

Design, Simulation and Manufacturing of A Rectangular Micro Strip Antenna on The Body

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ABSTRACT

In this research, we have designed a microstrip antenna with a low weight, flat configuration and capability of being located on the body. We used CST Studio Suite for simulation. This antenna works at central frequency 2.4 GHz. The value of parameter S is -30 dB meaning the impedance adaptation has been done correctly. Also, the value of VSWR is 1.065 which shows the maximum power transfer between transfer line and antenna has been done well and there is a good adaptation between antenna impedance and transferring impedance. In another word, antenna has an effective performance. The radiation pattern of antenna is all-direction.

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INTRODUCTION

1.1 The importance of micro strip antenna:

In 1970s, micro strip antenna became common for space applications while today they are used commercially (Ashkenazy *et al.*, 1985). They are made up of a metal piece on a sub strata attached to earth (Sanad, 1994). The metal piece can have different forms (Allard and Werner, 2002). Circular and rectangular patches, shown in figs (1-a), (1-b), are the most common ones (Jin, 1997). Due to simplicity of analysis and manufacturing, radiative features are desirable and especially radiations with crossing polarization are low (Conway and Scanlon, 2007).

Micro strip antennas have low volume, adaptability with planar and non-planar surfaces while they are simple and cheap to manufacture by new technology and sustainable in terms of mechanics and compatible with MMIC designs which can be adapted with features of resonance frequency, polarization, radiative pattern and impedance (Wemer *et al.*, 2002). The antennas can be installed on plane surface, space ships, missile, satellite, automobile and cell phone (Rezapour, 2013).

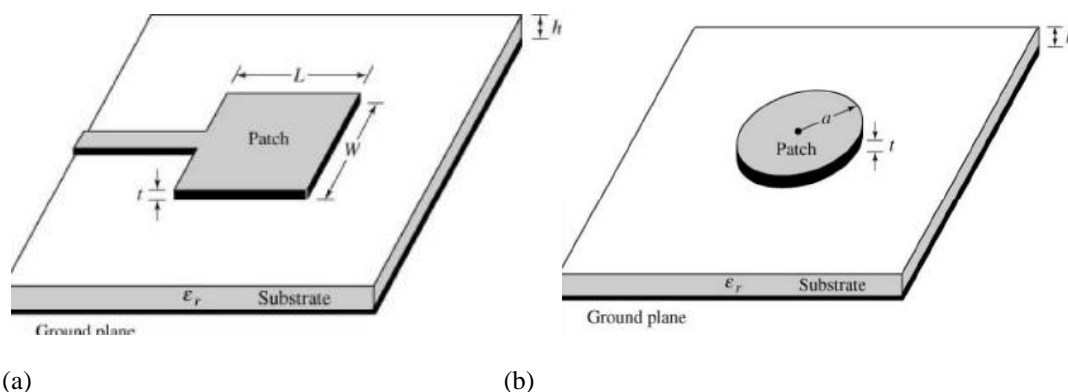


Fig. 1 a & b: Microstrip antenna (c,d) rectangular and circular

1.2 Types of microstrip antenna configuration:

There are different configurations for microstrip antenna (Das, 1991). Four common configurations are microstrip line, coaxial probe, hole coupling and adjacent coupling (Corzine and Mosko, 1990). Microstrip antenna with coaxial probe feeding (Correia *et al.*, 2009).

1.3 The required parameters for design:

Resonance frequency of a rectangular micro strip antenna can be designed in terms of path width and length, height and dielectric conductivity between conductive micro strip and underlying surface (Allard and Werner, 2001). The practical length and width can be computed by transmission line method, as seen below (Rezapour, 2013).

$$W = \frac{c}{2f_r} \sqrt{\frac{2}{\epsilon_r + 1}} \quad (1-1)$$

In this equation, ϵ_r is the dielectric constant.

