ROHDE & SCHWARZ

Manual

MODULATION ANALYZER FAM

334.2015.54

R 42219 - 1

Table of Contents

Tables within the text

Illustrations within the text

Table of Contents

Table of Contents

Table of Contents

ROHDE&SCHWARZ

FAM

MODULATION ANALYZER FAM (IEC625Bus)
55 kHz to 1360 MHz

Microprocessor .... automatic tuning for analysis
....
High-accuracy modulation measurement with AM, FM and phase modulation

RF measurement with 10 Hz resolution

Modulation frequency measurement with 0.1 Hz resolution

Distortion measurement at 30 fixed frequencies

Simultaneous readout of three parameters measured

Selectable test bandwidth, CCIR and CCITT weighting filters

AF voltage measurement (10 Hz to 200 kHz) with weighting filters

Remote control via IEC-bus interface

Data sheet
334 201
E – 2

Options

The FAM can be delivered or retrofitted with a number of options to suit different requirements.

1-GHz and 1.36-GHz Frequency-range Extensions FAM-B2

extend the frequency range of the FAM up to 1000 MHz or 1360 MHz (two models with otherwise equal characteristics).

CCITT Weighting Filter FAM-B6

in line with CCITT Rec. P 53.A for weighted measurement of unwanted modulation (perceived-loudness-characteristic filter).

CCIR Weighting Filter FAM-B7

in line with CCIR 468-2 and DIN 45405 for weighted measurement of unwanted modulation (perceived-loudness-characteristic filter; with required quasi-peak-responding detector built in).

DIST and SINAD Meter FAM-B8

for automatic measurement of modulation distortion or of distortion of external AF signals at 30 fixed frequencies from 30 Hz to 20 kHz.

Reference Oscillator SMS-B1

temperature-controlled, improves the frequency stability (temperature coefficient 1×10^{-7} in the operating temperature range; crystal aging 5×10^{-8}/month).

Operation

The front panel of the FAM is divided into three functional sections for easy operation and clear presentation of the results, several parameters being displayed simultaneously:

Left-hand section	**Carrier-frequency** display and entry (with manual tuning)
Middle section	**Result** display and setting of operating modes
Right-hand section	**Modulating-signal** display measuring section for modulating frequency, distortion, SINAD

Frequency setting. Setting is performed **fully automatically** under microprocessor control. When a signal is applied, the FAM tunes automatically to the input frequency within about 3 s and displays this frequency on the left-hand section with a resolution of 10 Hz.

If automatic tuning is not desired in specific cases or not possible, e.g. with heavily modulated AM signals (m > 80 %) or if several RF signals are applied, the tuning frequency can also be set by **keyboard entry**.

Example: Sequence of keys for manual entry of a frequency of 102.55 MHz:

[1] [0] [2] [.] [5] [5] [MAN]

The entered frequency is indicated for about 3 s on the left-hand display; the frequency of the applied signal is then measured again, the FAM retaining however the entered frequency setting.

Setting of RF level attenuator is also possible via keyboard or IEC bus (special function).

Weighting, detection. For weighting the modulation signal different deemphasis time constants (with FM) and filters can be selected. For proper weighting of the modulation signals (wanted or unwanted modulation) different types of detectors are available.

DEEMPH

■	50 µs
■	75 µs
■	750 µs
□	OFF

FILTER

HP 300 Hz	■	■	LP 200 kHz
HP 30 Hz	[ ]	[ ]	LP 20 kHz
HP 10 Hz	■	■	LP 3 kHz
CCIR	■	■	CCITT

Front-panel section: middle keyboard for weighting bandwidths and FM deemphasis

Deemphasis. Three switch-selectable deemphasis time constants are available for FM. By changing the position of an internal plug-in link the selected deemphasis can be rendered effective for the FM-MPX output (on rear panel) only, but not for the modulation display.

Filters. Three highpass and three lowpass filters provide a great variety of weighting bandwidths and suppress unwanted signals. The combination of HP 30 Hz and LP 20 kHz is in line with the filter to DIN 45405 Rec. 76 for noise voltage measurements. Standard filters (perceived-loudness-characteristic filter) to CCITT with rms-responding detector and to CCIR with quasi-peak-responding detector can be inserted for weighted S/N measurements. The filters are available as options which can also be retrofitted.

Type of detection. For measuring the amplitude of the AF modulation signals different types of detection can be chosen:

Peak-responding detection with indication of positive peak value P +, negative peak value P– and arithmetic mean – most frequently employed for measuring unwanted modulation – (P + P)/2, or true rms-responding detection (e.g. for measuring unwanted modulation). The CCIR weighting filter option includes the prescribed quasi-peak responding detector.

RF input frequency or
set frequency,
resolution 10 Hz (f_{in} < 1 GHz)

4-digit result of modulation measurement
(frequency deviation / phase / deviation /
modulation depth)
or AF input voltage,
relative value indication (% or dB)

Tendency indication of
modulation measurement
result (quasi analog),
for adjustments

AF modulation frequency /
AF frequency measurement up to 1 kHz
with 0.1 Hz resolution;
with option also distortion or SINAD measurement

Relative value display of measured data
in % or dB (related to key-entered reference value)

Automatic frequency setting
with RF signal applied

ROHDE & SCHWARZ · MODULATION ANALYZER · FAM · 55 kHz – 1360 MHz   334.2015.54

100.200 14 MHz   43.99 kHz   1024 kHz

RELATIVE

AUTO   MAN   FM   ΦM   AM   VOLT   REF   %   dB   OFF   AF-FREQ   DIST   SINAD

Switchover between modulation frequency
measurement / distortion measurement / SINAD
measurement (right-hand display section)

MADE IN GERMANY

Frequency setting by acceptance
of the frequency entered in MHz
(displayed for 3 s)

DEEMPH   FILTER   DETECTOR

7   8   9

4   5   6

1   2   3

0   .

Detection modes for pos. / neg. / average
peak value; true rms value (automatic
setting with voltmeter operation);
for sinewave: rms value converted to
peak value

50 μs   HP 300 Hz   LP 200 kHz   P+   RMS

75 μs   HP 30 Hz   LP 20 kHz   P+P/2   RMS/√2

750 μs   HP 10 Hz   LP 3 kHz   P–   PEAK CCIR

OFF   CCIR   CCITT   OPTION

Data input for RF (MAN),
reference value (REF),
special functions (S)

Quasi-peak-responding detection (option)

Shift key for entry of
special functions

RF
10 mV – 3 V

VOLTMETER
10 Hz – 200 kHz

REMOTE

AF
1 V

POWER

Program filter for unwanted modulation /
AF noise voltage measurement
(option; can be retrofitted)

RF input   50 Ω   100 kΩ

AF output (stabilized level)

FNr. 102542/5

IEC-bus control / manual operation

Demodulation modes
(FM / φM / AM) or
voltmeter operation

Deemphasis time
constants for FM
demodulation (effective
either for display and
all outputs or for stereo
MPX output only)

Voltmeter input
(floating)

Highpass und lowpass filters (for example
in unweighted noise voltage measurement:
HP 30 Hz + LP 20 kHz

MODULATION ANALYZER · FAM

Reference frequency
output (TTL)
or input (> 0.5 V,
sinewave or
squarewave);
10 MHz

Control
connections

Address setting

Openings for
front-panel
connections

Demodulator outputs: AM   FM (stereo-capable)

4

5

OPERATION, DISPLAY

Modulation measurement, AF voltage measurement

The keyboard of the middle section is used for setting the type of demodulation FM, φM, AM or voltage measurement; on the display above the keyboard the **modulation measurement results** with the associated units are read out digitally. An additional analog display in the form of a light spot moving around a circle greatly facilitates adjustments by providing a tendency indication. The measurement ranges may also be set by keyboard entry (special function).
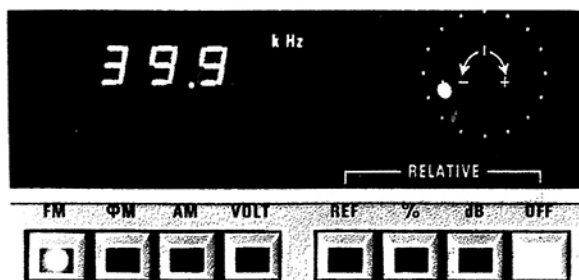
Front-panel section: middle display/keyboard for modulation measurement results and operating mode selection

Display of results (absolute or relative). The measured modulation is read out not only as absolute value, but also as relative value in % or dB, related to a key-entered reference value. This is very convenient if frequency responses are to be determined as a function of modulation frequency or carrier frequency, or if S/N measurements have to be performed.

Example: For measuring the unweighted FM S/N ratio of an unmodulated RF signal, referred to a standard deviation (e. g. 40 kHz), only the following settings are required:
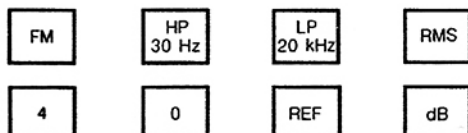
With the OFF button the relative mode can be switched off and the absolute value measured is indicated again.

Modulation frequency/distortion measurement
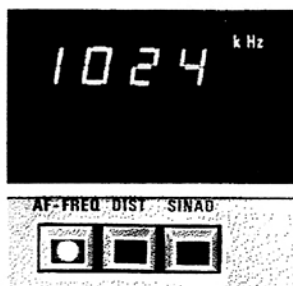
Front-panel section: right-hand display/keyboard for modulation frequency and distortion measurements

In the AF-FREQ mode the modulation frequency or – with voltmeter operation – the AF frequency is read out in four digits on the right-hand display. For frequencies below 1 kHz the resolution is 0.1 Hz; code frequencies for squelch switching can thus be measured with sufficient accuracy.

In the DIST or SINAD mode option FAM-B8 can be used for measuring the distortion of the modulation signal in % or the SINAD value in dB at the following 30 fixed frequencies in the range from 30 Hz to 20 kHz:

    30/40/.../100 Hz
    200/300/.../1000 Hz
    2/3/.../10 kHz
    12.5/15/17.5/20 kHz

Frequency tuning of distortion meter is automatic. In special cases frequency setting by keyboard entry (special function).

The smallest measurable distortion of typically 0.02 % (corresponding to a SINAD value of 74 dB) is sufficient for measuring the modulation distortion even of high-grade modulation sources.

Evaluation of external AF signals

The entire AF section comprising weighting filter, frequency counter, detector and distortion meter can be used for the evaluation of an external AF signal via a separate input socket. The FAM can thus be used as an automatic AF voltmeter and as a psophometer.

Separate use of the RF and AF section of the FAM

The possibility of using the RF and the AF section of the FAM separately permits the connection of an external stereodecoder into the signal path of the FAM. It is thus possible to measure for instance the frequency response, crosstalk and S/N ratio in both channels of a stereo-modulated FM signal. For special tasks any external AF filter can be connected in the same way.

Measurement of stereo multiplex signals using Modulation Analyzer FAM
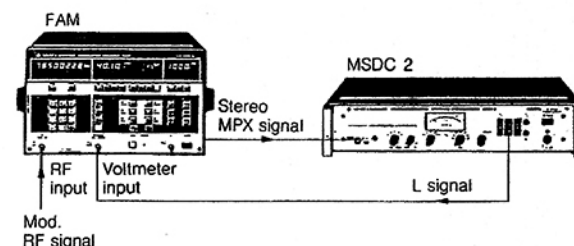
Demodulated stereo signal, available at FM output of Modulation Analyzer FAM

6
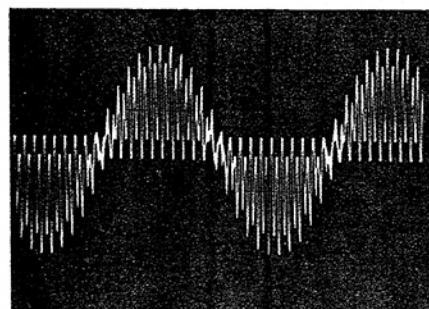
Programming

The FAM has an IEC-bus interface (IEC 625-1), so it can be controlled by an external computer, e.g. the R&S Process Controller PPC or PUC. The FAM can function both as listener and talker. Thus it is suitable for use in automatic measuring systems for testing transmitters and transceivers in development, production and quality control.

The control instructions are in line with IEC standard 625-2. Each instruction consists of a header made up of two letters, a numerical value (only for frequency or reference value entry) and a delimiter.

Example:

Keyboard setting:	Programming instruction:
Frequency 102.5 MHz	BW 102.5
FM demodulation	BP
Detector P+	GQ

Several control instructions – separated by a comma – can be combined in a program line:

BW 102.5, BP, GQ

A measurement call causes the measurement results (RF, modulation, modulation frequency) to be output:

Example:

Measurement call:	Programming instruction:
RF frequency	IQ
RF + modulation + AF frequency	IW

Programming example for the R&S Process Controller PUC for setting the FAM and subsequent data fetching:

FAM address: 29

100 IECOUT29,"BP"	Switchover to FM
110 IECOUT29,"FV,FQ"	Setting HP 30 Hz. LP 20 kHz
120 IECOUT29,"GQ"	Switch on peak-responding detector
130 IECOUT29,"IW"	Measurement call for RF frequency. FM deviation and modulation frequency
140 IECIN29,A$	Acceptance of measured values
150 PRINTA$	Print instructions

Characters read out:

RT10000003E+01,BP4050E+01,EQ1000E+00,

	RF frequency in Hz
	FM deviation in Hz
	Mod. frequency in Hz

An LED (REMOTE) signals the remote control mode of the FAM. All keys, with the exception of the LOCAL key, are thus disabled. Manual control of the FAM can be restored with this LOCAL key.

Format of IEC-bus instructions

1. Setting instructions

Format

- Delimiter (carriage return)
- Data
- Header (instruction)

2. Data output

Format

- Header
- Measurement data
- Exponent character
- Sign
- Exponent data (2-digit)
- Separator
- Delimiter (carriage return)
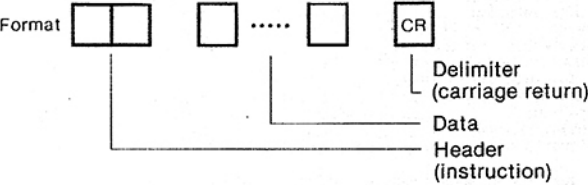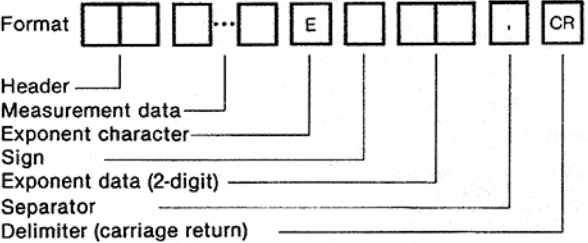
The output format does not change; always the full number of digits is output (see table). Formatting the data therefore causes no problems.

Display	Operating mode		Header	Digits	Unit
RF	AUTO		BT	8	Hz
	MAN		BW	8	
Modulation/ voltmeter	Modulation	FM	BP	4	Hz
	Modulation	φM	BQ	4	RAD
	Modulation	AM	BR	4	%
	Voltmeter	VOLT	BS	4	mV
	Relative	%	CR	4	%
		dB	CT	4	dB
AF/DIST/ SINAD	AF-FREQ		EQ	4	Hz
	DIST		ER	4	%
	SINAD		ET	4	dB

Specifications

Frequency range .... 55 kHz to 120 MHz
with option FAM-B2 1.36 GHz .. 55 kHz to 1360 MHz
with option FAM-B2 1 GHz ..... 55 kHz to 1000 MHz
Frequency setting .... automatic [1]) or manual
  Display .... 8-digit readout
  Resolution, $f < 1000$ MHz .... 1 Hz or 10 Hz
    $f \geqq 1000$ MHz ...... 1 Hz or 100 Hz
Frequency error and drift .... ±1 digit + error of reference frequency
Reference oscillator............ standard   option SMS-B1
  Crystal aging .... $< \pm 1 \times 10^{-6}$/month $< \pm 5 \times 10^{-8}$/month
  Temperature coefficient ...... $< \pm 1 \times 10^{-6}$/°C $< \pm 1 \times 10^{-7}$ over total op. range

RF input .... $Z_{in} = 50\,\Omega$, BNC female connector
Input level range
  55 kHz to 550 MHz .... 10 mV to 3 V (–27 to +22.5 dBm)
  550 to 1050 MHz .... 20 mV to 3 V (–21 to +22.5 dBm)
  1050 to 1360 MHz .... 30 mV to 3 V (–17 to +22.5 dBm)
RF level attenuator programmable via IEC bus or keyboard.

---

[1]) Frequency measurement and automatic tuning for AM $\leqq 80\%$;
for $f_{in} \geqq 550$ MHz up to 60%.

