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# Frequency Hopping for GSM Base Station Tests with Signal Generators SME

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Application Note 1GPAN28E

A. Winter 07.95

Products:

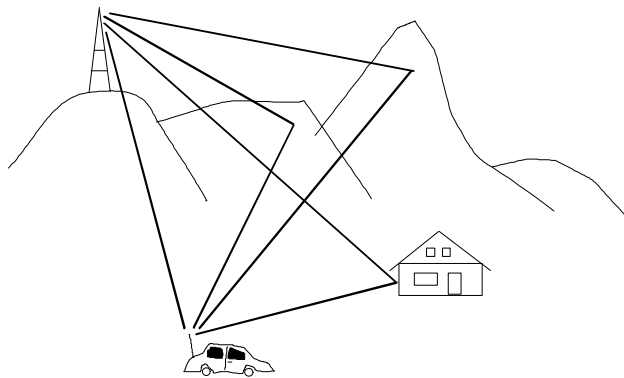
**Signal Generator SME**  
**Software Package SME-K1**



**ROHDE & SCHWARZ**

## Introduction

One of the problems in digital radiocommunications is the so-called multipath propagation. Usually the signal reaches the receiver not on the direct way from the transmitter to the receiver or not only via this path, but is also routed along reflection paths which may be different in intensity. The effect of such reflections on the transmission quality is reduced by an equalizer integrated in the receiver. It may however occur that the reflected signals arrive at the receiver with such an unfavourable phase that they cancel out each other. This cancelling effect, which is also referred to as fading, is however dependent on the position of the transmitter or receiver, so that often it is already sufficient to change the position by less than half a wavelength (that means approx. 15 cm for GSM) to improve the receiving conditions. Moreover, fading also depends on the transmitter frequency which influences the phase of the signals at the reception site. Changing the frequency from one channel to the other (200 kHz frequency offset) may already improve the communication quality from very poor to very good. Especially for transmitters or receivers moving slowly or not at all, a frequency change is an ideal means for improving the communication quality.



Multipath reception

GSM and PCN standards therefore also provide for calls from the mobile phone to the base station and vice versa to be set up at changing frequencies in the individual TDMA frames. This method is called frequency hopping since transmitter and receiver are so to say hopping from one frequency to the other. Another advantage of frequency hopping is that interference that may be caused by more distant radio cells as a result of transhorizon effects will disturb radiocommunication in individual time slots only, provided that the transmitter in the remote radio cell is hopping in a different frequency

scheme than the one in the local cell. Without frequency hopping a very large distance would be required between cells using the same frequency, this distance can be considerably reduced with frequency hopping and the so-called frequency reuse factor and hence the utilization of the available frequencies is much better with frequency hopping.

## Requirements on base stations

While Mobile phones are allowed to require approximately 3 time slots for switching from transmission to reception, base stations must be able to transmit and receive at a new frequency in every time slot in the frequency hopping mode. This behaviour must of course be tested and measurements carried out on the base station transmitter and receiver.

## Solution with two SME generators

Since there is no signal generator which is able to settle at different frequencies from one to the next time slot with GSM modulation, a solution to this problem was found by linking two Signal Generators SME in such a way that they alternately provide signals at different frequencies. The following outstanding features of Signal Generator SME are used to advantage:

- Fast settling time < 0.5 ms at new frequencies
- Frequency and level setting via lists
- Built-in pulse generator (SM-B4)
- Built-in pulse modulator (SM-B3 or SM-B8)
- Modulation to GSM / PCN standard
- Programmable modulation data

Signal Generator SME comes in two models which differ in the frequency range. SME 02 is able to generate signals from 5 kHz to 1.5 GHz and thus suitable for the frequency range of the GSM network, whereas SME 03 with up to 3 GHz covers the range of the PCN network.

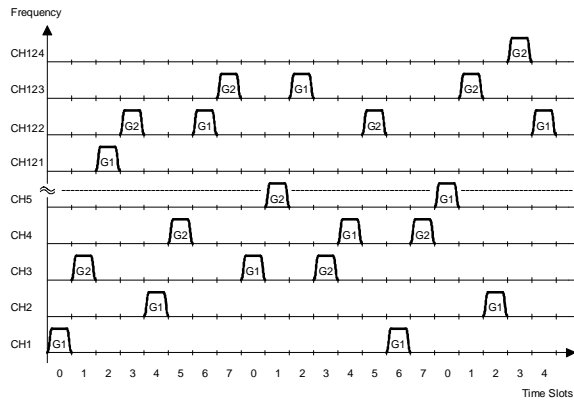
## Operating principle

The two Signal Generators SME are connected with each other and adjusted so that they alternately furnish signals in a GSM time slot at different frequencies. The generator output signals are combined via a power combiner. To simplify description of the test configuration and settings, the signal generators are in the following referred to as SME #1 and SME #2.