Then, the effective dielectric constant can be found.

$$\epsilon_{eff} = \frac{\epsilon_r + 1}{2} + \frac{\epsilon_r - 1}{2} \left[1 + 12 \frac{h}{W} \right]^{-1/2} \quad (1-2)$$

The expansion length is as following.

$$\Delta L = 0.412h \frac{(\epsilon_{reff} + 0.3) \left(\frac{W}{h} + 0.264 \right)}{(\epsilon_{reff} - 0.258) \left(\frac{W}{h} + 0.8 \right)} \quad (1-3)$$

Real L in meter can be obtained.

$$L = \frac{c}{2f_r \sqrt{\epsilon_{reff}}} - 2\Delta L \quad (1-4)$$

The design of microstrip antenna has often three stratas or two stratas (Martin and Werner, 2001). In the 3-strata method, antenna of earth surface and patch are located on both sub stratas while in the two-strata method, the earth surface and patch are coupled on one side of sub strata (Ramirez and Alexopoulos, 1998). As the two-strata design brings about low volume and is economical, we rely on it.

Methodology:

2.1 Stages of design and manufacturing of the proposed microstrip antenna:

In design and manufacturing a microstrip antenna, the following stages must be considered.

1. Circuit design by required forms in main environment of CST
2. Providing suitable format for manufacturing from software environment
3. Providing film from layout
4. Manufacturing the piece
5. Testing the built piece.

2.2 Designing microstrip monopolar antenna in the frequency 2.4 GHZ by CST software:

To design a microstrip circuit, we must determine the required frequency and specific conditions considered by designers while being aware of the type of sub strata. The designer must implement the design of consideration in software environment and provide the conditions to taken the output such as port and taking layout from circuit. The initial pattern of design is a rectangular microstrip antenna circuit obtained by (1-1) to (1-4) and with a modification for a smaller design for 2.4 GHZ.

In the first stage of design, we place the shapes in the main environment of software. We must determine the type of substrate of circuit, thickness and ϵ_r and Get the element values. We used substrate FR4 with H= 1.6 mm and $\epsilon_r= 4.3$ which is available in our country.

Design of coplanar waveguide monopolar antenna in CST software:

All the stages of designing antenna with CPW method and microstrip monopolar antenna are the same. The main difference was in earth plane in which path and earth plane are located on one side at a little distance from feeding line and coupled. Regarding the requirement of low volume design, we try to reduce the size. One

way to reduce volume is to use charge in path The technique of making a circle on the path was presented along with manual setting. Figure2 shows the schematics of a monopolar antenna with CPW method.

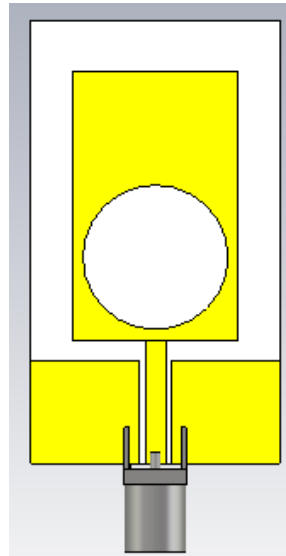


Fig. 2: final form of monopolar antenna with CPW method

Results:

3.1 output result of simulating coplanar waveguide monopolar antenna in CST software:

Having complete the design, we specified the frequency range of 1-3.5 GHz to get the output. Then, we determine the required output.

3.2 1D result output:

The 1D output consists of parameters (S11). As seen in fig 3, the value of output is nearly -30 db and reaches 50 ohm in impedance adaptation.

