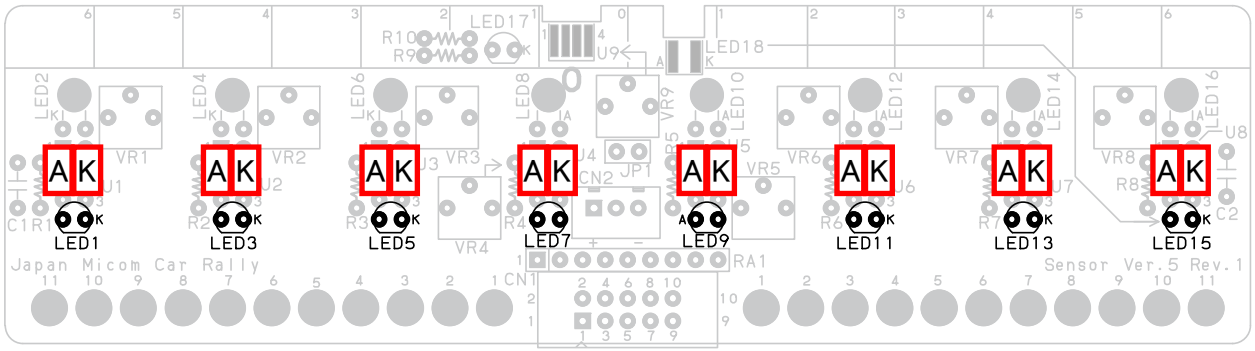


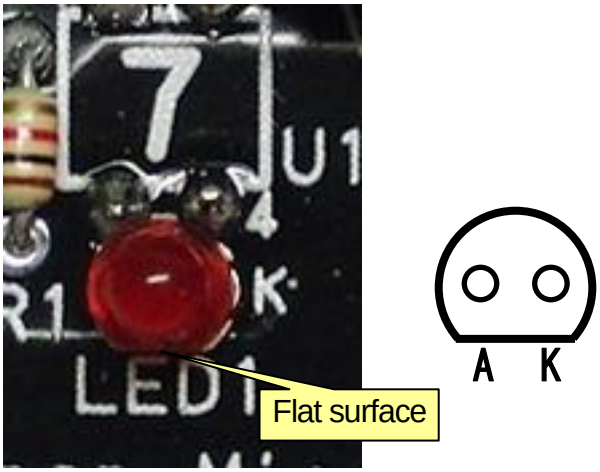
2	Normally, leads of a resistor array are not cut. However, because the board being used is thinner than usual (board is 1.2 mm thick, usual thickness is 1.6 mm), the leads protrude. **Cut the leads.**

3.11. Mounting the LEDs (Red)

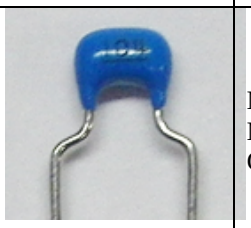
Part No.	Name	Model	Photo	Manufacturer	Q'ty
LED1,3,5,7, 9,11,13,15	LED (red)	EBR3338S or equivalent		Stanley Electric Co.	8

Solder eight LEDs (red). Pay attention to their orientation.

