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Fast recalibration of test and measurement equipment

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ABSTRACT

A testing line in a factory comprises equipment that tests the stream of consumer devices-under-test (DUTs) that come down a line. The equipment needs periodic, e.g., daily, calibration to ensure that measurements produced by the equipment are accurate. Calibration of test equipment is done using reference devices, known as golden units. Golden units are expensive and are rated only for a limited number of calibration cycles. Golden units wear away relatively rapidly and need frequent replacement, a significant expense at a large factory.

This disclosure presents techniques that enable periodic calibration of test equipment using the very devices undergoing test. A golden station, which is maintained for reliable and accurate measurement, is introduced and kept separate from testing lines. Production DUTs that have undergone testing along the testing line are randomly picked and reverified at the golden station. Measurement differences between testing line and golden stations are traced to mis-calibrated testing-line equipment. The wear-and-tear, expense, and burden of maintenance and replacement associated with golden units is thereby reduced or eliminated.

KEYWORDS

- reference station
- RF calibration
- RF tolerance
- golden station
- golden unit
- measurement tolerance

BACKGROUND

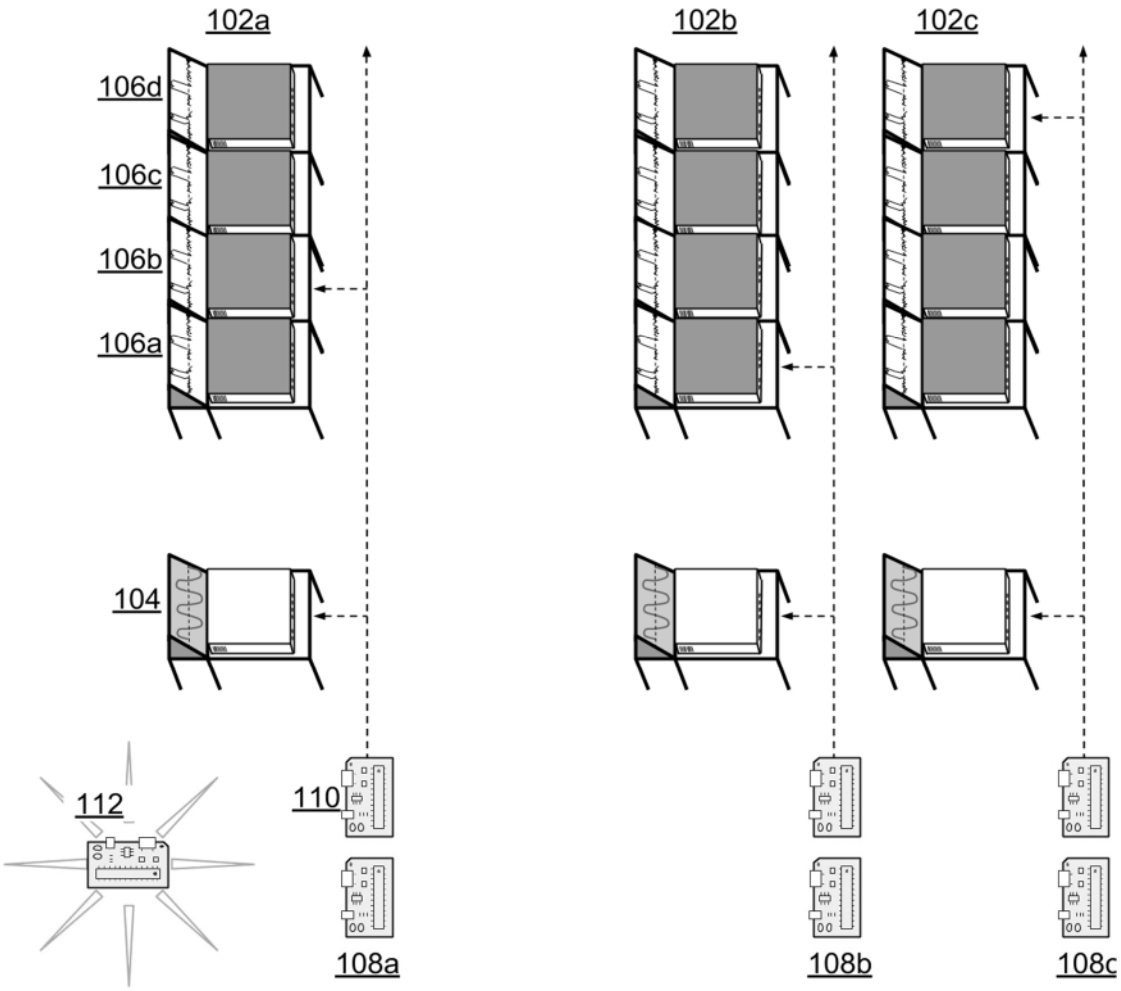

Fig. 1: Factory setup for mass testing of consumer electronic devices