SPECIFICATIONS

Amplitude modulation measurement

Modulation frequency range ...	10 Hz to 200 kHz	
	10 Hz to 20 kHz for f_{in} < 3.6 MHz	
Max. measurable mod. depth ...	100 %	
Display	4 digits + analog indication	
Units	absolute: %; relative: % or dB	
Resolution	0.25 % (of rdg), max.: 0.005 % (AM)	
Error	mod. ≦ 80 %	mod. > 80 %

with peak.-resp. detector (plus peak residual AM)

f_{mod} 30 Hz to 60 kHz	≦ ± 2 %	≦ ± 5 %
60 to 100 kHz	≦ ± 4 %	≦ ± 10 %
Residual AM [1]) at f	≦ 550 MHz	> 550 MHz

With CCITT weighting and

rms-resp. detector	≦ 0.01 %	≦ 0.02 %
Weighting bandwidth		
30 Hz to 20 kHz	≦ 0.05 %	≦ 0.05 %
CCIR weighting	≦ 0.05 %	≦ 0.1 %

Incidental AM with FM [2])
(f_{mod} 1 kHz, 50 kHz deviation,
meas. bandwidth 30 Hz to 3 kHz) 0.1 %
AF distortion (at AF output;

f_{mod} 30 Hz to 20 kHz)	≦ 120 MHz	> 120 MHz
40 % mod.	≦ 0.2 %	≦ 0.4 %
40 to 80 % mod.	≦ 0.4 %	≦ 0.6 %

AM measurement ranges (11) programmable

Frequency modulation measurement (with input freq. ≧ 4.25 MHz)

Modulation frequency range ... 10 Hz to 200 kHz
Max. measurable frequency
deviation ... 500 kHz (100 kHz with input frequ. ≦ 4.75 MHz)
Display ... 4 digits + analog indication
Units ... absolute: Hz, kHz; relative: %, dB
Resolution ... 0.25 %, max.: 0.1 Hz
Error ... deviation ≦ 100 kHz | dev. > 100 kHz

with peak-resp. detector (plus peak residual FM)

f_{mod} 30 Hz to 60 kHz	≦ ± 1.5 %	≦ ± 3 %
60 to 100 kHz	≦ ± 3 %	≦ ± 6 %

with rms-resp. detector (plus residual FM)

f_{mod} 30 Hz to 60 kHz	≦ ± 3 %	≦ ± 3 %
60 to 100 kHz	≦ ± 6 %	≦ ± 6 %

Residual FM at f	≦ 120 MHz	120 to 550 MHz	550 to 1050 MHz	1050 to 1360 MHz
With CCITT weighting and rms-resp. detector	≦ 1 Hz	≦ 3 Hz	≦ 6 Hz	≦ 12 Hz
Weighting bandwidth 30 Hz to 20 kHz, with rms-resp. detector	≦ 5 Hz	≦ 14 Hz	≦ 25 Hz	≦ 50 Hz
With CCIR weighting and deemphasis and squelch	≦ 6 Hz	—	—	—

Stereo S/N ratio, weighted
to CCIR, referred to 40 kHz
deviation (f_{in} ≦ 120 MHz,
v_{in} ≧ 20 mV) ... typ. 72 dB
Incidental FM with AM + peak residual FM
(f_{mod} 1 kHz, m = 50 %; test
bandwidth 30 Hz to 3 kHz) ... ≦ 20 Hz
AF distortion (at AF output;
f_{mod} 30 Hz to 20 kHz)
75 kHz deviation ... ≦ 0.1 %
500 kHz deviation ... ≦ 0.5 % (input freq. > 10 MHz)
Stereo separation
at f_{mod} 30 Hz to 15 kHz ... ≧ 46 dB (typ. 50 dB) at stereo output
f_{mod} = 1 kHz ... ≧ 50 dB
Deemphasis ... 50/75/750 µs, switch-selected
FM measurement ranges (13) programmable

Phase modulation measurement (with input frequency ≧ 4.25 MHz)

Modulation frequency range ... 300 Hz to 20 kHz
Maximum measurable phase
deviation ... 500 rad (up to 1 kHz mod. freq.)
Display ... 4 digits + analog indication
Units ... absolute: rad; relative: %, dB
Resolution ... 0.25 %, max.: 0.001 rad
Error with peak.-resp. detector ... ≦ ± 3.5 % + peak residual φM
with rms-resp. detector ... ≦ ± 5 % + residual φM

Residual φM at f	≦ 120 MHz	120 to 550 MHz	550 to 1050 MHz	1050 to 1360 MHz
Weighted with CCITT filter: rad	≦ 0.002	≦ 0.003	≦ 0.006	≦ 0.012
bandwidth 30 Hz to 20 kHz: rad	≦ 0.005	≦ 0.01	≦ 0.02	≦ 0.04

AF distortion (at AF output),
deviation 4 rad ... ≦ 0.1 %
φM measurement ranges (13) programmable

AF detector

Peak-responding detector ... positive or negative peak of AF or their arithmetic mean
Rms-responding detector ... true rms response, indication as rms or for sinewave converted to peak; crest factor 10

Weighting filters

High pass (1-dB cutoff frequency) 10 Hz (2 Hz at 3 dB by changing connection), 30 Hz and 300 Hz (12 dB/octave)
Low pass (3-dB cutoff frequency) 3/20/200 kHz (24 dB/octave min.)

[1]) With input level 6 dB above minimum; > 250 mV for f_{in} < 3.6 MHz.
[2]) In frequency range specified for FM measurement.

CCITT filter (option FAM-B6) ... weighting network acc. to CCITT Rec. P53
CCIR filter (option FAM-B7) ... weigthing network acc. to CCIR Rec. 468-2 (Rev. 78) combined with quasi-peak detector

AF frequency display

Frequency range ... 10 Hz to 200 kHz
Display ... 4-digit readout
Resolution ... 0.1 Hz up to 1 kHz
Error at f > 100 Hz ... ± 0.1 % at S/N > 40 dB
at f < 100 Hz ... ± 0.1 Hz at S/N > 60 dB

Distortion measurement ... with option FAM-B8

Test frequencies (total of 30) ... 30/40 to 100 Hz
200/300 to 1000 Hz
2/3 to 10 kHz
12.5/15/17.5/20 kHz

Autom. adjustment
(S/N > 30 dB) ... tuning range ± 3 %, automatic switchoff when frequency is outside of measurable range
Display ... 4 digits, THD in % or SINAD in dB
Display range ... 0.1 to 50 % (THD), 6 to 60 dB (SINAD)
Error (d ≦ 10 %) ... ≦ ± 10 % of rdg or ≦ ± 1 dB ± 1 digit
Test frequencies programmable

AF voltmeter

Frequency range ... 10 Hz to 200 kHz
Measurement range ... 0.1 mV to 3 V (max. 5 V_p)
Display ... 4-digit readout
Units ... absolute: mV; relative: %, dB
Resolution ... 0.1 mV
Error with LP 3/20 kHz ... ≦ ± 1.5 % ± 0.1 mV
without LP ... ≦ ± 1.5 % ± 0.4 mV (30 Hz to 60 kHz)
≦ ± 3 % ± 0.4 mV (60 to 100 kHz)
Weighting ... all AF measuring facilities in the FAM (detectors, weighting networks, frequency counter, distortion meter) can also be used in voltage measurements (LP 200 kHz not included)
Input ... Z_{in} ≧ 400 kΩ ‖ 300 pF floating; BNC female connector
Voltage measurement ranges (11) programmable

Outputs

AM signal output (V_{rms}) ... max. 1 V into 2 kΩ at 100 % mod.
FM stereo signal output (V_{rms}) ... 1.5 V at 40 kHz dev. corresp. to + 6 dBm across 600 Ω (for crosstalk see FM)
AF output (V_{rms}) ... 350 mV to 1 V depending on modulation or AF voltage

IEC-bus interface ... in accordance with IEC 625-1; 24-pin Amphenol connector
Listener and talker functions ... AH1, T4, L2, RL1, DC1

Measurement periods

RF and modulation measurement triggered (frequency,
RF and AF measurement ranges
programmed, P+ or P-) ... at a frequency resolution

(For input frequ. > 120 MHz: T + 100 ms)	10 Hz	1 Hz
FM, φM ≦ 250 ms		≦ 2050 ms
AM ≦ 420 ms		≦ 2300 ms

Automatic RF, modulation and AF measurement
when changing frequency or
after applying the RF level ... typ. 3.5 s
after settling ... typ. 1.5 s
DIST/SINAD-measurement ... typ. 6 s
after settling ... typ. 2 s

General data

Operating temperature range ... + 5 to + 45 °C
Storage temperature range ... – 40 to + 70 °C
RFI suppression ... VDE radio protection mark: DBP 527 GI
Mechanical loading capacity ... shock- and vibration-tested to DIN 40046, Part 7 and 8 (corresp. to IEC Publ. 68-2-27 and 68-2-6)
Power supply ... 115/125/220/235 V ± 10 %, 47 to 440 Hz (80 VA); safety class I
Dimensions, weight ... 345 mm × 198 mm × 370 mm, 13.5 kg

Ordering information

Order designation ... ▶ Modulation Analyzer FAM
FAM 55 kHz to 120 MHz ... 334.2015.54
Accessories supplied ... power cable, adapter (for PC boards)
FAMA and options ... see flyer 843600

Options
Reference Oscillator ... SMS-B1 ... 302.8918.02
1.36-GHz Frequency-range
Extension ... FAM-B2 ... 334.4918.02
1-GHz Frequency-range
Extension ... FAM-B2 ... 334.4918.04
IEC-625-1 Interface [3]) ... FAM-B4 ... 334.5914.02
CCITT Filter ... FAM-B6 ... 334.5614.02
CCIR Filter ... FAM-B7 ... 334.5514.02
DIST/SINAD Meter ... FAM-B8 ... 334.5714.02
19" Adapter ... FAM-Z9 ... 349.7318.02

---

2.   Preparation for Use and Operating Instructions

Values quoted in this section are not guaranteed. Only the specifications
listed in the Data Sheet are binding.

2.1   Legend for Front-panel Controls

Ref. No.	Designation	Function
1	MHz	8-digit display field for displaying measured input frequency (RF); when button 25 is pressed the value of the manually entered tuning frequency appears briefly.
2		Modulation display; 4-digit display field for selectable display of frequency deviation, phase deviation, depth of modulation (AM), LF input voltage (at voltmeter input 19), or for displaying a reference value or deviation from a reference value.
3	Hz, kHz, %, RAD mV, dB	Displays the units appropriate to the center display 2, in accordance with the operational mode selected.
4		Quasi-analog display; the variation in the modulation display 2 can be observed. Rotation in clockwise direction: increase of measured value. Rotation in counterclockwise direction: reduction of the measured value.
5		4-digit display field for displaying LF (modulation frequency) or (optionally) the LF distortion factor, depending on operational mode selected.
6	Hz, kHz, %, dB	Displays the units appropriate to the right-hand display 5.
7	AF-FREQ., DIST, SINAD	Buttons for selecting the LF operation mode. In operational mode AF-FREQ. the measured LF appears in the right-hand display 5. During operation with the "Distortion meter" facility (optional) on pressing the button DIST, the LF distortion factor is displayed in %, and on pressing the button SINAD, it is displayed in dB.

Ref. No.	Designation	Function
8	REF, %, dB, OFF	By means of button REF, a reference value entered on keyboard 23 is accepted. It appears in the center display field 2. A reference value can be entered depending on the operation mode selected as follows: FM in units kHz φ M in units RAD AM in units % Volt in units mV A subsequent pressing of the buttons % or dB causes the deviation from the current measured value to appear in the central display field 2. The reference value previously entered can be redisplayed in 2 by pressing the button REF again. The relative mode can be switched off by means of the button OFF. Then the absolute measured value will be displayed again.
9	DETECTOR RMS RMS $\cdot$ $\sqrt{2}$ PEAK CCIR	When button RMS is pressed the RMS value of the LF signal will appear in display field 2. When the button RMS $\cdot$ $\sqrt{2}$ is pressed, the RMS value of the LF signal multiplied by $\sqrt{2}$ will appear in the display. Button for switching in a detector as per CCIR Standard into the LF branch (only possible with option B7).
10	POWER	Mains switch
11	AF ←⊙	LF output (after LF level adjustment and filter weighting) BNC socket.
12	DETECTOR P+ $\dfrac{P + P}{2}$ P-	Keys for selecting the detector for the LF branch: When the button P+ is pressed, the positive peak value of the LF signal appears in display 2. When button $\dfrac{P + P}{2}$ is pressed, the arithmetic mean of the positive and negative peak values is displayed. When button P- is pressed, the negative peak value of the LF signal is displayed.

Ref. No.	Designation	Function
13	CCITT	Button for switching in a filter, as per CCITT Standard, into the LF branch. (Possible only with Option B6).
14	FILTER LP 200 kHz LP 20 kHz LP 3 kHz	Keys for switching a lowpass filter with an upper cutoff frequency of 3 kHz, 20 kHz or 200 kHz into the LF branch.
15	LOCAL	Button for switching over from IEC bus control to manual operation.
16	CCIR	Button for switching in a filter as per CCIR Standards, into the LF branch. (Possible only with the B7 Option.)
17	REMOTE	LED for displaying the remote controlled condition (with Option B4) in IEC bus operation.
18	FILTER HP 300 Hz HP 30 Hz HP 10 Hz	Keys for switching in a highpass filter with a lower cutoff frequency of 10 Hz, 30 Hz or 300 Hz into the LF branch.
19	VOLTMETER 10 Hz to 200 Hz $\geq$ 400 kΩ —⊖	Floating LF voltmeter input; insulated BNC jack. Max. input voltage: 5 V_p
20	DEEMPH 50 µs 75 µs 750 µs OFF	Keys for switching in the Deemphasis 50 µs, 75 µs, or 750 µs for frequency modulation. The OFF button switches off the Deemphasis.
21	S	Shift button for entering special functions: Simultaneously a digit key must be operated on keyboard 23. Lamp lights when a special function is selected.
22	RF 10 mV - 3 V 50 Ω —⊖	RF input; BNC socket
23	0, 1, 2, 3, 4, 5, 6, 7, 8, 9 ●	Keyboard for entering data for the input frequency (RF) in conjunction with the button MAN (25), and a reference value in conjunction with the button REF (keyboard 8), as well as for entering special functions.

Ref. No.	Designation	Function
<u>24</u>	FM, φM, AM, VOLT	Keys for selecting the operational mode. When the button FM is pressed, the center digit field <u>2</u> displays the measured frequency deviation in Hz or kHz. When the button φM is pressed, the digit field <u>2</u> displays the phase deviation measured in radians. When the button AM is pressed, the digit field <u>2</u> displays the depth of modulation in %. When the button VOLT is pressed, an LF voltage at the voltmeter input <u>19</u> is displayed in millivolts.
<u>25</u>	MAN	Button for setting equipment to a frequency (MHz) previously entered via keyboard <u>23</u>. This causes the manually set frequency to appear briefly (for approx. 3 s) on display <u>1</u>.
<u>26</u>	AUTO	Button for setting equipment to automatic operation (automatic frequency search and level setting).
<u>27</u>	RF 10 mV - 3 V 50 Ω —⊕	Hole for remounting the RF input <u>22</u> on the rear side of the unit.
<u>28</u>	VOLTMETER 10 Hz - 200 kHz —⊕ ≥ 400 kΩ	Hole for remounting the voltmeter input <u>19</u> on the rear side of the unit.
<u>29</u>	REF FREQ. 10 MHz ⊕→	Reference frequency output; 10 MHz-TTL level (can be plugged into reference frequency input).
<u>30</u>	AF 1 V ⊕→	Hole for remounting the AF output <u>11</u> on the rear side of the unit.
<u>31</u>	DEMODULATOR FM ⊖-STEREO-MPX	FM demodulator output; capacity for stereo
<u>32</u>	DEMODULATOR AM ⊖→	AM demodulator output
33	DATA I/O	Connection for IEC bus programming (Option B4)

Ref. No.	Designation	Function
34	ADDRESS	Switch for setting the IEC bus equipment address (Option B4)
35		Mains plug
36		Fuse holder and mains voltage selector.

2.2   Preparation for Use

The modulation analyzer FAM is designed for mains supply voltages of 115 V, 125 V, 220 V and 235 V. The unit is delivered from the factory set for 220 V operation.

To adapt it for operation from another AC supply voltage, the fuse holder in the AC voltage selector 36 (Fig. 2-4) is taken out and with the specified fuse so inserted that the AC supply voltage marked on the cap is positioned under the arrow in the plug fuse housing. The instrument is then ready for operation with the new voltage. The fuses for all permitted AC voltages are included in the accessories supplied.

For mains voltages of 220 V and 235 V a fuse with the rating T1.0 (1 A) is required; 115 V or 125 V operation requires a T2.0 fuse (2 A).

The modulation analyzer FAM is 3/4 the width of a 19-inch unit.

Suitable rack adapters are available for installation into a 19-inch rack (see Recommended Accessories). To accomplish this, remove the side screws, remove both covers of the FAM and then remove the side strips as well as the carrying handle. The threaded holes for attaching the rack adapter are already present on the unit.

To enable relocation of the inputs and outputs from the front panel to the rear of the unit, punched holes are provided in the rear panel.