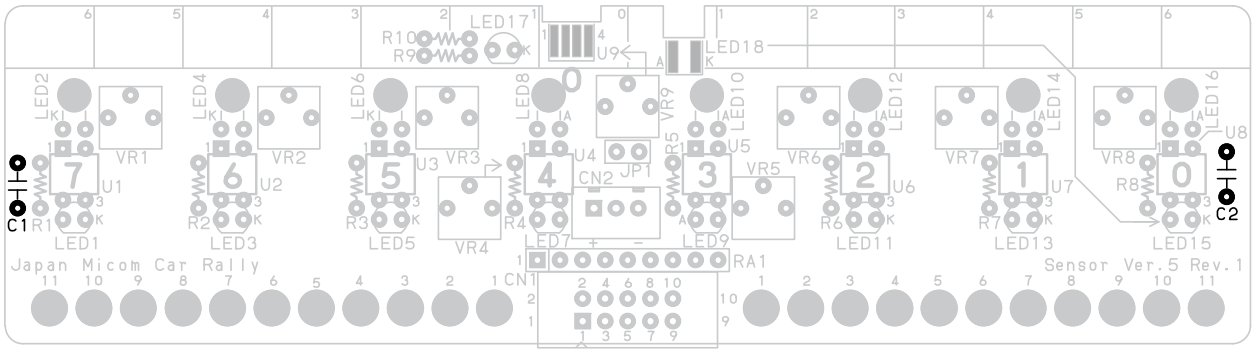


1		The photo shows LED1 after it has been soldered. The bottom of the LED is a flat surface.

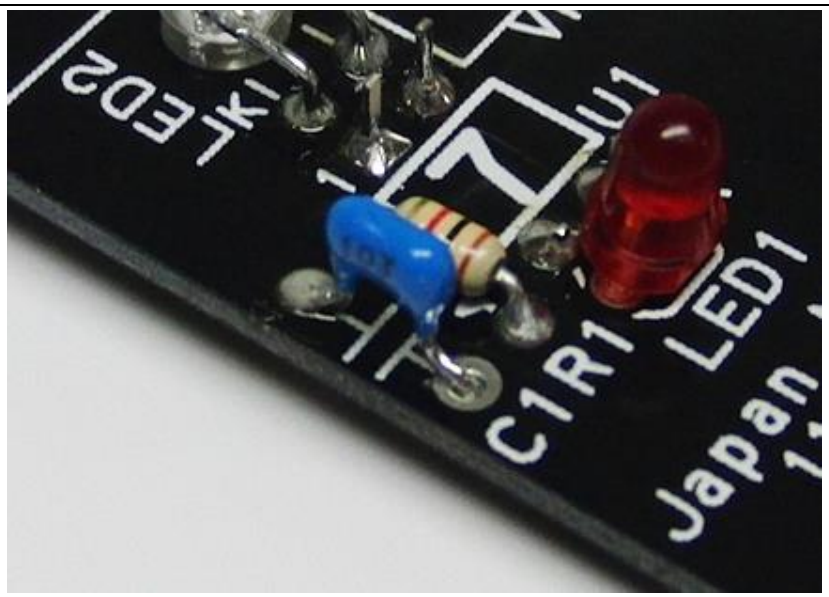
3.12. Mounting the Laminated ceramic capacitor

Part No.	Name	Model	Photo	Manufacturer	Q'ty
C1,2	Laminated ceramic capacitor	RPEF11H104Z2K1A01B 0.1 µF (104) 5.08 mm pitch	 No polarity	Murata Manufacturing Co., Ltd.	2

