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QVoice
Application Note

Antennas for QVoice

Version Overview

Vers.	Date	Author	Modification
1.0	15.09.2006	Stephan Affolter	First edition
1.1	4.12.2006	Stephan Affolter	Table and Level diagram added, minor changes

Document:	80000840-QVAN 1.0 en
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Status:	Released
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On	15.09.2006

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1 Overview

Operators of mobile radio networks need to carry out benchmarking and coverage tests, a process that involves operating several test terminals simultaneously, particularly in the case of benchmarking tests. Some of the terminals are equipped with two antenna connectors to provide external antennas. These antennas are usually mounted on the roof of a car.

This causes a number of challenges:

- The installation is complicated
- The vehicle becomes conspicuous
- Given the limited spacing between the antennas, there is a risk of mutual interference between the measuring equipment.

The priority, then, is to come up with a solution that solves these issues. Combining the antennas using couplers (combiners, power splitters) seems the obvious solution.
However the use of couplers is not straightforward either; the pros and cons are listed below, together with recommendations for the antenna arrangement best suited for different types of test measurement.

Measurement types:
Benchmarking in urban areas
Benchmarking indoors
Benchmarking in rural areas
Coverage tests

The last section contains recommendations for the use of couplers.

2 Operating test terminals inside a vehicle

There is no denying the fact that several test terminals have to be operated inside a vehicle in order to carry out quality measurements.

In principle it is possible to use either the mobiles' own antennas or external antennas. An external antenna is an antenna that is connected to the test mobile and mounted on the vehicle's roof. (The antenna integrated in the mobile is then disabled.)

Technicians inside the vehicle are exposed to considerably stronger electromagnetic fields if no external antennas are used.

The effect on people is controversial, even though the radiation is non-ionising.

2.1 Reproducibility of results

Quality measurements in telecommunications networks are useful only, if the results obtained by driving along the same test route several times produce comparable results under the same conditions. (Communication traffic density.)

Installing the antennas in a specific arrangement (roof of the vehicle), helps to achieve this target.

Any other method provides more or less random results.

If for example the mobiles are set up inside a vehicle in such a way that they simulate an ordinary user's position, then the following parameters can have a random effect:

- Cab design (metal / plastic)
- Windscreen properties (metallised / non-metallised)
- Arrangement of the test terminals inside the vehicle
- Radiation pattern of the test terminals antenna(s)
- Number of people inside the vehicle

More importantly, the combined influence of these parameters is undefined and can easily amount to 30 dB and more.

A 30 dB attenuation can result in a decrease in coverage area by a factor of 100 (see nomogram in Chapter 4.3).

Given the circumstances described above, the results of test drives carried out with antennas integrated in the mobiles are not really systematically indicative. It is unlikely that the results can be used for any network tuning.

Considering these influencing parameters we advise against carrying out drive tests with QVoice test equipment without external antennas.

2.2 Attenuation due to cables and connectors

Any coaxial cable connected to QVoice and any connector fitted entails losses. The choice of cable type is therefore crucial.
Unfortunately it is the cables easiest to fit (i.e. thin cables) that present the greatest loss ratios.

Examples of coaxial cable attenuation for a 3 m cable at a frequency of 2.3 GHz:

RG 174 5,3 dB (∅ approx. 2.5 mm)
URM76 2,4 dB (∅ approx. 5 mm) [QVoice antenna feeder]
RG 58 3,0 dB (∅ approx. 5 mm)
RG 213 1,4 dB (∅ approx. 10.5 mm)

Each plug connection entails an additional attenuation of approx. 0,1 to 0,2 dB.

Both cable and connector losses are irretrievable; a certain amount of compensation can be achieved by using gain antennas.

2.3 Additional attenuation (attenuator)

Some users of QVoice test systems also add attenuators into the antenna feeders leading to the fix installed vehicle antennas. Known values are 10 to 15 dB.

This additional attenuation simulates the penetration attenuation of the base station signal into the vehicle. It is assumed that this attenuation is typical.

While the size of the attenuation merely simulates a certain situation, it does allow reproducible results to be recorded. Of course it is not just the received signal but also the transmitted signal of the test terminal used that is attenuated by the same factor. The relevant repercussion on coverage (distance or area) can be found in the nomogram in Chap. 4.3.

The nomogram contains two examples: one for a 10 dB attenuation (= an area factor of approx. 4) and one for a 30 dB attenuation (= an area factor of 100).

