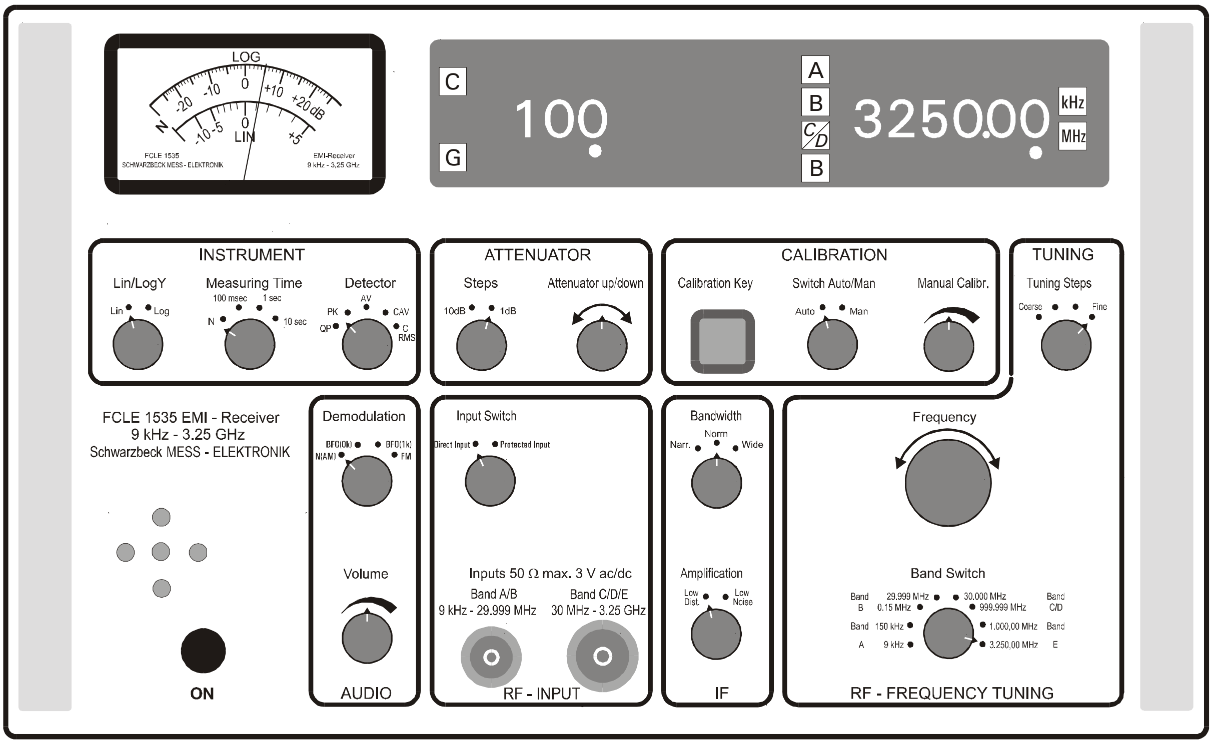
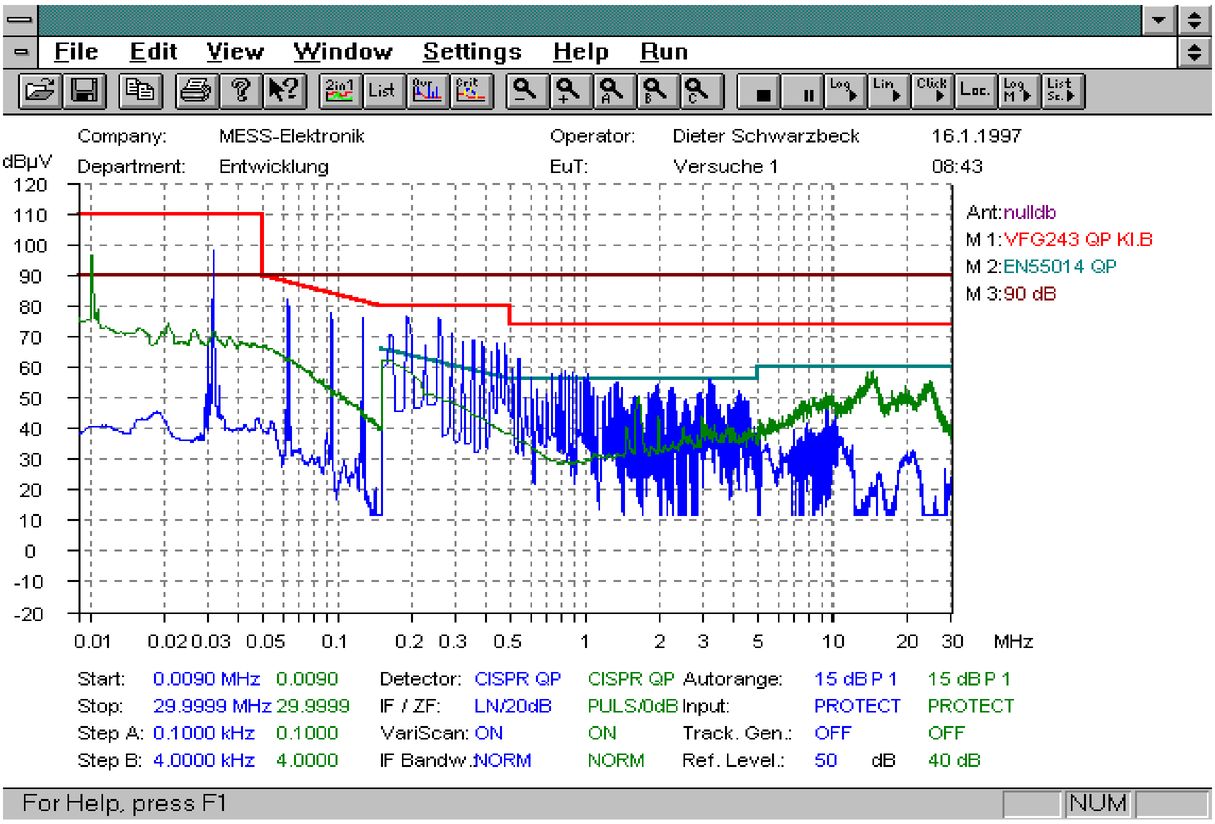
SCHWARZBECK MESS - ELEKTRONIK

An der Klinge 29 D-69250 Schönau Tel.: (+49)6228/1001
Fax.: (+49)6228/1003 E-mail: office@schwarzbeck.de

FCLE 1535 Interference Measuring Receiver
9 kHz - 3250 MHz





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1 FCLE 1535 Introduction

For many decades interference measuring receivers were designed to cover one or two emc frequency bands. Designing receivers for a single band is still reasonable because of the fact that conducted voltage measurement below 30 MHz (band AB) with a L.I.S.N. and fieldstrength measurement beyond 30 MHz (band CDE) with antennas require completely different receiver virtues.

In band AB (frequency range 9 kHz - 30 MHz) the most important measurement is conducted interference (voltage) measurement. The limits are relatively high and sometimes the equipment under test delivers powerful pulse spectrum to the receiver via the L.I.S.N.. Only emc - receivers with a very robust front end will work without non - linear pulse limiters.

In band CD (frequency range 30 MHz - 1000 MHz) the most important measurement is fieldstrength using antennas. The limits are very low and antenna factors and cable loss make the situation even worse. So the receiver has to deal with the combination of broad band pulse spectrum which is still present at these frequencies and high sensitivity to measure the low limits.

In band E (above 1 GHz) it is assumed that no broad band pulse spectrum exists and therefore the receiver should be optimised for best sensitivity.

One common receiver front end for 9 kHz to several GHz cannot fulfil these contrary requirements without substantial compromise.

It is for this reason that the FCLE 1535 has separate units for the bands.
Only auxiliary functions are shared.

