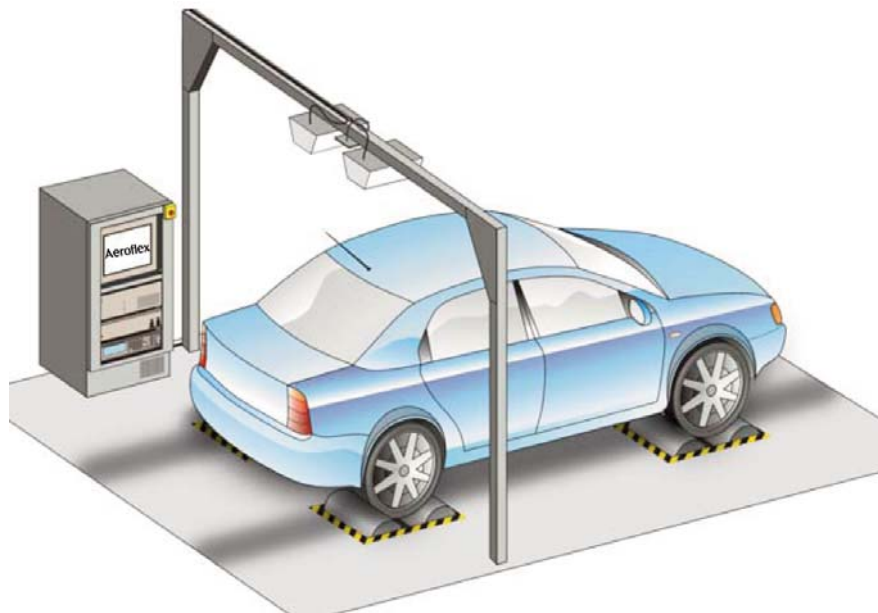


Application Note



Automotive Test - Reducing Radio Related Warranty Costs



Growing expectations from customers and the desire to reduce warranty costs are encouraging vehicle assemblers to review their approach to radio testing.

With its in-depth understanding of radio test and ability to deliver customized systems, Aeroflex is the ideal partner to provide cost-effective solutions for end-of-line testing.

Not many years ago vehicles were equipped with a simple AM/FM entertainment radio and perhaps a tape cassette facility. Some had CD players. These days, users' expectations of more advanced entertainment and communications within the vehicle have resulted in the introduction of cellular radios with hands-free capability, integrated speaker systems, satellite location and traffic warning systems. This trend is likely to continue with new systems such as collision avoidance being progressively introduced.

Radio and audio equipment supplied for automotive assembly is thoroughly tested prior to dispatch and has a low failure rate. However, incorrect assembly of individual components and equipment can result in poor performance. Attempted rectification of these problems in the field normally involves exchanging equipment - and this does not normally cure the problem. Full investigation and resolution of the problem only takes place after repeated complaints from the customer. This adds cost and reduces customer confidence.

Dealers are not well equipped to properly diagnose radio related faults and often take the simple route of exchanging the radio unit in the hope that it will satisfy the customer. However, the radio is rarely the real cause of the problem.

The typical average warranty cost associated with radio equipment problems is around \$2.50 per vehicle. This may not sound like much, but multiplied by the number of vehicles going through a large assembly plant, it adds up to a lot of money.

Through a better approach to radio equipment warranty costs can be reduced by as much as 70%.

Customer Satisfaction

We should remember that somewhere out there is the customer who is looking forward to a comfortable and safe driving experience. The vehicle is primarily a means of transport and in the past this primary function was really all that mattered and the focus in assembly was on achieving a reliable and safe vehicle.

Progress has moved us on from that primary function and the customer will be travelling in an environment which offers him or her access to a wide range of external services - ranging from broadcast radio to satellite based navigation aids.

As all of the radio signals related to these services are outside the vehicle, some means has to be provided to couple the external signals to the relevant internal modules.

For broadcast (entertainment) radio the vehicle will be fitted with a suitable antenna, antenna amplifier, cables, and of course, the radio receiver itself. All of the items fitted during the assembly process are supplied pre-tested, but need to be assembled correctly if quality reception is to be obtained.