In zones with very good coverage and small cell ranges it is certainly possible to conduct drive tests using additional attenuators. These areas usually have very high field strengths for reception. Consequently the transmitter output of the test terminal is also kept low, which is why no noteworthy change in the test results is to be expected.

2.4 Antennas for six test terminals

A fully fitted Ascom QVoice Symphony Chassis is capable of operating up to six test terminals simultaneously.

If no further measures are applied, such an arrangement would require a total of 13 antennas: two for each test terminal (1x GSM + 1x WCDMA) and 1 for GPS.

To reduce the number of antennas on the vehicle roof for the reasons mentioned earlier, it makes sense to use RF couplers. It is important to note that combining test terminals using couplers entails an additional attenuation in both the transmit and receive mode. For instance combining six mobiles onto a common antenna reduces the coverage area to between 25% and 50%.)

The coupler inputs are themselves isolated by approx. 20 dB.

In many – but not all – applications combiners can be used without problem to reduce the number of antennas.

3 Impact of couplers and additional attenuators depending on objectives

Additional attenuation measures (such as couplers and/or attenuators) can have a greater or lesser impact, depending on the **objective** of the measurements.

3.1 Test measurements in urban areas (not inside buildings)

(Benchmarking outdoors, urban)

Urban areas are usually planned for high traffic density, with small cell ranges. The cell boundaries are mainly affected by obstacles (buildings). In these environments hardly any difference is to be expected from the use of a coupler, compared with individual antennas. Likewise for unwanted side effects due to blocking.

3.2 Test measurements inside buildings

(Benchmarking indoors, walk tests)

Due to penetration losses (additional attenuation due to the building structure) significantly lower receive signals are to be expected in general inside buildings than on open streets.

Ascom QVoice Walk test systems of QVM3G generation use the mobiles' own antennas for walk tests, i.e. neither external antennas, nor couplers. As a result, no additional attenuations are introduced; however the risk of mutual interference by the mobiles is comparatively high, due to the short distances (see Blocking).

The new portable QVoice System, which is based on components of the QVoice Symphony generation, is equipped with a 4 way combiner (insertion loss approx. 7 dB) and a common antennas (one for GSM, one for WCDMA, gain 6 dB) for the test mobiles. The resulting attenuation (approx. 1 dB) it entails is taken into account as a compromise for:

- a compact solution
- the lesser likelihood of mutual interference among the mobiles
- no dominance by any particular mobile as a result of its positioning
- the use of the same test mobiles for measurements in the vehicle (ext. antenna connections)

3.3 Test measurements in rural areas (not inside buildings)

(Benchmarking outdoors, rural)

Usually, rural areas are planned with high area coverage in mind for a comparatively low traffic volume and large cell ranges. The cell boundaries are not as much affected by buildings, as by the topography. Coverage can be affected as a result of any additional attenuation due to the use of combiners; there is also the risk of blocking due to mutual interference. This is due mainly to the low receive field strengths and the high output power of the test terminals.

3.4 Test measurements for coverage tests

(Coverage)

If the degree of coverage of an area is to be measured (e.g. to verify the mobile network planning) no additional attenuating components should be used which affect the natural (planned) propagation limits, neither couplers nor additional attenuators. This applies to the coverage on both, drive tests and in buildings tests, irrespective of whether the measurements are carried out using test calls (i.e. intrusively) or passively (using scanners, i.e. non-intrusively).

If systems with antennas using combiners are used, the impact of such devices must be taken into account in the interpretation of results (see nomogram in Chap. 4.3).

4 Technical background

This section contains information on the technical background for various effects such as change in range and blocking.

The technical requirements for the mobile terminals are set out in the specifications of 3GPP TS 25.101 (for GSM ETSI TS 125 101) and serve as design constraints for terminal developers.

When specifying the technical data, the directly adjacent use of mobile phones wasn't taken into consideration

A minimum distance of 5 m (outdoors) and 1 m (indoors) was assumed when specifying the requirements for the mobiles.

4.1 Device effects

If mobile phones are operated closer to one another than intended by the specifications, the following questions arise:

- How does the phone's own transmitter respond under the influence of a strong (interfering) signal from outside?

The section:

ETSI TS 125 101 V3.13.0 **6.7 Transmitter intermodulation**

describes the specifications of transmitter intermodulation.