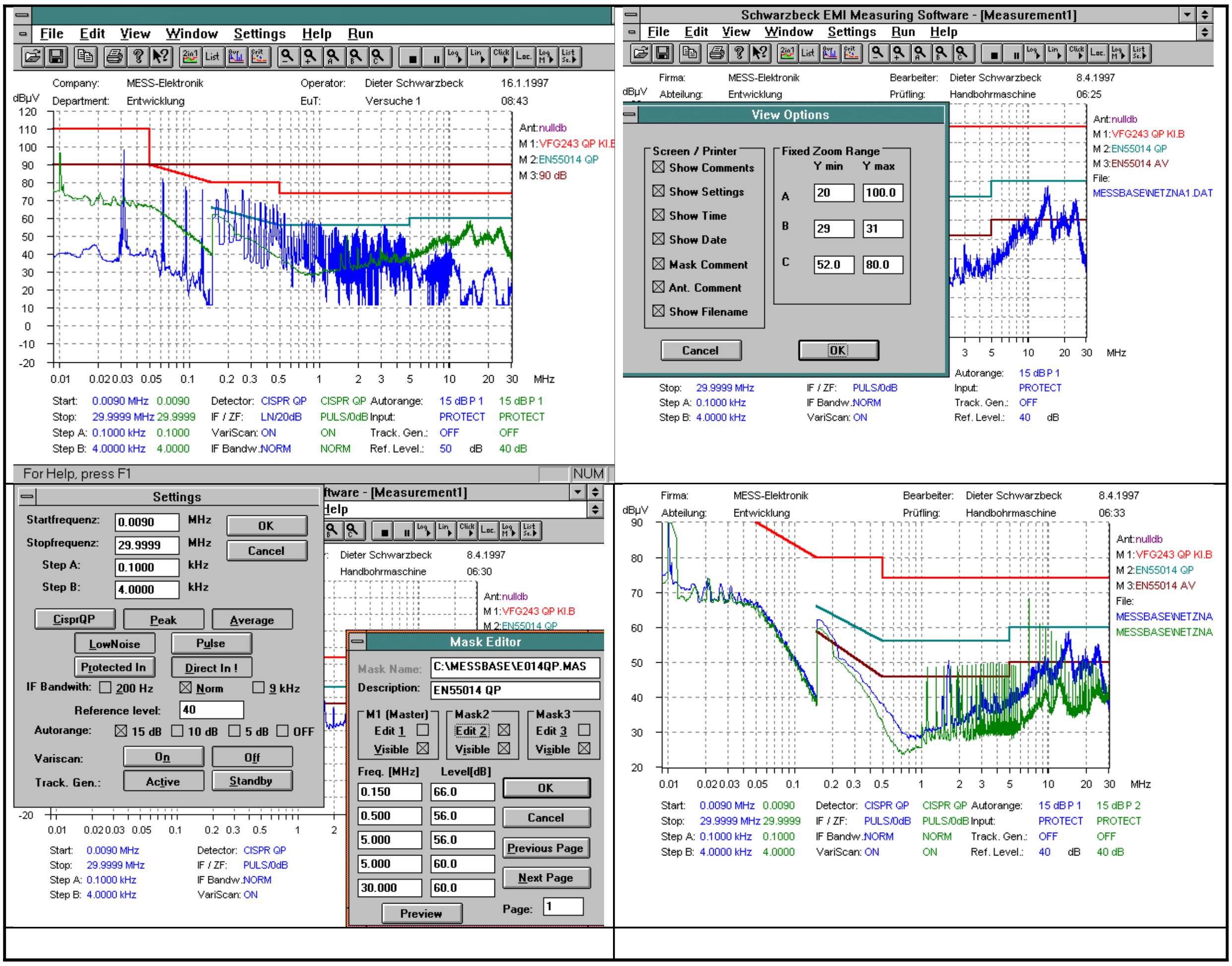
It is due to this unique design that the FCLE 1535 is equal to or better than any single band receiver on its specific band.
This specific circuit design begins on the front panel with two different r.f. - input connectors.

2 FCLE 1535 Front panel operation

The FCLE 1535 has a complete front panel for manual operation with many measurement options.
The front panel is clearly divided in areas.
The bands A/B/C/D/E with their lower and upper frequencies are selected via a rotary switch.
A big moving coil meter serves for comfortable reading of the measurement.
Reading the meter at 0 dB "centre of meter" automatically presets the receiver's dynamic range at the best position between internal noise and saturation.
A peak - gating circuit with 3 different gating times shows the maximum reading of even a slow pulse.
The audio with built in loudspeaker helps to identify am - and fm - signals.
A bfo - circuit identifies even unmodulated sine wave signals (narrow band).

3 Messbase-Software for Emission-tests under MS-WINDOWS 95/98/NT/2000/XP

- Easy to learn and to use
- Fast & Reliable with Variscan and Autorange
- High security against overload using mask-guidance
- User editable limits and antenna factors guarantee high flexibility
- Interactive final measurements with automatic test report generation
- Automatic creation and scan of frequency lists
- Free scalable prints
- User definable creation of test reports
- Convenient graphic features and data transfer to other Windows applications
- Marker with integrated final measurement capability
- Subranges reduce measuring time and provide data reduction
- Remote control for LISN or coaxial switching unit included
- Additional IEEE 488-devices can be integrated on request
- Attenuation measurements > 100 dB for site performance checks or insertion loss of filters
- Comparison of two measured diagrams and up to 3 masks simultaneously
- Accelerator keys for frequently used functions speed up operation
- Click measurement with 10 samples per second
- Context sensitive Online Help
- Macros performing up to 32 time-consuming measurements
- Find the Maximum Envelope out of a set of measurements



4 Specifications

Detektoren		
	CISPR Quasi-Peak	QP
	Peak	PK
	Average	AV
	CISPR-Average	CAV
	CISPR-RMS	CRMS

Frequency			
Frequency ranges	Band A 9 kHz - 150,99 kHz		
	Band B 150 kHz - 29,999 MHz		
	Band CD 30 MHz - 999,999 MHz		
	Band E 1000 MHz - 3.259,99 MHz		
Reference frequency accuracy	$3x10^{-6}$		
Frequency display	Band A 100 kHz, 10 kHz, 1 kHz, 100 Hz, 10 Hz		
(front panel)	Band B 10 MHz, 1 MHz, 100 kHz, 10 kHz,1 kHz		
	Band CD 100 MHz, 10 MHz, 1 MHz, 100 kHz, 10 kHz, 1kHz		
	Band E 1 GHz, 100 MHz, 10 MHz, 1 MHz, 100 kHz, 10 kHz		
Level			
Step attenuator			
Voltage level	Band A 0-120 dBµV		
for 0 dB	Band B 0-120 dBµV		
centre of instrument	Band CD 10-120 dBµV		
	Band E 10-100 dBµV		

Internal noise level

Band	**Detector**	**Bandwidth** Narrow	Norm	Wide
A	Quasi-Peak	-------------------------------	-30 dBµV (200 Hz/- 6dB)	------------------------------
A	Peak	-------------------------------	-25 dBµV (200 Hz/- 6dB)	------------------------------
A	Average	-------------------------------	-35 dBµV (200 Hz/- 6dB)	------------------------------
B	Quasi-Peak	-------------------------------	-14 dBµV (9 kHz/- 6dB)	------------------------------
B	Peak	-------------------------------	-9 dBµV (9 kHz/- 6dB)	------------------------------
B	Average	-------------------------------	-19 dBµV (9 kHz/- 6dB)	------------------------------
C/D	Quasi-Peak	-10 dBµV (9 kHz/- 6dB)	-4 dBµV (120 kHz/- 6dB)	+4 dBµV (1 MHz/- 6dB)
C/D	Peak	-5 dBµV (9 kHz/- 6dB)	+1 dBµV (120 kHz/- 6dB)	+9 dBµV (1 MHz/- 6dB)
C/D	Average	-15 dBµV (9 kHz/- 6dB)	-9 dBµV (120 kHz/- 6dB)	-1 dBµV (1 MkHz/-6dB)
E	Quasi-Peak	0 dBµV (120 kHz/- 6dB)	+7 dBµV (1 MHz/- 6dB)	------------------------------
E	Peak	+5 dBµV (120 kHz/- 6dB)	+12 dBµV (1 MHz/- 6dB)	------------------------------
E	Average	-5 dBµV (120 kHz/- 6dB)	+2 dBµV (1 MHz/- 6dB)	------------------------------

Noise Indication Band E 1 GHz-3 GHz typ.

Maximum input voltage level for r.f. - input attenuation >10 dB

Band	Direct Input	Protected Input
AB	Sine wave 130 dBµV Spectral pulse density 96 dBµV/MHz	Sine wave 141 dBµV
CD	Sine wave 130 dBµV Spectral pulse density 96 dBµV/MHz (<0,5 nsec.)	--
E	Sine wave 130 dBµV	--

Level display (Front panel)

Attenuator	100 dB, 10 dB, 1 dB
Meter linear	(10 dB), -5 dB, 0 dB centre of meter, + 5 dB , linear voltage
Meter logarithmic	-20 dB, 0 dB , + 20 dB, centre of meter, linear voltage

R.f. - Input

Band	AB	CD	E
R.f.- Connector	BNC - connector 50 Ω	N - Connector 50 Ω	
VSWR	<1,2 (Attenuator >10 dB)	<1,2 (Attenuator >10 dB)	<1,8 (Attenuator >16 dB)

In- and Outputs (Rear panel)

Band	AB	CD	E
I.f - Output standard	45 kHz	2 MHz	
I.f.- Output optional	40 MHz	10,7 MHz	
L.I.S.N - control Sub-D 9-pin	for PC - control of Schwarzbeck L.I.S.N		
Sub-D 25-pin	Control and Power supply of auxiliaries		
IEC - bus - remote control	for PC - control via optional, built in interface		

Dimensions, Weight, Power supply

Mains, Power supply	100 V - 240 AC, 50 - 60 Hz	Power consumption < 50 VA (35 W typ.)
Cabinet Dimensions	450 x 280 x 470 mm	
Weight	approx. 29 kg	

Remarks: Technical data is valid after a 30 minutes warm - up under the specified environmental conditions. The calibration cycle and the self calibration must be observed. Data without tolerance and nominal - data are typical.