Fig. 1 illustrates a typical factory setup for mass testing of radio-frequency (RF) consumer devices, e.g., smartphones, tablets, etc. Several parallel testing lines (102a-c), e.g., numbering in the hundreds, operate simultaneously. A testing line includes an RF calibration station (104) and several RF test stations (106a-d). Each testing line processes a continuous stream of consumer devices under test (108a-c), or parts thereof, e.g., printed circuit boards (PCB), main logic boards (MLB), etc. A given device under test (110) is calibrated at the RF calibration station (104), and proceeds to one of the RF test stations along the line. At a

calibration station, the device under test (DUT) is calibrated, e.g., parameters such as receiver sensitivity, target RF output power, etc. are set after accounting for component variations. At a testing station, the DUT is made to emit RF power, and the emitted power is measured to check if target RF power is accurately reached.

The RF calibration and RF test stations themselves continuously drift such that these stations need periodic calibration, e.g., once daily. A reference device, also known as golden unit (112), is used to calibrate the RF calibration and RF test stations. The golden unit is similar to a device under test, except it has tight margins on its performance and is known and tested to operate as such.

The golden unit is not inexpensive. The connectors of a golden unit are rated only for a limited number, e.g., fifty, plug-unplug cycles, after which it loses calibration accuracy. On a factory floor with hundreds of RF calibration or test stations, it is not unusual for several golden units to be consumed daily to keep the RF test stations accurately calibrated. As new golden units arrive to replace worn-out ones, a team of technical experts expend effort to maintain the new arrivals, thereby adding to production costs. The calibration of a testing line using the golden unit is not only time consuming, it also interferes with and reduces production along that line.