The impact of this effect is largely irrelevant to Ascom QVoice test equipment. No intrinsic interference of the measurement system is to be expected. It is the spectrum of the transmission signal that is affected, which at most can affect other services.

- How does a receiver respond in the presence of a considerably stronger unwanted signal at the same time as a weak wanted signal?

In the tables

ETSI TS 125 101 V3.13.0 **7.6 Blocking characteristics**

And

3GPP TS 25.101 V 4.9.0 Rel. 4

are the figures and conditions for blocking characteristics. The impact of this effect is explained below.

4.2 Blocking

Blocking is defined as follows in the ETSI standards (ETS 300 607-1):

Blocking is a measure of the ability of the receiver to receive a wanted input signal in the presence of an unwanted input signal, without exceeding a given degradation.

The degradation is measured in reduction of sensitivity. (Up to complete loss of reception)

In the case GSM / GSM (wanted- / unwanted signal), blocking effects can only occur if time slots more or less overlap. This cannot be avoided while performing benchmarking tests.

In technical literature, one can find blocking as a subset of "near-far effects".

What determines blocking behaviour?

The implementation of the electrical characteristics defined in the standards provides the guidelines for device design. The blocking behaviour is mainly determined by the filters of the receiver's front end.

As a rule devices are designed in such a way that these characteristics are just about reached. If they were exceeded, the product costs would be higher.

Table 1 Minimum requirements GSM

(Extract of the Standard ETS 300 607-1)

Frequency	Blocking level in dBm	
	GSM 900	GSM 1800
835 MHz to < 915 MHz	0	
> 1000 MHz to 12,75 GHz	-23 ①	
100 KHz to 1705 MHz		0
> 1920 MHz to 1980 MHz		-10

Table 2 Minimum requirements WCDMA

(Extract of the Standard 3GPP TS 25.101 V 3.13.0)

3GPP TS 25.101 V 4.9.0 Rel. 4 Tab. 7.7 Out of Band blocking (extract)

Parameter	Unit	Frequency range 3
DPCH_Ec	dBm/3.84 MHz	-114
$\hat{I}_{or}$	dBm/3.84 MHz	-103.7
$I_{blocking}$ (CW)	dBm	-15
F_{uw}	MHz	1<f <2025 2255<f <12750
UE transmitted mean power	dBm	20 / 18 (for Power class 3 /2)

Table 3 Combinations

Receiver Wanted Signal	Transmitter Unwanted Signal	Rec. blocking at dBm	Transmit. Pwr. dBm	Min att. no blocking dB
GSM 900	GSM 900	0	33	33
GSM 900	GSM 1800	-23	30	53
GSM 900	UMTS	-23	18	41
GSM 1800	GSM 900	0	33	33
GSM 1800	GSM 1800	-10	30	40
GSM 1800	UMTS	-10	18	28
UMTS	GSM 900	-15	33	48
UMTS	GSM 1800	-15	30	45
UMTS	UMTS	-15	18	33

Discussion of the content

This table shows the attenuation (Min att.) that is necessary from a transmitter to a receiver in order to prevent blocking at the input of the receiver. The values highlighted with colour are the critical ones.

As blocking in GSM only happens when timeslots overlap, it is obvious that WCDMA is more vulnerable than GSM in respect of blocking.

Therefore it is not recommended to combine GSM and WCDMA onto one antenna.

If additional attenuators are inserted in the respective feeder in order to increase the isolation, the respective reduction in coverage hast to be taken into consideration, interpreting results.

The figures from the table are illustrated in the following examples

900 MHz receiver, 1800 MHz GSM transmitter

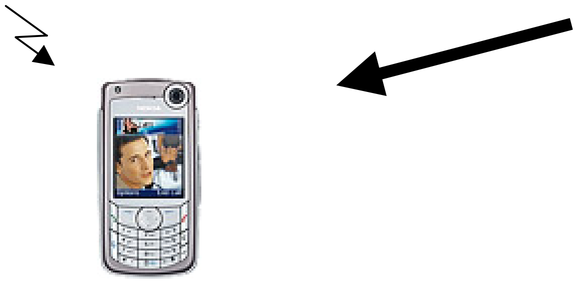
An unwanted signal, with a frequency in the 1 to 12 GHz range (GSM 1800) and imposed with a level of –23 dBm (see table 1①) or higher, is blocking a mobile phone receiving in the 900 MHz band.