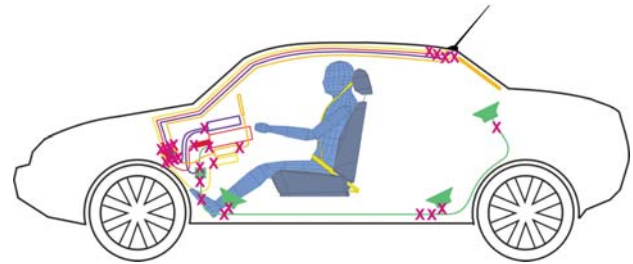
By itself the radio receiver will be of little use to the driver and loudspeakers will be fitted to distribute the sound around the vehicle. Modern cars may have as many as twelve or more loudspeaker units grouped in clusters and fitted to the doors or rear parcel shelf. Different loudspeakers will handle bass, middle and treble sounds and the absence of any one loudspeaker can affect the overall sound quality enjoyed by the driver.

The cellular phone circuit can be a separate installation or it can be integrated with the radio. Sometimes the antenna has multiple elements allowing it to operate in the broadcast AM and FM bands for the vehicle radio as well as the cellular bands for the phone.

The cellular phone will often share the same loudspeakers as the broadcast radio, but will also have its own microphone module to allow hands-free use while driving.

To help with navigation vehicles are increasingly being fitted with GPS (Global Positioning by Satellite) systems which rely on a special antenna element to receive the high frequency signal from the orbiting satellites. Interconnection between GPS and cellular phone systems is also becoming more common as a means of alerting emergency services and providing the vehicle location in the event of an accident.

TV equipment may also be fitted for passenger entertainment or for use by the driver when the vehicle is stationary. Antennas integrated into the rear windscreen are commonly used and are connected to the TV receiver module through another feeder cable.

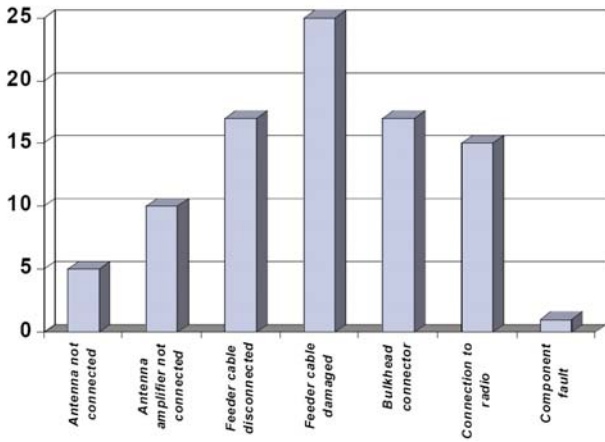


Each "X" in this picture represents a point where a connection takes place and in a typical vehicle more than 30 individual connectors will be present in the various radio, cellular phone, GPS, TV and loudspeaker circuits. Each connector is a potential weakness in the circuit as it relies on an assembly worker to correctly mate the two halves without causing any damage to the cable or connector.

Our experience in looking at test processes in vehicle assembly plants shows that the testing is:

- Subjective - often relying on the human ear or eye for a decision on the test outcome, in turn leading to a...
- Need for skilled operators, but even with trained staff we find that...
- Inconsistent results are obtained and finally with the natural drive to reduce test costs...
- Poor fault coverage results.

An examination of the true faults found in a vehicle shows that process related problems such as connectors not properly mated or cables damaged during installation dominate. Faults due to the radio equipment itself are rarely significant (thanks to the testing carried out by the manufacturers).



Radio related faults often rank in the top three of all warranty costs and their impact on the owner is often more serious than other areas.

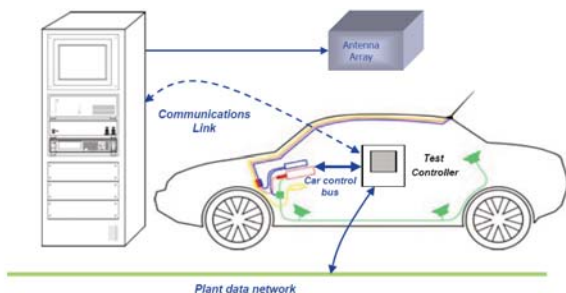
The Test Requirement

The need for test is driven by the desire to improve the quality of the finished product. In looking at radio related equipment our main requirement is to test the assembly process objectively and by improving the overall vehicle quality, create a happy customer and in turn reduce warranty returns yielding a business payback to the assembly plant.