2.3   Manual Operation

2.3.1   Switch-on Condition

After being switched on, the unit displays the software version in the left-hand display field for about 2 s. Specifically, this consists of two numbers with a decimal point (MSB on left). Subsequently, the unit assumes the following initial status.

The unit switches to automatic operation (button AUTO, 26, lights up), i.e. it carries out an automatic frequency and level adjustment in the event that an RF signal within the specified frequency and level range is present at RF input 22 (Fig. 2-5). If this is not the case, the unit carries out a continuous search, indicated by zero readings on all displays. In its initial condition, the FAM is also in operating mode AM Demodulation (button AM lights up) and display 3 shows the units %.
AF-FREQ. is selected on keyboard 7 (i.e. the modulation frequency is measured); the units Hz light up on display 6.
In the LF branch, the weighting filters 30 Hz highpass (HP 30 Hz) and 20 kHz lowpass (LP 20 kHz) are switched in (keyboards 14, 18). The peak value rectifier P+ (keyboard 12) functions as detector.

Initial settings:
    AUTO
    AM%
    AF-FREQ. Hz
    30 Hz HP 20 kHz LP
    P+

2.3.2   Operational Mode Setting AUTO-MAN

2.3.2.1   Setting for Search and AUTO Automatic Range

In the operational mode AUTO (initial setting of the unit, or selected by pushing appropriate button), the FAM adjusts itself automatically to frequency and level upon application of an RF signal within the specified frequency and level range to the RF input 22 (Fig. 2-5). The measured carrier frequency in MHz will appear on frequency display 1.

The input signal will be demodulated (AM, FM or phase demodulation) according to the operational mode selected on keys 24. The LF level divider sets itself automatically and the center display 2 will display the appropriate measured value with the correct units (display 3).

In the case of a modulated carrier, the unit in operating mode AF-FREQ

will indicate the measured modulation frequency on display 5, along with the appropriate units Hz or kHz on display 6.

In case of varying input readings: frequency, level (RF), depth of modulation or deviation, the unit will automatically readjust itself. A prerequisite for the operating mode AUTO is a depth of modulation (AM) of m < 80% because at greater depths of modulation the frequency counter (RF) supplies unreliable results. With larger variations in the frequency of the applied signal, it is recommended to switch off the RF level for about 1 s in order to avoid incorrect frequency tuning (e.g. onto image frequency - see 4.1.1).

2.3.2.2 Manual Setting of Input Frequency (RF)

By means of the button MAN 25 (Fig. 2-5) the unit can be set to the desired frequency (RF); the frequency search is inoperative in operational mode MAN.

The entry sequence is as follows:

Using keyboard 23 enter the numerical value of the frequency in MHz, e.g. 103.4.

Using button MAN 25 transfer this frequency into the display 1: 103.4 MHz.

Manual entry of frequency with a resolution of 1 kHz is possible. The frequency will be displayed for approx. 3 seconds. Then the frequency at the RF input 22 will be measured and displayed.

The FAM however stores the frequency setting entered.

Pressing the button MAN again (without previous digit entry) will cause the stored frequency setting to re-appear briefly in display 1. Using the button AUTO 26 the FAM can be reset to the automatic mode. The operational mode MAN is especially practical for demodulating heavily amplitude-modulated RF signals (m > 80%). In the case of several simultaneously present RF signals it is possible in principle to set the unit to one of them using the MAN button. It is necessary, however, to take into account the fact that the reading may be affected by several simultaneously appearing signals (there is no preselection in the RF section), because of the possibility of subsidiary wave mixing in the case of unfavourable frequency relationships. This influence can be ignored if the simultaneously present spurious signals are at least 20 dB lower than the useful signal being measured.

Limited measuring accuracy of the modulation display and the frequency display (NF) must be anticipated in cases where the difference between the frequency entered and the frequency actually present at the RF input is too great. If this is the case, dashes (--------) will appear periodically in the left-hand frequency display field (1).

2.3.3   Setting of Operational Mode for the Modulation
Type and Modulation Display

By pressing the appropriate button FM, ᵧM, AM, VOLT of the keys 24
(Fig. 2-5), the corresponding output signal of the frequency, phase or
amplitude modulator, or the signal present at the voltmeter input, will
be fed to the LF analyzer and will be displayed as frequency deviation,
phase deviation, modulation depth or LF input voltage, each with the
appropriate units on the centre display 2.

2.3.3.1   Frequency Demodulation Mode FM

In operational mode FM the frequency deviation of a signal at the RF input
is displayed in Hz (for frequency deviations < 1 kHz) or kHz units on the
center display 2 (Fig. 2-5).

FM demodulation is basically possible for input frequencies $\geq$ 4.25 MHz. Measure-
ment is also possible for frequencies from 3.5 to 4.25 MHz. It should be noted how-
ever, that in this range the frequency deviation is displayed in inverted form
(P+ interchanged with P-) and a sideband change (see 2.3.4.2) is not possible.

The maximum measureable frequency deviation for input frequenies $\leq$ 4.75 MHz
is limited to $\leq$ 100 kHz; above this level the deviation is limited to
$\leq$ 534 kHz (see Data Sheet for specified values).

It should be borne in mind that in operational mode FM, the frequency display
(RF) becomes ineffective for input frequencies < 3.5 MHz and displays zeros
(also applies to the right-hand and center displays).

Selection of deemphasis

By means of the buttons 50 µs, 75 µs and 750 µs (keys 20, Fig. 2-5) it is
possible to switch into the LF branch deemphasis of the appropriate time
constant when operating in the FM mode (keyboard 24) (see Fig. 2-9). It is
thereby possible to compensate for the effect of preemphasis present on the
test subject.

In factory delivered units, the deemphasis, when switched in, is effective
on the FM output (31), the modulation display (2) and the AF output (11).
By reconnecting a plug-in link on the demodulator module, it is possible to
render the switched in deemphasis ineffective for the display and AF outputs,
but not for the FM stereo output (31) on the rear side of the unit. To per-
form the conversion, remove the unit's covers and unscrew cables K8 and K31

and then remove the demodulator board. After opening the cover, the plug-in links are readily accessible.
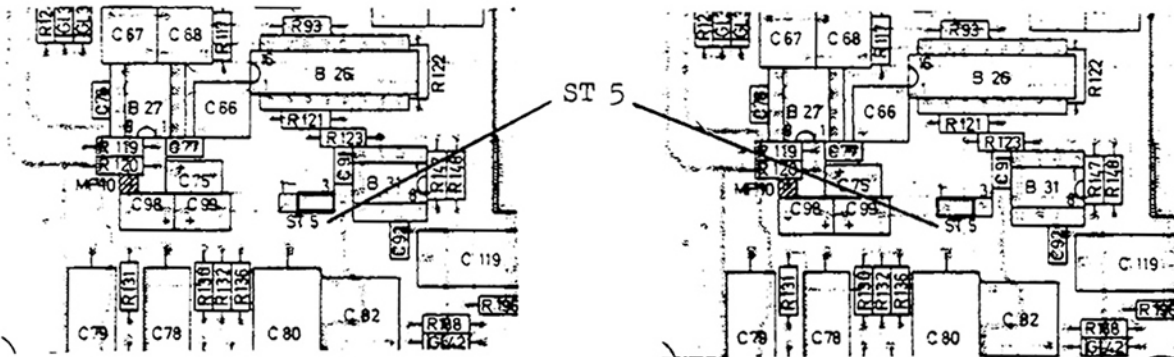
Switched-in deemphasis
effective for modulation
display and AF output
(as factory delivered).

Switched-in deemphasis in-
effective for modulation
display and AF output

Fig. 2-1   Position of plug-in link (Deemphasis)

In the initial setting of the unit, or after pressing the button OFF. on the keys (20) the deemphasis is ineffective.

2.3.3.2   Phase Demodulation Mode φM

In operational mode φM the phase deviation of a signal present at the RF input is displayed with the units Radian (RAD) on the center display $\underline{2}$.

For this purpose, the LF signal supplied by the FM demodulator is fed to a network which, for frequencies > 300 Hz, has a slope of 6 dB/octave and hence produces from the frequency demodulation a phase demodulation (for modulation frequencies $\geq$ 300 Hz).

The lower cut-off frequency is determined by the φ M filter (see Fig. 2-9). In the mode φ no RF filter is selectable.

For RF input frequency data see paragraph 2.3.3.1 Frequency Demodulation. Furthermore and similar as described under FM the maximum measurable phase deviation for input frequencies $\leq$ 4.75 MHz is limited to 100 RAD.

2.3.3.3   Amplitude Demodulation Mode AM

In operational mode AM the depth of amplitude modulation of an RF input signal with the unit % is displayed on the center display 2.

In contrast to input frequencies > 3.6 MHz, for frequencies of 55 kHz to 3.6 MHz at the RF input, the signal is not converted but fed directly to the AM demodulator working in wide-band mode. The LF bandwidth is then 20 kHz (-3 dB). When button LP 200 kHz is pressed this is shown by periodical dashes in the center display field to indicate the irregular operating mode.

For AM measurements where m > 80 % the frequency present (RF) must be entered manually (see 2.3.2.2).

In the position MAN, modulation depth measurements are possible up to several 100%.

2.3.3.4   LF Voltage Measurement Mode VOLT

In operatinal mode VOLT the LF voltage present at the voltmeter input is displayed with the unit millivolts (mV) on the center display 2 (Fig. 2-5). The rms rectifier is automatically cut in.

By voltmeter operation without an RF signal at the RF input the frequency display (RF) 1 will show zeros.

Separate use of the RF and LF section of the FAM

After switching over to operational mode VOLT, the RF signal previously present in operational mode AM, FM or ᵞM will still be counted by the frequency counter and displayed in the left-hand display. The signal will also be analyzed by the FM and AM demodulators, the AM output and FM output will remain in operation.

Frequency and level may not however be varied again.

This makes it possible to operate the RF and LF sections of the FAM separately, e.g. a stereo frequency-modulated RF signal can be analyzed using a stereo decoder (e.g. MSDC2).

This is done by the following procedure:

The modulated RF signal is fed into the RF input of the FAM (position FM, LP 200 kHz). At the FM output (31, rear side of unit, see Fig. 2-6) the

demodulated stereo MPX signal is available and can be fed to a stereo decoder, whose LF output is connected to the voltmeter input of the FAM. When switching over to operational mode VOLT, the LF voltage supplied from the decoder is measured and displayed in mV. Using a relative display (see Paragraph 2.3.3.6) it is now possible to carry out with ease frequency response measurements on the two LF channels, or S/N measurements with analysis by the various LF filters available in the FAM.

To permit a new RF calibration of the FAM, switch temporarily back to the starting mode, FM, LP 200 kHz, with a modulated RF signal present.

2.3.3.5 Analog Display

The measurement of the modulation and voltage display <u>2</u> is presented in display field <u>4</u> (Fig. 2-5) in analog form. An increase in the measured value produces a clockwise rotation; a decrease produces a counter-clockwise rotation. The resolution of the analog display is related to the resolution of the modulation display.

The analog display is especially practical for adjustment of the maximum or minimum of a measurement.

2.3.3.6 Relative Display and Input of Reference Values

Depending on the operational mode selected on the keyboard <u>24</u> (Fig. 2-5), FM ΥM, AM or VOLT, a reference value can be entered with keyboard <u>23</u> as follows:

$$
\left.
\begin{array}{ll}
\text{FM} & \text{with units kHz} \\
\text{ΥM} & \text{with units RAD} \\
\text{AM} & \text{with units \%}
\end{array}
\right\} \quad \text{- peak values}
$$

VOLT   with units mV   - rms values

The format for reference value entries is as follows:

FM, ΥM, AM: XXX.X
      VOLT: XXXX

Initial zeros can be omitted (exception: for FM, ΥM and AM the zero before the comma).

This value is transferred by pressing the button REF of keyboard <u>8</u>.

By subsequently pressing the buttons % or dB, the display field 2 will indicate in % or in dB the deviation of the actual reading from the reference value entered. The display in % may thus be converted into the corresponding dB value or vice versa.

Possible range of presentation:

> -99.9% to +100%
>
> -99.9 dB to +20 dB.

The reference value entered can be displayed again without previously entering a number, simply by pressing the REF button. The relative mode is especially useful for frequency measurements in the LF range (modulation frequency response) or (in the case of logarithmic presentation) for measurement of the signal/noise ratio.

Example of a measurement:

To measure the unweighted signal-to-noise ratio (FM) of an RF signal with reference to a standard deviation (of e.g. 40 kHz), proceed as follows:

Entry:	FM	(24)
	HP 30 Hz	(18)
	LP 20 kHz	(14)
	RMS	(9)
	40.0	(23)
	REF	(8)
	dB	(8)

The FM unweighted signal-to-noise ratio in dB, with reference to a frequency deviation of 40 kHz, appears in the modulation display.

Using the OFF button of the keyboard 8 the relative mode can be switched off again and display 2 will again show the absolute reading. The reference value remains stored.

2.3.4   Special Functions, Button S

Using the special function button S (21, Fig. 2-5), in conjunction with the numbers 1,2...9 (keyboard 23), the unit can be put into the special operating conditions described below. For this purpose, first press and hold button S and then simultaneously press one of the numbers. In the special function mode button S is lighted.

All special functions that are switched on, can be switched off by pressing the button S* in conjunction with button 0.

* First press button S and hold it down, then press digit key and release both at the same time.

R 42219 - 2.13

2.3.4.1   S1 - Side Band Change - Inversion of Demodulated
Signal in FM and ᵩM Mode

By pressing button S*together with button 1, the other side band (image frequency) for RF input frequencies $\geq$ 4.25 MHz can be measured. In the modulation modes FM and ᵩM, the modulation signal is thereby inverted (FM, AF output), and the positive peak value rectifier (P+, PEAK) measures the negative peak value of the modulation and vice versa.

2.3.4.2   S2 - Peak Hold

By pressing button S*together with button 2, the peak-hold mode is selected (when P+ or P- rectifier switched on). The highest peak value is then contin-uously indicated. This indication can be erased when buttons S*and 2 are pressed again. All other instrument settings remain unchanged.

2.3.4.3   S3 - Holding an RF Frequency, RF Level, and LF Measurement
Range Setting

By pressing button S*in conjunction with button 3, an FAM range setting once made can be held.

Frequency and level settings (RF) as well as the LF level setting will then no longer be changed if the RF input signal or the modulation changes. However the frequency measurements (RF and LF) and the display of the modulation readings (2 and 4) remain operative.

If the set measuring range of the modulation display is exceeded upwards or downwards, this is shown by dashes (——.-) in the center display field (2).

The operational mode S3 is useful for measurements during which the RF signal is not continuously present but where a rapid analysis of the modulation is important, e.g. when carrying out selective call measurements on radio equip-ment. In this operational mode it is also possible to measure non-periodic spikes.

For this purpose it is necessary to lock the unit with a periodic modulation signal within a suitable internal measuring range in the automatic or manual mode.

In mode S3, all buttons on the unit are inoperative except for the special function keys.

---

* First press button S and hold it down, then press digit key and release both at the same time.

2.3.4.4   S4 - Manual Entry of Distortion Test Frequencies

It is possible with special function S4 to select the distortion test frequencies either manually or with the IEC-bus (see data sheet). This function can also measure very noisy signals (SINAD measurements) in which case automatic calibration of the distortion meter is not possible.

The test frequency is input in "hertz" as follows:

Example: input distortion test frequency 3 kHz
            "3 0 0 0 S*4"

The test frequency is displayed for about 2 s in the right-hand (AF) display and the AF button is also illuminated. Subsequently, the test result is displayed. If there is no data input (only S4), the distortion meter is set to the currently measured AF frequency, provided it is admissible.

Inadmissible AF frequencies are identified by the entry (---.-) in the AF display. Special function S4 is switched off, with the result that the frequency of the distortion meter is automatically adjusted.

Care is to be taken to ensure that the AF signal applied to the distortion meter does not deviate from the input test frequency by more than the tolerance given in the data sheet; a deviation when using special function S4 will not be shown (as opposed to automatic distortion measurements).

The special function S4 is switched off with S0.

2.3.4.5   S5 - Manual Entry of RF Level Divider

For some FAM applications, e.g. when measuring the amplitude of a fluctuating signal or during triggered operations (see 2.3.4.7), it can be appropriate or even necessary to switch the automatic RF level control out of operation and manually (or by IEC-bus) set the RF level divider. This can be achieved with a two-digit code in conjunction with special function S5.

Example: input 0 dB attenuation for RF level divider (corresponds to
            an input level ≈ 30 mV)
            "0 0 S*5"

If S5 is input without any data, the current (automatically set) RF level setting is assumed.

The attenuator code differs according to the frequency range, i.e. < 3.5 MHz or > 3.5 MHz.

---

* First press button S and hold it down, then press digit key and release both at the same time.

It is to be noted that the corresponding RF input levels are approximate, and in particular at higher frequencies (> 800 MHz) deviations of up to 6 dB from the optimum RF level can occur.