GSM 1800 phones have a maximum output of +30 dBm, i.e. the attenuation between the phones must be 53 dB or higher (refers to a weak wanted signal).

Example for a GSM900 as receiver, GSM1800 as transmitter

Wanted signal weak 900 MHZ

Unwanted signal strong 1800 MHz



GSM900
Receiver blocking: (①)
–23dBm @ 1 ... 12 GHz

GSM 1800
Transmitter output
+30 dBM

No risk of blocking, if the isolation between the test mobiles is greater than 53 dB.

900 MHz GSM receiver, WCDMA transmitter

An unwanted signal with a frequency in the 1.9 to 12 GHz band (WCDMA) and imposed with a level of –23 dBm (see table 1①) or higher creates blocking at a test mobile phone receiving a weak signal in the 900 MHz band.

WCDMA phones have a maximum output of +18 dBm, i.e. the isolation between the mobiles must be 41 dB or higher.

Important

The cases considered here are worst-case scenarios, i.e. the blocking effects occur only, if the wanted signal is low on the receiving test mobile, and the output power is high on the transmitting test mobile. (Unwanted signal).

4.2.1 Influence of couplers and attenuators on blocking

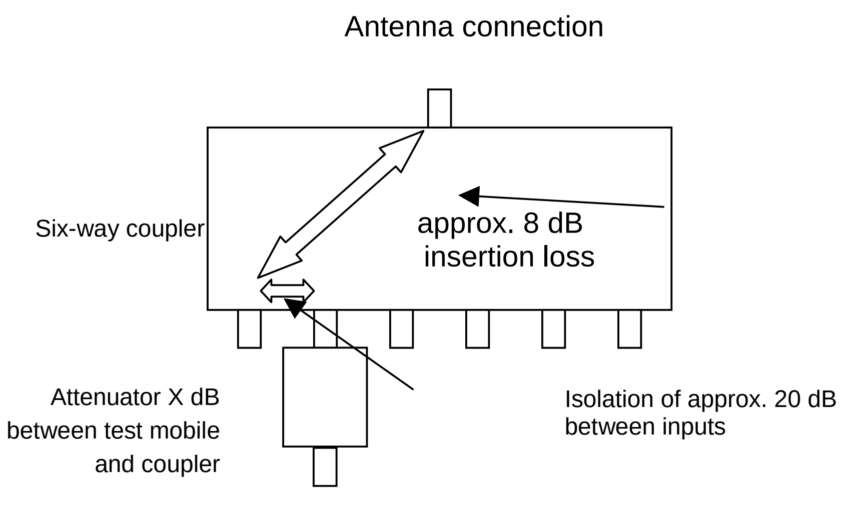
The inputs of combiners are isolated one from the other by a value specified by the manufacturer (see Annex data sheet). In the case of a 6-way coupler the isolation is approx. 20 dB.

If a combiner is used in the example of a 900 MHz receiver and a 1800 MHz transmitter, which requires an attenuation of 53 dB to prevent blocking, the risk of blocking is obvious. If the transmitter output is considerably less than +30 dBm and/or the wanted signal is greater, the risk of blocking diminishes or disappears altogether.

The same mechanism comes into effect when using attenuators. In fact, any attenuators used have a dual effect, since they are built into the antenna feeders (transmit and receive).

In practice, the risk of blocking becomes negligible with the combined use of combiner and attenuator.

The degree of area coverage is, of course, reduced as a consequence of the additional attenuation.

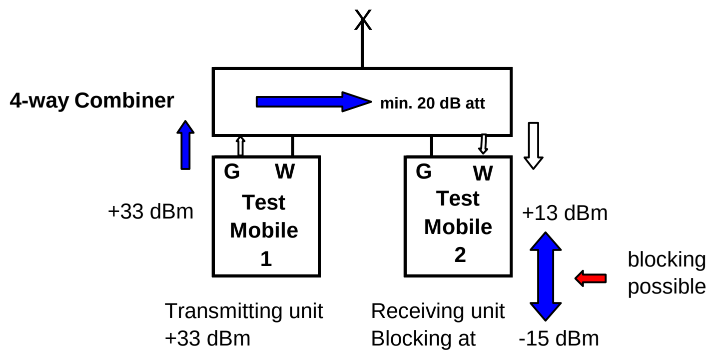


If couplers and attenuators are used simultaneously, the risk of mutual interference diminishes towards zero; it is important to note the resultant reduction in area coverage.

