

Automatic measurement and detection of GSM interferences

Poor speech quality and dropped calls in GSM networks may be caused by interferences as a result of high traffic load. The radio network analyzers from Rohde & Schwarz make the detection of such sources of error quick and efficient. A new algorithm automatically analyzes measurement results and, in addition, unambiguously identifies interferers.

Detection of GSM interferences – more important than ever

GSM networks are still the workhorses of network operators, as the expansion of WCDMA networks is lagging behind. However, the higher the traffic load in such GSM networks – primarily as a result of voice telephony – and the higher the number of carrier frequencies added per sector, the greater the risk of problems caused by interferences. This translates into poor speech quality and dropped calls.

GSM interference measurement systems from Rohde & Schwarz support users in detecting such sources of interference: One outstanding example is the R&S®TSMU radio network analyzer, which was launched in 2003. Together with the R&S®ROMES coverage measurement software, the analyzer helps to quickly and efficiently measure GSM interferences and to identify potential interferers in the individual network [1]. While the basic test setup and T&M method remain the same, the following innovations/enhancements have been introduced over the past two years:

The R&S®TSMx radio network analyzers are extremely powerful. The [R&S®TSMQ radio network analyzer](#), for example, (see FIG below) not only supports networks of all standards (WCDMA, GSM, CDMA2000®) but can also simultaneously perform measurements in all standards.



- The R&S®TSMQ radio network analyzer [2] (see box on left) is one of these new products. Compared to the R&S®TSMU, it provides a higher measurement speed in GSM networks (100 channels/s instead of 80) and thus maximizes the chance of detecting interferers.
- The new R&S®ROMES4COI GSM interference software option unambiguously identifies interferers based on power measurements performed in timeslots, thus eliminating the time-consuming testing of potential interference frequencies displayed on the list of interfering signals.
- Owing to an improved GUI, operation has become even easier.

New software option analyzes measurement results fully automatically

Previously, the GSM network scanner within the R&S®TSMU / R&S®TSMQ platform could only measure BCCH or C0 channels. It was not able to detect traffic channels (Cx) or individual timeslots. Although the R&S®ROMES coverage measurement software did provide a selection of potential interferers together with current receive levels, the displayed measurement results still had to be evaluated by the user.

Now, the new algorithm can fully automatically analyze measurement results and unambiguously identify interferers. For details on the new measurement method, see box on pages 13 and 14. A completely new method developed by Rohde & Schwarz, which has been implemented in the R&S®ROMES coverage measurement software and in the firmware of the GSM network scanners, now enables users to individually measure the power in specific timeslots while using the same hardware configuration. If the measured signal component (i.e. the cell causing the interference) is strong enough, the source of error can be detected. This is done by identifying the training sequence code (TSC), which, using the base station list, can unambiguously be assigned to a base station color code (BCC) and thus to a cell.

Seq.	Time	Details	Serving cell	Chan.	C/I[dB]	Mobile
1	11:32:26,113	Mobile measured C/I ...	München	0	4.1	Z560[1]
2	11:32:28,941	Mobile measured C/I ...	München	0	4.1	Z560[1]
3	11:32:34,581	Mobile measured C/I ...	München	0	4.1	Z560[1]
4	11:32:35,987	Mobile measured C/I ...	München	46	9.4	Z560[1]
5	11:32:37,409	Mobile measured C/I ...	München	0	4.1	Z560[1]
6	11:36:18,598	Mobile measured C/I ...	München	0	4.1	Z560[1]
7	11:36:23,396	Mobile measured C/I ...	München	0	4.1	Z560[1]
8	11:36:26,223	Mobile measured C/I ...	München	0	4.1	Z560[1]
9	11:36:12,774	RxLev/RxQual thresh...	München	24	-	Z560[1]
10	11:40:55,681	Mobile measured C/I ...	München	0	9.2	Z560[1]
11	11:44:33,274	Mobile measured C/I ...	M-Riem-M...	90	9.5	Z560[1]
12	11:44:47,399	RxLev/RxQual thresh...	München	H	-	Z560[1]
13	11:44:46,659	Mobile measured C/I ...	München	0	7.6	Z560[1]
14	11:45:03,603	Mobile measured C/I ...	München	123	8.9	Z560[1]
15	11:46:46,290	RxLev/RxQual thresh...	München	98	-	Z560[1]
16	11:47:40,446	RxLev/RxQual thresh...	M-Steinhausen...	H	-	Z560[1]
17	11:49:27,946	Mobile measured C/I ...	München	46	9.6	Z560[1]
18	11:49:28,946	Mobile measured C/I ...	München	17	9.8	Z560[1]
19	11:49:38,947	Mobile measured C/I ...	München	0	5.0	Z560[1]
20	11:49:30,962	Mobile measured C/I ...	München	17	7.6	Z560[1]
21	11:49:29,962	Mobile measured C/I ...	München	46	9.9	Z560[1]