DESCRIPTION

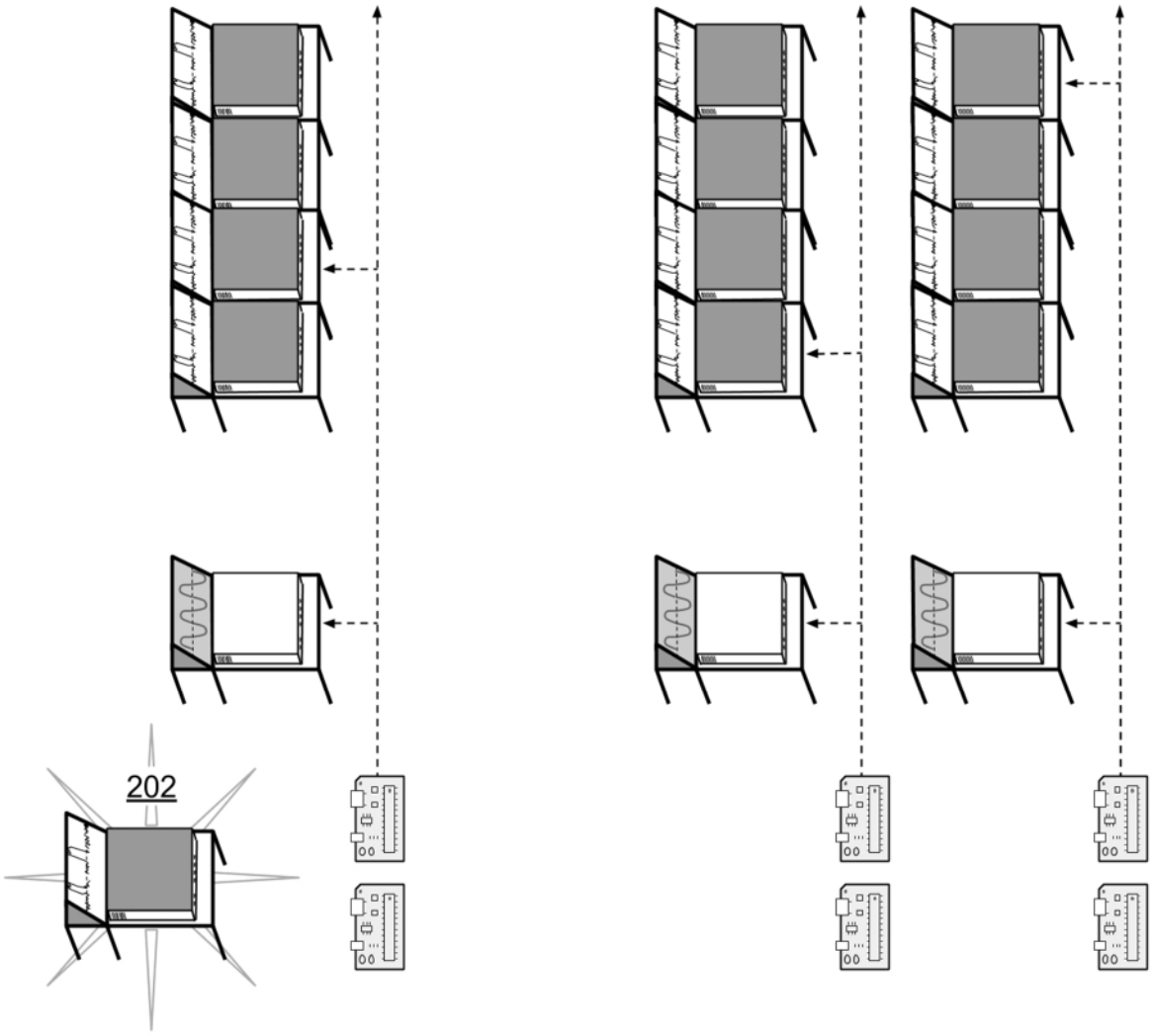

Fig. 2: Fast calibration of test & measurement equipment using golden station

Per techniques of this disclosure (illustrated in Fig. 2) an offline reference test station, also known as golden station (202), is introduced for the purpose of calibrating equipment along testing lines. The golden station is similar to an RF test station of a testing line, except that it is offline (not on any production or testing line), and is maintained such that it has very high, reliable, and reproducible measurement accuracy. A separate golden unit, not shown, may be

used to calibrate the golden station. Other methods of maintaining the golden station may also be used.

The techniques of this disclosure use production DUTs to calibrate equipment along a testing line as follows (illustrated in Fig. 3).