Solder two laminated ceramic capacitors.



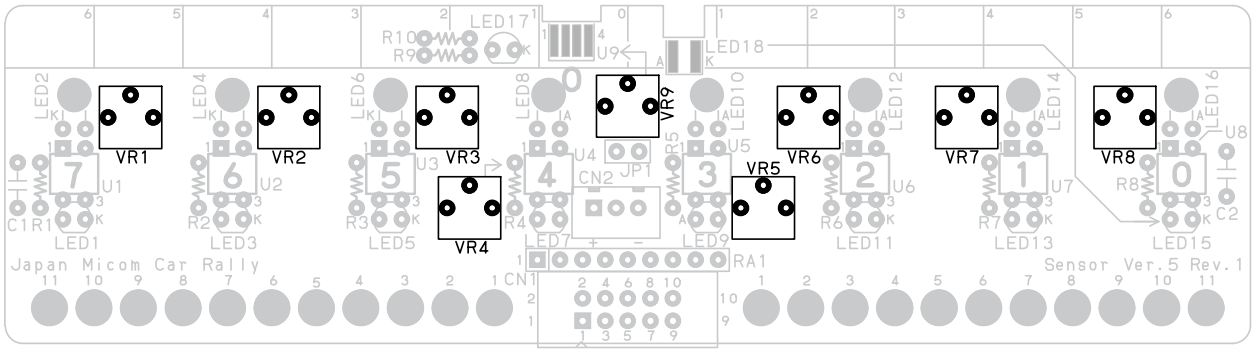
"104" is written on the laminated ceramic capacitor. If the side with the "104" faces outwards, it will be easier to see when checking the capacity of the capacitor later. By the way, 104 means 10×10^4 [pF] = 100,000 [pF] ＝0.1 [µF].