With frequencies > 3.5 MHz, the level data is referenced to unmodulated signals. With up to 100% AM signals, an attenuator code of approximately 6 dB higher is to be selected (the peak value of a 100% modulated signal is 6 dB higher than an unmodulated signal of the same level), and with lower modulation depths, a correspondingly higher level attenuation of 4 dB (up to approximately 60% AM) or 2 dB (up to approximately 30% AM) is sufficient.

The overloading of the RF level divider is indicated during AM demodulation by the entry (----.-) in the middle display which may be used for setting guidance.

The special function S5 (and all other selected special functions) is switched off by SO.

<u>Note particularly:</u> After the RF level divider has been set, the RF level is no longer monitored, i.e. the display indication of the RF frequency or the modulation is present even without an RF signal. It is thus possible to perform frequency or modulation measurements with levels considerably less than the specified minimum input level (with corresponding decrease in measurement accuracy).

$f_{in} < 3.5$ MHz Approximate input level	Attenuation (dB)	Code	$f_{in} > 3.5$ MHz Approximate input level	Attenuation (dB)	Code
10 to 30 mV	0	00		0	00
	3	02		2	01
	6	04	to 30 mV	4	02
to 100 mV	9	06		6	03
	12	10		8	04
	15	12		10	05
	18	14		12	06
to 300 mV	21	20	to 100 mV	14	07
	24	22		16	13
	27	24		18	14
to 1000 mV	30	26		20	15
	33	30		22	16
	36	32	to 300 mV	24	17
	39	34		26	23
to 3000 mV	42	36		28	24
				30	25
				32	26
			to 1000 mV	34	27
				36	33
				38	34
				40	35
				42	36
			to 3000 mV	44	37

2.3.4.6   S6 - Manual Entry of AF-level Attenuation (measurement range)

By using the special function S6, it is possible to set the AF level divider and thus also the measurement range with AM, FM and φM demodulation. The use of the function is necessary for various FAM applications.

For example:

- triggered operations (see 2.3.4.7)
- with spurious modulation measurements when a strong spurious signal outside the AF weighting bandwidth would lead to overloading
- with strong pulsed fluctuations of the AF signal which would require permanent readjustment of the AF-level attenuator (spurious modulation measurements, monitoring broadcast transmissions, etc.)
- FAM service, etc.

The entry of the measurement range is made with the following two-digit code in conjunction with the special function S6.

Example: FM measurement up to 16.5 kHz (range upper limit)

"0 7 S*6"

* First press button S and hold it down, then press digit key and release both at the same time.

If the special function S6 is input without any data, the current (automatically set) measurement range is set.

It is to be noted that with FM/φM demodulation, the lower measurement range has various valid codes dependent on the LP 200 kHz filter. It is to be recommended that after using LP 200 kHz or after switching from LP 200 kHz to LP 3 kHz, 20 kHz or CCITT, CCIR, the desired measurement range be reselected.

For AM demodulation, a relatively inaccurate measurement range can only be used because the upper limit of the range also depends on the RF level which is adjustable in 2 dB steps (3 dB when $f \leq 3.5$ MHz).

When underdriving by about 30 dB from the upper limit or when overloading occurs, dashes (----.-) appear in the middle display. The display of overload and underdrive conditions is dependent on peak values.

The special function S6 and all other selected special functions are switched off by SØ.

Code Table – AF Measurement Range

Keypad entry: D D S 6
IEC-bus command: H V D D

Division factor	Code		Measurement range with		Code	Measurement range with VOLT		Measurement range with AM (%)
	without LP 200 kHz	LP 200 kHz	FM (kHz)	φM (RAD)		(mV)	Peak voltage (mV)	
1	00	–	0 to 0.13	0 to 0.13	00	to 3.6	to 5.2	> 0.1
1/2	01	20	to 0.26	to 0.26	01	to 7.3	to 10.4	> 0.2
1/4	02	21	to 0.52	to 0.52	02	to 14.5	to 20.5	> 0.4
1/8	03	22	to 1.04	to 1.04	03	to 29	to 41	> 0.8
1/16	04	23	to 2.05	to 2.05	04	to 58	to 82.5	> 1.5
1/32	05	24	to 4.1	to 4.1	05	to 116	to 165	> 3
1/64	06	25	to 8.25	to 8.25	06	to 235	to 333	> 6
1/128	26	26	to 16.5	to 16.5	07	to 470	to 665	> 12
1/256	27	27	to 33.3	to 33.3	10	to 940	to 1335	to > 25
1/512	30	30	to 66.5	to 66.5	11	to 1880	to 2670	to > 50
1/1024	31	31	to 133.5	to 133.5	12	to 3770	to 5340	to > 100
1/2048	71	71	to 267	to 267				
1/4096	72	72	to 534	to 534				

2.3.4.7   S7, S8 - Triggered Operation

The triggered operation of the FAM is particularly useful in systems requiring the shortest possible measurement time and measurements to be made at a specific moment in time (trigger) (e.g. radio detection). After entering the special functions S7 or S8, all automatic functions are inoperative. (With the exception of the frequency and measurement range adjustments of the distortion meter, if distortion or SINAD measurements have been selected.)

It is only possible to switch to trigger operation if the RF frequency has been previously entered (see 2.3.2.2).

The key "AUTO" provides the trigger and is illuminated together with the trigger "MAN" for the duration of the measurement. Subsequently, the new test result is entered in the display and remains displayed until a new trigger occurs or the trigger operation is erased (with S0).

When taking triggered measurements, the following points should be noted:

a) There is no control in the unit to check if the applied RF frequency is the same as either the set or programmed frequency of the unit.

   Modulation measurements are only correct when the difference between the applied frequency and set value of the unit is < 64 kHz.

   In order to keep the test results accurate during RF frequency measurements, the following frequency differences should not be exceeded. There are three frequency ranges to be distinguished:

	Applied frequency	Frequency set at unit
Range I:	55 kHz to 3.5 MHz	55 kHz to 3.5 MHz
Range II:	3.5 MHz to 120 MHz	3.5 MHz to 120 MHz
Range III:	120 MHz to 1360 MHz [1)	Input frequency ± 1 MHz

   [1) only with option B2.

b) Similarly, there is no RF level monitoring in the unit so that the user must take care that the RF level divider is correctly set.

   In particular, note that even without an applied RF signal frequency and modulation values are output in the displays or to the IEC-bus (random values), especially with frequencies > 3.5 MHz.

c) In the modulation display, overload is indicated (only after the trigger!) if the set measurement range has either been exceeded or has not been reached. (If the input falls short of the measurement range by more than 30 dB, (---.-) is displayed.)

The overload or underdrive indicator is dependent on the peak values of the AF signal even if a different detector is used.

Data is only guaranteed for test results which are < -10 dB from the corresponding range limit (peak value).

With AM operation, overload is indicated in the modulation display in any case if the RF level is too great for the set RF level divider((---.-) is displayed).

d) If distortion/SINAD measurements and special function S8 are selected, the calibration of the distortion meter occurs after the trigger. The measurement range of the distortion meter is not programmable since no appreciable time saving can be achieved. However, it is recommended that the distortion measurement frequency be set (see 2.3.4.4).

2.3.4.7.1   S7 - Triggered Measurement of RF Frequency and Modulation

By using special function S7 (with the sacrifice of the modulation frequency measurement), the briefest measurement time can be achieved.

The measurement time (including data output from the controller) is:
for FM, φM and V - < 250 ms; for AM - < 450 ms.

Special function S7 is selected by entering "S*7". SØ switches off special function S7 (and all other selected special functions).

2.3.4.7.2   S8 - Triggered Measurement of RF Frequency, Modulation and AF Frequency (or Dist./SINAD values)

With special function S8, triggered measurement of all three test results available in the displays is possible.

The measurement time with AF measurement selected (including data output from the controller) for FM, φM and V $\rightarrow$ 550 ms max.; for AM $\rightarrow$ 700 ms max.

Special function S8 is selected by entering "S*8". SØ switches off special function S8 (and all other selected special functions).

---

* First press button S and hold it down, then press digit key and release both at the same time.

2.3.4.8   S9 - Switching RF Frequency Resolution to 1 kHz

By using special function S9, the normal frequency resolution of the FAM of
10 Hz (up to 1 GHz) or 100 Hz (> 1 GHz) can be improved to 1 Hz. Frequencies
up to 99.999999 MHz can then be fully displayed.

With frequencies from 100.000000 to 999.999999 MHz, the overflow of the dis-
play is by one most significant digit and with frequencies $\geq$ 1 GHz, by two
most significant digits.

With RF frequencies < 10 MHz, unused most significant digits are entered as
zeros in the display (as opposed to the usual practice with frequency measure-
ments).

The normal RF frequency measuring time of 200 ms is increased to 2 s at the
frequency resolution of 1 Hz, the measurement cycle of the FAM increases
correspondingly.

In addition to the improved frequency resolution, another particular advantage
of special function S9 is better frequency accuracy with FM (or φM) modulated
signals.

Switching to 1 Hz frequency resolution is accomplished by entering "1 S*9".
To switch back to normal operation, enter "0 S*9" (only special function S9
is switched off) or "S∅" (all selected special functions are switched off).

---

* .First press button S and hold it down, then press digit key and release
both at the same time.

2.3.5   Selection of Weighting Filters (HP, LP, CCITT, CCIR)

Various weighting filters can be switched into the LF branch of the FAM.
By means of the buttons HP 300 Hz, HP 30 Hz, HP 10 Hz (keys 18, Fig. 2-5)
various highpass filters with corresponding cut-off frequencies can be
switched in; by means of buttons LP 200 kHz, LP 20 kHz, LP 3 kHz (keys 14)
a low pass filter of the respective cutoff frequency can be switched in (see
Fig. 2-7 and 2-8).

In position HP 30 Hz, LP 20 kHz the requirements of DIN Standard 45405
(Proposal 76) and CCIR 468-2 regarding extraneous voltage filters are met.

In mode VOLT and position LP 200 kHz no filter edge is operative; the LF
band width is determined by the cut-off frequencies of the LF amplifier.

By positioning a plug-in link on the filter/rectifier module (ST71) it is
possible to extend the lower cutoff frequency for the AF output on modes
FM, AM, VOLT to 2 Hz (-3 dB). The switched 10 Hz, 30 Hz, 300 Hz high pass
filters remain inoperative in this case.

To perform the conversion to 2 Hz cutoff frequency, remove the top cover
after unscrewing the 4 retaining screws. Then remove the filter/rectifier
module.
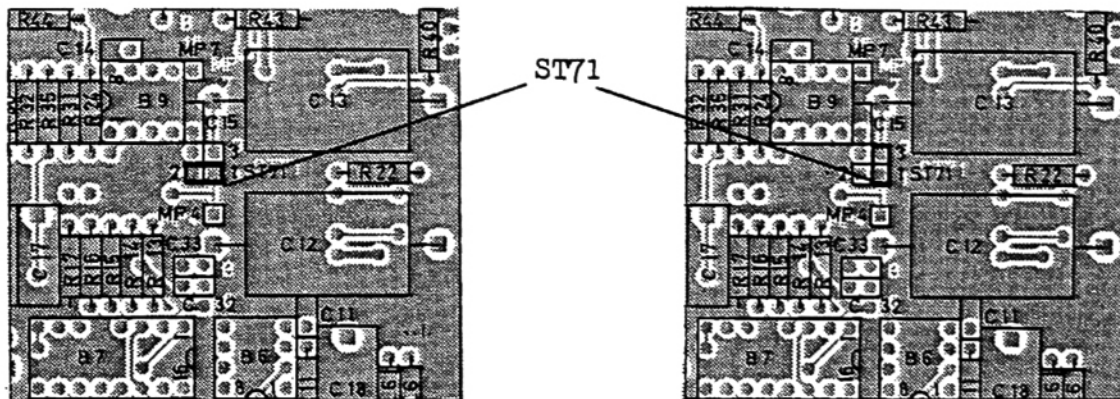
High pass filter operative
(as factory delivered)

High pass filter inoperative; lower
cutoff frequency for AF output:
2 Hz (-3 dB)

Fig. 2-2   Position of plug-in link (2 Hz cut-off frequency)

In conjunction with the Option B6, it is possible by means of button CCITT (13) to switch a CCITT filter into the LF branch. (For measurements in accordance with CCITT Standards, it is required that measuring be done with R.M.S. value rectifiers: press button RMS; keys 9).

Button CCIR permits (but only in conjunction with Option B7) the switching in of a noise voltage filter as per CCIR Standards (Recom: 468-2) into the LF branch. For measurements in accordance with CCIR Standards, it is possible, in addition, to switch in the quasi-peak rectifier PEAK CCIR 9 provided.

No HP or LP filter can be cut in in addition to a CCIR or CCITT filter. When an HP or LP filter key is pressed, the CCIR or CCITT filter becomes inoperative.

2.3.6   Selection of the LF Rectifiers

By means of buttons P+, P- (12, Fig. 2-5), the modulation display 2 is made to display the positive or negative peak value of the modulation or LF signal. With button $\frac{P + P}{2}$, the arithmetic mean of the positive and negative peak values is formed and displayed. With buttons RMS (keys 9), a true RMS value rectifier becomes operative for display 2. By means of button RMS $\cdot \sqrt{2}$, the value measured by the RMS value rectifier is multiplied by $\sqrt{2}$ and is displayed in display 2 (i.e. converted to peak value for sinusoidal signal.

In conjunction with Option B7, the button PEAK CCIR (keys 9) can be used to switch in a quasi-peak value rectifier as per CCIR Recommendation 468-2 (Rev. 76). This rectifier makes noise and extraneous measurements as per DIN 45405 possible. With modulation by a sinusoidal signal, the quasi-peak rectifier displays the rms value.

2.3.7   Low Frequency Measurement

By setting AF-FREQ (keys 7, PAM basic setting), display 5 (Fig. 2-5) will show the modulation frequency. By setting VOLT (keys 24, the frequency of the LF being fed into the input of the voltmeter 19, either in Hz or kHz (6) will be displayed. For frequencies $\leq$ 10 kHz measurement of the period, and conversion into frequency takes place. Above this level, a frequency measurement is carried out. For correct frequency measurement (degree of precision as per specification) sufficient LF S/N ratio is required.

In the case of statistical LF signals, e.g. demodulated residual FM, the frequency measurement may produce a changing display.

2.3.8 Measurement of Distortion and SINAD

In conjunction with the option DIST and SINAD Meter FAM-B8, the FAM can be used to measure the modulation distortion factor or the distortion factor of an LF signal applied to the voltmeter input 19 (Fig. 2-5). The measurement is made by determining the ratio between the levels ahead of and behind a narrow-band band-stop filter. This filter is tuned automatically. The following LF test frequencies are possible:

30 Hz to 100 Hz	in 10-Hz steps
100 Hz to 1 kHz	in 100-Hz steps
1 kHz to 10 kHz	in 1-kHz steps
10 kHz, 12.5 kHz, 15 kHz, 17.5 kHz, 20 kHz	

Measurement is possible within ±3% around the **nominal test frequencies.**

After pressing the DIST or SINAD button (keyboard 7), the LF distortion factor in % or SINAD in dB appears in the righthand display field 5.

If the test frequency departs from the above values by more than 3%, the right-hand display shows ---.- (only if the DIST or SINAD buttons are pressed). These buttons have no effect if the DIST and SINAD Meter option is not provided.

AF output (11):

At this output an LF signal dependent on the mode FM, ʄM, AM or VOLT selected on keyboard 24 (Fig. 2-5), is available. This signal is weighted by the selected filters (buttons 13, 14, 16, 18). The amplitude lies within the range 300 mV to 1 V. The minimum load to be connected is 2 kΩ.

AM output (32):
(rear side of unit,
see Fig. 2-6)

Present at this output is the LF signal supplied by the AM demodulator, irregardless of whether mode FM, ʄM, AM or VOLT is selected. The output level is max. 1 V for 100% AM, dependent on both the AM modulation depth and to an extent, on the RF input level. Minimum load to be connected is 2 kΩ.

For external S/N measurement at the AM output, it is therefore necessary, in order to produce a reference value (e.g. for 10% AM), to lock the FAM initially in terms of its internal RF level setting, through feeding in the unmodulated RF signal and pressing buttons S (21) and 5 (23) (see 2.3.4.5).

For RF input frequencies < 3.6 MHz, the transfer bandwidth at the AM output is 30 kHz (-3 dB); for RF input frequencies > 3.6 MHz, 200 kHz (-3 dB).

FM output (31):
stereo-MPX
(rear side of unit)

At this output the LF signal supplied by the FM demodulator, independent of the operating mode selected; FM, ʄM, AM or VOLT, is present. In position LP 200 kHz, this signal has stereo capability. The transfer bandwidth is 200 kHz (-3 dB). A stereo decoder (e.g. MSDC2) can be connected to this output. In mode FM, with low-pass filter < 200 kHz and deviations of < 8.5 kHz, the bandwidth at the FM output is 50 kHz (-3 dB) with exception of position LP where it is 200 kHz.

The output level is 0 dBm (≈ 1.545 V) into 600 Ω load for 40 kHz deviation. For deviations > 100 kHz, the level is 0 dBm (≈1.545 V) for 160 kHz deviation.