The hopping frequencies are stored in lists in the two SME generators. This method has the advantage that no external computer control is

required which, because of the necessary data traffic via IEC/IEEE bus, would make the settings much slower. The frequencies are not subject to any restriction. Each generator can hop from the lowest possible to the highest operating frequency.

The following diagram is to illustrate the possibilities of the LIST mode.



Frequency hopping in list mode

For each frequency the associated level is also stored in the lists. This enables incoming signals of different strength to be simulated for receiver testing. The level difference may amount up to 20 dB. A list may contain up to 2000 frequency/level entries. It is also possible to generate several (up to 10) lists, the number of entries per list being then however reduced accordingly.

In the example described below the lists of SME #1 and SME #2 have four entries each. The two SME generators are successively set to

Frequency / MHz:	890	891	900	901	914	915	910	910
Level / dBm:	6	6	6	6	6	6	0	6

The signal generators are activated with level attenuation control (LEVEL ATT.) which is stored in the data memory of option SME-B12 (XMEM), with GSM slope control (GSM-SLOPE) being switched on. The pulse slope of the signal generators thus has the shape prescribed for GSM. (The level 0 dBm for 910 Mhz is just set to show the level setting capabilities of the List Mode.)

The signals generators are modulated with data which are also stored in the data memory XMEM. They contain the usual GSM information such as tail bits, user data, training sequence, additional user data and further tail bits. Each of the two SME generators may contain different data which are however repeated everytime the generator is activated. To ensure that the data are available exactly at the time the respective generator is activated, they must be shifted in the memory by

the number of bits required by the generator to settle at the frequency. In this example 153 bits corresponding to a time of 565  $\mu$ s have been inserted (see list of data bits in the Appendix).

Frequency switching and modulation control are triggered by an external signal, so that correct timing is always ensured.

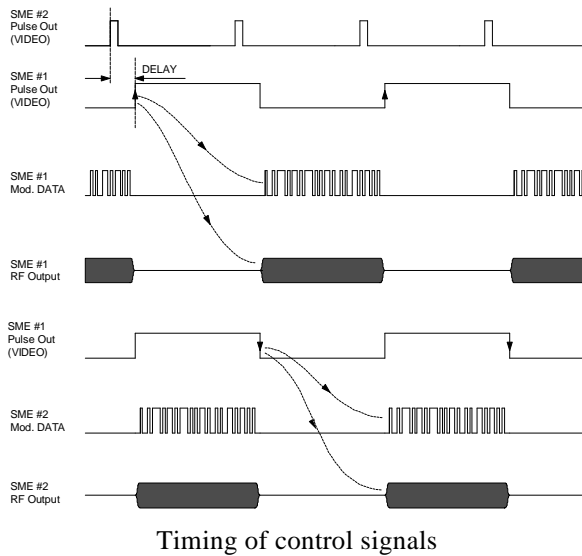
In the example described the trigger pulses are derived from the VIDEO output of the pulse generator in SME #2 which otherwise is not required. Pulse generator #2 is set to a pulse width of 1  $\mu$ s and a pulse period of 576.92  $\mu$ s so that it supplies a pulse for each GSM time slot. Instead of this pulse, an external sync pulse may of course also be used for controlling the sequence.

The sync pulse triggers the pulse generator in SME #1. The pulse generator is set to a pulse period of 1.15384 ms (2 time slots) and a pulse width of 576.92  $\mu$ s. The delay (PULSE DELAY) which can also be adjusted is initially set to a value of 15  $\mu$ s. This delay allows fine adjustment of the timing if an external trigger pulse is used. For triggering by the pulse generator of SME #2 this value is meaningless. The set pulse width must however accurately be matched to the period of the trigger pulse so that at the output of the pulse generator in SME #1 a duty cycle of exactly 1:1 is obtained. With this setting, every second sync pulse will be suppressed.