5 Setting up the receiver

The FCLE 1535 is intended for use in a dry laboratory environment in- or outside of shielding rooms or unechoic chambers.
The normal operating position is horizontal.
Please read the safety information very carefully.

Safety - Information

The receiver is operated with mains voltages from 110 V (100 V) to 240 V a.c. 50 Hz / 60 Hz.

In the power supply the safety ground wire is connected to the receiver's ground via a ferrite choke. This was made to avoid rf coupling because of multi grounding. The wire used for the choke has the necessary gauge for the current needed for the fuses to blow. The transformer was designed according to the rules of the German standard "Schutzklasse 2" for isolated appliances.
Primary and secondary windings are located on separate parts of the coil former and therefore have a very good isolation and a very small cross capacitance. Both mains wires are protected by fuses, which can be changed only by using a tool..

The **mains switch** *is also located in the power supply unit and driven by an isolated shaft coming from the front panel. In the receiver therefore there are no high voltages. The primary part of the power supply is tested for 4000 volts ac eff. 50/60 Hz.*
To comply with the regulations of most countries, the receiver was designed for the use with a safety ground connector. If for some reason a safety ground connection is not wanted, we recommend total isolation by an isolation transformer (100 VA).

If the mains plug of the standard cable has to be changed because of some different foreign standard, it is very important to connect the yellow/green safety ground to the safety ground of the mains. This connection has to be checked carefully! In the final system there is usually a second grounding via the L.I.S.N., which itself is grounded via the metal wall of the shielding room.

Problems because of this second grounding will not occur because of the ground choke, which is introduced in the safety ground wire of the receiver.

Extreme care is necessary when connecting a L.I.S.N.: According to CISPR-(16)- and VDE(0876) they use high grounding capacitances. Using a NSLK (50 Ω// 50 µH + 5 Ω) this ground current can reach up to 0,9 A. Such a L.I.S.N. must therefor be grounded before connecting to mains. Grounding is possible either by connecting the ground clamps of the L.I.S.N. to the metal wall of the shielding room or by connecting the rear safety ground clamp with the mains ground. The NSLK-types use a fixed mains connector which makes a safety ground connection when plugging in. Double safety is given by the connection to the metal wall of the shielding room already made before. FI-switches which sense the current on the safety wire are not useful because of the ground current of the L.I.S.N. This would result in a instantaneous disconnection. An isolation transformer can be a solution if such problems occur.
Only qualified personnel is authorised to connect a L.I.S.N.!

Mains Voltage Selector/Fuse Holder

Disconnect mains cable before working on voltage selector/fuse holder!

The receiver uses a linear regulator power supply with a conventional transformer at the input to avoid any interference problem common with switching regulators.
The desired mains voltage is selected by rotating the inner area of the voltage selector to the correct position.
Different mains voltage leads to different supply current, so there are two different fuse - currents to choose.
Remove the holder box and insert the correct fuses.

6 Front panel

The front panel is divided into functional areas which are described on the following pages.

The LED - elements behind the red window are nearly invisible in the OFF - state.

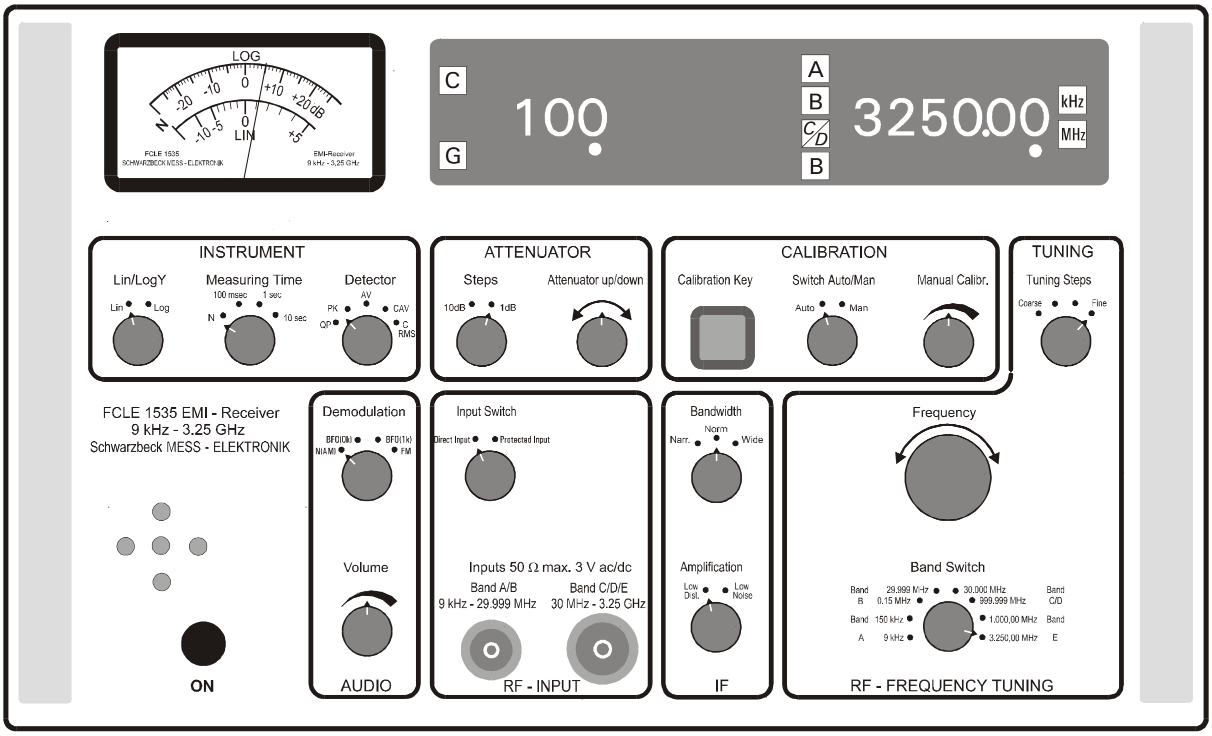
Some LEDs may be OFF even when the receiver is switched ON.

The receiver is switched ON / OFF by pushing the button on the bottom left side of the front panel.

The IEEE - interface is switched ON / OFF with the respective switch on the rear panel.

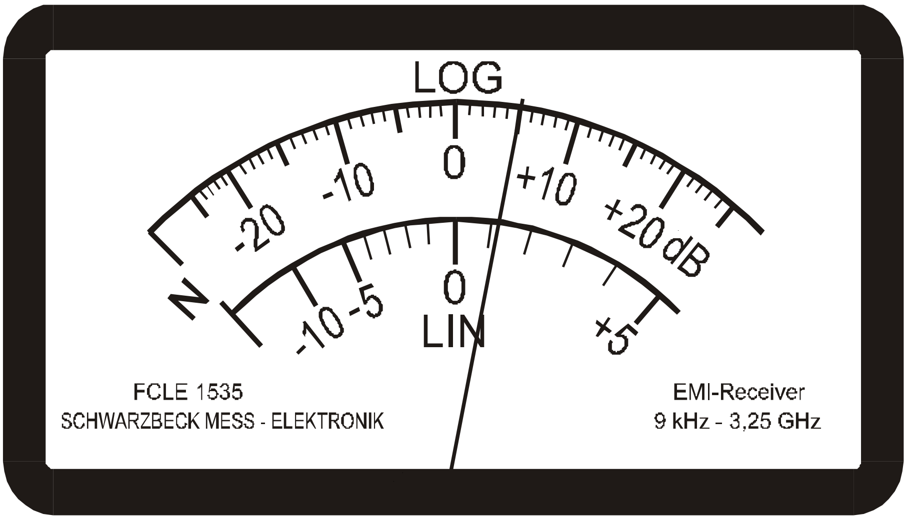
A red line is visible when the switch is in the ON - position

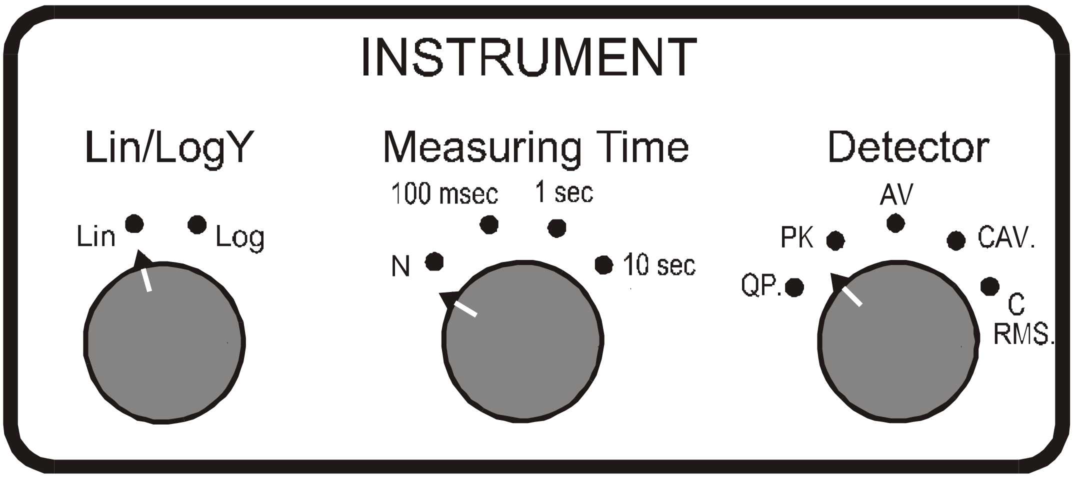
We recommend to switch OFF the interface when not in use.