4.2.2 Level Diagrams

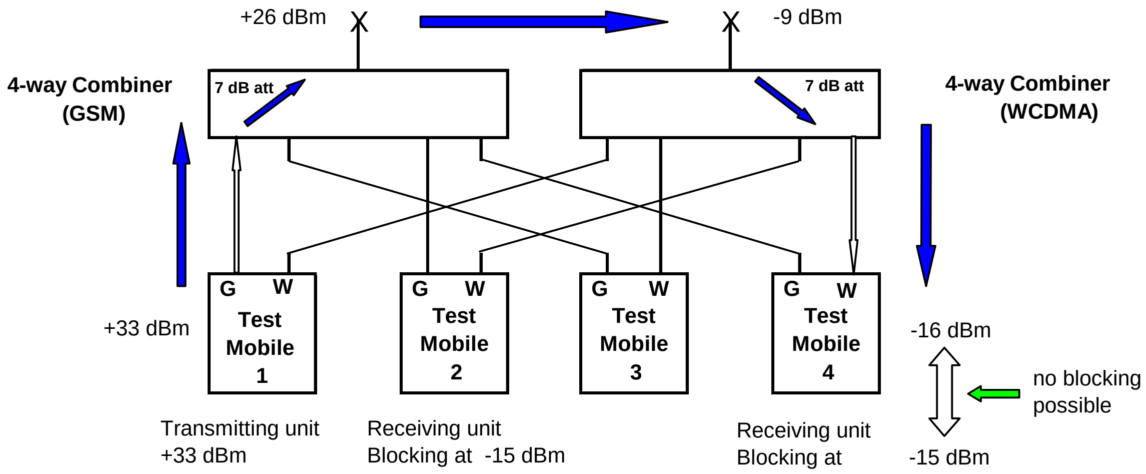
In the following level diagrams the risk of blocking is explained in two examples:

The test mobiles operating in different technologies (GSM WCDMA) are combined onto one antenna via combiner.



There is risk for blocking.

The test mobiles operating in different technologies (GSM WCDMA) are connected to different antennas, they are separated approx 50 cm.



There is no risk for blocking in this arrangement.

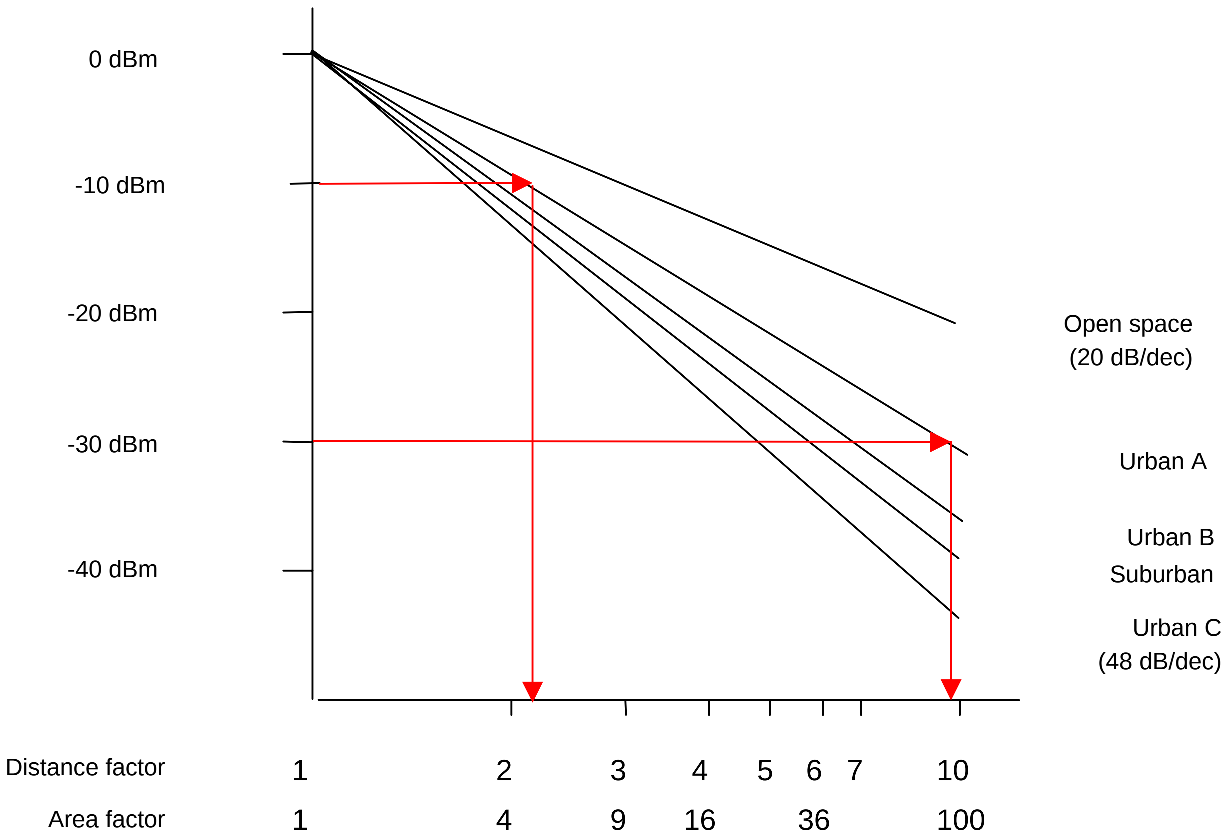
See also 4.5 for basic structure and 6 for recommendations