Voltmeter input (19):

In operational mode VOLT (keyboard 24) the voltmeter input is switched to the LF analyzer.

The input is floating; the common-mode rejection is typically 80 dB.

The maximum common-mode drive is limited to ±10 V (referred to chassis ground).

The maximum input voltage is 5 V_p.

The FAM is delivered with its voltage input floating (see figure) in order to avoid earth loops while measuring voltage.
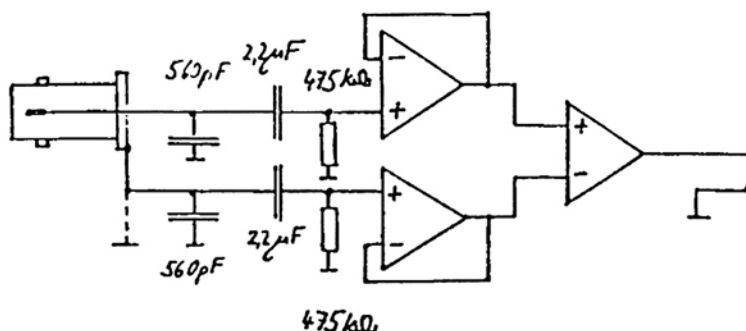
A common-mode voltage (e.g. hum) between the outer and inner of the connector (referred to ground) is suppressed with a common-mode voltage rejection of 80 dB and, as a rule, has no effect.

However, under some circumstances, because of the floating input, problems may arise:

1. The common-mode drive of the voltmeter input is limited to ± 10 V approx. (referred to chassis ground); if this common-mode voltage is exceeded, the common-mode rejection becomes ineffective.

   High common-mode voltages can occur between the device under test and the FAM (both connected to the AC supply) when, for instance, there is a strong AC supply interference.

2. RF pick-up at voltmeter input.
   This can occur particularly with long connecting cables or with floating inputs at the voltmeter socket.

   With small voltages to be measured and unfavourable connections to the AF output, RF oscillations can occur at the voltmeter input due to feedback and lead to incorrect measurements.

For these and similar problems, the following remedies may be applied:

1. Connect the ground (chassis) of the device under test and the FAM together via a low impedance (FAM ground - for instance, the outer conductor of the RF or AF socket).

2. Connect the outer conductor of the voltmeter socket to the FAM chassis ground. This is achieved by removing the bottom covers of the unit and soldering a short wire connection between the outer conductor of the BNC socket (solder tag) and ground (screen strip) - (see figure).

2.3.10   Reference Frequency Input - Output (29)

The FAM modulation analyzer contains a 10 MHz crystal reference oscillator, the frequency stability of which determines the accuracy of the frequency counter, and from which the mixer oscillators are synchronized.

At the BNC socket <u>29</u> (Fig. 2-6) the reference frequency at TTL level for external control purposes is available. The FAM can also be supplied with an external reference frequency of 10 MHz, if for example, it is to be supplied from another unit or from a central standard frequency source. An internal modification is necessary for this purpose.

The same socket is then used as input. A sinusoidal signal of 10 MHz with 0.5 V is sufficient but a TTL level signal can also be applied.

However attention should be paid to spectral purity of the highest degree for the reference being fed in, when operating with Option B2 "1.36 GHz frequency expansion".

On delivery of the unit, the BNC socket <u>29</u>, REF-FREQ. is connected as an output.

To switch over for use as a reference input plug-in links on the board "Reference oscillator microprocessor 334.3111" must be reconnected. Remove the covers from the unit, unscrew the cables K24, K25, K26 and K32, and remove the microprocessor board. After opening the snap cover the plug-in links are readily accessible. Remove BU2; plug BU5 into ST4 between 4 and 5 and BU4, between 2 and 3.
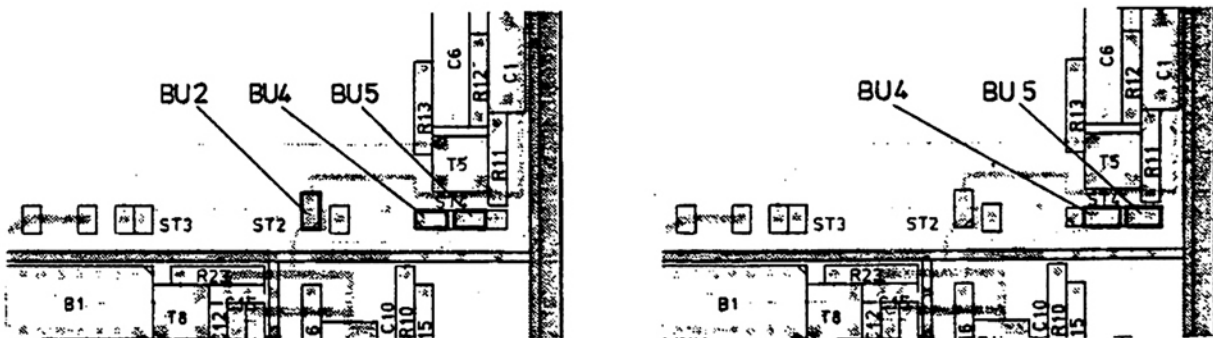
Reference output   Reference input

Fig. 2-3   Position of plug-in links (reference frequency)

Caution:

After modification for reference frequency input, ascertain that the external reference frequency signal is present at the socket 29 (Fig. 2-6) before switching on the equipment. During operation of the equipment uninterrupted supply of the reference frequency signal must be ensured. If the reference frequency supply fails, the equipment must be switched off immediately: failure to do so may lead to overloading the display diodes.

2.4   Remote-controlled Operation

2.4.1   Address Setting

In order to operate the FAM via the IEC bus, the unit address for the
LISTENER and TALKER function must be set. A prerequisite for this is that
the option FAM-B4 be installed. The 5 address switches (34, Fig. 2-6) can be
operated through an opening in the unit's housing, without having to open
the FAM. For addressing purposes, the switches 1 through 5 are provided; the
setting is made in binary code (switch 1 = LSB, switch 5 = MSB).

Fig. 2-4 shows the position of the address switches on the unit housing.
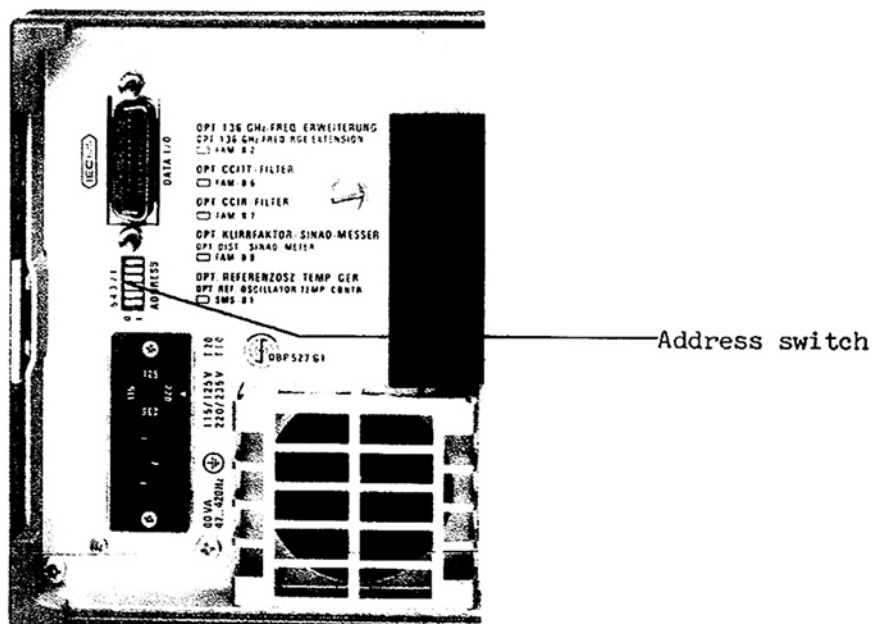
Fig. 2-4   Address switches

When delivered, the FAM is set to the decimal address 29.

Table 2-1   Binary equipment address with decimal equivalent

| ASCII Chracter | | Binary address | | | | | Decimal equivalent |
| Listen Address | Talk Address | Address switch | | | | | |
		A5	A4	A3	A2	A1	
(SPACE)		0	0	0	0	0	0
!	A	0	0	0	0	1	1
"	B	0	0	0	1	0	2
#	C	0	0	0	1	1	3
$	D	0	0	1	0	0	4
%	E	0	0	1	0	1	5
&	F	0	0	1	1	0	6
'	G	0	0	1	1	1	7
(	H	0	1	0	0	0	8
)	I	0	1	0	0	1	9
.	J	0	1	0	1	0	10
+	K	0	1	0	1	1	11
Comma	L	0	1	1	0	0	12
-	M	0	1	1	0	1	13
.	N	0	1	1	1	0	14
/	O	0	1	1	1	1	15
0	P	1	0	0	0	0	16
1	Q	1	0	0	0	1	17
2	R	1	0	0	1	0	18
3	S	1	0	0	1	1	19
4	T	1	0	1	0	0	20
5	U	1	0	1	0	1	21
6	V	1	0	1	1	0	22
7	W	1	0	1	1	1	23
8	X	1	1	0	0	0	24
9	Y	1	1	0	0	1	25
:	Z	1	1	0	1	0	26
;		1	1	0	1	1	27
<		1	1	1	0	0	28
=		1	1	1	0	1	29
>		1	1	1	1	0	30

2.4.2 Data Transfer Format

2.4.2.1 Setting Commands

The setting commands for the FAM can be subdivided into the following:

- Control instruction without data input.
- Control instruction with data input (e.g. for reference value and fre-
  quency setting).

In each case, the format consists of a header with two letters and a
delimiter, whereby all characters are to be transferred in ISO-7-bit code
(ASCII code).

In the case of control instructions which enter fixed values, the desired
initialising data are entered after the header. The units can be seen from
Table 2-2. When fixed values are to be entered, the overall range of the
FAM must be taken into consideration. This may not be exceeded.

Table 2-2   Instructions

FORMAT

```
+-----+  +----------+  +----+
|     |  |          |  | CR |
+-----+  +----------+  +----+
                          |_____ Delimiter (carriage return)
                 |_____ Data
     |_____ Header
```
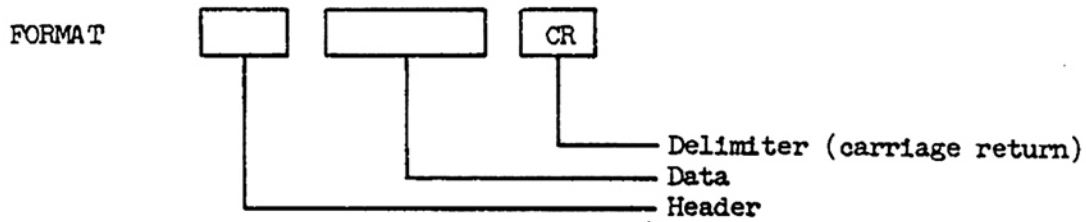
FUNCTION		INSTRUCTION (HEADER)	DATA	UNIT
a) Switchover to automatic AUTO		BT	-	---
Remote controlled frequency setting MAN		BW	anywhere within the measurement range, only the 7 leading digits will be recognized	MHz
b) Operational mode:				
Modulation FM		BP	-	--
↑M		BQ	-	--
AM		BR	-	--
Voltmeter VOLT		BS	-	--
c) FM deemphasis:				
OFF		DP	-	--
50 µs		DQ	-	--
75 µs		DR	-	--
750 µs		DT	-	--
d) Filters:				
LP 200 kHz		FP	-	--
LP 20 kHz		FQ	-	--
LP 3 kHz		FR	-	--
HP 10 Hz		FU	-	--
HP 30 Hz		FV	-	--
HP 300 Hz		FW	-	--
CCITT +)		FS	-	--
CCIR +)		FT	-	--

+) optional

R 42219 - 2.33

FUNCTION	INSTRUCTION (HEADER)	DATA	UNIT
e) Rectifiers:			
RMS	GP	-	--
+P	GQ	-	--
-P	GR	-	--
$\dfrac{P + P}{2}$	GS	-	--
RMS $\cdot \sqrt{2}$ +)	GT	-	--
CCIR +)	GU	-	--
f) Operational mode:			
AF-FREQ +)	EQ	-	--
DIST +)	ER	-	--
SINAD +)	ET	-	--
g) Reference value entry:			
REF	CQ	anywhere within measuring range, max. of 4 will be recognized.	in mode: FM: kHz φM: RAD AM: % VOLT: mV
Relative measurement:			
%	CR	-	--
dB	CT	-	--
OFF	CP	-	--
h) Special functions:			
Special functions off	HP	-	--
IF position inverted	HQ	-	--
Peak hold	HR	-	--
Automatic inhibited	HS	-	--
Extended special functions:			
Distortion measurement frequency	HT	specified measurement frequency five digits max.	Hz
RF attenuator	HU	two digit code	--
AF attenuator	HV	two digit code	--

+) optional

R 42219 - 2.34

FUNCTION	INSTRUCTION	DATA	UNIT
Switching to triggered operation (only in "MAN") and measurement of:			
RF frequency + modulation	HW	-	--
RF frequency + modulation + AF frequency	HX	-	--
Measurement trigger (only effective in trigger operations)	BT	-	--
RF frequency resolution 1 Hz	HZ	1	--
(RF frequency resolution 10/100 Hz)	HZ	$\emptyset$	--

2.4.2.2   Output of Measurement Data

Each call for data output (of a reading) causes the FAM to read out the corresponding digit field once. These data are given out in ASCII code via the IEC bus.

Within one string only <u>one</u> instruction for data output may occur, but any number of control instructions may occur.

The output format is shown in Table 2-3.
It consists similarly of a header, which represents the corresponding oper-
ating mode, plus the measurement data with the exponent character E and sign
(of the exponent), as well as the exponent data.

Table 2-3   Measurement call and data output

OUTPUT FORMAT: [   ] [   ] [E] [   ] [   ] [,] [CR]

Header ——————————————┘
Measurement data ———————————┘
Exponent Character ————————————┘
Sign ————————————————————————————┘
Exponent Data (2-digit) ————————————————┘
Separator ——————————————————————————————————┘
Delimiter (carriage return) ————————————————————————┘
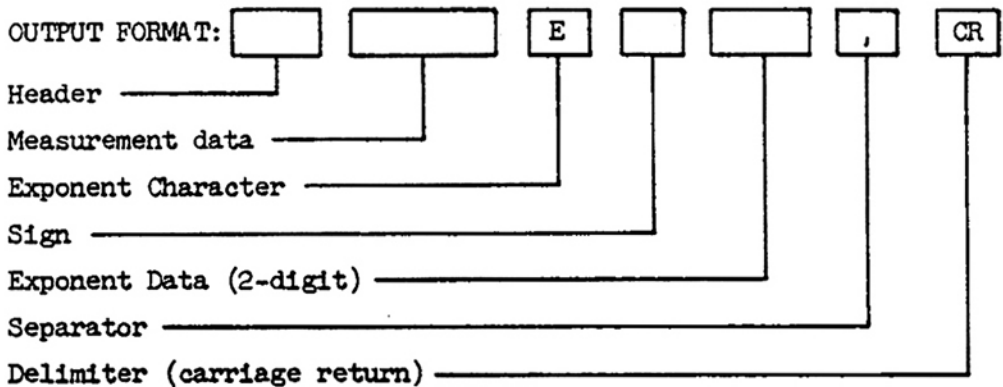
CALL		DATA OUTPUT			
Digit field	INSTRUC-TION	in mode	HEADER	DATA 3) (max. digits)	UNIT
Frequency display (HF) 1	IQ	AUTO MAN AUTO inhibited	BT BW BW	8 8 8	Hz
Digit field 2	IR	Modulation FM Modulation ↑M Modulation AM Modulation VOLT Relative % dB	BP BQ BR BS CR CT	4 4 4 4 4 2) 4 2)	Hz RAD % mV % dB
Digit field 5	IT	AF-FREQ DIST 1) SINAD 1)	EQ ER ET	4 4 4	Hz % dB

1) optional
2) with negative values the data output consists of 3 digits plus sign.
3) The full number of digits is always displayed, the unused high-order
   digits being displayed as spaces or zeros.

2.4.2.3   Calling for Several Digit Fields Simultaneously

Additionally, it is possible with the FAM to read out several digit fields simultaneously using one instruction. The advantage of this is that all the results stem from the same measuring cycle.

Only one instruction for data output may occur within one string, but any number of control instructions may occur.

Table 2-4   Measurement call from several digit fields

Digit field			Instruction
HF frequency digit field	modulation digit field	LF digit field	
+)	+)	-	IS
+)	-	+)	IU
-	+)	+)	IV
+)	+)	+)	IW

+) The contents of these digit fields are transferred.

2.4.2.4   REMOTE/LOCAL - Button

When being activated from a controller, the FAM automatically goes into the condition REMOTE where it remains even after completion of the call. This operational mode is indicated by the LED 17 REMOTE (Fig. 2-5). The function buttons are inoperative. Manual operation of the FAM is not possible. If the FAM is to be set for manual operation, this can be done in two different ways:

1) By pressing the button LOCAL (15). Firstly however, the program cycle of the controller must be stopped.
2) By output of the control command GTL (GO TO LOCAL) by means of the controller, via the IEC bus.