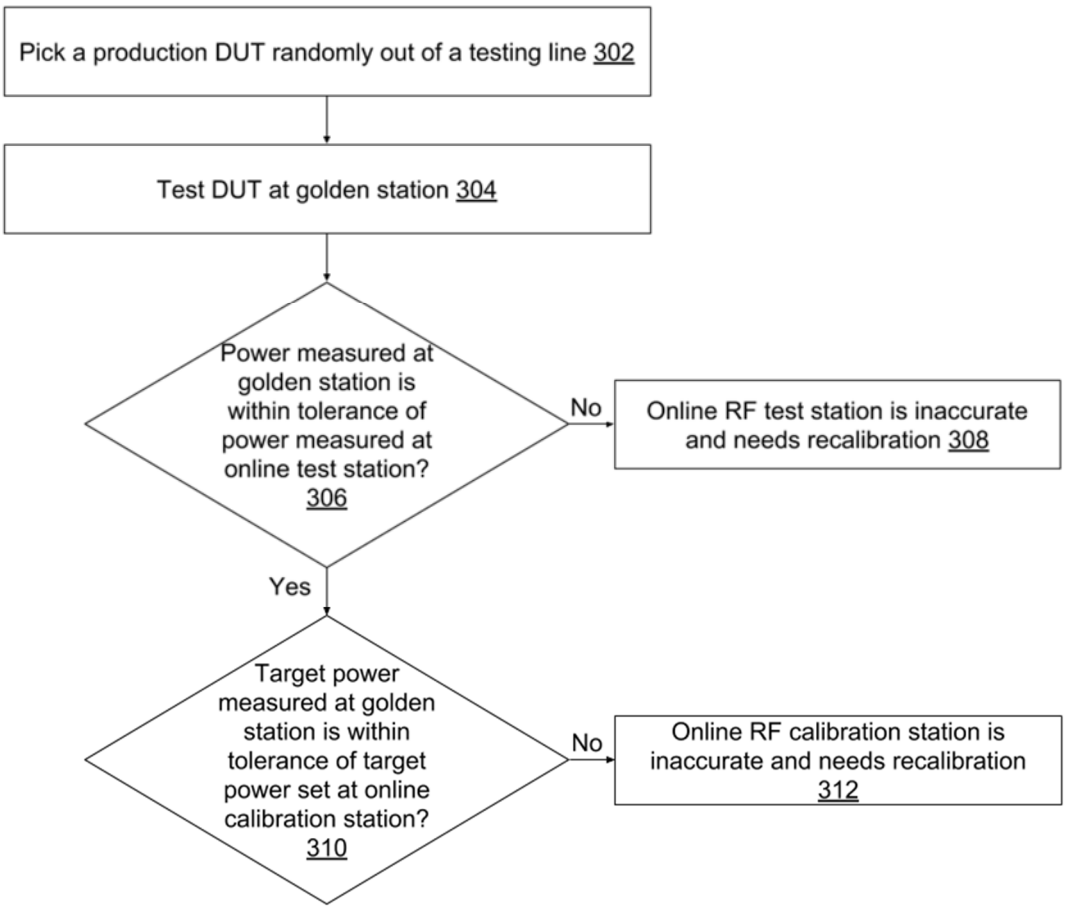

Fig. 3: Fast calibration using golden station and production DUTs

1. At predetermined intervals, e.g., daily, a DUT that has been calibrated and tested by equipment of a testing line is randomly picked off a testing line (302), and once again calibrated and tested at the golden station (304).

2. If the power emitted by the DUT, as measured at the golden station, is outside a margin of tolerance when compared to the measurement taken by the testing-line RF test station (306), then the testing-line RF test station needs recalibration (308).
3. If the target power set at the DUT, as measured at the golden station, is outside a margin of tolerance when compared to the target power set by the testing-line RF calibration station (310), then it is determined that the testing-line RF calibration station needs recalibration (312).

If recalibration of testing-line equipment is necessary, then such calibration is performed until the target power and the emitted power, as measured at golden and testing-line stations, are each within respective tolerance limits. Measurement differences between golden and testing line stations are investigated at the RF bands at which the DUTs are rated to operate.

During a calibration cycle, at least as many DUTs are re-verified at the golden station as there are calibration and test stations in testing lines. Thus, if the calibration cycle is once-per-day, and there are one hundred testing lines each with a single RF calibration station and four RF test stations, then five hundred DUTs (one for each station, or five per testing line) are daily picked off testing lines and re-verified at the golden station. Given that a typical testing line may process hundreds-to-thousands of consumer devices daily, a burden of five DUTs per testing line is acceptable.

Since the techniques described herein reduce or eliminate the use of golden units to calibrate testing line equipment, the question of golden unit wear-and-tear does not arise. No human technical experts expend time or effort maintaining golden units. The expense associated with repeated replacements of golden units is thus eliminated. Per techniques of this disclosure, testing lines are not interfered with for the purpose of calibration unless mis-calibration is

detected by the golden station. A single measurement at a golden station can identify two potential mis-calibrations, e.g., at an RF calibration station and a RF test station along a testing line. The number of plug/unplug cycles is distributed across several, e.g., hundreds, of DUTs randomly picked off the testing lines, thereby reducing wear-and-tear. Use of a golden unit, if any, is made only to maintain the golden station, again making wear-and-tear less of a concern.

CONCLUSION

This disclosure presents techniques that enable periodic calibration of test equipment using the very devices undergoing test. A golden station, which is maintained for reliable and accurate measurement, is introduced and kept separate from testing lines. Production DUTs that have undergone testing along the testing line are randomly picked and reverified at the golden station. Measurement differences between testing line and golden stations are traced to mis-calibrated testing-line equipment. The wear-and-tear, expense, and burden of maintenance and replacement associated with golden units is thereby reduced or eliminated.