VOR-Receiver Tests using the Signal Generator SMT

Application Note 1GPAN10E

H.-G. Titze 06.94

Products:

Signal Generator SMT

ROHDE&SCHWARZ

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VOR Test Procedures using the Signal Generator SMT

The following paragraphs are intended to show the capabilities of the Rohde&Schwarz Signal Generator SMT performing VOR*) air navigation receiver tests. The procedures presented should not be considered binding or mandatory. It is expected that the user once familiar with the use of SMT for VOR/ILS receiver tests will design and implement procedures which satisfy equipment and regulatory requirements.

This application note is part of a series of three application notes describing the use of the Signal Generator SMT for air navigation receiver testing. The other application notes are:

VOR/ILS Testing with the Signal Generator SMT (1GPAN09E), which gives an overview of the capabilities of the SMT for air navigation receiver testing and describes the basics of the VOR and ILS systems.

and

ILS Test Procedures using the Signal Generator SMT (1GPAN11E), which presents a collection of ILS and Marker Beacon tests.

Introduction

The VOR tests included do not require any other equipment besides SMT. To be able to generate VOR test signals the SMT has to be equipped with option SM-B6, Multifunction Generator.

To prevent incorrect settings of the SMT each test starts with the "PRESET" command. The sequence of the settings should be followed.

In addition to the manual operation the corresponding IEEE commands are given.

Equipment connections:

To perform receiver tests the antenna input of the receiver has to be connected to the signal generator's output connector. No other connections are necessary.

Attention!

In order to avoid damage of the receiver front end, the output level of the generator SMT must not exceed the maximum allowed input level of the receiver.

VOR Receiver Tests

1 VOR Receiver Bearing Accuracy Tests

Purpose: This test determines the bearing accuracy of the receiver under test.

1.1 Omni-Bearing Selector 0°, direction: FROM

SMT setting:

Manual operation:	Remote control:
PRESET	"*RST;*CLS"
RF LEVEL: -47 dBm	":POW -47dBm"
FREQUENCY: 108.000 MHz*)	":FREQ 108.000MHz" *)
MODULATION: VOR VOR DEFAULT SETTING	":VOR:PRESET;STATE ON"

*) In all examples a VOR frequency of 108 MHz was chosen. For other VOR frequencies see appendix (Table 1)

Receiver setting:

Set omni-bearing selector to 0°.

Receiver test:

- CDI (Course Deviation Indicator) pointer should be centered.
- Ambiguity indicator should indicate FROM.
- CDI pointer error should not exceed receiver specification

1.2 Omni-Bearing Selector 0°, direction: TO

SMT setting:

Manual operation:	Remote control:
MODULATION: VOR DIRECTION: TO	":VOR:DIR TO"

Receiver test:

- CDI (Course Deviation Indicator) pointer should be centered.
- Ambiguity indicator should indicate TO
- CDI pointer error should not exceed receiver specification

1.3 Omni-Bearing Selector 30°, direction: FROM

SMT setting:

Manual operation:	Remote control:
MODULATION: VOR DIRECTION: FROM	":VOR:DIR FROM"
MODULATION: VOR BEARING ANGLE: 30 deg	":VOR 30deg"

Receiver setting:
Set omni-bearing selector to 30°.

Receiver test:

- CDI (Course Deviation Indicator) pointer should be centered.
- Ambiguity indicator should indicate FROM
- CDI pointer error should not exceed receiver specification

1.4 Omni-Bearing Selector 30°, direction: TO

SMT setting:

Manual operation:	Remote control:
MODULATION: VOR DIRECTION: FROM	":VOR:DIR TO"
MODULATION: VOR BEARING ANGLE: 30 deg	":VOR 30deg"

Receiver setting:

Set omni-bearing selector to 30°.

Receiver test:

- CDI (Course Deviation Indicator) pointer should be centered.
- Ambiguity indicator should indicate TO
- CDI pointer error should not exceed receiver specification

Repeat steps 3 and 4 for each 30 degree increment of the VOR bearing.

2 VOR Receiver 30Hz-VAR-Tone modulation depth sensitivity

Purpose: This test determines the sensitivity of the bearing accuracy of the receiver under test due to fluctuations of the 30Hz-VAR-Signal.

2.1 Omni-Bearing Selector 0°, direction: TO

SMT setting:

Manual operation:	Remote control:
PRESET	"*RST;*CLS"
RF LEVEL: -47 dBm	":POW -47dBm"
FREQUENCY: 108.000 MHz	":FREQ 108.000MHz"
MODULATION: VOR VOR DEFAULT SETTING	

Receiver setting:
Set omni-bearing selector to 0°.