1		C1 was soldered.

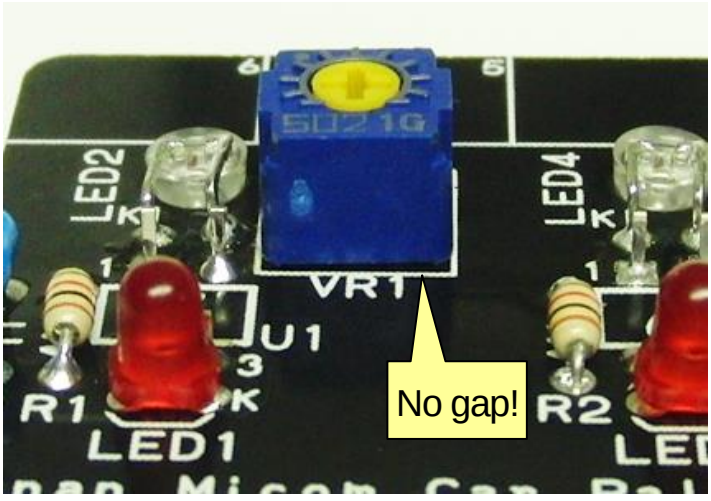
3.13. Mounting the Volumes

Part No.	Name	Model	Photo	Manufacturer	Q'ty
VR1,2,3,4,5,6, 7,8,9	Volume	CT-6P 5kΩ (502)		Nidec Copal Electronics Corporation	9

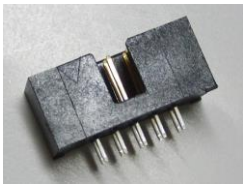
Solder nine volumes.



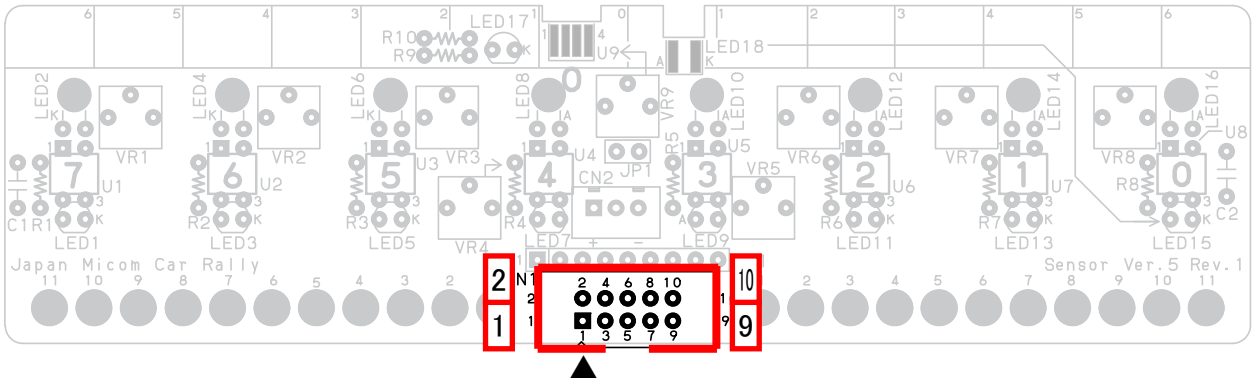
"502" is written on the volume. 502 means 50×10^2 [Ω] = 5,000 [Ω] ＝ 5 [kΩ].