Switching back to REMOTE mode is possible only by means of a fresh activation via the IEC bus.

Furthermore it is possible, using the instruction LLO (LOCAL LOCK OUT) to render the LOCAL button inoperative.

2.4.3   Examples

In the following examples of remote-controlled operation, the preset unit address <u>29</u> (decimal) in the FAM is a prerequisite. From the wide selection of desk-top computers for data input and output via the IEC bus, the "PUC" of R&S and the Tektronix "4051" were chosen.

<u>Table 2-5</u>   <u>Examples of setting instructions</u>

Function	R&S "PUC"	Tektronix "4051"
a) Rectifier RMS	IECOUT 29, "GP"+ CHR$(13);	PRINT @ 29: "GP"
b) Filter LP 3 kHz	IECOUT 29, "FR"+ CHR$(13);	PRINT @ 29: "FR"
c) Deemphasis 50 µs Rectifier -P	IECOUT 29, "DQ,GR" +CHR$(13);	PRINT @ 29: "DQ,GR"
d) Deemphasis OFF Filter LP 200 kHz HP 30 Hz Rectifier +P	IECOUT 29, "DP,FP,FV,GQ" +CHR$(13);	PRINT @ 29: "DP,FP,FV,GQ"

<u>Table 2-6</u>   <u>Examples of fixed-value entry</u>

Function	R&S "PUC"	Tektronix "4051"
RF frequency 23.0 MHz	IECOUT 29, "BW23" +CHR$(13);	PRINT @ 29: "BW23"
RF frequency 112.245 MHz	IECOUT 29, "BW112.245" +CHR$(13);	PRINT @ 29: "BW112.245"
Reference value FM 500 Hz Here FM must be in mode FM.	IECOUT 29, "CQ0.5" +CHR$(13);	PRINT @ 29: "CQ0.5"
Reference value AM 12.5% Here the FM must be in mode AM.	IECOUT 29, "CQ12.5" +CHR$(13);	PRINT @ 29: "CQ12.5"

In the case of setting commands comprising data (e.g. frequency, reference value) make sure that no unnecessary empty spaces are transferred. This applies, for instance, wherever data from the PPC/PUC of R&S are transferred in the form of variables.

Example: Frequency to be set: 100 MHz
                FAM address: 29

Incorrect: Y=100
                IECOUT29,"BW"+STR$(Y)

When converting the variables into a data string, the leading character is an empty space (sign position) which is transferred via the IEC bus; consequently the command is not accepted by the FAM.

This empty space can be suppressed in the PPC/PUC with the formatting command MID$.

Correct: Y=100
                IECOUT29,"BW"+MID$(STRS(Y),2)

In this case transfer starts with position 2 of the data to be transferred i.e. no empty space is transmitted.

Examples of measurement calls with data output (FAM as Talker) are shown in Table 2-7. The units of the measurement data displayed are given in Table 2-3. Firstly, the measurement call instruction is executed (Table 2-3). Following this, the data can be read in via the IEC bus and displayed.

Table 2-7   Examples of measurement calls with data output

Example 1:

Digit field 1: HF frequency 7.927500 MHz in mode AUTO

	R&S "PUC"	Tektronix "4051"
Definition of delimiters and waiting time, once only at beginning of program	IECTERM 13 IECTIME 100	Already contained as delimiter: Carriage return; therefore no definition necessary.
Measurement call	IECOUT 29, "IQ" +CHR$(13);	PRINT @ 29: "IQ"
Data read-in	IECIN 29, B$	INPUT @ 29: B$
Output data in string B$	BT 792750E+01,	BT 792750E+01,

Example 2:

Digit field 2: Modulation FM 125.5 kHz.

	R&S "PUC"	Tektronix "4051"
Output data after IR measurement call	BP1255E+02,	BP1255E+02,

Example 3:

Digit field 3: modulation AM   37.5%
Digit field 5: AF frequency   998.5 Hz

Simultaneous readout of both displays:

	R&S "PUC"	Tektronix "4051"
Output data after measurement call IV	BR3750E-02, EQ9985E-01,	BR3750E-02, EQ9985E-01,

Table 2-8   Example for formatting a data output

for the PUC of R&S

Formatting after call for measurement "IW" (3 displays).

ET10590001E+01,EF4010E+01,EQ1020E+00,

```
100 IECOUT29,"IW"
110 IECIN 29,D$
120 RF =VAL(MID$(D$,3,12))/1E6
130 MO =VAL(MID$(D$,18,8))/1E3
140 AF =VAL(MID$(D$,29,8))/1E3
150 PRINT" RF-FREQ.       DEVIATION    MOD.-FREQ."
160 PRINT
170 PRINTRF;"MHZ    ";MO;"KHZ    ";AF;"KHZ"
```

ET10590031E+01,EF4020E+01,EQ9994E-01,   FAM data string D$

RF-FREQ.   DEVIATION   MOD.-FREQ.   Data displayed on
                                              PUC screen
105.90031 MHZ   40.2 KHZ   .9994 KHZ

Note: INTERFACE CLEAR, DEVICE CLEAR

If the program of the computer is stopped during data exchange with
the FAM, restarting an IEC-bus program might cause difficulties.

To avoid these problems, we recommend to give an INTERFACE CLEAR
command before a new program is started.

The DEVICE CLEAR command sets the FAM (or any other instrument
connected) back to initial conditions.

Function	R&S PUC	TEK 4051
INTERFACE CLEAR	IECCLEAR:IEC ←— CLEAR	INIT
DEVICE CLEAR	IECDCL	WBYTE @20:

Examples of Programs with the Special Functions
(for Process Controller PUC from R&S)

Setting the measurement frequency of the
distortion meter to 5 kHz: IECOUT29,"HT50000"

Presetting the RF level to 100 mV approx.
(unmodulated, f > 3.5 MHz):   IECOUT29,"HU07"

Presetting the modulation measurement
range (FM) for a max. frequency deviation
of 133.5 kHz: IECOUT29,"HV31"

Example of an application of the PEAK HOLD function

The largest peak deviation of a broadcast transmitter is measured at the
IF output of a receiver during a measurement period of 10 s and displayed
on the controllers screen.

```
100 IECDCL:IECCLEAR:IEC+CLEAR
110 IECTERM13:IECTIME100
120 IECOUT29,"BW10.7"
130 IECOUT29,"BP,GQ,FP"
140 IECOUT29,"HU00,HV31"
150 IECOUT29,"HR"
160 HOLD10000
170 IECOUT29,"IS"
180 IECIN29,A$
190 PRINTA$
200 GOTO150
```

Line 100, 110: Program descriptor

        120: Setting FAM input frequency (receiver IF)

        130: Selecting FM demodulation, LP 200 kHz and P+ rectifier

        140: RF level divider set to input level of 10 mV, deviation
             measurement range set to 133 kHz

        150: Select PEAK HOLD (i.e. PEAK value switched out)

        160: Duration of measurement period 10 s

        170: Call for measurement

        180: Read command

        190: Print command

        200: Jump to renew measurement

Note: The program would also work without presetting the RF and AF measure-
ment ranges in line 140; in this case, however, line 140 requires a
waiting command, for instance HOLD 3000.

Notes and Examples of Triggered and Remote-controlled Operation of FAM
(examples are valid for Process Controller PUC from R&S)

For triggered, remote-controlled measurements, refer to paragraph 2.3.4.7
of the manual.

After the measurement trigger "BT", data can be read out of the FAM (after
the appropriate settings); the call for measurement (e.g. "IQ") of the non-
triggered operation of the FAM is not applicable during triggered operations.

Program example of a normal and its corresponding remote-controlled triggered
measurement of an RF signal: f = 10.7 MHz, 20 mV, FM deviation ≈ 40 kHz.

Normal measurement:

```
100 IECDCL:IECCLEAR:IEC←CLEAR
110 IECTERM13:IECTIME100
120 IECOUT29,"BF"
130 HOLD1000
140 IECOUT29,"IS"
150 IECIN29,A$
160 PRINTA$
```

Line 100, 110: Program descriptor
         120: Switchover to FM demodulation
         130: Waiting time of 1 s
         140: Call for measurement
         150: Read command
         160: Print command

Triggered measurement:

```
100 IECDCL:IECCLEAR:IEC←CLEAR
110 IECTERM13:IECTIME100
120 IECOUT29,"BW10.7"
130 IECOUT29,"BF"
140 IECOUT29,"HU00,HV30"
150 IECOUT29,"HW"
160 IECOUT29,"BT"
170 IECIN29,A$
180 PRINTA$
```

Line 100, 110: Program descriptor

       120: Setting frequency to 10.7 MHz

       130: Switchover to FM demodulation

       140: Setting the RF divider to 10 mV input level,
             Setting the FM deviation range to 64 kHz

       150: Switchover to triggered operation; measurement of
             RF frequency and modulation

       160: Measurement trigger

       170: Read command

       180: Print command

3. Maintenance and Repair

3.1. Required Measuring Equipment and Accessories

Pos.	Equipment	Required Features	R&S-Model	Used in Section
1	RF-Frequency-Counter	range 55 kHz to 1.4 GHz error $< 1.10^{-8}$		3.2.3. 5.3.2.1 5.3.4. 5.3.5. 5.3.7.
2	RF-Generator	f = 55 kHz to 120 MHz f = 55 kHz to 1.36 GHz residual frequency modulation at $B = 20$ kHz: < 3 Hz rms	SMUV 301.0120.52 XPC 337.8014.52	3.2.2. 3.2.5.
3	Power Signal Generator	55 kHz to 120 Mhz (1360 MHz with B2) output > 3 V / 50 Ω		
4	AM-FM-Modulator	FM: $k < 0.02\%$ f mod = 10 Hz to 200 kHz frequency response: $\leq 0.2\%$ 30 Hz to 100 kHz AM: $k < 0.05\%$ f mod = 10 Hz to 200 kHz frequency response: $\leq 0.5\%$ 30 Hz to 100 kHz		3.2.5. 3.2.6.
5	RF-Spectrum Analyzer	Dynamic range $\geqq 80$ dB		5.3.6. 5.3.7. 5.3.8.
6	RF-Voltmeter with probe and insertion head	frequency range 55 kHz to 1.5 GHz	URV 4 292.5012.02	5.3.4. 5.3.5. 5.3.6. 5.3.7. 5.3.8.
7	Stereo-Coder	cross-talk < 56 dB, 30 Hz to 15 kHz	MSC 2 230.9314.04	3.2.5.4.
8	Audio Generator	2 Hz to 200 kHz error $\leq 0.2\%$ 30 Hz to 100 kHz distortion $\leq 0.02\%$ up to 20 kHz frequency accuracy: $\leq 0.01\%$		3.2.4. 3.2.5. 3.2.6. 3.2.7. 5.3.3.

Pos.	Equipment	Required Features	R&S-Model	Used in Section
9	Digital Voltmeter AC, DC	error $\leqq$ 0.1% 30 Hz to 60 kHz error $\leqq$ 0.2% 10 Hz to 100 kHz	UDS 6 346.9210.02	5.3.1 5.3.2.3 5.3.6.1
10	Audio-Distortion Meter	range $\leqq$ 0.01% 30 Hz to 20 kHz		3.2.5.3 3.2.6.4 3.2.7
11	Millivoltmeter	frequency range 10 Hz to 1 MHz	UVN 110.2994.02	3.2.4.4 5.3.3 5.3.6
12	Psophometer		UPGR 228.1915.03	5.2.8.2
13	DC Power-Supply	V = 0 to 5 V	NGM 117.7110... NGR 100.5048...	5.3.2.3 3.2.8.4
14	Waveform Generator	with sinewave burst		3.2.8.4
15	Stereodecoder	crosstalk attenuation > 56 dB, 30 Hz to 15 kHz	MSDC 2 281.0514.04	3.2.5.4
16	Sweep Tester	range: 50 to 150 MHz dynamic > 50 dB	SWOB 5 333.0019.52 + SWOB 5-E1 333.5610.02 + SWOB 5-Z1 333.7513.52	5.3.8.7
17	Attenuator	attenuation error $\leqq$ 0.2 dB at 5 kHz	DPS 334.7217.02 DPSP 334.6010.02	3.2.8.4

3.2   Checking the Rated Specification

3.2.1   Display and Keyboard

Check the initial condition after switch-on <u>without</u> an RF-signal at the RF-jack
and <u>without</u> an audio-signal at the voltmeter input.

The display must show the following indications or conditions after switching on:

00000000	on the rf-indicator ($\underline{1}$)
0.000	% on the modulation meter ($\underline{2}$) or ($\underline{3}$)
000.0	Hz on the AF frequency display ($\underline{5}$) or ($\underline{6}$)

The keys listed below must be illuminated:

AUTO	($\underline{26}$)
AM	($\underline{24}$)
AF-FREQ	($\underline{7}$)
HP 30 Hz	($\underline{18}$)
LP 20 kHz	($\underline{14}$)
P+	($\underline{12}$)

All other indicators and keys must be extinguished.

To check the keyboard, perform all the operations described in section 5.3.2.
and check the indicators and keys.

3.2.2   Frequency Range

- Set FAM to: AUTO, AM
- Measuring set-up: Connect RF generator to RF-jack of FAM

3.2.2.1 Basic Unit 120 MHz

Output voltage: 10 mV across 50 Ω

The RF-indicator must follow the frequency of the RF-generator when tuning
from 55 kHz to 120 MHz.
The frequency-counter must show zeroes in the entire frequency range, when the
input voltage is < 3 mV or when the instrument is in the search mode with the
input-relay ticking. This is also the indication for input frequencies $\leqq$ 52 kHz
and $\geqq$ 120.5 MHz.

3.2.2.2 Option B2

The test described in 3.2.2.1 is extended to frequencies $\leqq$ 1360 MHz.
The voltage must be increased to 20 mV above 550 MHz and to 30 mV above 1050 MHz.
The instrument must switch to the search mode at voltages < 1/4 of the specified
input level and when the frequency limits are exceeded: the RF-indicator will
show zeroes and the input-relay ticks.

3.2.2.3 Test at Maximum RF-Input Level

Set the test generator output to 3.0 V. Vary the frequency in the range 55 kHz
to 120 MHz (1360 MHz with the B2 option). The modulation indicator must not
indicate ----.- (overdriving).

3.2.3.   Reference Frequency and RF Counter

- Set FAM to AM, AUTO mode
- Measuring set-up: Connect RF-frequency counter to reference frequency output.
                       Connect RF-generator to RF-input jack (22).

The relative error measured at the reference frequency output must not exceed:

$\pm 1 \cdot 10^{-6}$ per month + $1 \cdot 10^{-6}/^{\circ}C$ for the standard reference
                                                                                 frequency oscillator

$\pm 5 \cdot 10^{-6}$ per month + $1 \cdot 10^{-7}$ in the operating   for the optional reference
                                                       temperature range   frequency oscillator SMS-B1

Set RF-generator to specified minimum input voltage at different frequencies
(Range: 55 kHz to 120 MHz, with option B2: to 1360 MHz). Check for permissible
value of indication error as before.

3.2.4.   AF Voltmeter and AF-Frequency Counter

- Set FAM to: VOLT, AUTO; begin with: HP 10 Hz, LP 200 kHz
- Measuring set-up: Connect audio-generator to input of voltmeter
                    and audio-voltmeter to AF-output.

3.2.4.1. Check Detectors

Input signal: 3,6204 V at 1 kHz at voltmeter input.

Detector:	P+	P-	P±	RMS	RMS·$\sqrt{2}$	CCIR	(Option)
max. indication	5190	5190	5190	3675	5190	3675	
desired value	5120	5120	5120	3620	5120	3620	
minimum indication	5050	5050	5050	3565	5050	3565	

3.2.4.2. Check Voltage Range

- Set FAM: VOLT, AUTO, DETECTOR RMS
            HP 10 Hz, begin with: LP 200 kHz

In the frequency range 30 Hz to 100 kHz apply different voltages in the range
0.4 to 3 V and compare with indication of voltmeter:

Allowable error in the frequency range:

30 Hz to 60 kHz: $\leq \pm 1.5\% \pm 0.4$ mV
60 kHz to 100 kHz: $\leq \pm 3\% \pm 0.4$ mV

- Set LP 20 kHz, adjust audio level to 0.1 to 3 V and check:

Allowable error in the frequency range:

30 Hz to 10 kHz: $\leq \pm 1.5\% \pm 0.1$ mV

3.2.4.3. Check AF-Frequency Counter

Apply frequencies > 100 Hz to 200 kHz to voltmeter input:
allowable indication error: $\leq \pm 1$ $^{0}/00$
at a S/N-ratio   > 40 dB at the AF-output.
(Measuring of S/N in mode "S3")

3.2.4.4. Check Filter HP and LP

- Connect audio-voltmeter to AF-output. Apply 3.6204 V at 1 kHz.
  Input the indicated value as reference. Press % or dB key.
  Inhibit the instrument with "S3".