For the best objectivity the test process should be incorporated at a point in the assembly line where the vehicle is stationary for a period of time. Typical positions are those areas where the headlamps and wheels are aligned or where the vehicle is on the rollers in the dynamic vehicle test (DVT) booths. Another alternative is the waiting area prior to the DVT booths where vehicles wait their turn in the test queue.

By carrying out the radio related tests in these areas no additional test time is needed the radio tests are carried out as a background process while other, mechanical tests are being performed.

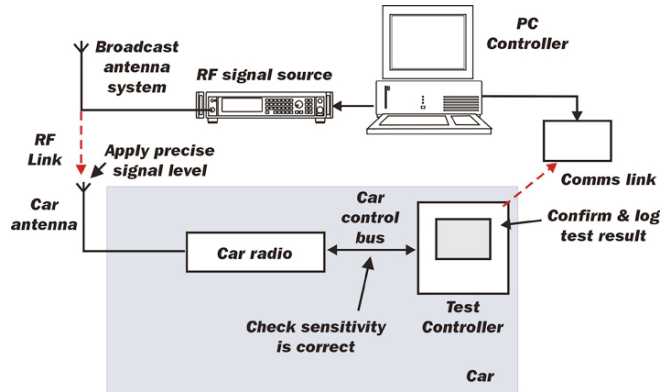
In assessing the test process Aeroflex is conscious that the key needs of the assembly plant are to test to a level which identifies process related defects. We are primarily testing the process not the component which has already been through rigorous checks. Our focus is the RF and audio signal path connectivity as these are the areas where experience suggests that most process related faults are introduced. We will also verify component functionality so that the small percentage of truly faulty radio related equipment is also captured by the testing.



RF signals from the Aeroflex system rack are fed to an antenna array which is mounted above the vehicle to be tested and is within 1 m of the vehicle antenna. This ensures that a carefully controlled signal level can be maintained at the vehicle antenna position.

The test controller within the vehicle initiates the test and controls the in-vehicle equipment, sending commands to the Aeroflex system via an infra-red link or network connection.

Test data is collected by the Test Controller, either from the Aeroflex system or from the in-vehicle equipment, and is passed to the plant data network as part of the normal recording of quality control data.



The Aeroflex Vehicle Radio Test System (VRTS) can either automate or provide repeatable manual tests to ensure that no process related assembly faults have been made.

For entertainment radio testing the signal generator applies signals in the AM and FM bands to the broadcast antenna system. The levels of these signals are calibrated to deliver predetermined test signals to the vehicle radio. The radio then reports the received signal strength over the diagnostic bus to the controller which compares the figure with pre-set limits. The AM tests are more comprehensive in order to check the antenna amplifier. Greater depth of test is also needed on AM to reflect the greater susceptibility of AM reception to antenna-related faults.

For cellular phone testing the operator is prompted to insert a test SIM card into the car phone. The remainder of the testing is then carried out automatically while the operator is involved in other activities.

The Aeroflex test system acts as a base station simulator providing a carefully controlled RF signal level at the vehicle antenna position. The signal level is chosen to be low enough such that if the cellular phone fails to register it can be deduced that there is a problem in the antenna, cabling or the phone module itself.

Having registered with the cellular phone, the phone is put into traffic mode (using its auto answer capability) and the functioning of the hands-free microphone system is checked by means of a series of test tones.

The resulting pass/fail notification is fed back to the Test Controller, confirming the status of the hands-free microphone operation and the results are then returned to the plant test system.

Loudspeaker testing (often referred to as speaker walk-round test) uses the entertainment radio channel as a method of delivering audio test signals to the loudspeaker system. Special test signals are used which allow the Vehicle Radio Test System to establish the correct operation of each loudspeaker cluster in turn - checking for the integrity of the bass, middle and treble elements.