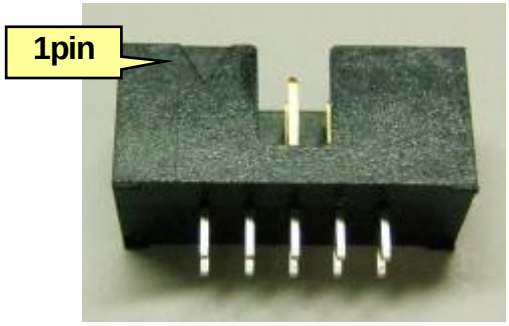
1		Mount the part closely so there is no gap, and solder it.

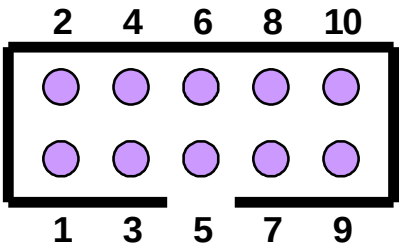
3.14. Mounting the 10P straight type convex connector

Part No.	Name	Model	Photo	Manufacturer	Q'ty
CN1	10P straight type convex connector	HIF3FC10PA2.54DSA	 ▼ mark is 1pin	Hirose Electric Co., Ltd.	

Solder one 10P straight convex connector. Pay attention to its orientation.

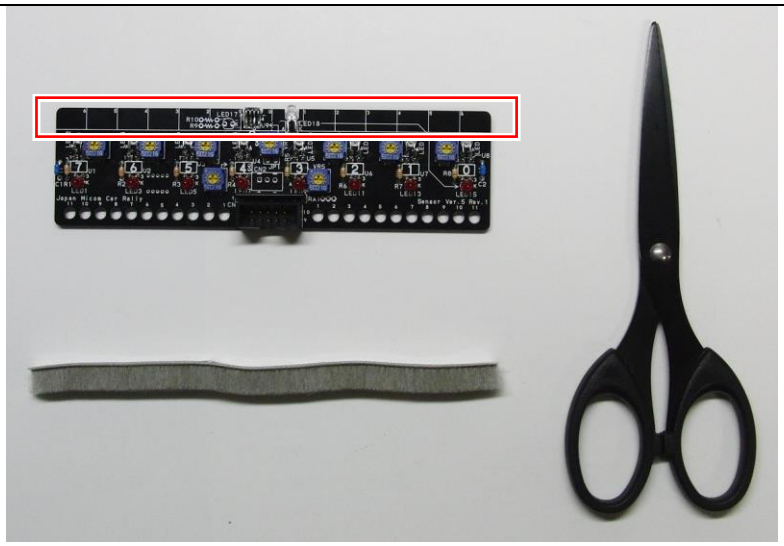
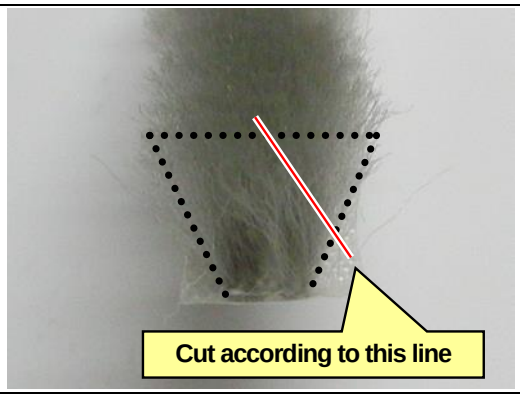
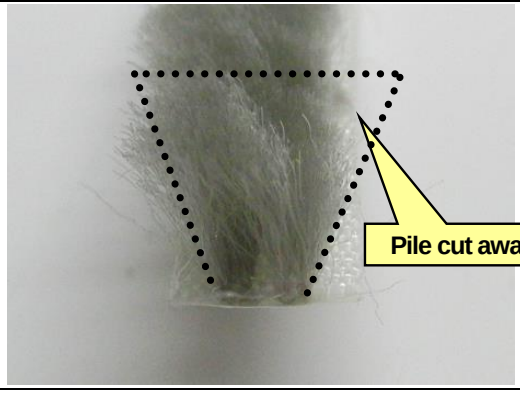