Check high-pass filter response (Fig. 2-7)
Check low-pass filter response (Fig. 2-8) except LP 200 kHz

Note: Testing with the FAM volts indicator is only possible until
          the dashes (- - - -) appear in the centre indicator
          (about 10 dB down on 1 kHz display value).

3.2.4.5. Check AF-Output Voltage

- Set FAM: as in 3.2.4.
- Measuring set-up: as in 3.2.4.4.

Increase input voltage of voltmeter at 1 kHz from 0.1 mV to 3 V and decrease again.
Check: max. level: 1 V $\pm$ 50 mV
          min. level: 400 mV $\pm$ 50 mV

3.2.5. FM Demodulation

3.2.5.1. Check FM Accuracy

- Set FAM to: FM, AUTO, HP 10 Hz, LP 200 kHz (20 kHz), P+
- Measuring Set-up:

```
┌─────────────────┐              ┌─────────────────┐
│  FM Modulator   │              │                 │
│  f_RF ≥ 10 MHz  │──────────┬───│    RF   FAM     │
│                 │          ┊   │                 │
└─────────────────┘          ┊   └─────────────────┘
        │ f_mod              ┊
        │                    ┊
┌─────────────────┐          ┊   ┌─────────────────┐
│  AF Generator   │          └╌╌╌│    Analyzer     │
└─────────────────┘              └─────────────────┘
```
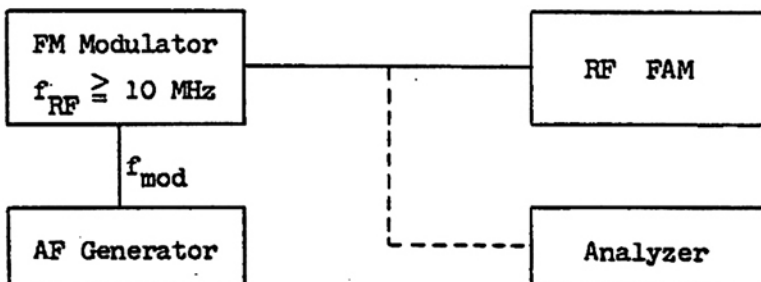
Set different frequency deviations up to 500 kHz in the modulation frequency range 30 Hz to 100 kHz and check the FAM frequency deviation display.

Note: for $\eta = \dfrac{\Delta f}{f_{mod}} = 2.405, 5.52$ etc.

the carrier will be cancelled; check with analyzer. Adjust for a carrier suppression of more than 60 dB by adjusting the deviation.

- f RF = 100 MHz

Measuring adjustment				FAM-Deviation Indication		
LP [kHz]	Δf [kHz]	f_{mod}	η	min.	desired value	max.
20	5	2.079 kHz	2.405	-1.5%	5 kHz	+1.5%
200	100	18.116 kHz	5.52	-1.5%	100 kHz	+1.5%
200	100	41.58 kHz	2.405	-1.5%	100 kHz	+1.5%
200	500	90.58 kHz	5.52	-6.0%	500 kHz	+6.0%

3.2.5.2. Check for Inherent Residual FM

- Set FAM: AUTO, FM
- Measuring set-up: Connect RF generator to RF input of FAM
    FAM must have CCITT filter (Option B6) or
    CCIR filter (Option B7).

Check FAM indication at different frequencies
4.25 to 120 MHz (for Option B2 4.25 to 1360 MHz).

$f_{in} =$	Inherent residual FM			
	4.25 ... 120 MHz	120 ... 550 MHz	550 ... 1050 MHz	1050 ... 1360 MHz
Filter CCITT (with DETECTOR RMS)	$\leq$ 1 Hz	$\leq$ 3 Hz	$\leq$ 6 Hz	$\leq$ 12 Hz
Weighting bandwidth 30 Hz to 20 kHz (with DETECTOR RMS)	$\leq$ 5 Hz	$\leq$ 14 Hz	$\leq$ 25 Hz	$\leq$ 50 Hz
Filter CCIR (with DEEMPH 50 µs and DETECTOR PEAK CCIR)	$\leq$ 6 Hz	/	/	/

<u>3.2.5.3.</u>   <u>Check AF Distortion Factor with FM</u>

(the signal at the AF output)

- Set FAM: FM AUTO, HP 10 Hz, LP 200 kHz

- Measuring set-up: the same as 3.2.5.1.,
                     connect audio distortion meter to output AF.

In the frequency range f mod = 30 Hz to 20 kHz check the distortion factor for:

Δf = 75 kHz :   max. 0.1%

Δf = 500 kHz :   max. 0.5%

<u>3.2.5.4.</u>   <u>Check Stereo Crosstalk</u>

- Set FAM to: FM, AUTO, LP 200 kHz

- Measuring set-up:

Deviation approx. 40 kHz
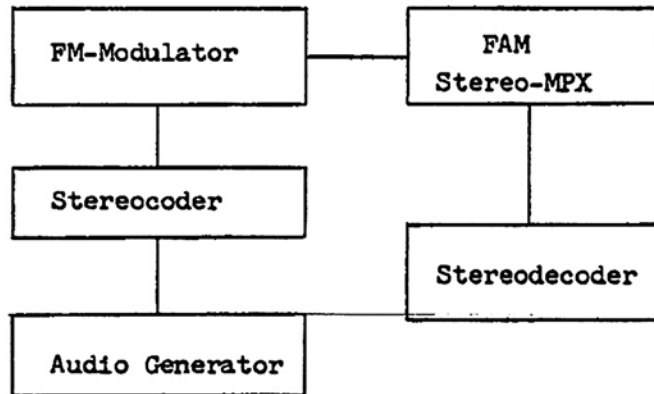
The stereo crosstalk of the FAM must be:

f mod = 30 Hz to 15 kHz : better than 46 dB

f mod = 1 kHz   : better than 50 dB

<u>3.2.5.5.</u>   <u>Check Synchronous FM</u>

- Set FAM to :   FM, AUTO, HP 30 Hz, LP 3 kHz, DETECTOR P+

- Measuring set-up: set modulator to f mod = 1 kHz and 50% AM.
                     Connect to FAM.

Maximum allowable indication of FM-deviation: $\leq$ 20 Hz (plus peak residual FM,
                                                        Int. Tol. 30 Hz).

Note: At frequencies > ca. 550 MHz this measurement can be made selectively at
      the AF (or FM-MPX) Output. The amount of residual FM (or the residual FM
      of the device under test) may be above the allowable value for the syn-
      chronous FM in this case. Another possibility consists in measuring the
      residual FM of an unmodulated signal and subtracting this measured value
      from the measured value <u>with</u> modulation.

3.2.5.6. Check De-Emphasis

- Set FAM to: FM, AUTO, HP 10 Hz, LP 200 kHz, DETECTOR P+
- Measuring set-up: as in 3.2.5.1.

Set for 40 kHz deviation. Take reading at f mod = 30 Hz as reference.
Press key "dB". Compare readings against reference de-emphasis curves in
Fig. 2-9.

3.2.6   Phase Demodulation

3.2.6.1. Check Accuracy

- Set FAM to: AUTO, φM, LP 200 kHz
- Measuring set-up: as in 3.2.5.1.

Set φM to 64 kHz and f mod = 1 kHz (= FM deviation):
input reference reading, press key "dB".

f_{mod}	300 Hz	1 kHz	10 kHz	20 kHz	
maximum indication	+10.7	+0.3	-19.7	-25.7	[dB]
desired value	+10.4	0	-20	-26	[dB]
minimum indication	+10.1	-0.3	-20.3	-26.3	[dB]

3.2.6.2. Check Residual FM

- Set FAM to: φM, AUTO, LP 20 kHz, or FILTER CCITT
                (optional), DETECTOR RMS
- Measuring set-up: Connect RF-generator to FAM

f in =	4.25 to 120 MHz	with Option B2		
		120 to 550 MHz	550 to 1050 MHz	1050 to 1360 MHz
FILTER CCITT	≦ 0.002 rad	≦ 0.003 rad	≦ 0.006 rad	≦ 0.012 rad
30 Hz to 20 kHz	≦ 0.005 rad	≦ 0.01 rad	≦ 0.02 rad	≦ 0.04 rad

3.2.6.3.   Check Synchronous φM at AM

- Set FAM to : φM, AUTO, LP 3 kHz, DETECTOR P+
- Measuring set-up: as 3.2.5.5.

Desired value of synchronous φM: $\leq$ 0.02 rad (plus peak residual FM,
See Note in Section 3.2.5.5.   Int. Tol. 0,03 rad).

3.2.6.4.   Audio Distortion Factor at φM
(signal at AF-output)

- Set FAM to: φM, AUTO, LP 200 kHz
- Measuring set-up: as in 3.2.5.1.,
                    connect audio distortion meter to output AF.

Adjust for a phase deviation of 4 rad at frequencies of 300 Hz to 20 kHz
and check the audio distortion factor. Desired value $\leq$ 0.1 %.

3.2.7.   Amplitude Demodulation

3.2.7.1.   AM < 3.5 MHz

- Set FAM to :   AUTO, AM, HP 10 Hz, LP 20 kHz, DETECTOR P+
- Measuring set-up:
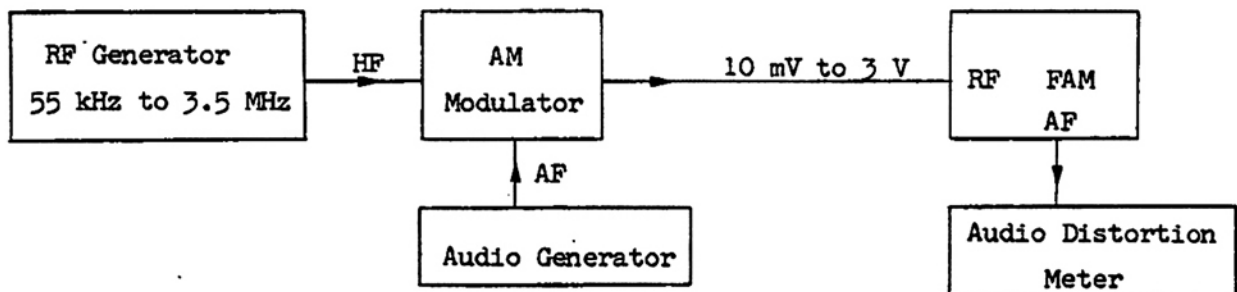
3.2.7.1.1. Check AM Accuracy

Check AM indicator at different voltages from 10 mV to 3 V and different
modulation factors from 5% to 80%:

Permissible Error:

$\leq$ 2% of measured value for f_{AF} = 30 Hz to 10 kHz

Set equipment with MAN key to the RF Input frequency. Modulate RF signal
with 100% modulation factor (AM). Check with oscilloscope.

Desired value FAM: 100% $\pm$ 5%

3.2.7.1.2. Check AM Distortion Factor
(at the output AF)

Allowable distortion factor: $m = 40\%:$ $\leq 0.2\%$
f mod = 30 Hz to 20 kHz : $m = 80\%:$ $\leq 0.4\%$

3.2.7.1.3. Check Inherent Residual AM

- Set FAM: AM, AUTO, filter and detector according to test
- Measuring set-up:

```
┌─────────────────────┐                    ┌─────────────────────────┐
│   RF-Generator      │      250 mV        │          FAM            │
│                     │ ───────────▶       │                         │
│  55 kHz to 3.5 MHz  │                    │  (with Option B6, B7)   │
└─────────────────────┘                    └─────────────────────────┘
```
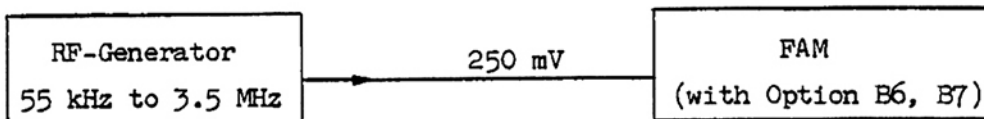
Permissible residual AM:

FILTER CCITT, DETECTOR RMS	$\leq 0.01\%$
HP 30 Hz, LP 20 kHz, DETECTOR RMS	$\leq 0.05\%$
FILTER CCIR, DETECTOR CCIR	$\leq 0.05\%$

3.2.7.2.   AM > 3.5 MHz

- Set FAM to :   AUTO, AM, HP 10 Hz, LP 200 kHz, P+
- Measuring set-up:

```
┌──────────────────────────┐     ┌──────────┐     ┌────────────────────────┐
│      AM-Modulator        │     │ RF    AF │     │        Audio           │
│                          │ ──▶ │          │ ──▶ │   distortion meter     │
│ f RF = 3.5 MHz to 1350 MHz│    │   FAM    │     │  (for 3.2.7.2.2. only) │
└──────────────────────────┘     └──────────┘     └────────────────────────┘
             ▲
             │
┌──────────────────────────┐
│     Audio Generator      │
│                          │
└──────────────────────────┘
```
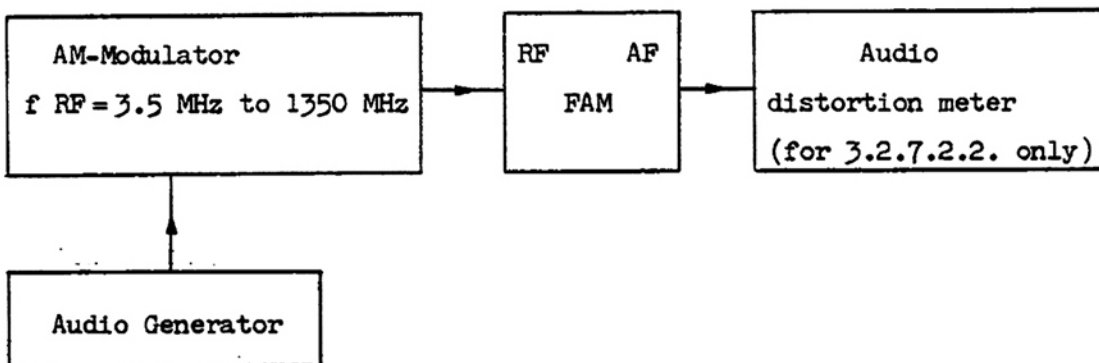
3.2.7.2.1.   Check AM Accuracy

Check AM indication at different levels from 10 mV to 3 V,
at different modulation factors from 5% to 80%.

Permissible indication error:

for f AF = 30 Hz to 60 kHz $\leq \pm 2\%$ of measured value +
$\qquad\qquad\qquad\qquad\qquad\qquad$ inherent peak residual AM

$\quad$ f AF = 60 kHz to 100 kHz $\leq \pm 4\%$ of measured value +
$\qquad\qquad\qquad\qquad\qquad\qquad$ inherent peak residual AM

Adjust equipment to RF input frequency and modulate the signal by 100% AM.

Desired indication FAM: 100% $\pm$5% (with fmod 30 Hz to 60 kHz)
$\qquad\qquad\qquad\qquad\quad$ 100% +10% (with fmod 60 kHz to 100 kHz)

3.2.7.2.2. Check AM Distortion Factor
$\qquad\qquad\qquad$ (at the AF output)

Allowable distortion factor:

f RF < 120 MHz:	f RF > 120 MHz
f mod = 30 Hz to 20 kHz at m = 40% $\leq$ 0.2%	$\leq$ 0.4%
at m = 80% $\leq$ 0.4%	$\leq$ 0.6%

3.2.7.2.3. Check for Inherent Residual AM

Set FAM to : AUTO, AM, filter and detector according to the measurement

RF-Generator		FAM
35 MHz to 1360 MHz	ca. 100 mV $\longrightarrow$	with Option B6, B7
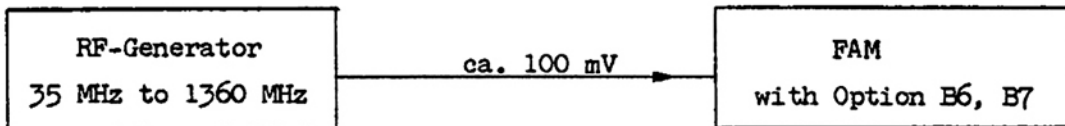
Allowable residual AM:	3.5 to 120 MHz
FILTER CCITT, DETECTOR RMS	$\leq$ 0.01%
HP 30 Hz, LP 20 kHz, DETECTOR RMS	$\leq$ 0.05%
FILTER CCIR, DETECTOR CCIR	$\leq$ 0.05%

3.2.7.2.4. Check Synchronous AM

Set FAM to: AM HP 30 Hz, LP 3 kHz, DETECTOR P+

Measurement set-up: as in 3.2.7.2.
$\qquad\qquad\qquad\qquad$ set deviation to 50 kHz, f mod = 1 kHz

max. indication of modulation: $\leq$ 0.1%

3.2.8.   AF-weighting Filter

(with Option "CCITT-Filter" FAM-B6 and Option "CCIR-Filter" FAM-B7)

3.2.8.1.   HP 10 Hz, HP 30 Hz, HP 300 Hz
            LP 3 kHz, LP 20 kHz

check as detailed in 3.2.4.4.