Receiver test:

- CDI (Course Deviation Indicator) pointer should be centered.
- Ambiguity indicator should indicate FROM.

2.2 VAR-Modulation Depth 25 %

SMT setting:

Manual operation:	Remote control:
MODULATION: VOR VAR DEPTH:25%	":VOR:VAR 25PCT"

Receiver setting: as under 2.1

Receiver test:

- CDI pointer error should not exceed receiver specification

2.3 VAR-Modulation Depth 35 %

SMT setting:

Manual operation:	Remote control:
MODULATION: VOR VAR DEPTH:35%	":VOR:VAR 35PCT"

Receiver setting: as under 2.1

Receiver test:

- CDI pointer error should not exceed receiver specification

2.4 VOR direction TO, VAR-Modulation Depth 35 %

SMT setting:

Manual operation:	Remote control:
MODULATION: VOR DIRECTION: TO	":VOR:DIR TO"

Receiver setting: as under 2.1

Receiver test:

- Ambiguity indicator should indicate "TO".
- CDI pointer error should not exceed receiver specification

2.5 VOR direction TO, VAR-Modulation Depth 25 %

SMT setting:

Manual operation:	Remote control:
MODULATION: VOR VAR DEPTH:25%	":VOR:VAR 25PCT"

Receiver setting: as under 2.1

Receiver test:

- Ambiguity indicator should indicate TO.
- CDI pointer error should not exceed receiver specification

Repeat tests for each 30 degree increment of receiver omni-bearing selector and SMT VOR bearing angle setting.

3 VOR Receiver RF frequency offset sensitivity

Purpose: This test determines the sensitivity of the bearing accuracy of the receiver under test due to variations of the RF frequency.

3.1 Omni-Bearing Selector 0°, direction: FROM

SMT setting:

Manual operation:	Remote control:
PRESET	"*RST;*CLS"
RF LEVEL: -47 dBm	":POW -47dBm"
FREQUENCY: 108.000 MHz *)	":FREQ 108.000MHz"
MODULATION: VOR VOR DEFAULT SETTING	":VOR:PRESET;STATE ON"

Receiver setting:

Set omni-bearing selector to 0°.

Receiver test:

- CDI (Course Deviation Indicator) pointer should be centered.
- Ambiguity indicator should indicate FROM.

3.2 Carrier frequency offset +1kHz, direction: FROM

SMT setting:

Manual operation:	Remote control:
FREQUENCY OFFSET: +1kHz	":FREQ:OFFS 1kHz"

Receiver test:

- Record CDI pointer error. It should not exceed receiver specifications.

3.3 Carrier frequency offset -1kHz, direction: FROM

SMT setting:

Manual operation:	Remote control:
FREQUENCY OFFSET: -1kHz	":FREQ:OFFS -1kHz"

Receiver setting: as under 3.1

Receiver test:

- Record CDI pointer error. It should not exceed receiver specifications.

3.4 Omni-Bearing Selector 0°, direction: TO

SMT setting:

Manual operation:	Remote control:
FREQUENCY OFFSET: 0kHz	":FREQ:OFFS 0kHz"
MODULATION: VOR: DIRECTION: TO	":VOR:DIR TO"

Receiver setting: as under 3.1

Receiver test:

- CDI (Course Deviation Indicator) pointer should be centered.
- Ambiguity indicator should indicate TO.

3.5 Carrier frequency offset +1kHz, direction: TO

SMT setting:

Manual operation:	Remote control:
FREQUENCY OFFSET: +1kHz	":FREQ:OFFS +1kHz"

Receiver setting: as under 3.1

Receiver test:

- Record CDI pointer error. It should not exceed receiver specifications.

3.6 Carrier frequency offset -1kHz, direction: TO

SMT setting:

Manual operation:	Remote control:
FREQUENCY OFFSET: -1kHz	":FREQ:OFFS -1kHz"

Receiver setting: as under 3.1

Receiver test:

- Record CDI pointer error. It should not exceed receiver specifications.

Repeat tests for each 30 degree increment of receiver omni-bearing selector and SMT VOR bearing angle setting.

4 VOR Receiver RF level sensitivity

Purpose: This test determines the sensitivity of the bearing accuracy of the receiver under test due to variations of the RF level.