FIG 3 If the defined limits for RxLev/RxQual are reached, an error message will be output in the event list.

Finding interferers

As in the past, the test mobile phone is operated in the endless call mode while the measurement is performed. If a defined minimum/maximum value of C/I or RxLev/RxQual is exceeded, an error message will be output in the event list. For example, in FIG 3, the values for RxLev/RxQual in the Time 11:46:46,290 column violate the limits set for channel 98.

The upper section of FIG 5 shows the results of the measurements that are performed in the timeslots: the impaired channel 98 (Cx) is highlighted in blue at the beginning of the timeslots and the associated C0 on channel 48 in yellow at the beginning of the timeslots. These highlighted areas represent the training sequences of the measured timeslots. The degree of saturation highlighted in orange corresponds to the relative receive power in the corresponding timeslot in this channel (to provide a better overview, the power display was normalized).

FIG 5 The new power measurement and analysis on a timeslot basis.

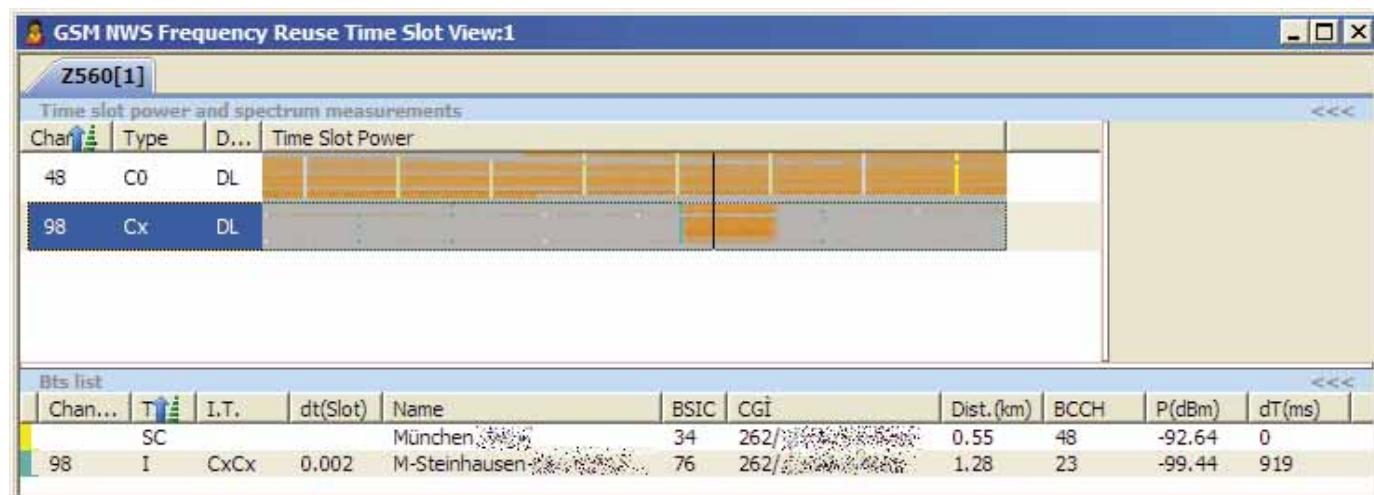
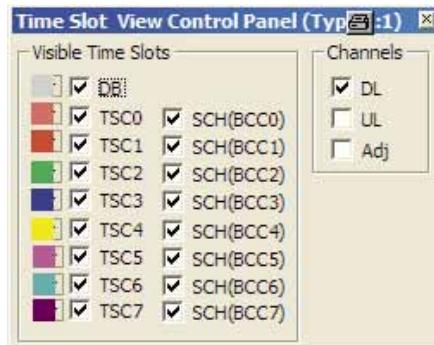


FIG 4 This window defines the display of identified training sequences in the timeslot view.