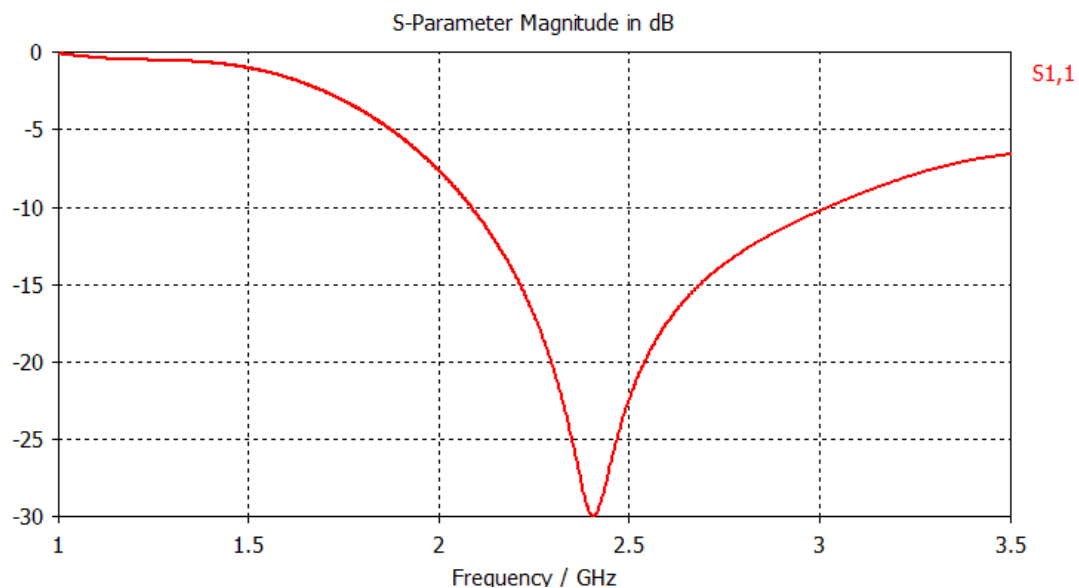


Fig. 3: the graph of S11 from simulation environment to design CPW monopolar design.

Fig4 the graph of S11 from Smith Chart in simulation environment to design CPW monopolar antenna.

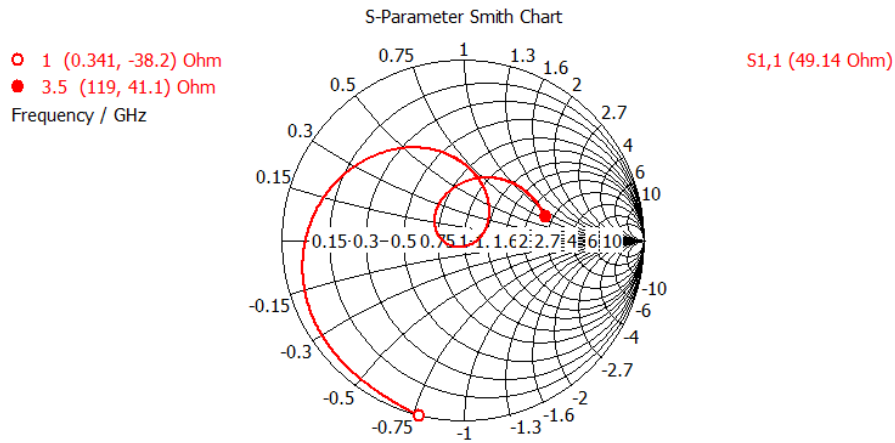


Fig. 4: the Smith Chart graph in simulation environment.

Fig 5 shows VSWR. As seen in the figure, the value of VSWR is close to 1 (1.065).

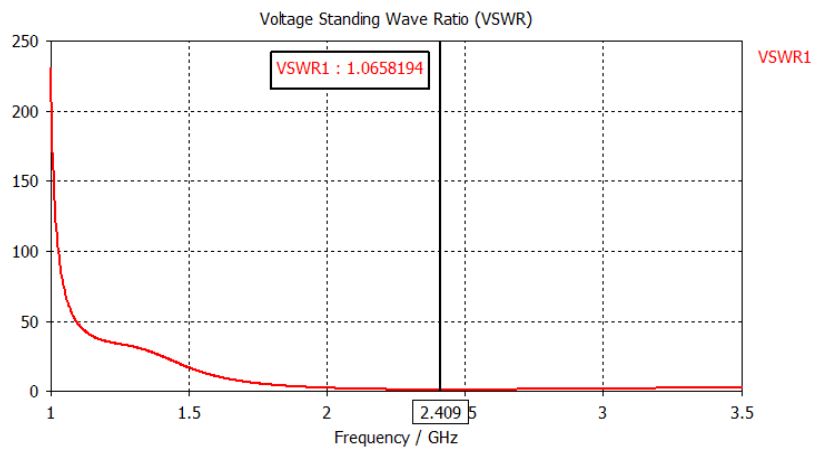


Fig. 5: shows the graph obtained from the simulation environment for CPW monopolar design.

3.3 2D/3D output:

Fig 6 shows the direction of electrical field from patch to eart plane.