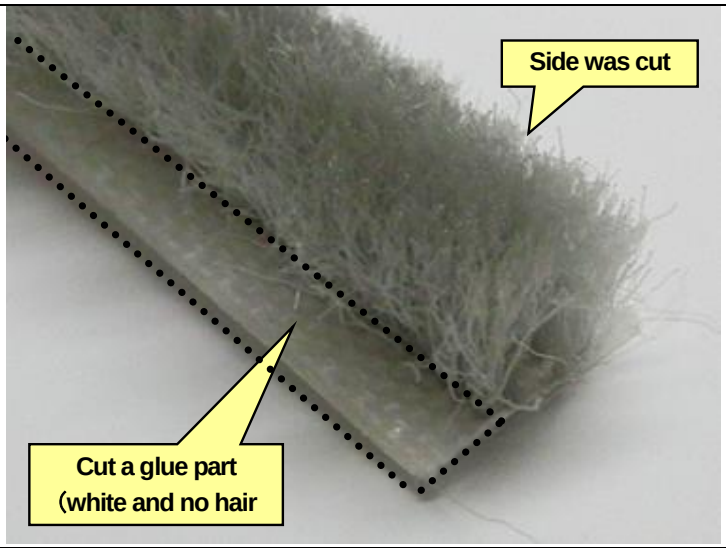
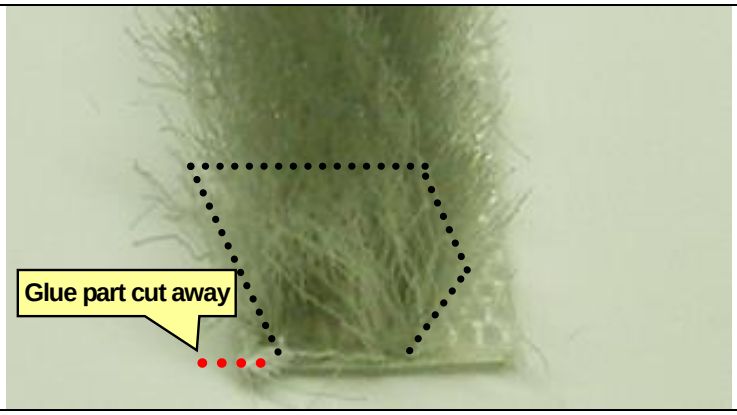
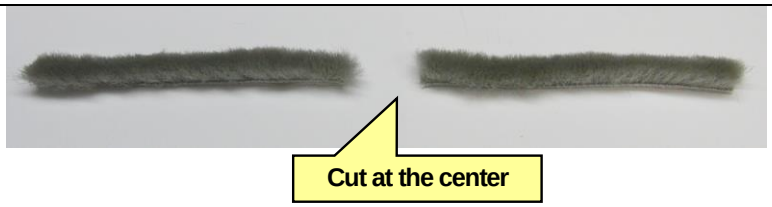
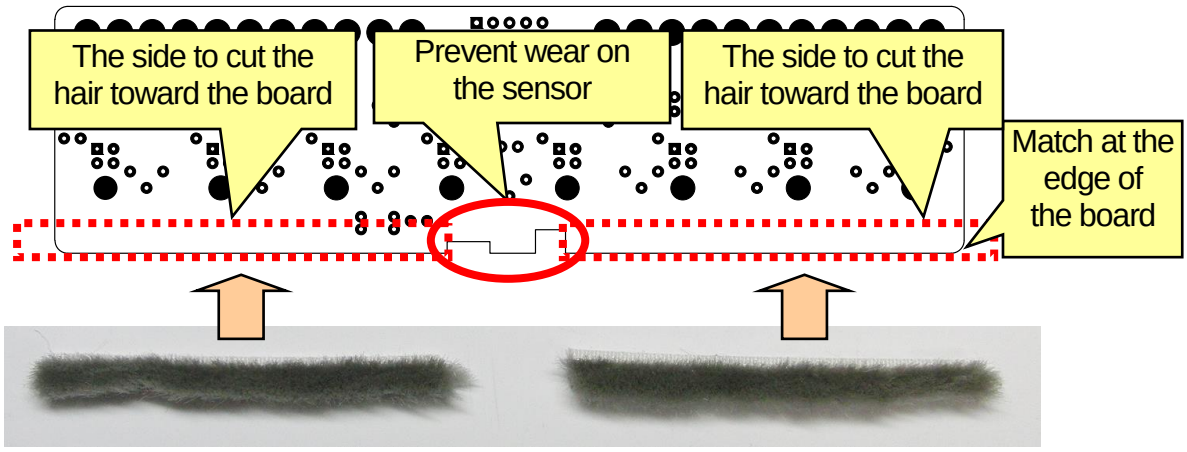
1		Pin 1 is indicated by the▼.