The timeslot view control panel (FIG 4) defines how identified training sequences are displayed in the timeslot view. The timeslot view thus displays the training sequences of different base stations in different colors. Since each cell broadcasts the same color code (BCC) on all carriers, a second color in the timeslot view indicates that a second base station was received. The example in FIG 5 shows timeslots that are highlighted in yellow (BCC 4) and in light blue (BCC 6): This reveals that they originate from different base stations.

If the black vertical line is positioned on the impairing timeslot using the cursor, the loaded BTS list of the operator allows the received cell to be identified unambiguously and displayed in the lower part of the window shown in FIG 5 (M-Steinhausen..., BCC 6 (light blue), power, distance, etc.). In addition, two different timeslot offsets between the channels are present, as displayed in the "dt(Slot)" column. This indicates two different interferers (with identical BCC but different timing offset) as all carriers of a cell are synchronized.

The new measurement method in detail

The ever increasing demand for transmission channels in GSM mobile radio networks and limited frequency resources call for the multiple re-use of frequencies. As a consequence, transmission channels are often impaired by a high number of co-channel and adjacent-channel interferences. As the structure of wanted and unwanted signals is basically the same, it is quite difficult to determine and discriminate between wanted and unwanted signal components. While mobile phones cannot be used for such tasks, the R&S®TSMx radio network analyzers from Rohde & Schwarz are ideal for such interference measurements.

Which signal structures are best suited for performing interference analysis?

Every base transceiver station (BTS) uses specific auxiliary signals to support the synchronization of the mobile phones with the network. Each cell broadcasts these auxiliary signals via a radio channel, which is usually referred to as the BCCH of the cell (or even more precisely, as the BCCH carrier or C0). The auxiliary signals are referred to as a frequency correction burst (FB) and synchronization burst (SB). All other frequencies used in the cell serve as traffic channels (TCHs or Cx) to transmit voice or data.

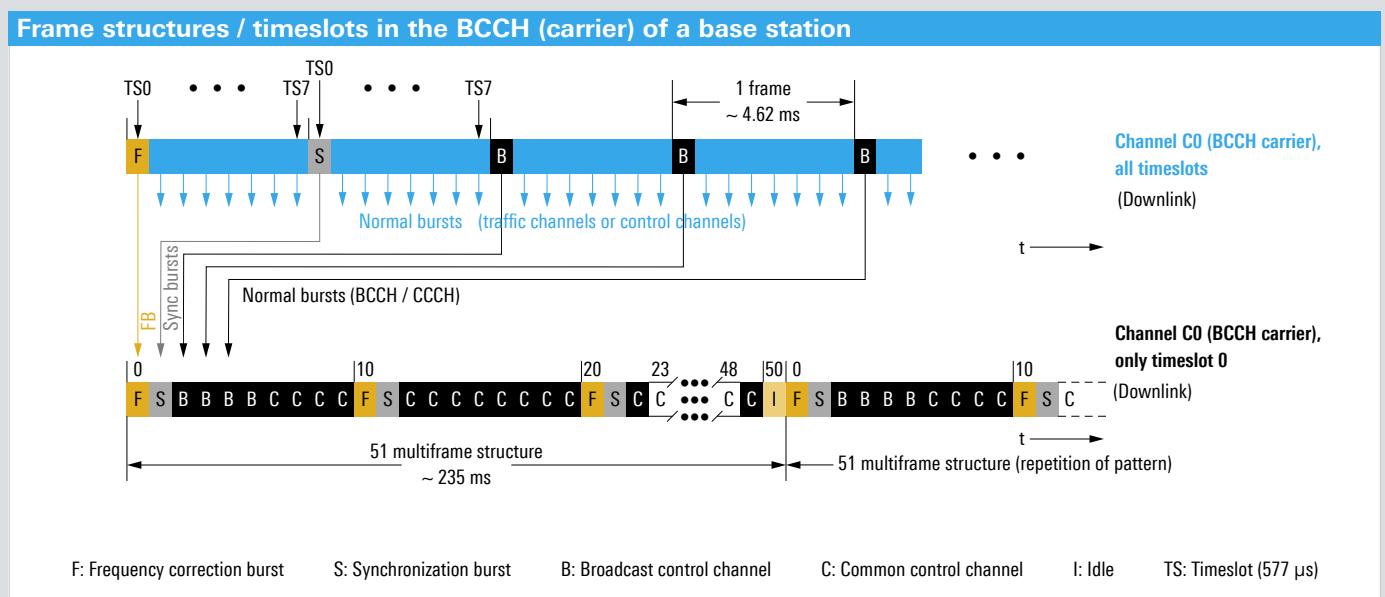
The FB is a frequency-shifted sinusoidal signal sent periodically on the BCCH carrier. This signal is a reference signal that supports the synchronization of the mobile phone in the

