DWD Production Test Concept III

Subject: Manufacturing guidelines for producing a DWD designed phone

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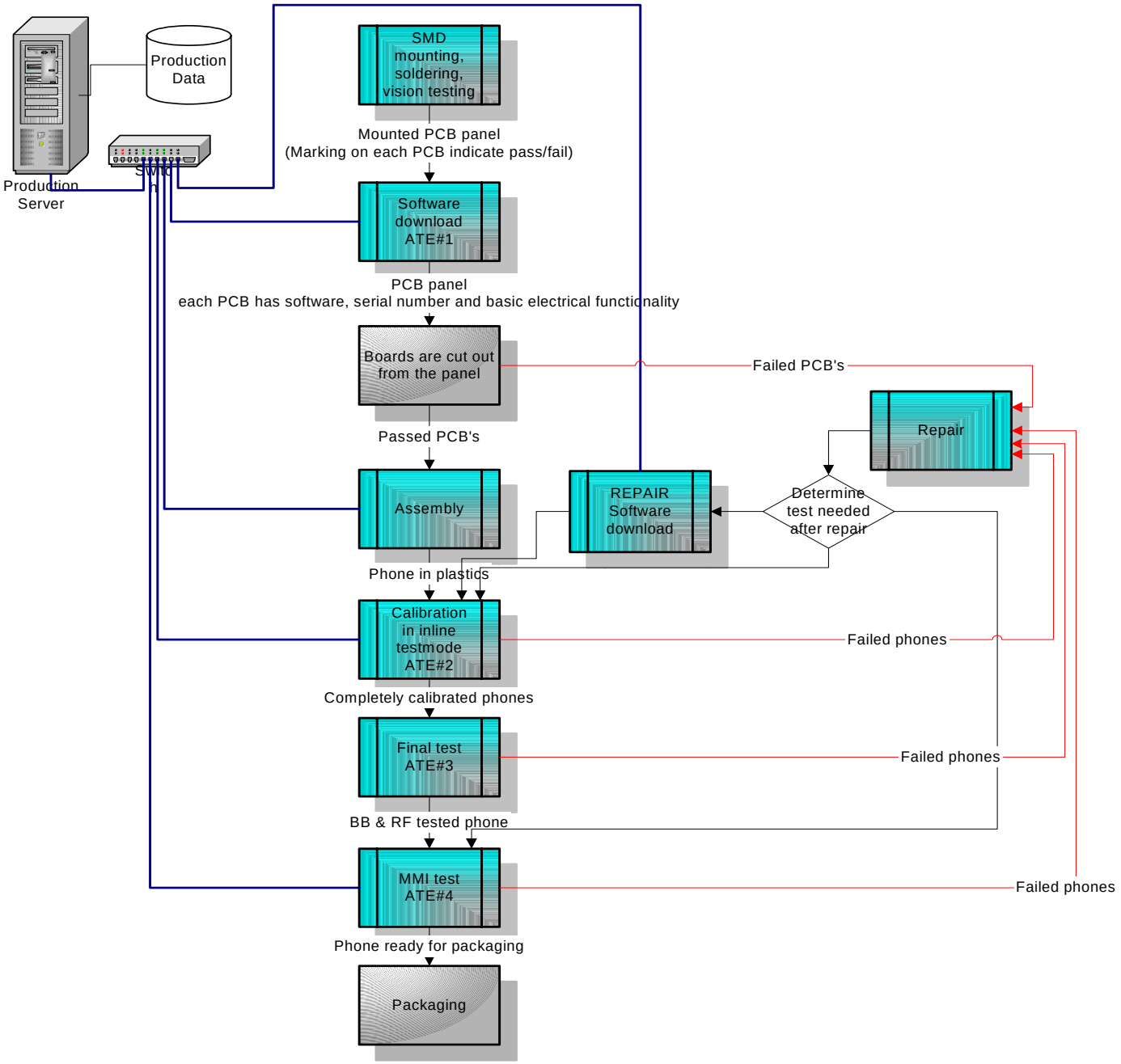
1. Introduction

The manufacturing of a DWD designed mobile phone can be done in several ways. The following is DWD's concept III for how to produce and test/calibrate the mobile phone. It contains a description of the mounting/assembly together with the testing and calibration needed at the various stages from the PCB mounting to the final boxed phone ready for shipment.

1.1. Production layout and brief description of tests

A simplified production setup is depicted in the figure below.