The output pulse of the pulse generator in SME #1 is picked up at the VIDEO output of SME #1 and applied to the TRIGGER input of SME #1. The positive slope of this signal controls switching of the frequency list in the SME #1 and starts readout of the modulation data from the XMEM memory. The trigger input of SME #2 is also connected and its trigger polarity set to the negative slope so that a time shift of exactly one time slot is obtained between the two signal generators.

The level attenuation stored in the data memory only allows values of 35 to 45 dB to be achieved which is not enough for most hopping applications. For this reason, level attenuation is combined with the pulse modulation allowing level attenuation of the non-active generator to over 80 dB. The pulse modulators in the two SME generators are driven by the output signal of the SME #1 pulse generator. For this purpose the SME #1 is set to internal pulse modulation (SOURCE PULS-GEN), however with inverted polarity. This signal is applied to the PULSE input of the SME #2 which is set to external pulse modulation (SOURCE EXT) with normal polarity.

The relationship between the various signals is illustrated in the diagram below.



## Preparations

For loading the modulation data into the XMEM modulation memory of the two SME generators, a PC with IEC/IEEE-bus card and properly installed IEC/IEEE-bus software (driver GPIB.COM) is required. It is advisable to make the generator settings also via the IEC/IEEE bus.

Two small software packages are supplied with this Application Note for your convenience. The IECCMD program is for setting the generators while the SME-K1 program is for loading the data memories of the signal generators.

For installing these programs on the IEC/IEEE-bus controller proceed as follows:

First copy the IECCMDP.EXE file into a separate directory IECCMD or an other directory of your choice on the hard disk of the PC. This file is a packed file which is automatically unpacked upon startup and loads the following files into the current directory of the hard disk:

```
IECCMD .EXE
IECCMD .TXT
SME .CNF
SET_SME .IEC
SET_SME .BAT
```

The required memory capacity is approx. 93 Kbyte.

The second software package, SME-K1, comprises the following files:

```
INSTALL .EXE
SME_____ .EX_
SME_K1 .DOC
```

It can be installed on the hard disk with INSTALL.EXE. We recommend to use the directory SME, which may however be renamed. The required memory capacity is approx. 1.55 Mbyte. If the capacity of the hard disk memory is limited, all files with the extension \*.SEQ except for the file HOPPING.SEQ can be cleared, which saves about 850 Kbyte.

Connect now the two Signal Generators SME as shown in the cabling scheme. Also connect the generators via IEC/IEEE-bus cable to the PC. SME #1 remains with IEC/IEEE-bus address 28, whereas SME #2 has to be set to address 26.

The modulation data can now be loaded into the two generators. Change to directory SME and start the program SME-K1 by entering SME↵ on the PC. How to operate the program is described in file SME\_K1.DOC. Load the data sequence HOPPING.SEQ into the program (press F3 and select HOPPING.SEQ) and transfer the data to SME #1 (press ALT-T and ↵). Quit the program SME-K1 (with ALT-X) and start it again, but this time with SME 26 ↵. 26 is the address of generator SME #2, into which the data are now to be loaded in the same way as described above.