4.1 RF level -87 dBm, direction: FROM

SMT setting:

Manual operation:	Remote control:
PRESET	"*RST;*CLS"
RF LEVEL: -87 dBm	":POW -87dBm"
FREQUENCY: 108.000 MHz	":FREQ 108.000MHz"
MODULATION: VOR VOR: DEFAULT SETTING	":VOR:PRESET;STATE ON"

Receiver setting:

Set omni-bearing selector to 0°.

Receiver test:

- CDI (Course Deviation Indicator) pointer should be centered.
- Ambiguity indicator should indicate FROM.
- Record CDI pointer error, it should not exceed receiver specification.

4.2 RF level -87 dBm, direction: TO

SMT setting:

Manual operation:	Remote control:
MODULATION: VOR VOR: DIRECTION: TO	":VOR:DIR TO"

Receiver setting: as under 4.1

Receiver test:

- CDI (Course Deviation Indicator) pointer should be centered.
- Ambiguity indicator should indicate TO.
- Record CDI pointer error, it should not exceed receiver specification.

4.3 RF level -21 dBm, direction: FROM

SMT setting:

Manual operation:	Remote control:
RF LEVEL: -21 dBm	":POW -21dBm"
MODULATION: VOR:DIRECTION:FROM	":VOR:DIR FROM"

Receiver setting: as under 4.1

Receiver test:

- CDI (Course Deviation Indicator) pointer should be centered.
- Ambiguity indicator should indicate FROM.
- Record CDI pointer error, it should not exceed receiver specification.

4.4 RF level -21 dBm, direction: TO

SMT setting:

Manual operation:	Remote control:
RF LEVEL: -21 dBm	":POW -21dBm"
MODULATION: VOR:DIRECTION:FROM	":VOR:DIR FROM"

Receiver setting: as under 4.1

Receiver test:

- CDI (Course Deviation Indicator) pointer should be centered.
- Ambiguity indicator should indicate TO.
- Record CDI pointer error, it should not exceed receiver specification.

Repeat tests for each 30 degree increment of receiver omni- bearing selector and SME/SMT VOR bearing angle setting.

5 VOR Course deviation Indicator Tests

Purpose: This test determines the CDI pointer sensitivity, response and linearity characteristics.

5.1 CDI pointer deflection sensitivity

SMT setting:

Manual operation:	Remote control:
PRESET	"*RST;*CLS"
RF LEVEL: -67 dBm	":POW -67dBm"
FREQUENCY: 108.000 MHz*)	":FREQ 108.000MHz"
MODULATION: VOR DEFAULT SETTING	":VOR:PRESET;STATE ON"
MODULATION: VOR BEARING ANGLE 10.00 deg	":VOR 10deg"

Receiver setting:

Set omni-bearing selector to 0°.

Receiver test:

- Measure the amount of CDI pointer deflection and compare it to the receiver specifications.

SMT setting:

Manual operation:	Remote control:
RF LEVEL: -21 dBm	":POW -21dBm"

Receiver setting: as under 5.1

Receiver test:

- Record any change in CDI pointer deflection and compare it to the receiver specifications.

SMT setting:

Manual operation:	Remote control:
RF LEVEL: -87 dBm	":POW -87dBm"

Receiver setting: as under 5.1

Receiver test:

- Record any change in CDI pointer deflection and compare it to the receiver specifications.

Repeat tests for each 10 degree increment of Bearing Angle from 10 to 360 degrees and for different VOR carrier frequencies.

5.2 CDI response time test

SMT setting:

Manual operation:	Remote control:
PRESET	"*RST;*CLS"
RF LEVEL: -67 dBm	":POW -67dBm"
FREQUENCY: 108.000 MHz*)	":FREQ 108.000MHz"
MODULATION: VOR:DEFAULT SETTING	":VOR:PRESET;STATE ON"

Receiver setting:

Set omni-bearing selector to 0°.

SMT setting:

Manual operation:	Fernsteuerbefehl:
MODULATION: VOR: BEARING ANGLE 10 deg	"VOR 10deg"

Receiver test:

- Determine the time required for pointer to deflect 70% of maximum deflection.
- Compare the time to the receiver specifications

5.3 CDI pointer linearity test

SMT setting:

Manual operation:	Remote control:
PRESET	"*RST;*CLS"
RF LEVEL: -67 dBm	":POW -67dBm"
FREQUENCY: 108.000 MHz *)	":FREQ 108.000MHz"
MODULATION: VOR VOR DEFAULT SETTING	":VOR:PRESET;STATE ON"

Receiver setting:

Set omni-bearing selector to 0°.

