

Strategy for using Automated Quality Control Test Equipment

I've worked as an electronics engineer in a number of different manufacturing environments. I've helped in various roles from design to production. Most of the products I've worked on require electronic circuit boards to be tested on automated function test equipment as a quality control test on the assembly line. And I've noticed in many cases that the design and use of these Function-testers is a last minute consideration and is not well thought out. And I've even seen gross examples in the manufacturing of medical equipment which prompted me to write this article.

Function test equipment is a quality control device. Their use may not be as critical for some products like toys or entertainment products or household appliances. The industry standard is that all devices must be designed, built, and tested so that there is no modes of failure that can harm the consumer. These are the UL standards that guarantee that the device will not cause electric shock, fires, or spew harmful gases, etc. However, there are some industries where quality control is more important, such as medical, or military, or aviation. In these industries, it may actually cause harm if the device stops working such as in the middle of a surgical or military operation or while the plane is in-flight. Such failures could be the cause of expensive lawsuits or loss of reputation and market share. So quality control is vitally important in these industries, and more

precautions needs to be taken in the design and use of automated quality control test equipment.

The whole purpose of automated QC test equipment is to catch failures before the products are shipped. If you don't care about catching failures, then you might as well not test them and just assume they are all good. However, there does not seem to be any industry standards on the design and maintenance of automated Function-testers. The Function-tester must not only not fail in a way that ever causes harm to the operator (This may require training of the operator to avoid harm), but the Function-tester should not fail in any mode that passes bad product.

Intuitively it seems unlikely that a Function-tester will break in a way that passes bad product. If they break, you'd expect them to not pass anything. However, that's just wishful guessing. And we really don't have any way of knowing the probabilities of a Function-tester breaking in a way that passes bad product. There should be design considerations of a Function-tester that takes into account the various ways it could break and how that effects pass/fail abilities. But to test these design considerations, a Failure Mode and Effects Analysis (FMEA) would have to be performed on the Function-tester. This procedure would open and short every wire in the Function-tester and confirm that it still fails bad boards. But this is a generalization based on a sample of one attempt to open or short each wire to see what happens. Besides, an FMEA involves deliberately breaking the Function-tester to see what happens. You would have to repair the Function-tester and deliberately break it again in a different way for each possible failure mode. That's usually done on the product itself since they are relatively inexpensive and you plan

to mass produce them so that there are many units to break and repair. But a Function-tester is usually very expensive and there may only be 2 or 3 units that ever exist. How reliably would a Function-tester work after breaking and repairing it 100's times? So an FMEA may not be an option.

If a customer complains or you get sued, how can you prove that you are employing reliable methods in your quality control? I've seen trials that involve complex testing equipment. The first substantive question that a lawyer will ask is, "Do you calibrate your equipment?" And the correct response is, "Yes, we test our equipment with known good and bad samples to confirm that it passes good ones and fail bad ones." Some companies will calibrate their Function-testers once a year. This usually involves a complicated procedure that compares values measured by the Function-tester with values obtained from calibrated measuring equipment. But this does not help with the next question, which is, "How often do you calibrate your testing equipment?" The more often you check it the better. So an easy and reliable way needs to often be used to make sure your Function-tester is catching bad ones and passing good ones. For you don't want to wait until you get returns from the field to find out your Function-tester is broken. At that point, it is too late, and you may be looking at a recall to ensure quality. So your liability and quality control are resting heavily on the reliability of the Function-tester.

The best way to insure that your Function-tester is working is to have a set of both good and bad units that you pass across it every so often to make sure it's still working. You might wish to check the Function-tester this way before and after a production

run, or every couple thousand units. That would have to be an executive decision based on the risk they are willing to take. And you can check these boards against calibrated measuring equipment at any time without interfering with production to make sure the measurements of interest on the boards are staying the same.

There are other reasons to have a set of calibration boards available. If a Function-tester should break, it would be best to have some known good and bad boards available to help fix the tester. It is impossible to repair a Function-tester without testing some actual units. Only then can you repeat the problem so that you can find the cause of it and then fix the tester. Only then can you know that it is fixed because it passes and fails units as required. The alternative is to wait until a production run so that you have boards in order to use some to fix the Function-tester. This puts an undue burden on the repair technician to quickly repair the Function-tester while production is waiting for the tester. What if the fix requires a part that may take weeks to come in? These known good and bad units can also be used to qualify the Function-tester when it is first built. You might also need them to adjust component values during the development of the tester. It would be best to first try to pass good ones because if the function tester itself should break boards, then you will more easily know that good ones are being broken than already bad ones are being broken. Besides, it is generally more difficult to acquire bad ones, so you want to treat them with special care.

So the only questions left are how to obtain bad units, and when is it not possible to obtain bad ones. I assume good units should

be readily available. The product to be function tested must be able to be constructed slightly out of tolerance in order to test whether the Function-tester will catch the slightly bad ones and pass the barely good ones. Some companies will think that the units to be tested are a random sampling with a nice bell curve for the values measured. And so they will test them as if they were random and hope that the Function-tester is working to filter out those units that are out of tolerance. But those filtering circuits could break at any time, and you wouldn't know it until you get returns from the field. It might be possible that some measurements being tested are outside your control and cannot be adjusted to be slightly within and slightly outside tolerance. I'm thinking of pharmaceutical pills, for example. Then we would have to rely on a complicated calibration procedure on the function tester to compare with known calibrated meters. That would be a last resort, though, not a first resort. A good engineer, however, will recognize that they can construct the units with slightly different components so that the units are deliberately slightly in or out of tolerance. These are used as highly valued calibration boards to make sure the quality control Function-tester is working as expected. You might wish to label or color code these calibration units so they are never sent outside the factory floor. It might also alert production workers to treat them with special care since they are hard to obtain.