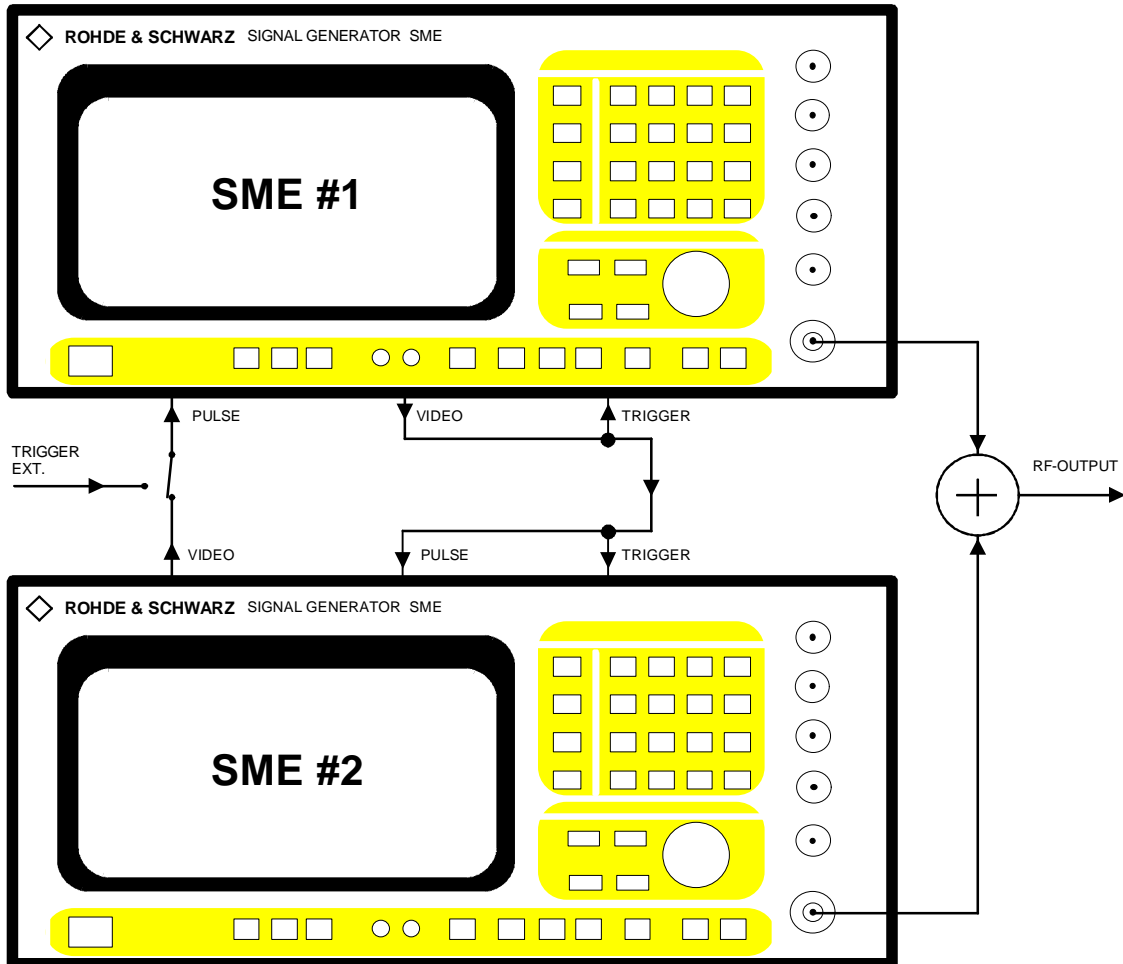
The two SME's are set using the program IECCMD.EXE. To do this change to the directory which contains the appropriate files, start the batch file SET\_SME.BAT and follow the informations given at the screen of the PC.

Loading the modulation data and instrument settings into the generators has of course to be done only once. Data and settings remain stored when the generators are switched off. Only learning of the frequency and level list in the list mode has to be repeated every time the instrument is switched on **and** every time the list mode has been quit. The external PC is however not required for this purpose.

## Connecting the instruments

The illustration below shows the cabling of the two signal generators. What is not shown in the picture but recommended and also included in the setting routines via PC, is the synchronization of the

reference frequencies of the generators. For this purpose, the REF sockets of the generators are interconnected and SME #2 is set to external reference frequency.



Cabling of Signal Generators SME

## Test run

If the IECCMD.EXE program has been used for setting the instruments, the generators are in hopping mode already. For a subsequent change of the generator settings, the list mode has to be left. First the sync pulse has to be switched off.

**Note:** It is important to switch off the sync pulses before changing settings since the SME firmware flow is affected by computer interrupts which are triggered

by the sync pulses. In some settings it may therefore happen that the SME processor is blocked by the sync pulses and the instrument cannot be operated any more.

If the sync pulse is supplied by the pulse generator of SME #2 as described above, the trigger mode of this pulse generator can simply be changed from AUTO to EXT so that the pulse generator is disabled until it is set to AUTO again.