SMT settings:

Manual operation:	Fernsteuerbefehl:
MODULATION: VOR BEARING ANGLE: 2 deg	":VOR 2deg"

Receiver test:

- Measure CDI pointer increments. Increments should be equal.
- Compare the readings to the receiver specifications

Repeat tests for each 2 degree increment of Bearing Angle from -10 to +10 degrees and for different VOR carrier frequencies.

6 CDI ambiguity indication test

Purpose: This test determines the CDI ambiguity indication stability in the presence of bearing angle and RF level variations.

SMT setting:

Manual operation:	Remote control:
PRESET	"*RST;*CLS"
RF LEVEL: -67 dBm	":POW -67dBm"
FREQUENCY: 108.000 MHz*)	":FREQ 108.000MHz"
MODULATION: VOR VOR DEFAULT SETTING	":VOR:PRESET;STATE ON"

Receiver setting:

Set omni-bearing selector to 0°.

Receiver test:

- CDI TO-FROM indicator should indicate a stable "FROM" indication while varying RF level and VOR bearing angle on SMT during the following tests.

SMT settings:

Manual operation:	Remote control:
MODULATION: VOR BEARING ANGLE: 60deg	":VOR 60deg"
RF LEVEL: -87 dBm	":POW -87dBm"
RF LEVEL: -21 dBm	":POW -21dBm"
MODULATION: VOR BEARING ANGLE: -60deg	":VOR -60deg"
RF LEVEL: -87 dBm	":POW -87dBm"
RF LEVEL: -21 dBm	":POW -21dBm"

Repeat these tests with VOR DIRECTION : TO

7 CDI Alarm Signal Test

Purpose: This test checks the operation of the VOR receivers alarm system under various signal conditions.

7.1 Variation of RF level

SMT setting:

Manual operation:	Remote control:
PRESET	"*RST;*CLS"
RF LEVEL: -67 dBm	":POW -67dBm"
FREQUENCY: 108.000 MHz (*)	":FREQ 108.000MHz"
MODULATION: VOR DEFAULT SETTING	":VOR:PRESET;STATE ON"

Receiver setting:

Set Omni Bearing Selector to 0 degree.

Receiver test:

- Verify that the alarm signal (warning flag) is not visible or off. It must not turn on during the following tests.

SMT settings:

Manual operation:	Remote control:
RF LEVEL: -87 dBm	":POW -87dBm"
RF LEVEL: -67 dBm	":POW -67dBm"
RF LEVEL: -21 dBm	":POW -21dBm"

7.2 Failure of RF level

SMT setting:

Manual operation:	Remote control:
RF OFF	":OUTP OFF"

Receiver test:

- Verify that the alarm signal or warning flag is visible.

7.3 No 9960Hz modulation signal

SMT setting:

Manual operation:	Remote control:
RF LEVEL: -67 dBm	":POW -67dBm"
MODULATION: VOR MODE: VAR	":VOR:MODE VAR"

Receiver test:

- Verify that the alarm signal or warning flag is visible and remains on during the following tests:

SMT setting:

Manual operation:	Remote control:
RF LEVEL: -87 dBm	":POW -87dBm"
RF LEVEL: -67 dBm	":POW -67dBm"
RF LEVEL: -21 dBm	":POW -21dBm"
RF LEVEL: -67 dBm	":POW -67dBm"

Receiver test:

- Verify that the alarm signal or warning flag remains visible while the RF level is being changed.

7.4 No 30Hz modulation signal

SMT setting:

Manual operation:	Remote control:
MODULATION: VOR MODE: SUBC+FM	":VOR:MODE FMS"

Receiver test:

- Verify that the alarm signal or warning flag is visible and remains visible during the following level variations:

SMT setting:

Manual operation:	Remote control:
RF LEVEL: -87 dBm	":POW -87dBm"
RF LEVEL: -67 dBm	":POW -67dBm"
RF LEVEL: -21 dBm	":POW -21dBm"
RF LEVEL: -67 dBm	":POW -67dBm"

8 VOR Receiver Sensitivity Test

Purpose: This test determines the minimum RF input level the VOR receiver requires to produce 50 % of the CDI pointer's standard deflection.

SMT setting:

Manual operation:	Remote control:
PRESET	"*RST;*CLS"
RF LEVEL: -67 dBm	":POW -67dBm"
FREQUENCY: 108.000 MHz	":FREQ 108.000MHz"
MODULATION: VOR DEFAULT SETTING	":VOR:PRESET;STATE ON"
MODULATION: VOR:BEARING ANGLE: 10deg	":VOR 10deg"

Receiver test:

- Verify that bearing display has changed 10 deg and the VOR rceiver's CDI pointer is deflected accordingly (Standard Deflection) Decrease SMT RF level until CDI pointer deflection is 50% of standard deflection.