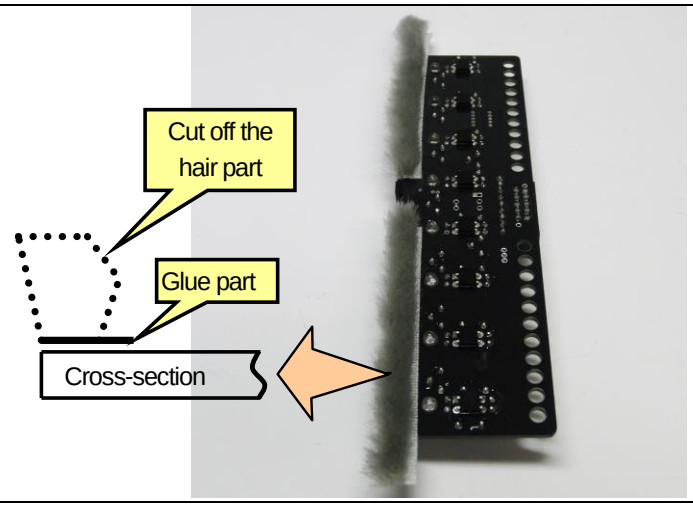
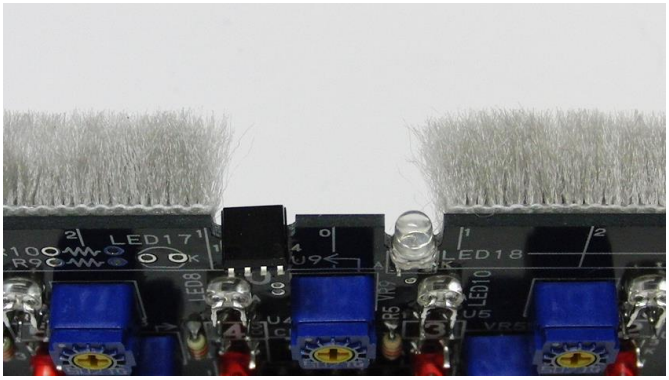
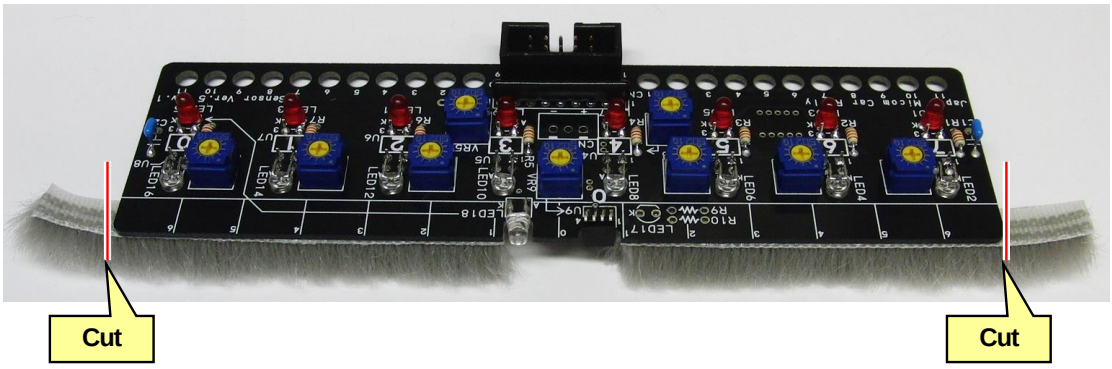
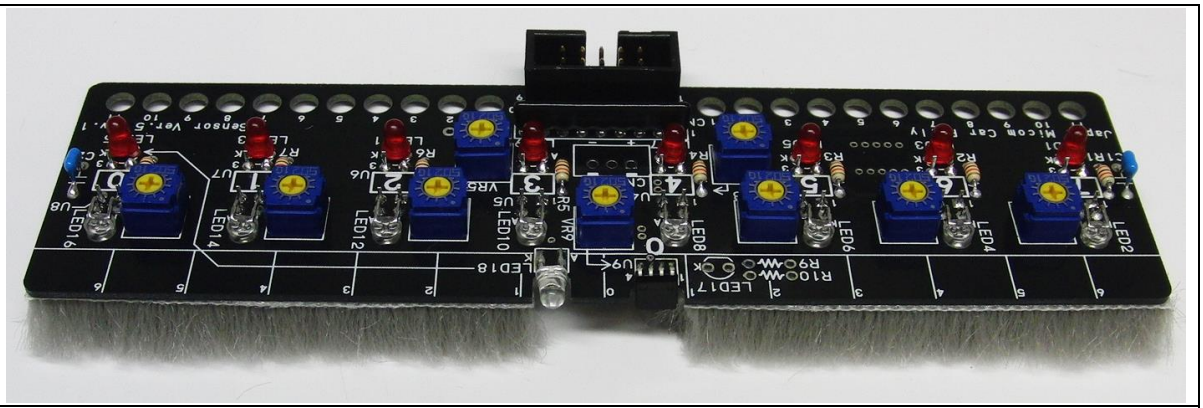
2		When viewed from the top, the pin numbers are as shown on the left.