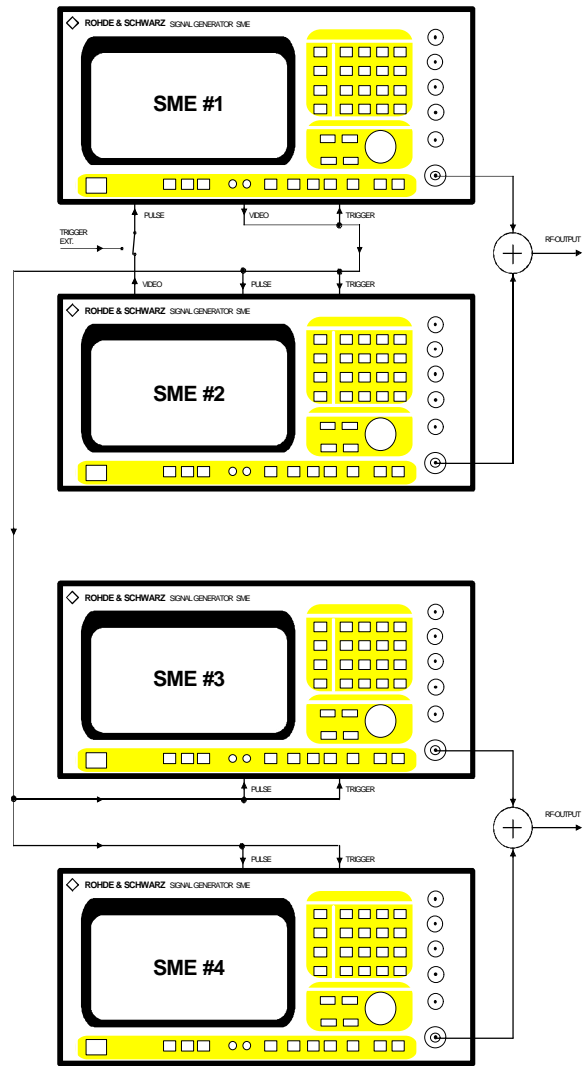
After modification of the desired settings and entering the list mode again (LIST MODE EXT STEP), frequency hopping can be restarted. Should as a result of the changes made to the settings the learnt list be lost, which is indicated by an error message on the SME, the LEARN function can be recalled. Synchronization of the lists in the two SME generators can be achieved by LIST RESET on both generators. Set afterwards the list mode to EXT-STEP again.

Once all settings have been made, the sync pulse can be applied again by switching the pulse generator in SME #2 to TRIGGER MODE EXT.

**Note:** Changing between the individual SME menus is much easier if two of the most frequently required menus are assigned to the MENU 1 and MENU 2 keys on the SME front panels (press ASSIGN MENU 1 or MENU 2).

### Further system extension

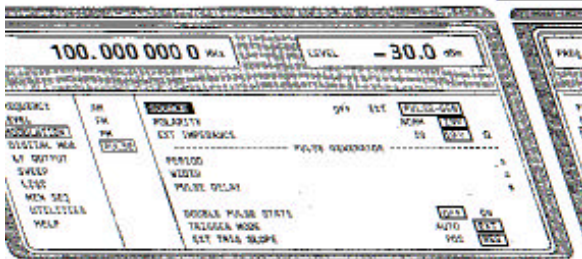
The test system can be enhanced by another two Signal Generators SME #3 and SME #4 to replace the local oscillators of the base-station receivers in the hopping mode for test purposes. These further generators need not be modulated of course. SME #3 and SME #4 are connected in the same way as SME #2. The settings of SME #3 correspond to that of SME #1, with pulse modulation of SME #3 being however set to an external source. SME #4 is set exactly the same way as SME #2. The frequency lists of SME #3 and SME #4 must of course take into account the shift by the intermediate frequency of the base-station receivers.



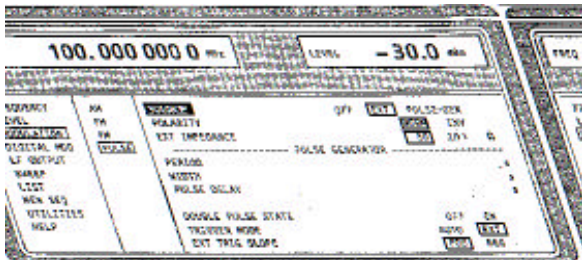
System with four SME generators

### Settings for manual control

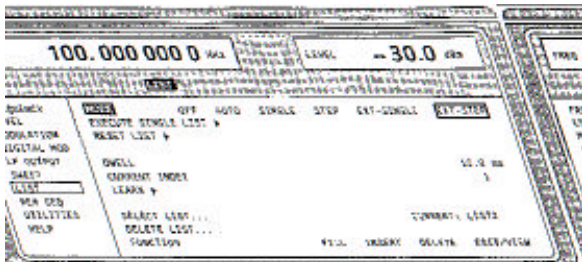
The screen displays show the SME setting menus for manual control. They are provided as a help if the IECCMD.EXE program cannot be used for any reason whatsoever.