7 Description of the areas and their function

7.1 Field I n s t r u m e n t



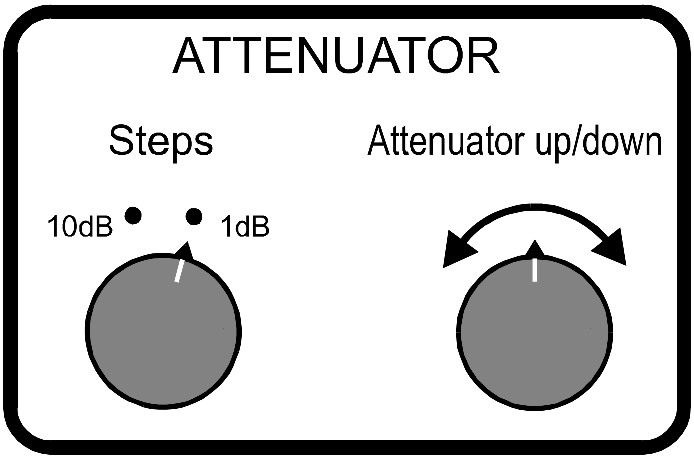


1. The switch L i n / L o g Y chooses the respective meter scale.
The lower scale is the linear scale for very precise measurement avoiding any side effects of a logarithmic converter. The scale responds in a linear law to the input voltage of the receiver, but the units of the scaling are dBs. This is the reason why the linear scale doesn't "look" linear. If the scaling would be made in voltage (µV, µV, V) the scale would "look" linear, but voltage (µV) instead of voltage level (dBµV) is very unusual in the emc - world. The upper scale shows the logarithm of the lower scale and is very convenient for overview measurement.

2. When the switch M e a s u r i n g T i m e is set to N, the meter indicator will follow instantaneously. Choosing the appropriate measuring time will show the maximum of slow pulses very easily even if they occur only for a short time.
The symbol "G" (Gate) will show as long as the measuring time is running.
At the end of the measuring time the maximum appears on the meter.

3. The switch D e t e c t o r determines the appropriate detector according to the measuring standards.

7.2 Field A t t e n u a t o r



The field A t t e n u a t o r serves for the control of the step attenuator.
The step attenuator attenuates the input signal to a level which is appropriate for the receiver's front end.

Switch S t e p s chooses between attenuator steps of 1 dB or 10 dB when the rotary encoder A t t e n u a t o r u p / d o w n is operated.

For an overview with the logarithmic scale 10 dB is convenient.

For precise measurement 1 dB is best choice.

Adjust the step attenuator until the indicator of the meter points to the 0 dB "centre of meter" of the linear scale.

The 3 - digit LED - display combines step attenuator, "Protected Input" and "Low Noise" or Low Distortion".
The active digit (1 dB. 10 dB) is marked by a LED.

The result is the sum of the 3 - digit display and the meter reading.

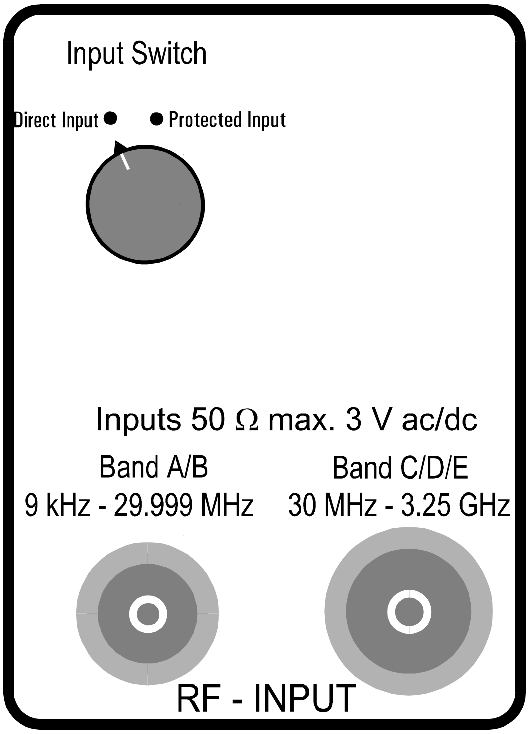
The scale on the left side of 0 dB "centre of meter" is negative (to be subtracted) and the scale right is positive (to be added).

Measuring with the FCLE 1535 is based on a compensation method.
Standard is the internal pulse generator.

The signal to be measured is attenuated by the step attenuator to a level equal to the standard.

So there are only 2 reliable and long term stable components really involved in the measurement.

7.3 Field R F - I n p u t



1. The FCLE 1535 provides 2 r.f. - input connectors.

The frequencies < 30 MHz, also called bands A and B belong to the (left) BNC-connector.

The frequencies > 30 MHz, also called bands C, D and E belong to the (right) N-connector.

Both connectors can be connected at the same time. For example a l.i.s.n. on the left and an antenna on the right.

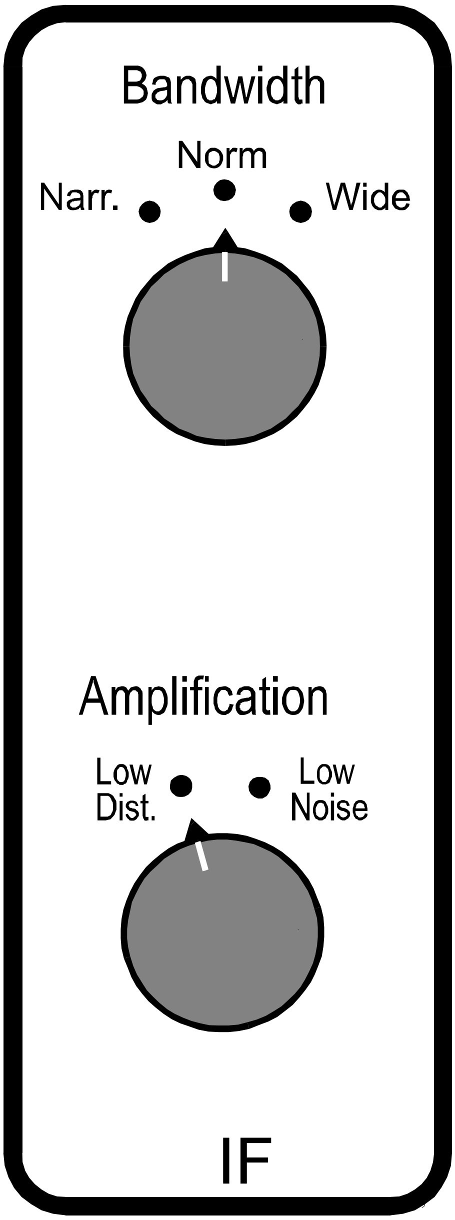
2. I n p u t S w i t c h connects the BNC - connector directly (Direct Input) to the receiver's front end or via a power attenuator (Protected input).

Practical limits in band AB always permit the power attenuator (Protected Input).
It is good practice to keep the power attenuator always switched on because it protects the receiver from high energy spikes coming from the l.i.s.n..

The power attenuator is not available in band CDE.

The N - connector is always directly connected to the input of the r.f. step - attenuator of the frequency range > 30 MHz.

7.4 Field I F



This field controls the receiver settings in the i.f.- section.

1. Switch B a n d w i d t h chooses different i.f. - bandwidths.
Position Norm automatically chooses the correct bandwidth according to CISPR 16.

Band A:
Always normal bandwidth 200 Hz / 6dB independent of the position.

Band B:
Always normal bandwidth 9 kHz / 6 dB independent of the position.

Band CD:
Narr.: 9 kHz / 6 dB
Norm: Normal bandwidth 120 kHz / 6 dB
Wide: 1 MHz / 6 dB

Band E:
Narr.: 120 kHz / 6 dB
Norm, Wide: 1 MHz / 6 dB

Narrow bandwidth reduces noise. This is useful for sine wave measurement near the noise floor.