4.3 Radio propagation

Radio fields propagate according to largely predictable and reproducible criteria. Typical examples are illustrated in the figure below.

They represent attenuation characteristics in various typical environments. If additional attenuation is inserted into a link, the corresponding change in range (reduction) can be read off directly.

Typical relative attenuation characteristics in various environments



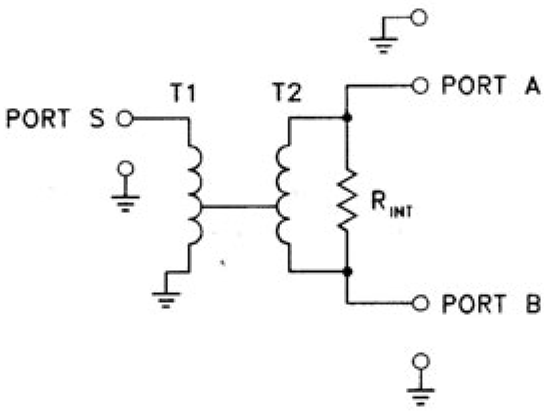
4.4 Combiners (couplers, power splitters)

A combiner is a module that allows several transmitter-receivers to be connected to one antenna. Unfortunately this type of connection doesn't just have the advantages mentioned above, but also has a number of detrimental technical disadvantages.

- The connection is lossy, with part of the signal irretrievably lost in both the transmit and receive path, with a resultant reduction in coverage area.
- The mutual decoupling of the combined devices is not ideal, as the devices may still directly influence one another. This influencing can cause blocking.

4.4.1 What does a coupler consist of?

Example: two inputs, one output



A coupler consists essentially of transformers and resistors; it is lossy network.

4.4.2 Technical data of couplers

Characteristic properties of couplers include **insertion loss** and **isolation** of the inputs.

Typical values for a six-way coupler are

8 dB for insertion loss and

20 dB isolation of the inputs.