3.15. Applying the Polyester Pile Tape

Part No.	Name	Model	Photo	Manufacturer	Q'ty
	Polyester Pile Tape	Approx. 150 mm		Available from various manufactures	

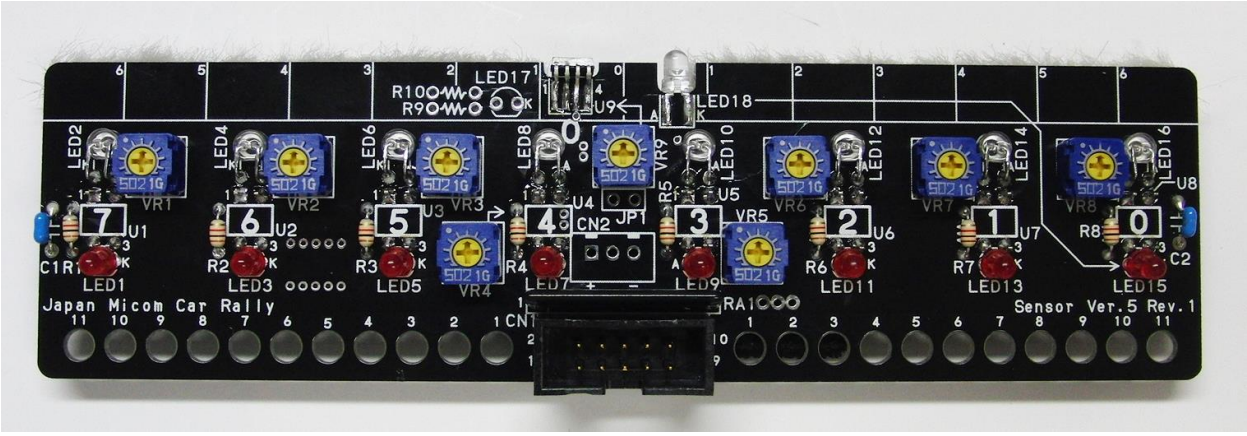
1		Prepare the sensor board, polyester pile tape (cushion), and a pair of scissors. The polyester pile tape is applied on the solder side to the portion of the sensor board indicated by the red rectangle in order to prevent the sensors from rubbing against each other at a constant height so they will react properly. The polyester pile tape must be modified because the spread hair of the polyester pile tape might disturb the link between the infrared LEDs and the photosensors underneath the board. Next we describe the process of modifying the polyester pile tape.
2		Use scissors to cut the top right portion of the pile. Leave the top left portion of the pile as is.
3		The photo shows the polyester pile tape after the top right portion has been cut away.

4		Cut the glue part of the opposite side of the cut surface using scissors or nippers.
5		Cut away.
6		Cut the polyester pile tape at the centre.
7	 Mount the polyester pile tape on the underside of the sensor board. The trimmed side should face inward away from the edge of the sensor board.	

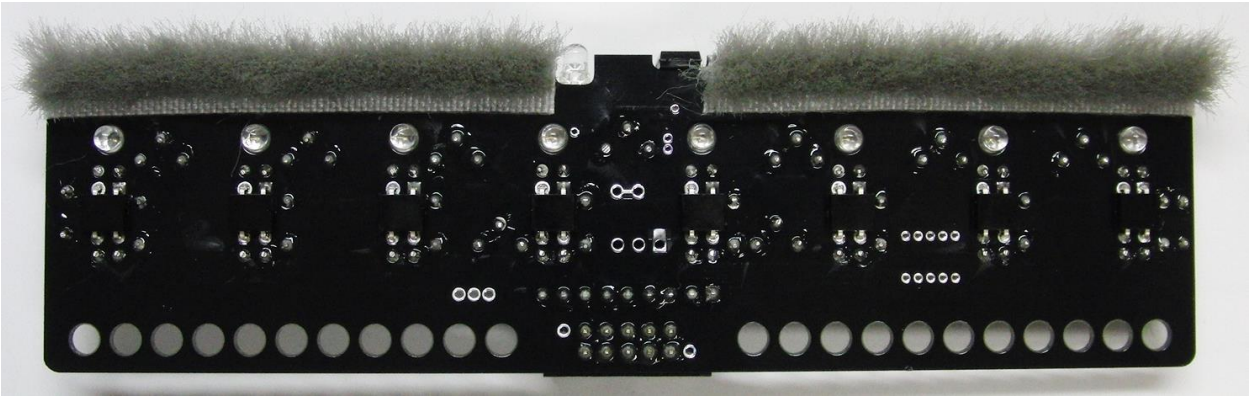
8		This is a view showing the solder side of the finished sensor board with the polyester pile tape mounted.
9		Do not mount polyester pile tape over the part in the middle where the start bar detection sensor is located.
10	 Cut off the ends of the polyester pile tape that stick out beyond the edge of the sensor board (red lines) to complete the task.	
11	 View of the board from the front after mounting of the polyester pile tape has been completed.	

3.16. Completion

The sensor board is complete. Visually check the board again for poor soldering, mounting of incorrect parts, and incorrect orientation. **The visual check must be performed.** Perform an operation test using the kit following the operation check manual.



▲Parts side



▲Solder side