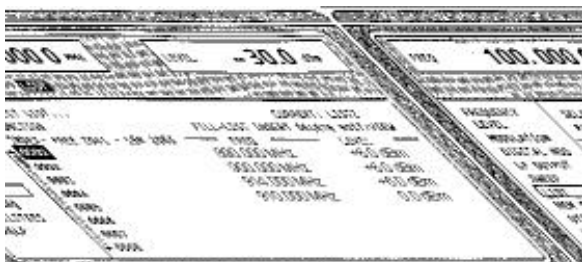
Settings for pulse generator SME #1



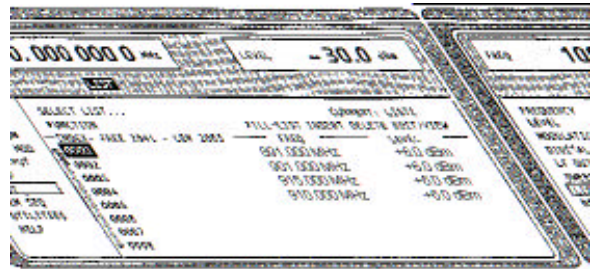
Settings for pulse generator SME #2



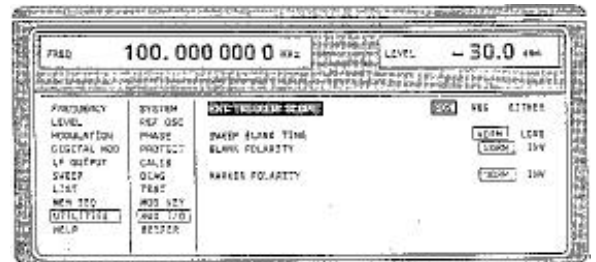
LIST MODE for both SME units set to EXT-STEP



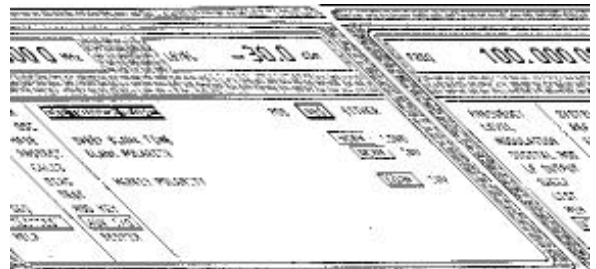
Frequency/level list for SME #1



Frequency/level list for SME #2



Setting UTILITIES / AUX I/O for SME #1



Setting UTILITIES / AUX I/O for SME #2





## Appendix

### List of setting commands for SME #1 and SME #2:

The IECCMD.EXE program uses the SET\_SME.CNF file with the following setting commands for SME #1 and SME #2.

```

PRINT:
PRINT:*****
PRINT: Automatic settings for SME #1 via IEEE Bus (address 28!)
PRINT: Application: Frequency Hopping Using 2 SME's
PRINT: Rohde & Schwarz 7/95
PRINT:*****
PRINT:

;----- Reset for SME -----
>SME1:*CLS
>SME1:*RST
>SME2:*CLS
>SME2:*RST
>SME2:TRIG:PULS:SOUR EXT
>SME2:ROSC:SOUR EXT
;--- Settings for SME #1, hopping application
>SME1:FREQ 900MHz
>SME1:POW 6dBm
>SME1:OUTP ON
>SME1:DM:TYPE GMSK
>SME1:DM:GMSK:STAN GSM
>SME1:DM:SOUR DATA
>SME1:DM:DATA:ALEV 40
>SME1:DM:STATE ON
>SME1:SOUR:DM:DATA:SEL "XMEM"
>SME1:DM:DATA:XMEM:MODE ALL
>SME1:DM:DATA:XMEM:LENGTH 312
>SME1:DM:DATA:XMEM:STAR 1
>SME1:DM:DATA:XMEM:TRIG ON
>SME1:DM:DATA:XMEM:TRIG:SLOP POS
>SME1:PULM:EXT:IMP 10 kOhm
>SME1:PULM:SOURCE INT
>SME1:PULM:POL INV
>SME1:PULM:STATE ON
>SME1:PULS:PER 1.15384ms
>SME1:PULS:WIDT 576.92us
>SME1:PULS:DEL 15us
>SME1:TRIG:PULS:SOUR EXT
>SME1:TRIG:PULS:SLOP NEG
>SME1:DM:GMSK:GSL ON
>SME1:SOUR:LIST:SEL "LIST0"
>SME1:LIST:FREQ 890.0MHz,900.0MHz,914.0MHz,910.0MHz;POW 6dBm,6dBm,6dBm,0dBm
>SME1:SOUR:LIST:LEARN
PRINT: Wait till learning of list in SME #1 is completed
WAIT_KEY
>SME1:FREQ:MODE LIST
>SME1:LIST:MODE STEP
>SME1:TRIG:LIST:SOUR EXT
>SME1:TRIG:SLOP POS
;----- Any errors on SME? -----
<SME1:system:error?
COMPARE:0,"No error"
PRINT:
PRINT:*****
PRINT: Automatic settings for SME #2 via IEEE Bus (address 26!)
PRINT: Application: Frequency Hopping Using 2 SME's
PRINT: Rohde & Schwarz
PRINT:*****
PRINT:
;--- settings for SME #2, hopping application
>SME2:FREQ 901MHz
>SME2:POW 6dBm
>SME2:OUTP ON
>SME2:DM:TYPE GMSK
>SME2:DM:GMSK:STAN GSM