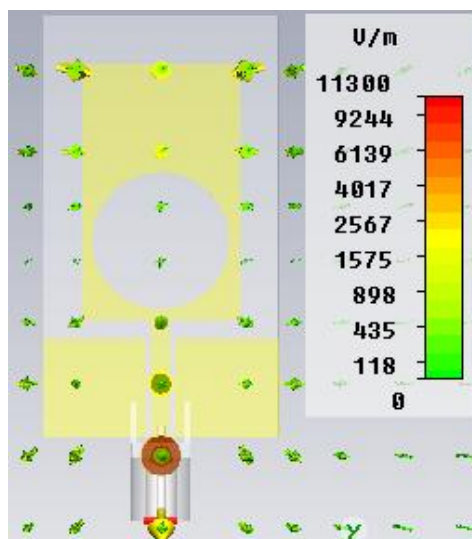


Fig. 6: the direction of electrical field in design of CPW monopolar antenna

Fig 7 shows the direction of magnetic field with a 90° phase difference with electric field.

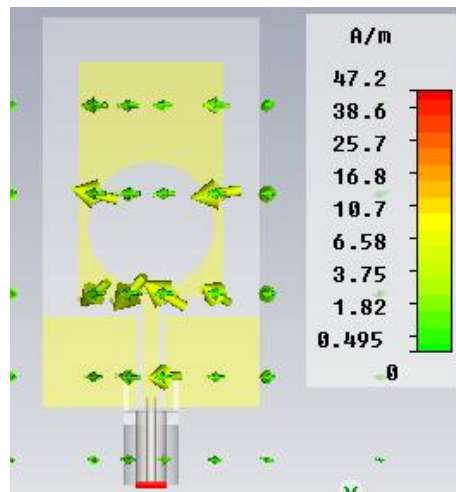


Fig. 7: the direction of magnetic field in design of CPW monopolar antenna

Fig 8 shows the surface current the maximum of which is on the feeding line and circle on patch.

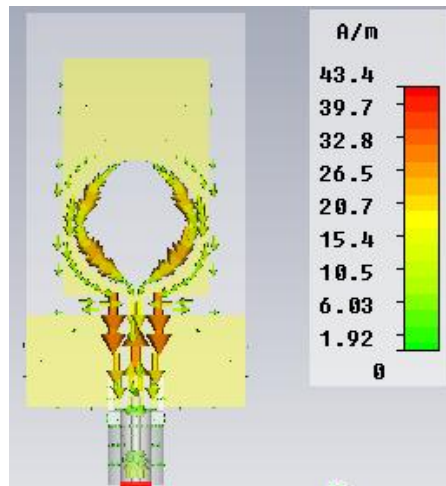


Fig. 8: the surface current in the design of CPW monopolar antenna

Fig 9 shows the distribution of current density, the maximum of which is on transfer line and feed width.

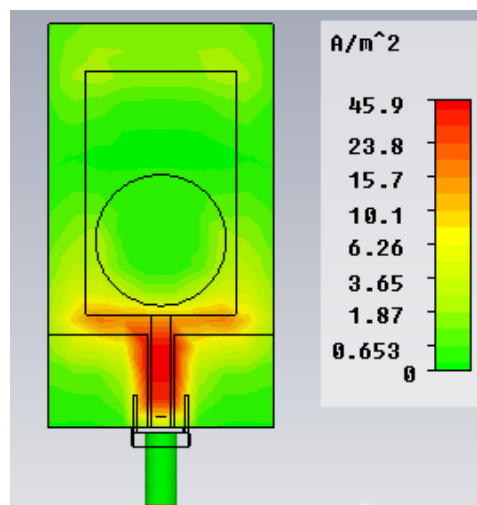


Fig. 9: the distribution of current density in design of CPW monopolar antenna.

3.4 Radiation pattern results:

In farfield analysis, we can observe a radiation pattern of an antenna which can be bidirection, monodirection or all-direction. We used all direction radiation pattern in our study for the farfield 3D output. The results of H-plane and E-plane of radiation pattern are shown in figure 11 and 12.

