A novel silicone rubber key automatic assembly system using placement machine

Xiaosong Ma¹,²*, Yukun Zhang¹, Keye Wu⁴, Changhua Tang³, Zihao Ming², Zhengqi Zhong², Hua Wang²
¹Foshan Hongjiachang Electronic Limited Co. Foshan, Guangdong, P. R. China
²Guilin University of Electronic Technology, Guilin, Guangxi, P. R. China
*email: glmaxiaosong@163.com

Abstract. Silicone rubber key is an on and off component assembled on PCB. However, the assembly of silicone rubber key has been by manual and it is low efficiency and higher labor cost. In order to solve this problem a new assembly method by using the surface mount placement machine is invented. The main improvement of this new products is that human work can be completely replaced. And the advantage of the new invention is that the production line does not need to change for the surface mount assembly. The only change is the placement nozzle which is to suck the component and then assembly the silicone rubber key on the PCB. Furthermore, the newly designed vibration materials loading device is equipped to increase the production rate.

1. Introduction
Silicone rubber key is an on and off component assembled on PCB. It consists four parts, including base, key cap, conductive rubber, and two pins which assembled in the hole of PCB. However, the assembly of silicone rubber key has been by manual and it is low efficiency and higher labor cost. In order to solve this problem a new assembly method by using the surface mount placement machine is invented. The advantage of the new invention is that the production line does not need to change for the surface mount assembly. The only change is the placement nozzle which is to suck the component and then assembly the silicone rubber key on the PCB.

2. Silicone rubber keys loading system and packaging
Silicone rubber keys loading system can be either tape reel loading system or vibration loading system. The differences are evident that tape reel cost high for the tape reel packaging and does not need special machine. But the vibration loading system needs additional designing a new vibration loading system. From present customers, vibration silicone rubber key loading system is welcome.

2.1. A Tape reel loading system
The tape feeder has a standard. They are in various widths related to the tape widths, see Fig. 1. The top foil of the tape is peeled off and carried away together with the empty carrier tape. The top foil reel becomes full after a time and then has to be emptied. More, the top foil reel tension varies as a function of time as the thickness of the foil on the reel increases: peeling off the top foil by pulling it between two driving wheels which hold the foil force constant. The advantage of this newer method is that there cannot be a problem with a top foil reel becoming full.
The tape used in our production line is shown below, the tape reel form of silicone rubber keys. The disadvantage of the tape reel form is the cost. Usually, the one tape reel silicone rubber key is two or three times as the original one without packaging.

Fig. 1. Tape reel form of silicone rubber key

2.2 Vibration loading system
Vibration silicone loading systems are welcome by the user due to its lower cost for each silicone rubber keys because most of the company only has certain forms of silicone rubber keys. If the vibration loading system can be suitable some forms, it will meet the requirements of the customer. The second reason is the amount of silicone rubber keys is very great. Therefore, customer needs only invest money on the vibration system once and they do not need invest any more for the production.

To meet the requirement of different customers, three types of vibration silicone rubber keys uploading systems are designed: one uploading rail, two uploading rails and three uploading rails, see Fig. 2, Fig.3, and Fig.4 the different upload rails system. The Fig.4 is not finished yet.

Fig.2 One loading rail feeder       Fig. 3 Two loading rails feeder

Fig. 4 Four loading rails feeder

3. The assembled the products
The assembled silicone rubber keys are shown in Fig. 5. Fig. 5(a) shows the front side and Fig. 5(b) shows the back side. The following requirements are needed for the assembly:
A. The assembled silicone rubber keys will not drop off from the PCB when do the dropping tests;
B. The assembled silicone rubber keys stick to the PCB steadily without any release from PCB holes which are used for holding the silicone rubber keys.

Fig. 5 shows the assembled and test results without any drop off or release. The test board is an array board which has 35 small PCB and later they will be separated. Each small PCB has one silicone rubber key on it.

![Fig. 5. The assemble silicone rubber keys on PCB](image)

4. Surface mount placement machine system

Surface mount machine is general purpose machine which is used to place electronic component on the PCB solder pads. These copper solder pads are printed a thin layer of solder paste.

For very small and simple chip placement, high speed chip shooter is used, and can be categorized according to the movement of placement mechanical parts. The first type is a stationary placement head and movable PCB and movable feeder table. The placement heads are distributed around the rotation center. Each head picks the component from the back rail feeder and the at front the placement head place a component at the same time. PCB can be move in X and Y directions in order to meet the position requirements. This kind of placement machine does not meet the silicone rubber keys assembly requirement because the silicone rubber keys materials loading system is a vibration device. The vibration loading device can’t move even it has one or four loading rails. The second type involves a fixed PCB and feeder bank, but a movable or revolver head. The principle is combining the advantages of the flexible pick-and-place systems with those of the high-performance shooter. The major difference compared to the pick-and-place systems is that, instead of a simple head, an X/Y gantry system carries one or more head with up to 12 or more vacuum nozzles. The placement head can pick more silicone rubber key at one and using CCD to check the deviation and aliment individually.

Fig. 6 shows a four placement heads placement machine, SMT assembly system. The silicone rubber keys loading system is a vibration loading system. It has two rails to uploading the silicone rubber keys, so the placement heads only can suck silicone rubber keys two at once. One routine needs two suck actions. After our silicone rubber are sucked, they are moved above four CCD to check the deviations. When the alignments are done, four silicone rubber keys are assembled one by one. In order to increase the assembly efficiency, four loading rails feeder are designed, see Fig. 4. If it is manually assembly the silicone rubber keys, skill worker will spend 15 second. If this machine is used, one second can assembly two silicone rubber keys.
5. Silicone rubber keys construction
The traditional conductive silicone rubber key is shown in the Fig. 7. The left light green and right light white ones are the traditional conductive silicone rubber keys. There are two pins under the rubber key’s base. And the pin is divided in two parts. The big diameter part is connected to the base and small diameter part is at the end. On the bottom side of the base, there is a round black conductive rubber for keys on and off operation. Corresponding PCB, there two holes for holding the rubber keys and conduct on-off for the circuits. The assembly for human is as follow. Insert the two pins form top side of PCB by hand into the two holes in the PCB from front side and pull the small pin part from bottom side until the big size pin rest in the holes fully. Fig. 8 shows the new silicone rubber key. The difference is the pin at the end, which is changed into the tape shape or a large ring is added between the tape or larger diameter pin.

6. Surface mount placement nozzle
The suck and place nozzles are shown in Fig. 9, Fig. 10 and Fig.11. Fig. 9 shows initial design and newly designed nozzle. The initial one had positioning problem.
Fig. 10 shows the nozzles on the placement head, mainly for assembly efficiency four nozzles are used. Fig. 11 shows the working nozzle, which suck one rubber key.

7. Conclusions
In this paper, a novel and automatic placement machine are designed for placement of silicone rubber keys. The function nozzles are designed to meet the placement requirement compared to the tradition nozzle which consist of only a small suction tube. And different loading rails are produced for different. This machine can increase production rate up to 30 times and also one machine can replace 60 personals work.

References
[1] X.S Ma, et al. The Research and Accomplishment of Standardization and Serialization of SMT/A Silicone Connectors[C]. ICEPT2020, 2020
[2] X.S Ma, et al., 2000. A novel and automatic assembly-able conductive silicone rubber key by placement machine[C]. ICEPT2020, Guangzhou, China. 120-125
[3] C.C Zhao and J.K Zhang. Silicone rubber and its application. Chemistry Industry Publisher, Beijing, 2015.
[4] Y.H Hou et al. Modern rubber manufacturing processes. Chemistry Industry Publisher, Beijing, 2017.