```

## Frequency Hopping with Signal Generator SME

```

>SME2:DM:SOUR DATA
>SME2:DM:DATA:ALEV 40
>SME2:DM:STATE ON
>SME2:SOUR:DM:DATA:SEL "XMEM"
>SME2:DM:DATA:XMEM:MODE ALL
>SME2:DM:DATA:XMEM:LENGTH 312
>SME2:DM:DATA:XMEM:STAR 1
>SME2:DM:DATA:XMEM:TRIG ON
>SME2:DM:DATA:XMEM:TRIG:SLOP NEG
>SME2:PULM:EXT:IMP 50 Ohm
>SME2:PULM:SOURCE EXT;STAT ON
>SME2:PULM:POL NORM
>SME2:PULM:STATE ON
>SME2:PULS:PER 576.92us
>SME2:PULS:WIDT 1us
>SME2:DM:GMSK:GSL ON
>SME2:SOUR:LIST:SEL "LIST0"
>SME2:LIST:FREQ 891.0MHz,901.0MHz,910.0MHz,915.0MHz,910.0MHz;POW 6dBm,6dBm,6dBm,6dBm
>SME2:SOUR:LIST:LEARN
PRINT: Wait till learning of list in SME #2 is completed
WAIT_KEY
>SME2:FREQ:MODE LIST
>SME2:LIST:MODE STEP
>SME2:TRIG:LIST:SOUR EXT
>SME2:TRIG:SLOP NEG
PRINT:*** Start pulse generator
WAIT_KEY
>SME2:TRIG:PULS:SOUR AUTO
;----- Any errors on SME? -----
<SME2:system:error?
COMPARE:0,"No error"
ECHO:ON
;----- Goto Local SME -----
PRINT:*** To return to local control press the 'local' key on the SME

```

### Modulation data for data memory XMEM

Bit position in time slot	Bit position in XMEM	Number of bits	DATA	LEV ATT	BURST	Remarks
	1 to 153	153	don't care (all 0)	all 1	don't care	Offset
1 to 3	154 to 156	3	000	0	don't care	Tail
4 to 60	157 to 213	57	PRBS	0	don't care	Data (PRBS)
61	214	1	1	0	don't care	Flag
62 to 87	215 to 240	26	00100101110000100010010111	0	don't care	Training Sequence Midamble 0
88	241	1	1	0	don't care	Flag
89 to 145	242 to 298	57	PRBS	0	don't care	Data (PRBS)

## Frequency Hopping with Signal Generator SME

146 to 148	299 to 301	3	000	001	don't care	Tail
149 to 156.25	302 to 309	8	all 1	all 1	don't care	Guard

Bits 1 to 153 serve as filler bits for compensating the time required for frequency settings of the SME generators. They can be used for fine adjustment of the modulation data within the time slot.

### Software supplied

SME\_K1.EXE comprises:

- INSTALL .EXE
- SME\_\_\_ .EX\_
- SME\_K1 .DOC

IEC\_CMDP.EXE comprises:

- IECCMD .EXE
- IECCMD .TXT
- SME .CNF
- SET\_SME .IEC
- SET\_SME .BAT