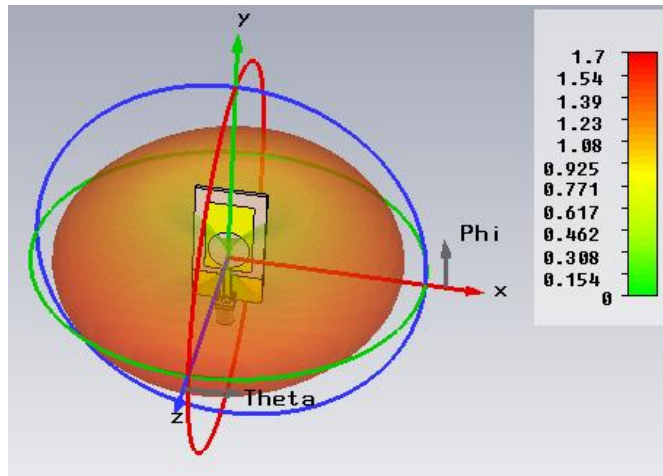


Fig. 10: the graph of radiation pattern from simulation environment in CPW design

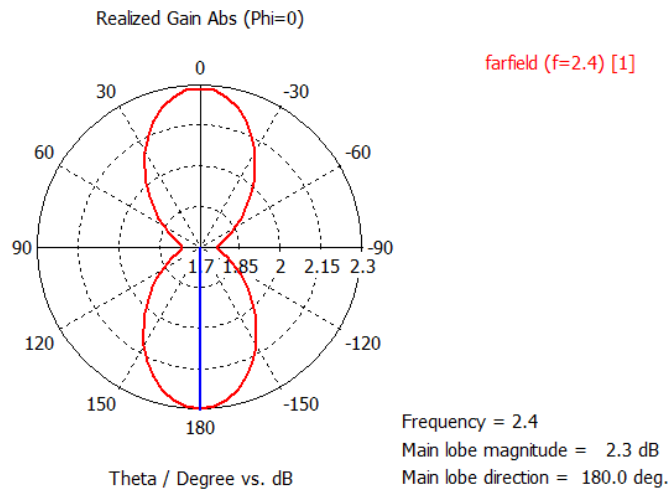


Fig. 11: the graph of radiation pattern of simulation environment in E-plane for CPW design

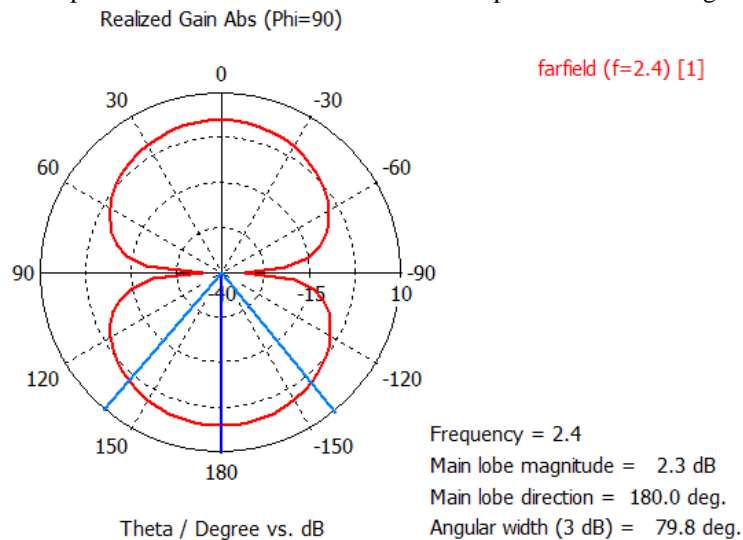


Fig. 12: the graph of radiation pattern of simulation environment in H-plane for CPW design

Manufacturing stage of designed antenna:

Having finished the analysis and simulation of antenna by software, we manufactured the device by real values to compare it with theoretical analysis.

3.5.1 manufacturing stages of antenna circuit:

Fibre board is washed with detergent and antioxidant materials (washing powder + chloride 20%). The board is dried with dried air and a micron thin photoresist is sprayed on it with a spray positive 20. The device is spinned at 300 rpm so that the photoresist becomes homogenous. We put the board in warm and dry air to be dried. The film is placed on the board in the vacuum device so that the film sticks to board. Then it is put in the fliner mask device (uv is radiated in great focus) and the positive part of photoresist stays.

In photo radiation stage, the eart plane of fiber is covered with wide stick and the board is put in developer solution (Acid chlorophric) so that the part of board which has appeared is removed and the circuit lines are apparent.

In the next stage, the labels are removed and propanol alcohol is used to clean the remained photoresist. The Sn extract is put into the solution to protect our conductor against oxidization. The board is then ready to be punched.