The goal is to make sure that product runs smoothly through the assembly line. We don't want the Function-tester to ever create a bottle-neck that slows down production. This requires close cooperation between Design-engineering and Test-engineering. The product should be designed so it can be easily tested. And it should be designed so that it can easily be adjusted with

component changes so that the product is slightly in and out of normal tolerance. This allows construction of calibration boards to ensure the reliability of the Function-tester. And for high volume products it would be best to have a back up Function-tester in case one breaks down. That way you can keep the production line moving while you repair the other Function-tester.

It is Design-engineering's responsibility to identify measurements that confirm that the product is operating within tolerances. And it is Test-engineering's responsibility to ensure that the Function-tester is taking these measurements reliably. Obviously, it is not expedient to measure every single thing on a product. Perhaps only the major inputs and outputs of the device need to be measured, and we can assume that the signals between the components are operating normally. If engineering discovers that there are some problem areas, then those signals will have to be measured as well. Some typical things to measure on electronic assemblies would be the power supply voltage being supplied to all the integrated circuits and the frequency of the oscillators to the microcontrollers or timing circuits. You will also need to activate input buttons and monitor output relay closures and make sure that sensor inputs are within expected values.

Keep in mind that the Operator of the Function-tester may be required to push a sequence of buttons, turn knobs, and observe outputs in order to confirm that the product is functioning correctly. For example, an Operator may have to confirm that all the pixels of a display are working. And test code in the form of special programming just for testing purposes may be required to

exercise all the functions to be checked on the factory floor. And after function testing is done, the product needs to be programmed with normal operating code.

Engineers can put different components on the boards so they are slightly in and out of tolerance to see if the Function-tester catches them. For example, most electronic circuit boards will have a power supply that needs to be checked by the Function-tester. Many times these power supplies are regulated by integrated circuits (ICs). Some of these regulator ICs are fixed to one voltage level. And there are usually versions of the same IC that are adjustable with the use of certain resistor values. You will want to use the adjustable version of the regulator IC in order to install resistors values that put the power supply slightly out of tolerance. A lot of the time the boards will still otherwise function with a slightly out of spec power supply, but you don't want to pass those boards for quality and liability reasons. If there is no room on the board for these resistors, then you need to find a non-adjustable version of the regulator IC that is out of spec as you desire. These are rare. The manufacture of the regulator IC may have some available. But you may have to pay extra for the manufacture to sort for them. And you may have to sign a waiver acknowledging that they are out of spec. The manufacturer will not guarantee that they continue to operate at a particular voltage. So you may have to check often with calibrated meters that they still have the value you expect.

Likewise, if your Function-tester measures the frequency of an oscillator to a microprocessor, you will want to find a crystal or resonator that is slightly out of spec. The manufacturer may have some available just for these purposes. Or you may have to

pay for sorting and sign off to indemnify the manufacture, etc. Make sure you're only signing off on the out of tolerance parts. You still want to hold the manufacture responsible if they sell you out of spec parts that are used in the product that's shipped. Or if your device relies on the input from a sensor that's compared to a known precise resistance, you'll want to get a resistor value that puts the measurement slightly beyond the tolerance. Precision resistors are usually easy to come by in various values. Or you may have to buy quite a few and measure each until you find the right value.

This brings up the question as to which components will maintain their values, whether they are in or out of tolerance. Which components age well? And which components change with heat or vibration or use? Relays can open and close with different timing, or vibration can change their abilities. Electrolytic capacitors can dry out and change their capacitance value. But components like resistors, transistors, ceramic capacitors, and crystals have values that rely on the dimensions of their initial construction, and after constructed are not likely to change unless used outside their specified tolerances. Also, you will want to use multi-stranded wire in the construction of the Function-tester since it may be subject to being opened and repaired many time, or it may be subject to excess vibration. Single stranded wire will easily break under vibration. Also, make sure that any printed circuit boards inside the Function-tester have a solder mask layer, and they may also need to be conformal coated as extra protection again shorting of exposed pins and wires. The factory floor can be quite dusty, and this dust can get inside the Function-tester and short out wire and pins.

It concerns me that industry may not be aware of these needs to make bad as well as good product for quality control purposes. It may be the case that no manufactures are even willing to give you out of spec components for your calibration boards. You may have to construct out of tolerance components by putting parts in series or parallel to get the values you need. This can easily be done with resistors and capacitors and inductors. But crystals and voltage regulator ICs will be a problem. The temptation will be to simply fix any broken boards and sell them for profit. But perhaps some of them should be kept for the purpose of confirming the operation of the Function-tester.

Function-testers for electronic boards are usually constructed with spring loaded po-go pins that make contact with test points on the board when it is pushed down once the board is lined-up. The po-go pins usually contact only one side of the board, and this leaves the other side exposed. To make it easy to calibrate the Function tester (at least once a year), test points for critical measurements can also be put on the exposed side (Top-side) of the board. That way you can probe the top-side of the board with calibrated meters and compare with what the Function tester measures through the po-go pins on the bottom side of the board.