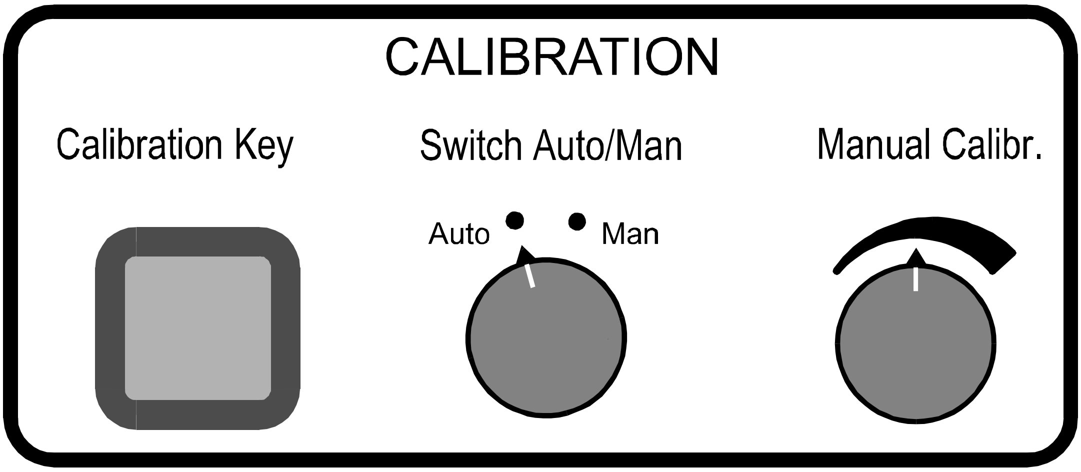
Wide bandwidth is convenient to measure signals with drifting or wobbling frequency.

Measuring pulse spectrum with a bandwidth different from the standard will result in different reading!

The proposed measurement in band E with 1 MHz bandwidth and the peak - detector results in an extremely high noise level.
For narrow - band sine wave signals Narr. (120 kHz / 6 dB) will give less noise.
Under the above condition it is possible to use the average detector with even lower noise indication.
This method is not possible for broad band and modulated signals!

2. Switch A m p l i f i c a t i o n determines the receiver's i.f. - amplification.
Position Low Distortion means low signal level on the receiver's front end and will show high noise indication. This reduces overload and intermodulation for best response to broad band pulse spectrum
Position Low Noise means high signal level leading to low noise indication.
There is a danger of saturation and intermodulation with broad band pulse spectrum.
In Band E the switch is disabled and the receiver chooses the best combination of r.f- and i.f. amplification for best sensitivity.

7.5 Field C a l i b r a t i o n



For highest precision the receiver has different pulse generators for the different bands

When the C a l i b r a t i o n K e y is pushed, the pulse generator corresponding to the receiver's tuning frequency is activated and connected to the front end.
The pulse noise can be heard as a "hum" or "buzz" via the loudspeaker.
While the calibration process is running the symbol C can be seen in the red window near the right side of the meter.

In position Auto of the switch S w i t c h A u t o / M a n the receiver automatically adjusts the amplification to the correct value when the calibration process was started by pushing the C a l i b r a t i o n K e y only for a moment.

The meter indicator will move from the left to the right until it stops on 0 dB "centre of meter", where the process is completed.

In position Man of the switch S w i t c h A u t o / M a n the user adjusts the receiver's amplification by rotating "Manual Calibration" while the calibration key is constantly pushed. When the indicator has reached 0 dB "centre of meter" the calibration process is done.

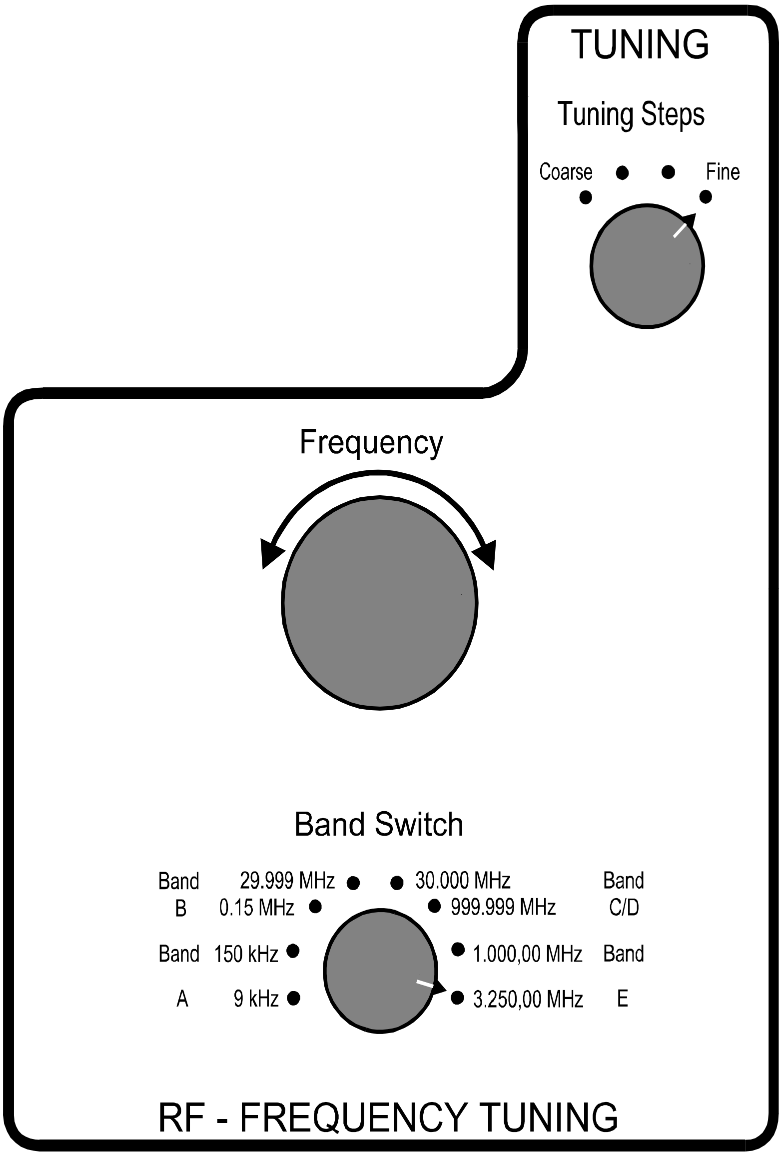
The manual calibration is very useful in the every day laboratory work as a compensation or offset. The 0 dB "centre of meter" can be shifted by some dBs to use external generators as a reference or to compensate for cable loss.

Attention:

Switch in position Auto: The receiver automatically calibrates whenever bands are changed.

This is not the case in position Man!
As the calibration data may differ from band to band by some dBs, the measurement may be wrong without recalibration after changing bands!

7.6 Field R F - F R E Q U E N C Y - T U N I N G



Switch T U N I N G selects the digit to tune the frequency when rotating the rotary encoder.
The active digit is marked by a LED below.

The frequency display is in kHz or MHz according to the LEDs on the right side.

The coarse steps are used for overview, the fine steps for precise measurement of narrow band signals.

Steps and display automatically adapt to the practical requirements of the bands.

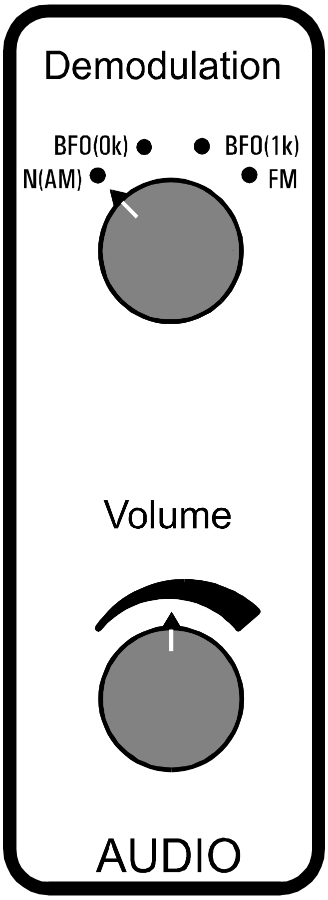
Switch B a n d S w i t c h chooses the bands.
For each band there are positions for upper and lower frequency limit.

These positions give fast and convenient access to the corner frequencies of every band.

When Calibration Auto is chosen, the receiver recalibrates after changing bands with B a n d S w i t c h .

This is not the case in position Man!
As the calibration data may differ from band to band by some dBs, the measurement may be wrong without recalibration after changing bands!

7.7 Field A U D I O



It is good practice to listen to the audio of interference signals to discover their nature and origin.

Switch D e m o d u l a t i o n selects various demodulators.

N(AM) is a standard a.m - demodulator similar to those used in a.m - radios. This corresponds to radio stations in Band B.
Pulse spectrum is heard as a "hum" or "buzz". Radio stations can be easily identified in order to prevent them from being misunderstood as emc - signals.
N(AM) is available on all bands.

The precise frequency of a sine wave signal can be determined using the BFO (0 kHz).
Approaching a sine wave signal from lower frequencies gives a "beat" getting lower until the beat is zero, when both frequencies are equal.

Towards higher frequencies also the "beat frequency" is getting higher until the signal fades.