Then, we use substrate FR4 of H= 1.6 mm thickness and $\epsilon_r=4.3$ and a SMA releaser to tes the circuit.

3.5.2 the results of manufacturing:

After transforming the design to film, we test the results of manufacturing the device with network analyser with the results shown in fig 13.

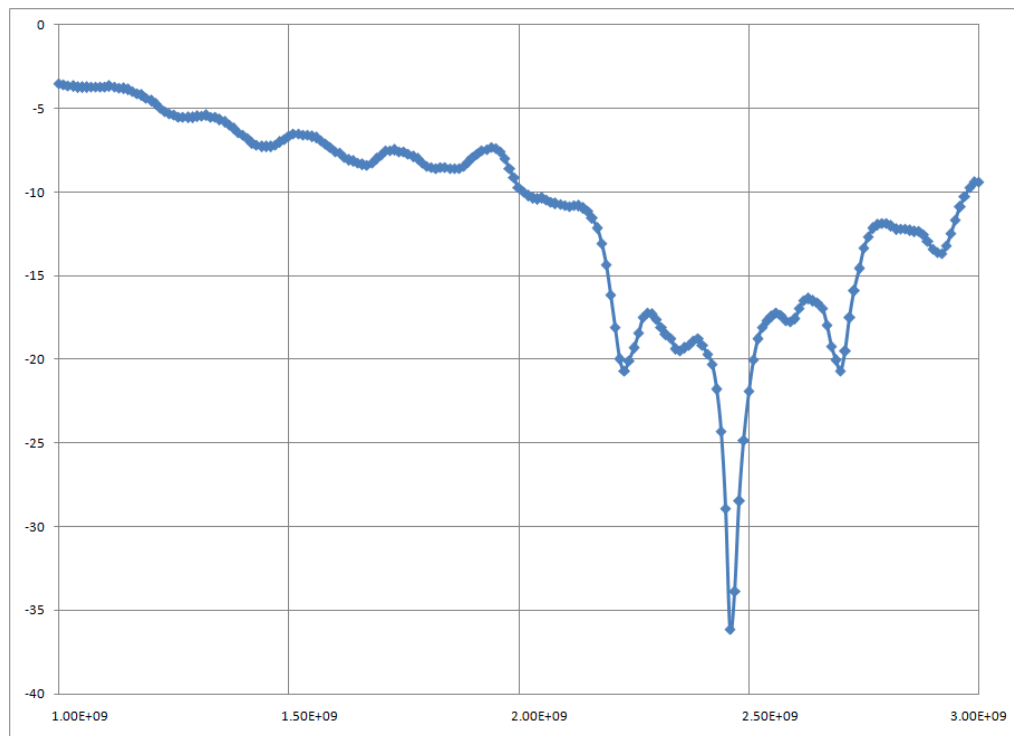


Fig. 13: the graph S11 for CPW design

Discussion:

Based on the searches in internet, there has not been found any microstrip antenna in central frequency 2.4GHZ. by the way, the outstanding feature of this design is low volume which makes it possible to be installed on human body. On the other hand, this antenna has suitable adaptation of input and output impedance. There are some points to present so that the practical requirments of manufacturing microstrip transfer lines and greater productivity become clear.

choice of substrate:

With the limitations of choosing fibers in the market, the suitable fiber is chosen by the designer from an economical point of view. It is suggested that the fiber is provided and the design and computer simulation are performed on the fiber. The fiber used in this design is 1.6 mm high with dielectric constant 4.3.

4.2 Shield effect:

As the signal of high frequency passes the transfer line, there appears radiation. Therefore, the circuit must be placed in a metal box or shield to prevent from field intervention on line. In addition, the box must be protected against mechanical damage. The box height must be at least 5 times as much as fibre height to prevent propagation.

4.3 The effect of ϵ_r :

This parameter is important in the choice of fibre, which is 2 for antenna application but 4-10 for non-radiative circuits. The large values of this parameter cause line wavelength and circuit size to become small.

4.4 The effect of $\tan \delta$:

The loss tangent for fibre is at one thousandth order. Except for rare cases, low loss tangent is a quality criterion.

port install:

We must try to use simple and qualified ports not to intervene with line and microscope must be used to increase the accuracy for port soldering.

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