9 Generating Morse Coded Identity Signals

The MEMORY SEQUENCE facilities of the Signal Generator SMT can be configured to generate Morse coded identity signals used to identify VOR transmitter stations. The identification code consists of 3 letters. Table 2 shows the Morse code for the letters a to z of the alphabet.

Letter	Morse Code	Letter	Morse Code
a	.-	n	-.
b	-...	o	---
c	-.-.	p	.--.
d	-..	q	--.-
e	.	r	.-.
f	..-.	s	...
g	--.	t	-
h	....	u	..-
i	..	v	...-
j	.---	w	.--
k	-.-	x	-..-
l	.-..	y	-.--
m	--	z	--..

Table 2: Morse-Code

The dwell time of a dash ("-") equals three times the dwell of a dot (".") . The space between two symbols equals the dwell time of a dot , the space between two letter the dwell time of a dash. The dot dwell time for air navigation identification codes is set to 100ms.

To use the MEMORY SEQUENCE for Morse code identity simulation the signal generator should be set up as follows:

9.1 Storing of VOR settings

Set the signal generator in the VOR mode and store the setting with COM/ID STATE = OFF in a memory

location. This setting represents the "ON" signal of the morse code.

Store the same setting with COM/ID STATE = ON in another memory location ("OFF" signal)

Use the MEMORY SEQUENCE function to enter the timing of the desired Morse code sequence. Use the following durations:

dot (".") : 100ms, space (" ") : 100ms, dash ("-") : 300ms, letter space : 300ms, word space : 6 s

9.2 Example Morse Code:

According to Table 2 the Morse code for "MUC" is :

M U C

- - . . - - . - .

9.3 Programming the MEMORY SEQUENCE

Table 3 shows the correct timing of the memory sequence. The "ON"-signal of the Morse code is stored in memory location 11, the "OFF"-signal in memory location 10.

Index	Letter	Memory	Dwell	Remark
1	M	11	300ms	Dash, "-"
2		10	100ms	Space
3		11	300ms	Dash, "-"
4		10	300ms	Letter Space
5	U	11	100ms	Dot, "."
6		10	100ms	Space
7		11	100ms	Dot, "."
8		10	100ms	Space
9		11	300ms	Dash, "-"
10		10	300ms	Letter Space
11	C	11	300ms	Dash, "-"
12		10	100ms	Space
13		11	100ms	Dot, "."
14		10	100ms	Space
15		11	300ms	Dash, "-"
16		10	100ms	Space
17		11	100ms	Dot, "."
18		10	6s	Word Space

The MEMORY SEQUENCE can be sent using the AUTO or the SINGLE mode of the MEM SEQ menu.

10 Appendix

VOR Carrier Frequencies (MHz)

108.00	112.00	114.00	115.95
108.05	112.05	114.05	116.00
108.20	112.10	114.05	116.05
108.25	112.15	114.10	116.10
108.40	112.20	114.15	116.15
108.45	112.25	114.20	116.20
108.60	112.30	114.25	116.25
108.65	112.35	114.30	116.30
108.80	112.40	114.35	116.35
108.85	112.45	114.40	116.40
109.00	112.50	114.45	116.45
109.05	112.55	114.50	116.50
109.20	112.60	114.55	116.55
109.25	112.65	114.60	116.60
109.40	112.70	114.65	116.65
109.45	112.75	114.70	116.70
109.60	112.80	114.75	116.75
109.65	112.85	114.80	116.80
109.80	112.90	114.85	116.85
109.85	112.95	114.90	116.90
110.00	113.00	114.95	116.95
110.05	113.05	115.00	117.00
110.20	113.10	115.05	117.10
110.25	113.15	115.10	117.15
110.40	113.20	115.15	117.20
110.45	113.25	115.20	117.25
110.60	113.30	115.25	117.30
110.65	113.35	115.30	117.35
110.80	113.40	115.35	117.40
110.85	113.45	115.40	117.45
111.00	113.50	115.45	117.50
111.05	113.55	115.50	117.55
111.20	113.60	115.55	117.60
111.25	113.65	115.60	117.65
111.40	113.70	115.65	117.70
111.45	113.75	115.70	117.75
111.60	113.80	115.75	117.80
111.65	113.85	115.80	117.85
111.80	113.90	115.85	117.90
111.85	113.95	115.90	117.95

Table 1