Due to the very narrow bandwidth of band A, the a.m.-demodulator is very ineffective.
The BFO in this case is the better choice.

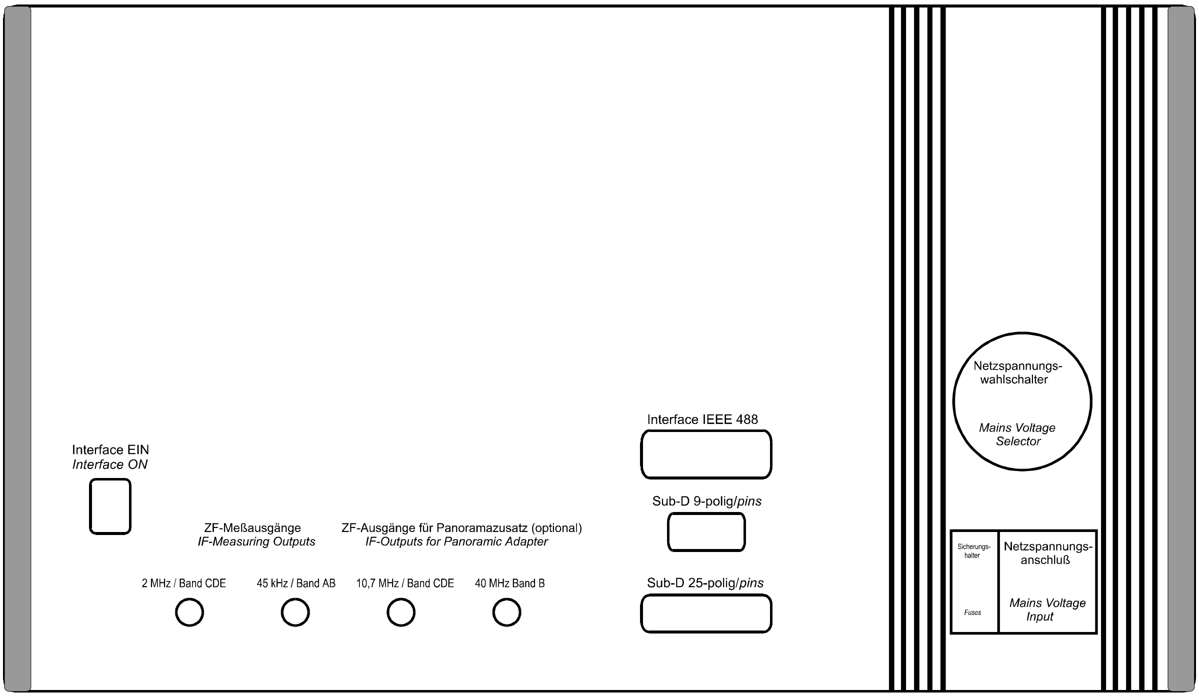
The BFO is only available in band AB.

FM is available in bands CDE to reveal frequency modulation.
This corresponds to the fm - radio stations and land / mobile radio services.

FM is not available in band AB.

V o l u m e controls audio volume of the loudspeaker.

8 Rear panel



Please read chapter Safety - Information and Mains Voltage Selector/Fuse Holder on page 5

Switch I E E E - I n t e r f a c e is ON, when the red line is visible.
Switch ON Interface only when you need it.

15 Sub - D - connector 25-pins

Pin	Function
1	Ground
2	(+12 V for frequency range 30 MHz - 400 MHz and Band E) optional
3	(+12 V for frequency range 400 MHz -1000 MHz) optional
4	+12 V for Band AB
5	+12 V for Band CD
6	+12 V for Band E
7	
8	
9	
10	
11	
12	
13	
14	+12 V for external auxiliary equipment
15	-12 V for external auxiliary equipment
16	Output active demodulator
17	Output active demodulator signal ground
18	
19	
20	
21	
22	(+12 V Low Noise) optional
23	
24	
25	Instrument voltage (recorder Y)

16 Sub-D-Connector 9 pins L.I.S.N, remote control

Remote control via the 9 pin connector on the rear panel.

	D	C	B	A	Function	
0	0	0	0	0	no Phase	no ground choke
1	0	0	0	1	no Phase	no ground choke
2	0	0	1	0	Phase 0	no ground choke
3	0	0	1	1	Phase 1	no ground choke
4	0	1	0	0	Phase 2	no ground choke
5	0	1	0	1	Phase 3	no ground choke
6	0	1	1	0	no Phase	no ground choke
7	0	1	1	1	no Phase	no ground choke
8	1	0	0	0	no Phase	with grd. choke
9	1	0	0	1	no Phase	with grd. choke
A	1	0	1	0	Phase 0	with grd.choke
B	1	0	1	1	Phase 1	with grd.choke
C	1	1	0	0	Phase 2	with grd.choke
D	1	1	0	1	Phase 3	with grd. choke
E	1	1	1	0	no Phase	with grd. choke
F	1	1	1	1	no Phase	with grd.choke

Pin out of the 9 pin connector

Pin	Function
1	Remote (Logic 1, High for Remote)
2	D
3	C
4	B
5	A
6	Logic Ground
7	nc
8	nc
9	+12 V

All Signals ttl or 0 V / +5 V positive logic.

The control signals have to be present permanently. The chosen state of the L.I.S.N. is only present as long as the logic signals are present.
Normally the Schwarzbeck receiver provides the control signals via the connection of the 9-pin connectors on the rear panel.
Other receivers need interfacing.

8.3 FCLE-GPIB

Byte via GPIB	Pin Assignment 64-pin Connector	Strobe 1	Strobe 2	Write
Signals with multiple functions				
cmdbyte[0]=8	C 32	D / Z5	D / 80 dB	A/D 2048
cmdbyte[0]=4	A 31	C / Z5	C / 40 dB	A/D 1024
cmdbyte[0]=2	C 31	B / Z5	B / 20 dB	A/D 512
cmdbyte[0]=1	A 30	A / Z5	A / 10 dB	A/D 256
cmdbyte[1]=8	A 28	D / Z4	D / 8 dB	A/D 128
cmdbyte[1]=4	C 29	C / Z4	C / 4 dB	A/D 64
cmdbyte[1]=2	A 29	B / Z4	B / 2 dB	A/D 32
cmdbyte[1]=1	C 30	A / Z4	A / 1 dB	A/D 16
cmdbyte[2]=8	A 26	D / Z3	Direct Input	A/D 8
cmdbyte[2]=4	C 27	C / Z3	Low Noise	A/D 4
cmdbyte[2]=2	A 27	B / Z3	Band E	A/D 2
cmdbyte[2]=1	C 28	A / Z3	Band CD	A/D 1
cmdbyte[3]=8	C 26	D / Z2	Band B	Conv. OK
cmdbyte[3]=4	A 25	C / Z2	Band A	FCLE OK
cmdbyte[3]=2	C 25	B / Z2	M 2 Measuring time	Variscan slow
cmdbyte[3]=1	A 24	A / Z2	M 1 Measuring time	
cmdbyte[4]=8	C 24	D / Z1	M 0 Mesasuring timet	
cmdbyte[4]=4	A 23	C / Z1	BB Narrow	
cmdbyte[4]=2	C 23	B / Z1	BB Norm	
cmdbyte[4]=1	A 22	A / Z1	BB Wide	
cmdbyte[5]=8	A 20	D / Z0	Avg.-Detector	
cmdbyte[5]=4	C 21	C / Z0	Peak-Detector	
cmdbyte[5]=2	A 21	B / Z0	Preamplifier*	
cmdbyte[5]=1	C 22	A / Z0	Tracking-Gen.*	
cmdbyte[6]=8	C 19	Auto Calibration		
cmdbyte[6]=4	A 16	Reset Detectors		
cmdbyte[6]=2	A 19	A/D Conversion		
cmdbyte[6]=1	C 20	Write		
cmdbyte[7]=8	A 18	Strobe1		
cmdbyte[7]=4	C 18	Strobe2		
cmdbyte[7]=2	A 17	-		
cmdbyte[7]=1	C 17	-		
cmdbyte[8]=8	C 16	-		
cmdbyte[8]=4	A 15	-		
cmdbyte[8]=2	C 15	-		
cmdbyte[8]=1	A 14	Remote FCLE		
cmdbyte[9]=8	C 14	-		
cmdbyte[9]=4	A 13	-		
cmdbyte[9]=2	C 13	-		
cmdbyte[9]=1	A 12	-		
cmdbyte[10]=8	C 12	LISN A		
cmdbyte[10]=4	A 11	LISN B		
cmdbyte[10]=2	C 11	LISN C		
cmdbyte[10]=1	A 10	LISN D		

	Band A	Band B	Band CD	Band E
D / Z 5	(800 kHz)	(80 MHz)	800 MHz	(8 GHz)
C / Z 5	(400 kHz)	(40 MHz)	400 MHz	(4 GHz)
B / Z 5	(200 kHz)	20 MHz	200 MHz	2 GHz
A / Z 5	100 kHz	10 MHz	100 MHz	1 GHz
D / Z 4	80 kHz	8 MHz	80 MHz	800 MHz