frequency domain. The SB contains information that is used for synchronization in the time domain. Such information includes a characteristic bit sequence, also referred to as the extended training sequence (ETS), frame numbers, and the base station identity code (BSIC). This code offers one of the first means of differentiating between different signal sources.

The ETS is stored in each GSM mobile phone and is a unique parameter in the GSM world. Its length and uniqueness optimally support the synchronization process of a mobile phone. An impaired ETS on the transmission path enables GSM equipment to draw conclusions about potential losses in useful data. Actually, recognizing such an impaired ETS makes it possible to correctly decode the BSIC and the frame number (equalizer principle). Each cell broadcasts the FB and SB in a regular predefined time pattern (51 multiframe structure, FIG 1). This pattern is the key to determining or distinguishing between different signal components within a channel.

How do signal components from different sources differ in the receive channel?

Depending on how far various transmitting stations are located from the measurement system, signals using an identical pattern that are broadcast from different cells are received by the measurement system with different timing offsets and receive levels. In case of a fixed measurement location, the starting time of this characteristic 51 multiframe



structure always has the same timing offset provided that it originates from the same source. A different timing offset thus indicates that the received signal was broadcast from a different source (FIG 2).

If the measurement position and thus signal delays and levels change, the software compensates for such changes by processing position information, e.g. originating from a GPS receiver. Analysis is relatively easy if the sources are BCCH carriers.

What is different with interferences caused by traffic channels?

If the wanted / unwanted signals are traffic channels, characteristic recognition structures such as FB and SB are not present. The only way to identify and distinguish between signal components in traffic channels is to evaluate the normal training sequences (TSC) contained in every timeslot (burst).

However, an analysis based on normal training sequences requires more effort than that based on FB and SB. To perform a correct measurement, all TSCs must be analyzed and considered on a timeslot basis.

Due to the high measurement speed of the R&S®TSMx family of radio network analyzers and the new R&S®ROMES4COI software option, this is not a problem. These systems now enable users to measure and identify different signal components in the impaired channel also on a timeslot basis. The same principle also applies to traffic channels in the uplink, thus allowing uplink timeslots to be analyzed, too. By using the R&S®ROMES coverage measurement software and a base station list, users can quickly and efficiently identify which unwanted GSM signal components occur in a receive channel, how strong they are, and which station is broadcasting the signal.

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Different periodic timing offset at measurement location for BCCH (carrier) from different stations