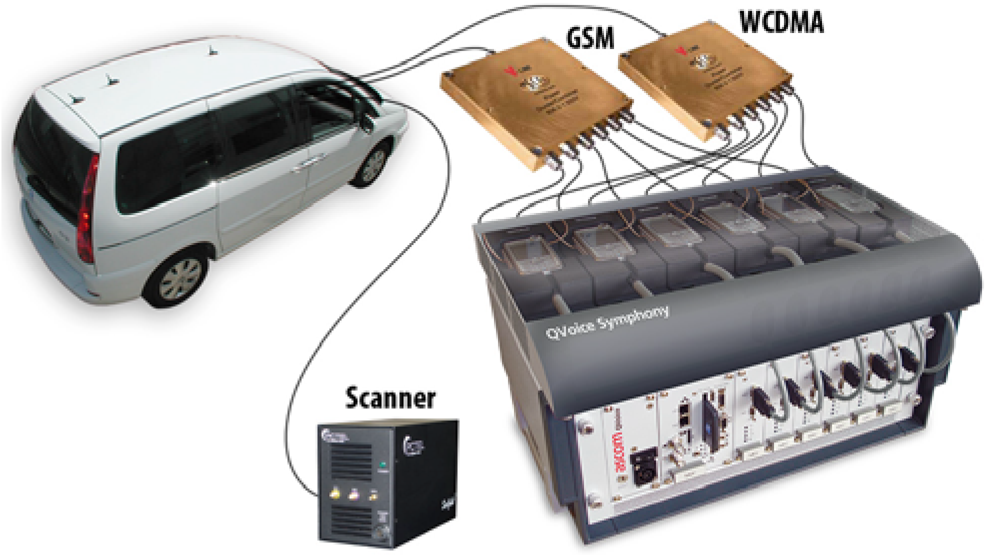
4.4.3 Suitable products

See Chapter 7. Annex

4.5 Basic structure of the QVoice Symphony with combiner

If the use of antenna combiners is indicated for drive tests, we recommend one combiner per technology /WCDMA / GSM) and a separate antennas for GPS and scanner, if used.

The additional antennas for GPS and scanner should be spaced to the practical maximum from the transmitting antennas of the test terminals.



5 Additional equipment

5.1 Scanner

Scanners are often used in addition to the test terminals to scan the electromagnetic field and to display the results according to selectable criteria. Since these devices are also subject to the same physical laws, unwanted effects can occur with scanners whenever there are significant differences in signal levels – even to the point of disabling the scanners.

The data gathered by scanner in a QVoice System can be disrupted if the conditions are unfavourable (weak receive signal, high transmitter outputs of the test mobiles).

Any couplers and/or attenuators used can greatly reduce such susceptibility.

Particular attention should be paid to the correlation of data with additional attenuations in the antenna feeder of the test terminals, but not in the scanner feeders.

5.2 GPS

Generally, the actual measurements are complemented with additional information pertaining to the current measurement location. This equipment is also subject to the same physical conditions as the test terminals or scanners. In other words, if the conditions are unfavourable, this equipment will also be disrupted.

However, since the equipment integrates, the effect usually goes unnoticed.

One particular handicap with GPS receivers is that the receiving signal is very weak and that normally active antennas with a high gain are used.

6 Recommendations

This section looks at the area of application for combiners and attenuators. Recommended products for combiners are listed in the Annex.

6.1 Principle

Whenever possible, drive tests with QVoice test systems should be carried out with antennas permanently installed on the vehicle roof, to ensure that the measurement results to be recorded are reproducible.

6.2 No combiners, no attenuators

Neither combiners nor attenuators should be used for coverage tests. If you are in any doubt, measurements should be conducted with one channel only at any one time.

When installing the antennas, ensure that the spacing between the antennas is as large as possible. Mutual interference among the test system has to be expected with GSM and WCDMA if the spacing is less than 1.5 to 2 m. This mutual interference causes channel changes (with GSM) and in the worst case dropped calls.

6.3 Combiners

The use of one or more combiners can be considered in order to avoid extensive and conspicuous vehicle installations. When interpreting measurement results, it is important to bear in mind that combiners are lossy and that the coverage of the system is reduced by the additional attenuation as a result. Due to the relatively low isolation of the inputs (20dB), there is a risk of intrinsic interference to the test system, due to blocking when using combiners, especially in areas with poor coverage. This type of interference is characterised by frequent channel (cell) changes or dropped calls.

6.4 Attenuators

Using attenuators to simulate penetration losses into the vehicle gives reproducible results; however it represents only one specific case of measurement practice. In areas of high channel availability and small cell radii, the influence on area coverage should be negligible.

6.5 Combiners and attenuators

The combined use of combiners and attenuators provides additional, desirable decoupling between the test terminals; however, the send and receive signals are attenuated. In many cases, the coverage is likely to be reduced. A test drive with and without combiners and attenuators will give an indication of the change in coverage.

7 Annex

Minicircuits

ZB6PD-2 (800-2000 MHz) (suitable for GSM only) (6-way)

http://www.minicircuits.com/

MECA Electronics. Inc.

806-2-1.400 Power Divider/Combiner (800-2000 MHz) (6-way)

(Suitable for GSM only)

806-S-1.900-M01 Power Divider/Combiner (800-3000 MHz) (6-way)

(Suitable for GSM and WCDMA)

www.e-meca.com

MTS Systemtechnik

LT8-544P-A2 (4-times)

(Suitable for GSM and WCDMA)

http://www.mts-systemtechnik.de/Coupler data sheets

Link to a downloadable dB calculator

http://www.dl5swb.de/html/mini_db-rechner.htm