SMD mounting:

A whole panel (e.g. 4 PCB's) is mounted at both sides. This process can be on one single line, which mounts both the front side and the rear side of the PCB, but since there are only a few components on the front side it might be advantageous to mount the front side on a separate low capacity SMD line.
If additional capacity is needed then the high capacity lines mounting the rear side could be duplicated and the low capacity line might still have enough capacity to feed the high capacity lines.
The RF shield could be mounted in this process depending on the mechanical concept.

At the end of the SMD mounting the phone has all components mounted on the PCB. The PCB's are cut out from the panel.

Software Download (ATE#1):

Software download is the first test station after the SMD mounting.
The software is downloaded into the phone together with default calibration parameters.
After software download is completed it is possible to store parameters in the phone such as calibration data and production flow control data.
At the end of the software download a production serial number is assigned and written into the parameter block of the flash.

Calibration in in-line mode (ATE#2):

This test station consists of a shielded box in which the phone is placed. The box contains a fixture, which is capable of supplying the phone with power. The fixture also contains audio transducers used to calibrate the acoustics. (Some customers do not calibrate or test the Audio system).

The purpose of this station is to perform the calibration of all electrical functions. The calibrations are all done in the inline test mode. The found calibration values are written to the parameter block of the flash (the eeprom emulation area).

1st Assembly

The PCB's are assembled into the plastics. All mechanic parts needed to have a fully functional phone are mounted in this step. This would be front and rear part, keyboard etc. Some mechanical parts that can be inserted later, e.g. display lens, markings, flaps etc. are not mounted in this step
The output of the 1st assembly is a complete phone that can be inserted in the Final test, and of cause all parts needed for and influencing this test must be mounted.

Final Test (ATE#3):

This test station consists of a shielded box in which the phone is placed. The box contains a fixture, which is capable of supplying the phone with power, and furthermore it contains a connector for connecting the test equipment with the tester and a test SIM card. The fixture also contains audio transducers used to test the acoustics. (Some customers do not calibrate or test the Audio system).

The phone is checked for compliance with some of the key GSM requirements on the RF performance and the acoustical performance. All tests are performed on the antenna connector, but some customers also remove the antenna connector as a part of the test and check the antenna performance via a test antenna in the shielded box..
The output from this test station is a fully functional & tested phone.

MMI test (ATE#4):

The purpose of this test is to secure that the MMI and the physical appearance of the phone is OK. The test is a visual inspection for scratches etc. A battery is inserted and a command from the PC initiates a test which starts the vibrator and the buzzer (1-2 seconds). Furthermore the display presents a test pattern and the operator is required to press all keys to test their functionality.
When the test is successful the result (together with the test parameters and the IMEI) is written to the eeprom and a confirmation is sent to the PC.

Repair Station

If a unit fails the testing at any point in the chain it is sent to the Repair Station" which allows the technician to set the MS into modes useful for performing measurements and locating faults/defects. This station can be one or more identical stations that are used to repair failed units from all testers, but based on economical decisions it could be dedicated stations used only to repair one type of faults/defects. The repair station should not perform the final testing of the repair, since inserting the MS into the normal production flow again does this.

Q-Test (not shown)

In order to maintain a specified quality level a Quality Tester is used to thoroughly measure on samples taken out from the products manufactured.
The Q-Test is in principle and extended "Test and Calibration" where especially the RF section is tested in temperature.

1.2. Additional Documentation

Can be found in separate documents describing

- Software Download (ATE1)
- In-Line Calibration Test (ATE2)
- Final Test (ATE3)
- MMI Test (ATE4)
- Q-Test
- Repair Station
- Production support in MS (describing the interface to the MS)

2. "EEPROM" programming in the production

All memory locations are ones when the flash is erased. A memory location can be programmed with one or more zeros on a random access basis, but if a one should be written the whole sector must be erased and reprogrammed. This is taken into account when selecting the bit representations of the various numbers written in the eeprom area of the flash.
The inline test starts with the software download, which automatically clears the whole flash including the eeprom area if it is not already empty, so in this case the flash will always be blank.

2.1. IMEI

The International Mobile Equipment Identity (IMEI) is a number, which is unique for every GSM phone in the world. The main objective is to be able to take measures against the use of stolen equipment or against equipment of which the use in the PLMN cannot or no longer be tolerated for technical reasons. Networks may use the IMEI to identify fraud or stolen mobiles. Information is contained in the IMEI by which the PLMN, after requesting it, can immediately decide whether or not to accept calls made by means of this equipment.