C / Z 4	40 kHz	4 MHz	40 MHz	400 MHz
B / Z 4	20 kHz	2 MHz	20 MHz	200 MHz
A / Z 4	10 kHz	1 MHz	10 MHz	100 MHz
D / Z 3	8 kHz	800 kHz	8 MHz	80 MHz
C / Z 3	4 kHz	400 kHz	4 MHz	40 MHz
B / Z 3	2 kHz	200 kHz	2 MHz	20 MHz
A / Z 3	1 kHz	100 kHz	1 MHz	10 MHz
D / Z 2	800 Hz	80 kHz	800 kHz	8 MHz
C / Z 2	400 Hz	40 kHz	400 kHz	4 MHz
B / Z 2	200 Hz	20 kHz	200 kHz	2 MHz
A / Z 2	100 Hz	10 kHz	100 kHz	1 MHz
D / Z 1	80 Hz	8 kHz	80 kHz	800 kHz
C / Z 1	40 Hz	4 kHz	40 kHz	400 kHz
B / Z 1	20 Hz	2 kHz	20 kHz	200 kHz
A / Z 1	10 Hz	1 kHz	10 kHz	100 kHz
D / Z 0	--	--	8 kHz	80 kHz
C / Z 0	--	--	4 kHz	40 kHz
B / Z 0	--	--	2 kHz	20 kHz
A / Z 0	--	--	1 kHz	10 kHz

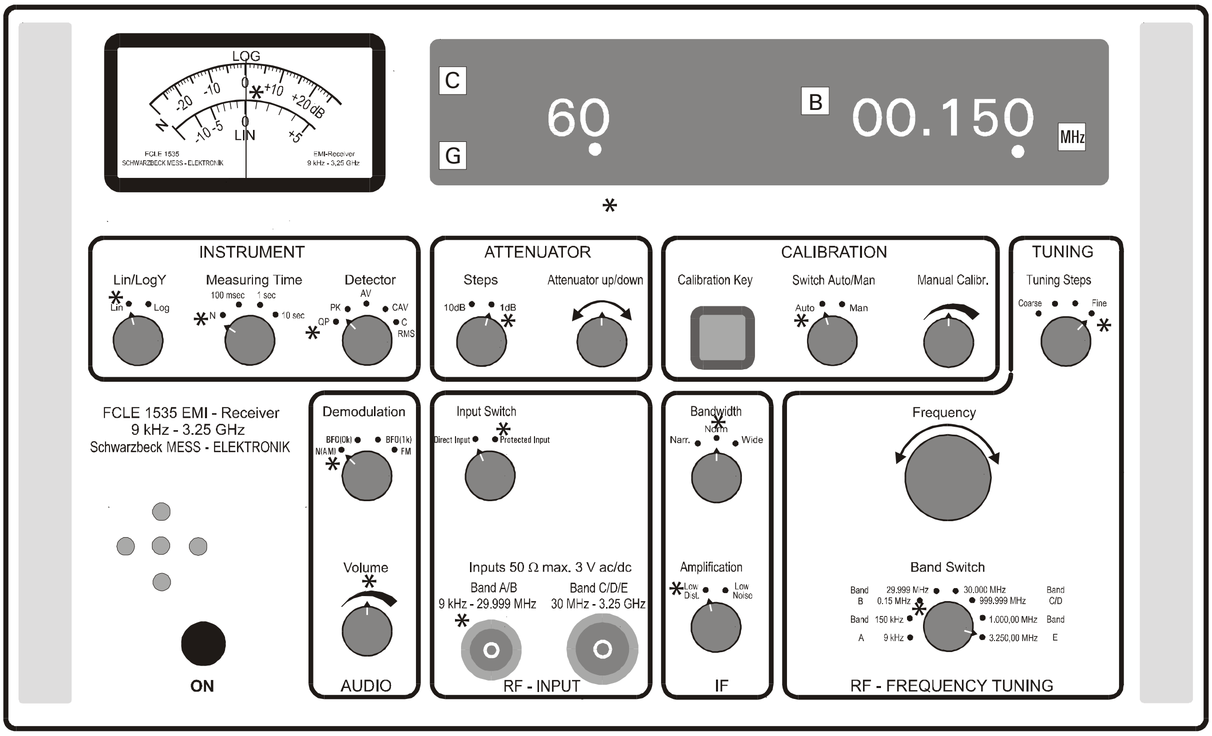
Messzeit M2	Messzeit M1	Messzeit M0	Function
0	0	0	Normal
0	0	1	100 msec
0	1	0	--
0	1	1	10 sec
1	0	0	1 sec
1	0	1	10 sec
1	1	0	--
1	1	1	--

9 Front panel measurement

Emc - measurement in band AB is mostly of the type conducted interference (voltage) using a l.i.s.n. as coupling device, which is connected to the left r.f. - input via a coaxial cable with bnc - connectors.
The antennas mostly used in band CDE are connected to the right r.f. - input via a coaxial cable with n - connectors.
The basic measurement procedure is the same for both antenna and l.i.s.n..
So the description below was written for band A/B and the l.i.s.n..

Step 1: Set the controls to the marked * positions before connecting the l.i.s.n..

<u>This is important for the I n p u t S w i t c h in position protected input!</u>



Step 2: Connect the r.f.- output of the l.i.s.n. to the receiver's left r.f. - input (bnc).

Step 3: Preset the attenuator (rotary encoder) to the limit which is given in the standard for the frequency to be measured.

Step 4: Preset the receiver frequency using the control (rotary encoder) F r e q u e n c y to the desired value.
Use position Fine (right) for band B.

Tuning with 1 - kHz - steps you can easily find the maximum of a narrow band (sine wave) signal.

Using this setting for band A will give 10 - Hz - steps which are fine enough for the very narrow 200 Hz - i.f. filter.

You may use this setting also for band CD to tune very smoothly with 1 kHz - steps, but for the 120 kHz - standard filter 10 kHz steps are faster and fine enough even for narrow band signals.

Use finer steps for narrow (non - standard) B a n d w i d t h .

For broad band overview measurement coarse step tuning is more convenient.

Step 5: Add the dB - reading on the meter - scale to the Attenuator reading to get the voltage level in dBµV.

For highest precision tune the attenuator until the meter indicator is near 0 dB "centre of meter", which is the best choice for the compromise between noise and saturation.

Depending on many factors (frequency, bandwidth, detector a.s.o.) there is a basic "meter reading" on the left side of the meter where the scale circles begin.
This is caused by the internal noise of the receiver.

Due to the fact that this noise is generated inside the receiver and not outside, it is not influenced by the input attenuator.
The reason is that the attenuator is located in front of the circuit which generates the internal noise.

It's absolutely wrong to misunderstand this internal noise as a measurement caused by an e.u.t..

The internal noise can be easily recognised using the audio.

If you are still uncertain just disconnect your coupling device (l.i.s,n., antenna) from the receiver's input.
Internal noise is still there.
External signals disappear.

More information in 10 (appendix).