Sound from the loudspeaker system is picked up by a radio microphone and fed back to the VRTS for analysis using signal processing and analysis techniques developed for military applications. It allows tests to be conducted in the high levels of ambient noise experienced in automotive plants and removes the subjective aspect of audio circuit performance.

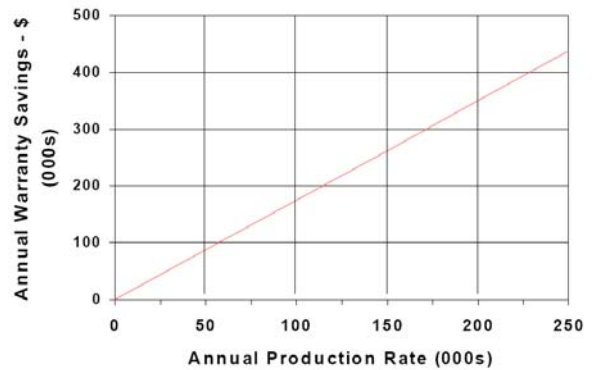
In the speaker walk-round test, the loudspeaker clusters are selected in turn (by the test controller) and the sound signals are analyzed to establish that all speaker elements (bass, middle and treble) are connected and functioning.

The Business Case

Early experiences with the introduction of the Aeroflex test system showed that up to 7% of vehicles passing through the assembly line had radio related problems. By using the test system the process faults can be rectified before the vehicle leaves the plant resulting in:

- Fewer faults being reported by customers
- Fewer radios swapped out by dealers in their attempts to correct the problems
- Lower warranty costs for the vehicle manufacturer based on the use of a proven test system

Quality improvements and better customer satisfaction are good objectives, but we recognize that a financial payback is also important to the automotive industry.



The chart shows the potential savings that can be made in radio related warranty costs depending on the assembly rate.

Based on typical warranty cost savings, a pay back within one year can be achieved for production rates over 45,000 vehicles per year.

Summary

It is recognized that the use of radio related equipment will continue to grow and the vehicle owner's expectation for proper operation will also grow as owners become more dependent on their infotainment and communications equipment.

Vehicle dealers may have relatively sophisticated equipment to help resolve mechanical problems but they have very little to help them properly diagnose faults in radio related items.

By using the Aeroflex test system a reduction of 70% in warranty return costs can be realized. So the message is really quite simple:

- Save costs, and in a market where maintaining or increasing market share is vital you can...
- Save customers.

CHINA Beijing
Tel: [+86] (10) 6539 1166
Fax: [+86] (10) 6539 1778

CHINA Shanghai
Tel: [+86] (21) 5109 5128
Fax: [+86] (21) 6457 7668

FINLAND
Tel: [+358] (9) 2709 5541
Fax: [+358] (9) 804 2441

FRANCE
Tel: [+33] 1 60 79 96 00
Fax: [+33] 1 60 77 69 22

GERMANY
Tel: [+49] 8131 2926-0
Fax: [+49] 8131 2926-130

HONG KONG
Tel: [+852] 2832 7988
Fax: [+852] 2834 5364

INDIA
Tel: [+91] (0) 80 4115 4501
Fax: [+91] (0) 80 4115 4502

JAPAN
Tel: [+81] 3 3500 5591
Fax: [+81] 3 3500 5592

KOREA
Tel: [+82] (2) 3424 2719
Fax: [+82] (2) 3424 8620

SCANDINAVIA
Tel: [+45] 9614 0045
Fax: [+45] 9614 0047

SPAIN
Tel: [+34] (91) 640 11 34
Fax: [+34] (91) 640 06 40

UK Cambridge
Tel: [+44] (0) 1763 262277
Fax: [+44] (0) 1763 285353

UK Stevenage
Tel: [+44] (0) 1438 742200
Fax: [+44] (0) 1438 727601
Freephone: 0800 282388

USA
Tel: [+1] (316) 522 4981
Fax: [+1] (316) 522 1360
Toll Free: 800 835 2352



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www.aeroflex.com
info-test@eroflex.com



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