The 14 digits of the IMEI is constructed as follows:

TAC (6 digits)	FAC (2 digits)	SNR (6 digits)	SVN (2 digits)

Where

- TAC is the Type Approval Code
- FAC is the Final Assembly Code
- SNR is the Serial NumbeR
- SVN is the Software Version Number

The IMEI (14 digits) is complemented by a check digit defined by the Luhn formula giving 15 digits in total. The Check Digit is not applied to the Software Version Number. The Check Digit shall avoid manual transmission errors, e.g. when customers register stolen MEs at the operator's customer care desk.

2.1.1. IMEI Security

The IMEI shall not be changed after the ME's final production process. It shall resist tampering, i.e. manipulation and change, by any means (e.g. physical, electrical and software). The manufacturer is responsible for ascertaining that each IMEI is unique and keeping detailed records of produced and delivered MS.

The above impose requirements to encryption of the IMEI, which is handled by the MS software.
It also defines requirements to a database maintained by the manufacturer in which details about each produced and delivered MS are kept.

2.1.2. Programming of IMEI

A dedicated command is sent over the serial interface to program the IMEI. The command can only be used once unless the whole flash is erased. The MS software automatically encrypts the IMEI and stores the encrypted data in the flash. The IMEI can be read at any time.

2.2. Parameters written by testers

The testers will make use of parameters stored in the Non Volatile memory to control the process flow. The parameters are also used to enable backward tracing of the test specifications with which the ME is calibrated.

It is a decision of the manufacturer, which parameters actually to use.

The parameters are listed in the following table.

Name	Description	Size bits
serial_no	Unique serial number of this device to link it to the production database	32
testseries_id	Used if a test series is run (default 0xFFFF)	16
upd_conf.id	Identification of the product in case there are more variants. Updated when serviced.	16
upd_conf.hw_version	Hardware version (parts list). Updated when serviced.	16
upd_conf.eep_version	“eeprom” version. Updated when serviced.	16
orig_conf.orig.id	Original identification of the product. Never updated.	16
orig_conf.hw_version	Original hardware version (parts list). Never updated.	16
orig_conf.eep_version	Original “eeprom” version. Never updated.	16
in_line.result	Test result (Fail=0xFFFF, Pass=0x0000)	16
in_line.nof_tests	Total number of tests the mobile has run through this test, bitmap	16
in_line.version	Test station hardware version	16
in_line.sw_version	Test station software version	16
in_line.spec	Test specification version	16
in_line.testsite_id	Identification of the actual test site in case there are multiple testers	16
calib.result	Test result (Fail=0xFFFF, Pass=0x0000)	16
calib.nof_tests	Total number of tests the mobile has run through this test, bitmap	16
calib.version	Test station hardware version	16
calib.sw_version	Test station software version	16
calib.spec	Test specification version, bitmap	16
calib.testsite_id	Identification of the actual test site in case there are multiple testers	16
mmi.result	Test result (Fail=0xFFFF, Pass=0x0000)	16
mmi.nof_tests	Total number of tests the mobile has run through this test, bitmap	16
mmi.version	Test station hardware version	16
mmi.sw_version	Test station software version	16
mmi.spec	Test specification version, bitmap	16
mmi.testsite_id	Identification of the actual test site in case there are multiple testers	16

Name	**Description**	**Size bits**
date.year	Year of production (programmed in the last test)	8
date.month	Month of production (programmed in the last test)	8
date.week	Week of production (programmed in the last test)	8
date.day	Day of production (programmed in the last test)	8
cust_parms.param_1	Parameters used for customer specific purposes – e.g. stock numbers	16
cust_parms.param_2		16
cust_parms.param_3		16
cust_parms.param_4		16
cust_parms.param_5		16
cust_parms.param_6		16
cust_parms.param_7		16
cust_parms.param_8		16
cust_parms.param_9		16

3. Production Network and Database

All test stations and repair sites (and possibly other PC's) are linked via Ethernet together with the Production Server.
The purpose of the server is to

- Store information required to identify the state of each phone in production
- Keep track of the units produced and shipped
- Allocate IMEI numbers when the testers request it
- Monitor status of each test station
- Perform statistical analysis of calibration parameters
- Perform statistical analysis of yield

The server stores a mirror of the parameters written by the testers to keep track of the production flow. It also stores the calibration values for later statistical analysis.

Estimated storage capacity is 2KB per phone produced, giving a total of approx. 2GB of storage per million phones

Equipment needed
Server: approx. 500MHz PC (e.g. Linux), 128MB RAM, 2 SCSI RAID arrays (1 for booting and OS, 1 for data storage), Tape Backup.
Network Switch
Database Application: MySQL is a good choice.