10 Appendix

10.1 Meter and Meter Reading

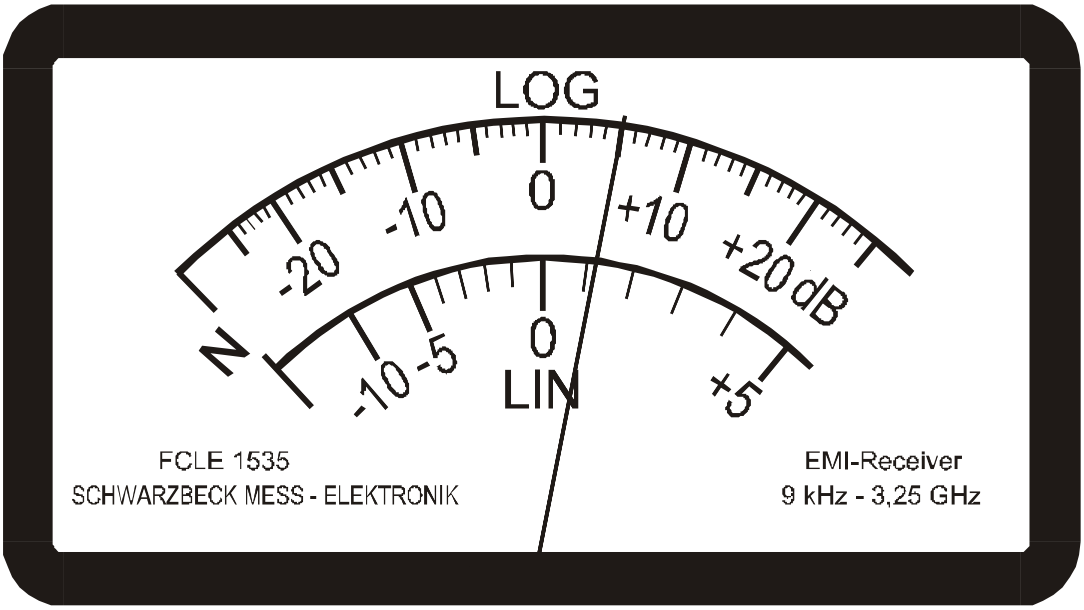
Basics

We consider an EMI - receiver as a frequency selective voltage meter.
Frequency selective means, that only a.c. - voltages of the tuned frequency are measured (within the specified bandwidth). Using the FCLE - receiver in the frequency range from 150 kHz to 30 MHz the bandwidth is 9 kHz (-6 dB).
A common analogue or digital multimeter also measures a.c. - voltages, but the measurement is not frequency selective in the useful frequency range.
This frequency range is limited by the low (some Hz) and high (some kHz) frequency limit, depending on the qualification of the meter in use.
The meter measures the sum, because all voltages within the range are fed to one rectifier.
One single high voltage dominates the measurement.
Weaker voltages on other frequencies don't influence the reading significantly.
The frequency selective EMI - receiver in contrast will show a multitude of voltages with different frequencies separately.
A common multimeter has a basic dynamic range in which different voltages can be measured without changing the range.
To extend the voltage range dividers are used to divide high voltages down to the basic range.
Common multimeters for example have switch positions for 200 mV, 2 V, 20 V, 200 V, 1000 V.
The smallest voltage to measure in the 200 mV-range is 0,1 mV, the highest 199,9 mV. Voltages < 0,1 mV are ignored, voltages > 199,9 mV show overflow.

In contrast to common multimeters which are scaled in V, EMI - receivers use a scaling in dBµV, which means dB over 1 µV.
The logarithmic dB - scaling is widely used in signal generators, pulse generators and receivers.
It is for this reason that the attenuator steps of the FCKL are also in dB.

Just like the multimeter the receiver has a basic dynamic range and an attenuator.
If the attenuator is switched to zero attenuation, a noise floor of less than -10 dBµV is measured in the frequency range 150 kHz - 30 MHz using the CISPR Quasi-Peak detector. 0 dB (centre of the meter scaling) is 0 dBµV/1 µV.
The right edge of the linear scale is +6 dBµV/2 µV.
The right edge of the logarithmic scale is +26 dBµV/17,8 µV.
The attenuator shifts this available dB - range into higher voltages, the attenuation has to be added to the meter reading.
This shift can also be made using the low noise position.
This attenuation is not added on the input, but near the output of the receiver and therefore reduces noise.
This makes measurement easier because of reduced noise errors, but it increases receiver loading which can result in errors caused by overload (saturation, compression, intermodulation).

10.2 Meter and Scaling



Zeroing

Mechanic zeroing of the meter: The indicator (pointer) is adjusted to the N - point on the left side of the meter scaling by turning the screw below the meter window.

Electric zeroing: Even when no signal is coming into receiver (coaxial cable disconnected), there are small „idle“ readings on the meter.
They are caused by the internal noise of the receiver and are different for different receiver settings. These noise reading is absolutely correct and no error.
Any method to avoid this basic noise would affect the measurement of small signals.

The noise reading depends on:

A) Linear and logarithmic scale: The logarithmic scale can show smaller signals than the linear one. This means that also the small „Noise Signal“ shows more indicator angle on the left side of the scale.

B) Low distortion / Low noise: Low distortion shows approx. 20 dB more noise than Low noise. Low noise gives a longer usable scale circle with the disadvantage of potential (non damage) receiver overload.

C) The frequency ranges band A (9 kHz - 150 kHz), band B (150 kHz - 30 MHz) and band CD (30 MHz - 1000 MHz) use different bandwidths and detector time constants. As a consequence the noise indication in band A is much lower than in band B or CD. Band E suffers most from noise because of the peak - detector and the 1 MHz - bandwidth. The receiver selects the i.f. - attenuation automatically. The switch is disabled.

D) The 3 different detectors differently convert receiver noise into noise reading. The Peak / Mil - detector shows the highest reading, followed by CISPR Quasi-Peak and Average.

Obviously a multitude of possible combinations lead to different noise readings.
It has to be considered that the same noise leads to different scale angles on linear and logarithmic scale, even though this is same reading.

The combination for the smallest noise reading is:
Frequency range: Band A (9 kHz-150 kHz)
Detector: Average

I.F. - Att.: Low noise
(Meter scale: Linear)

The combination for the highest noise reading is:
Frequency range: Band CD (30 MHz - 1000 MHz)
Detector: Peak
I.F. - Att.: Low distortion
(Meter scale: Logarithmic)

Usually CISPR Quasi-Peak is the standard detector.
The tables below show some characteristic noise readings for this detector.

Lin. Scale	Band A	Band B
low noise	very small	about 2 mm (0.1“) left of -10dB Point
low dist.	very small	very small

Log. Scale	Band A	Band B
low dist.	about 2 mm right of zero	high, about -14 dB *
low noise	very small	very small

* Using this setting, there may be a possible misreading caused by noise indication.
It is a good practice to listen to the sound coming from the receiver’s loudspeaker.
Usually there is a difference between receiver noise and an interference signal.
If you are unsure, disconnect the input coaxial cable to see and hear the difference.
Measuring near receiver noise floor should be avoided whenever possible, because the noise and interference to be measured add up to a higher reading.
Whenever possible reduce input attenuation to shift the indicator near the 0 dB (centre of meter) position.
This means best precision because of best compromise between noise and overload.

Scales

The upper scale is the logarithmic scale, the lower the linear scale.
Both of them have the 0 dB centre of meter.
On this point the receiver has optimum precision, which is derived from the internal pulse standard by substitution.
To the left precision is reduced because of receiver internal noise.
To the right precision is reduced because of potential overload (pulse compression especially with slow pulses / clicks).

Linear scale

Obviously the linear scale has no linear scaling (equal distances for dBs), which is somewhat of a contradiction.
The explanation for this strange behaviour is that the scale behaves linearly concerning voltages in V or µV, not dBµV.
The receiver converts the voltage on is input connector into proportional readings on the meter.
If we would make a scale in V or µV, this scale would be a linear scale.
However the scale used is a dBµV - scale, according to a logarithmic law.
Because of this logarithmic law the distances increase from left to right.
The table below shows this for some characteristic values.
Input voltage is in µV and the attenuator setting is 0 dB.

Input voltage in µV	Meter reading on the linear scale
0,316 µV	-10
0,354 µV	-9
0,398 µV	-8
0,446 µV	-7
0,501 µV	-6
0,501 µV	-5
0,630 µV	-4
0,707 µV	-3
0,794 µV	-2
0,891 µV	-1
1,000 µV	0 dB Centre of Meter
1,122 µV	+1
1,259 µV	+2
1,413 µV	+3
1,584 µV	+4
1,778 µV	+5
2,000 µV	+6

For the difference of 1 dB from -10 dB to -9 dB only an input voltage difference of 0,122 µV is needed.

For the difference between +5 dB and +6 dB we need 0,686 µV, nearly 6 times more.

This corresponds to the distances in the dB - scaling.

Logarithmic Scale

This scale permits a wide overview in a dB - linear scaling.
This is done by an analogue lin / log - converter.
In its right part the logarithmic scale can indicate 20 dB higher voltages, in its left part 15 dB smaller voltages than the linear scale.
Fast overview is easier this way, because switching of the attenuator is avoided.
On the other hand there are some limitations and problems, which could cause errors.

A) Errors caused by receiver noise:

Measuring within the frequency range of band B (150 kHz-30 MHz) and low distortion, a noise level of approx. -14 dB is present on the logarithmic scale, which might be considered as an interference signal caused by the d. u. t..

It is a good practice to listen to the loudspeaker to decide, whether it is noise or interference. Disconnecting the input coaxial cable shows clearly if the signal is produced inside or outside the receiver.

B) Overloading the receiver:
Even though the receiver is protected against damage especially in the protected input mode, there is a danger of wrong measurement especially when slow pulses are measured.

The situation is even worse, when the frequency spectrum shows big difference between minimum and maximum, which is often the case with high power inverters.

Connected to a l.i.s.n. they may well deliver interference voltages up to some volts to the EMI-receiver in the frequency range up to about 100 kHz.
At higher frequency the amplitudes are rapidly decreasing by 50 dB to 80 dB.
Such spectrum completely „consumes“ the available dynamic range of the receiver.

There is no safety margin to use the logarithmic scale near its +20 dB point in the low noise mode.

Under these circumstances a superimposed slow pulse might be measured too low, because the receiver has no more „breath“ left for the pulse.

On the other hand, the high voltages in the low frequency band might cause intermodulation distortion which could result in measurements at higher frequencies which are wrong, because they are produced in the receiver itself.

These problems occur far beyond the limits of standard measurements especially with high power, slow pulse equipment.

Standard equipment such as PCs and microprocessors don’t show these characteristics.

It is good practice to check measurement with the receiver on the safe side, which means low distortion on linear scale.