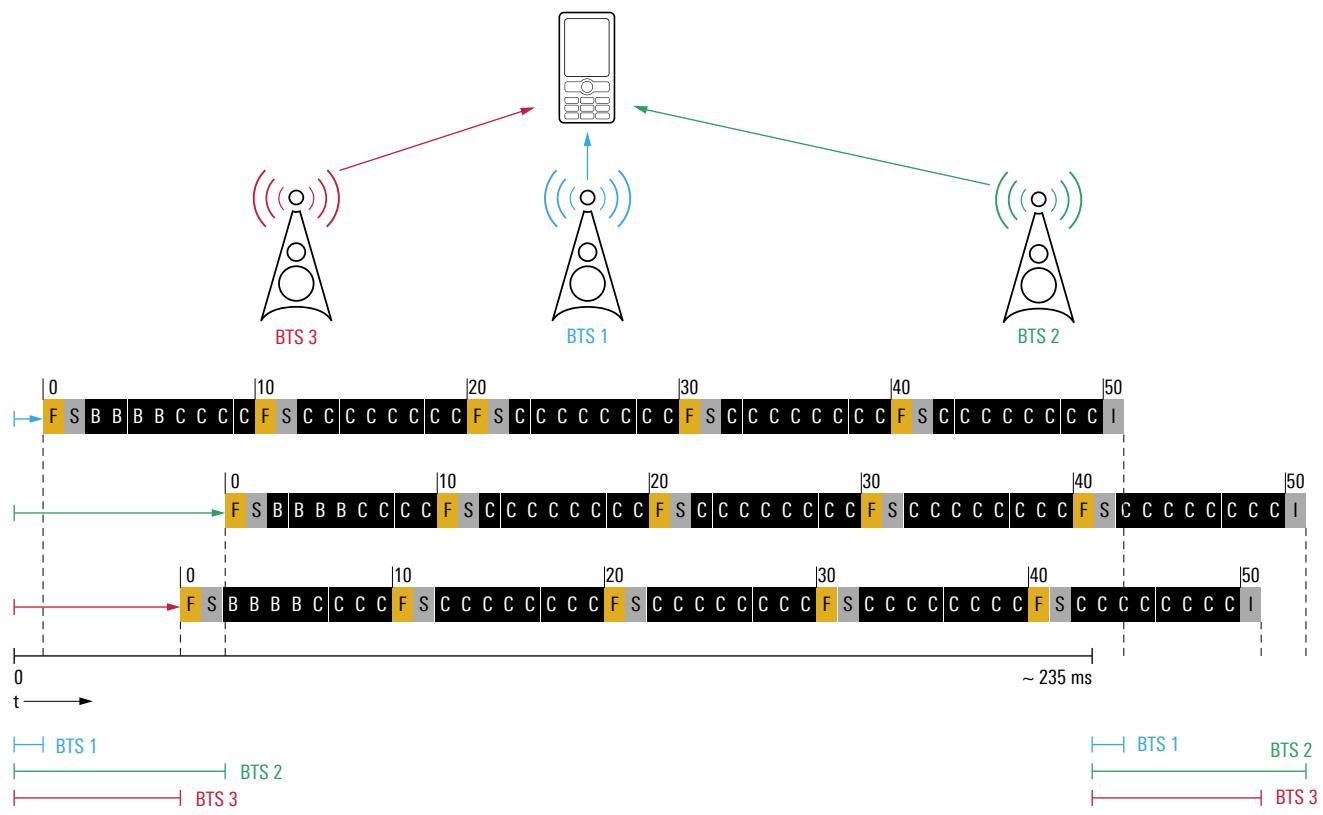


FIG 2 The different timing offset of the 51 multiframe structures shows that the received signals have a different source.

If the black vertical line is moved to another timeslot, the second interferer will also be displayed (FIG 6). In this example, the C0 of the "M-Moosfeld- ..." cell impairs traffic channel 98 of the test mobile phone.

Summary

As in the past, the latest method also enables users to measure and analyze interferences. And it allows "What if ... " ways of looking at detailed problems by modifying corresponding trigger thresholds. The system records initial measurement data, thus enabling users to run the algorithm at any time with modified limits.

The new implementation provides important additional information: Although the measurement time is the same, the new implementation considerably reduces the effort to analyze and verify the interfering cells and also reduces troubleshooting times. Since the time-consuming testing of multiple frequencies displayed on the list of interfering signals is no longer required, the staff in the operation and maintenance center also have a lot less work to do.

Current R&S®ROMES users merely need to perform a simple software upgrade. GSM network scanners that are already available simply need to update their firmware to the latest version.

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Abbreviations

BCCH	Broadcast control channel (also C0)
BSIC	Base transceiver station identity code (= NCC + BCC)
	NCC network color code
	BCC BTS color code
BTS	Base transceiver station
CCCH	Common control channel
C/I	Carrier-to-interference performance
ETS	Extended training sequence
FB	Frequency correction burst
FCCH	Frequency correction channel
RxLev	Reception level
RxQual	Reception quality
SB	Synchronization burst
SCH	Synchronization channel
TCH	Traffic channel (also Cx)
TSC	Training sequence code

REFERENCES

- [1] Radio Network Analyzer R&S®TSMU: Automatic detection of interferences in GSM networks. News from Rohde & Schwarz (2006) No. 190, pp 4–9
- [2] R&S®TSMx Radio Network Analyzers: Radio network analyzers for all tasks and any budget. News from Rohde & Schwarz (2007) No. 192, pp 5–8

FIG 6 A second interferer: In this example, the C0 of the cell named "M-Moosfeld- ..." also impairs traffic channel 98 of the test mobile phone.