3.2.8.2.   LP 200 kHz

(can be tested in AM or FM mode only; filters are integrated into
the corresponding detectors).

- Set FAM: FM (or AM), HP 10 Hz, LP 200 kHz, P+

- Measurement set-up: FM as in 3.2.5.1.
                         AM as in 3.2.7.1.

Inhibit FAM at a modulation signal of 1 kHz, check nominal filter response
at AF output with audio voltmeter (refer to Fig. 2-7.)

3.2.8.3.   Check CCITT Filter (Option FAM-B6)

- Set FAM to: VOLT, AUTO, start with DETECTOR RMS,
               HP 10 Hz, LP 200 kHz

- Measurement set-up: as in 3.2.4., further:
               apply 3.000 V, 800 Hz, transfer nominal indication
               3000 mV ± 45 mV with REF key as nominal value, switch in
               CCITT Filter, difference to HP 10 Hz, TP 200 kHz ± 1.5%.
               Inhibit equipment with "S3".
               Check nominal filter response with audio voltmeter at
               AF output according to 5.3.10.

3.2.8.4 Check CCIR Filter (Option FAM-B7)

A) Check Filter

- Set FAM to: VOLT, AUTO, start with DETECTOR RMS,
  HP 10 Hz, LP 20 kHz

- Measurement set-up: connect audio generator to AF Voltmeter input
  connect audio voltmeter to AF output.

Set audio generator to 0.500 V at 6.3 kHz

- Switch in Detector P+

Key in the nominal value 0.707 V_S via the keyboard.

- press REF key
- press dB key
- press CCIR key (16)

Nominal indication + 12.2 dB ±0.2 dB

Inhibit equipment with "S3"

Measure nominal filter response at AF output:
(Reference: voltage at 6.3 kHz)

Filter response: refer to table in section 5.3.11.1

B) Check CCIR (quasi-peak) detector

- Set FAM to: VOLT, AUTO, CCIR filter, CCIR detector
- Measurement setup: connect sine-burst generator via attenuator to
  FAM voltmeter input

a) Check with sinusoidal signal

Apply 0.775 V, 1 kHz to FAM voltmeter input:
nominal indication: 0.775 V ±12 mV

Take indication as reference value, switch to dB relative value indication,
set the FAM measurement range with special function S6 (10S6), switch off sinus-
oidal signal *); when signal is switched on again, the maximum display overshoot
must not exceed +0.3 dB of the final steady indication.

b) Check with single pulse

- FAM settings as in a)

Set the level of the 5-kHz sinusoidal signal so that FAM indicates 775 mV; take as
reference value, switch to dB relative-value indication. Switch on a single 5-kHz
sinusoidal burst of the same level as the continuous sinusoidal signal. Check the
maximum value of the indication as a function of the pulse duration with the table
in section 5.3.11.2.

c) Dynamic range check

- FAM settings as in a), REF OFF

Set the level of the 5-kHz sinusoidal signal so that the FAM indicates 940 mV
(maximum input); switch on a single sinusoidal burst of f = 5 kHz, pulse duration
= 0.6 ms, amplitude same as that of continuous sinusoidal signal. Take FAM display
value as reference value, switch to dB relative-value indication.

On switching in additional attenuation (with attenuator) of up to 20 dB max.,
the FAM display must follow the attenuation steps with an error ≤1 dB.

---

*) In this case, the output of dashes (---.-) by the display indicates
a lack of drive by more than 30 dB.

d) Check with pulse sequence

- FAM settings as in a), REF OFF

Set the level of the 5-kHz sinusoidal signal so that the FAM indicates 775 mV; take as reference level and switch to dB relative-value indication.

With a periodic, 5-kHz sinusoidal-burst signal whose pulse duration is 5 ms, check the FAM display (dependent on the pulse sequence frequency) with the table below (maximum display values).

Pulse repetition frequency Hz		2	10	100
Nominal amplitude dB		-6.4	-2.3	-0.25
Limiting values dB min.		-7.3	-2.9	-0.5
max.		-5.5	-1.7	0

e) Polarity error

- FAM settings as in a), clear special function S6,
  HP 30 Hz, LP 20 kHz

Apply a non-symmetric squarewave signal, pulse duration = 1 ms, pulse repetition frequency = 100 Hz to the FAM voltmeter socket. Input a pulse amplitude of about 1 V as a reference value, switch to dB relative-value indication.

When the polarity of the pulse is reversed, the maximum display deviation is to be $\leq \pm 0.5$ dB

3.2.9   Audio Outputs

3.2.9.1 Check AF Output

(refer to 3.2.4.5)

3.2.9.2 Check FM Stereo Output

- Measurement set-up and set-up of FAM as in 3.2.5.1.
  Connect audio voltmeter to FM stereo output of FAM.

Set deviation to 40 kHz, f mod = 1 kHz.

Nominal voltage at stereo output: 1.545 V $\pm$ 2.5 %
                                    ($\cong$ +6 dBm across 600 Ω)

3.2.9.3 Check AM Output

- Measurement set-up the same as in 3.2.7.1.
  Connect audio voltmeter to AM output.

Set to 100% AM and f mod = 1 kHz
by varying the RF output level, set to maximum output voltage.

max. output voltage: 1 V

Check for nominal filter response with audio voltmeter at output AF,

according to 5.3.10.

3.2.10. Check IEC-Bus

- Measurement set-up: apply RF signal to RF input,
                       control FAM remotely with a controller.

Program all listener- and talker-commands listed in section 2.4. and check
the correct execution of these commands at the front panel indicators of
the FAM, or check the data of the talker commands accepted by the controller,
respectively.

3.2.11   DIST and SINAD Meter

- Set FAM to: VOLT, DIST, HP 10 Hz, LP 200 kHz, RMS

3.2.11.1   Check Lowest Detectable Distortion Factor

- Measurement setup: Connect AF generator (k $\leqq$ 0.02%) to
                      the voltmeter input socket

A distortion factor of $\leqq$ 0.1% must be indicated on the meter at all given
test frequencies ($\pm$3%).

- Test frequencies: 30, 40 to 90 Hz
  ($\pm$3% each)   100, 200 to 900 Hz
  Level: 1 V   1,   2 to   9 kHz
                      10 kHz, 12.5 kHz, 17.5 kHz, 20 kHz

3.2.11.2   Check the Indication Accuracy

- Measurement setup: Connect two isolated AF generators to the
                      voltmeter input of FAM.

Example of test setup circuitry:
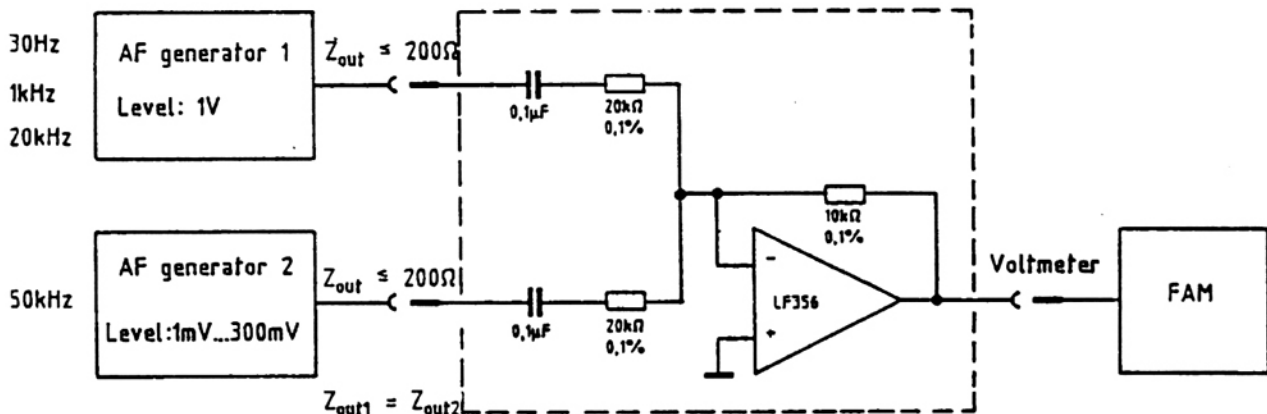
Level: 1   mV, 3   mV
       10   mV, 30   mV
      100 mV, 300 mV

Set AF generator 2 to 50 kHz and vary the level as shown below,
set AF generator 1 to 30 Hz, 1 kHz, 20 kHz at a level of 1 V;
check indication error:

AF generator 2: f = 50 kHz; level:	1	3	10	30	100.5	±0.5%
Indicated distortion when generator 1 is set to:						
f = 30 Hz, min.	0.08	0.26	0.9	2.7	9	%
1 kHz,	0.1	0.3	1	3	10	%
20 kHz, max.	0.12	0.34	1.1	3.3	11	%
Level: 1 V±0.5%						

3.3. Performance Test Protocol

R & S   Date   ....

Modulation Analyzer   Name   ....

Id.No. 334.2015.52

FNr. ....

Pos.	Feature	To be measured acc. to section	min	actual	max	Unit
1.	Functional test of display and keyboard	3.2.1	-		-	
2.	Check for required input level at different frequencies	3.2.2	-		-	
	55 kHz		-	...	10	mV
	3.5 MHz		-	...	10	mV
	120 MHz		-	...	10	mV
	The frequency applied must be indicated. (Errors: refer to 3.)					
	with option B2					
	550 MHz		-	...	10	mV
	1050 MHz		-	...	20	mV
	1360 MHz		-	...	30	mV
3.	Check reference oscillator and RF indicator: 10,000 MHz	3.2.3	-		-	
	a) Temperature stability		-			
	standard version		-	...	± 10	Hz/K
	option B1		-	...	± 1	Hz *)
	b) Aging		-		-	
	standard version		-	...	± 10	Hz/month
	option B1		-	...	± 0.5	Hz/month

*) in the operating temperature range

Pos.	Feature	To be measured acc. to section	min	actual	max	Unit
4.	Check voltmeter	3.2.4	-		-	
4.1	Check detector 3.6204 V	3.2.4.1				
	DETECTOR P+		5050	...	5190	mV
	DETECTOR P-		5050	...	5190	mV
	DETECTOR $\frac{P+P}{2}$		5050	...	5190	mV
	Apply 3.6204 V, 1 kHz to voltmeter input					
	DETECTOR RMS		3565	...	3675	mV
	Inhibit with "S3"					
	DETECTOR RMS · $\sqrt{2}$		5050	...	5190	mV
	Apply 1.439 V P+ (2035)		2004	...	2065	mV
	1 kHz RMS (1439)		1417	...	1460	mV
4.2	Voltage measuring range LP 200 kHz	3.2.4.2				
	V_{in} = 3000 mV f_{in} = 30 Hz		2955	...	3045	mV
	1 kHz		2955	...	3045	mV
	60 kHz		2955	...	3045	mV
	100 kHz		2910	...	3090	mV
	200 kHz		2700	...	3300	mV
	100 mV 1 kHz		98.1	...	101.9	mV
	60 kHz		98.1	...	101.9	mV
	100 kHz		96.6	...	103.4	mV
				...		mV
				...		mV
				...		mV
				...		mV
	10 mV 1 kHz		9.45	...	10.55	mV
	60 kHz		9.45	...	10.55	mV
	100 kHz		9.3	...	10.7	mV
	LP 20 kHz f_{in} = 30 Hz	3.2.4.2	0.9	...	1.1	mV
	V_{in} = 1 mV 1 kHz		0.9	...	1.1	mV
	10 kHz		0.9	...	1.1	

Pos.	Feature	To be measured acc. to section	min	actual	max	Unit
4.3	Check audio frequency counter LP 200 kHz V_{in} = 40 mV 10 Hz 100 Hz 10 kHz 200 kHz	3.2.4.3	- 9.9 99.9 9.99 199.8		- 10.1 100.1 10.01 200.2	 Hz Hz kHz kHz
4.4	Check HP and LP filters Attenuation referenced to 1 kHz HP 10 Hz, f_{in} = 10 Hz HP 30 Hz, f_{in} = 31,5 Hz HP 300 Hz, f_{in} = 300 Hz LP 3 kHz, f_{in} = 3 kHz LP 20 kHz, f_{in} = 16 kHz f_{in} = 22,4 kHz	3.2.4.4	- -1.2 -0.5 -1 -2 -0.5 -6		- -0.8 -0.2 -0.3 -1 -0.2 -2	 dB dB dB dB dB dB
4.5	AF output level f = 1 kHz	3.2.4.5	- 0.35	 ...	- 1.05	 V
5.	Check demodulation	3.2.5	-		-	
5.1	Check FM accuracy f_{RF} = 100 MHz Δf = 5 kHz f_{mod} = 2.079 kHz, LP 20 kHz Δf = 100 kHz f_{mod} = 18.116 kHz, LP 200 kHz Δf = 100 kHz f_{mod} = 41.66 kHz Δf = 500 kHz f_{mod} = 90.58 kHz	3.2.5.1	 4.93 98.5 98.5 470		 5.07 101.5 101.5 530	 kHz kHz kHz kHz

Pos.	Feature	To be measured acc. to section	min	actual	max	Unit
5.2.	Check for inherent residual deviation	3.2.5.2	-		-	
	f_{RF} = 5 MHz					
	CCITT		-	...	1	Hz
	30 Hz to 20 kHz		-	...	5	Hz
	CCIR		-	...	6	Hz
	f_{RF} = 61 MHz					
	CCITT		-	...	1	Hz
	30 Hz to 20 kHz		-	...	5	Hz
	CCIR		-	...	6	Hz
	f_{RF} = 120 MHz					
	CCITT		-	...	1	Hz
	30 Hz to 20 kHz		-	...	5	Hz
	CCIR		-	...	6	Hz
	with option 2					
	f_{RF} = 550 MHz					
	CCITT		-	...	3	Hz
	30 Hz to 20 kHz		-	...	14	Hz
	f_{RF} = 1050 MHz					
	CCITT		-	...	6	Hz
	30 Hz to 20 kHz		-	...	25	Hz
	f_{RF} = 1360 MHz					
	CCITT		-	...	12	Hz
	30 Hz to 20 kHz		-	...	50	Hz
5.3.	Audio distortion factor at FM	3.2.5.3	-		-	
	f_{RF} = 100 MHz					
	Δf = 75 kHz f_{mod} = 30 Hz		-	...	0.1	%
	= 1 kHz		-	...	0.1	%
	= 20 kHz		-	...	0.1	%
	Δf = 500 kHz f_{mod} = 30 Hz		-	...	0.5	%
	= 1 kHz		-	...	0.5	%
	= 20 kHz		-	...	0.5	%
5.4.	Stereo crosstalk	3.2.5.4	-		-	
	f_{RF} = 100 MHz					
	Δf = 40 kHz f_{mod} = 30 Hz		-	...	46	dB
	= 1 kHz		-	...	50	dB
	= 15 kHz		-	...	46	dB
5.5.	Synchronous FM	3.2.5.5	-		-	
	f_{mod} = 10 MHz					
	m = 50 % f_{mod} = 1 kHz		-	...	20*	Hz

*) plus peak residual FM

Pos.	Feature	To be measured acc. to section	min	actual	max	Unit
5.6.	Check deemphasis	3.2.5.6	-		-	
	Deemphasis Attenuation at f_{mod}					
	50 µs 3.183 kHz		2.7	...	3.3	dB
	75 µs 2.122 kHz		2.7	...	3.3	dB
	750 µs 212.2 Hz		2.7	...	3.3	dB
6.	Phase modulation	3.2.6.	-		-	
6.1.	Accuracy	3.2.6.1				
	FM deviation $\Delta f = 64$ kHz					
	$f = 1$ kHz, φM-deviation		-0.3	...	+0.3	dB
	$f = 300$ Hz, φM-deviation		+10,1	...	+10.7	dB
	$f = 20$ kHz, φM-deviation		-26.3	...	-25.7	dB
6.2.	Inherent residual deviation	3.2.6.2.	-		-	
	$f_{RF} = 5$ MHz					
	CCITT		-	...	0.002	rad
	LP 20 kHz		-	...	0.005	rad
	$f_{RF} = 61$ MHz					
	CCITT		-	...	0.002	rad
	LP 20 kHz		-	...	0.005	rad
	$f_{RF} = 120$ MHz					
	CCITT		-	...	0.002	rad
	LP 20 kHz		-	...	0.005	rad
	<u>with option FAM-B2</u>					
	$f_{RF} = 550$ MHz					
	CCITT		-	...	0.003	rad
	LP 20 kHz		-	...	0.01	rad
	$f_{RF} = 1050$ MHz					
	CCITT		-	...	0.006	rad
	LP 20 kHz		-	...	0.02	rad
	$f_{RF} = 1360$ MHz					
	CCITT		-	...	0.012	rad
	LP 20 kHz		-	...	0.04	rad
6.3.	Synchronous φM at AM	3.2.6.3				
	$f_{RF} = 10$ MHz					
	$m = 50$ % $f_{mod} = 1$ kHz		-	...	0.02 *	rad
6.4.	Audio distortion factor	3.2.6.4.				
	Phase deviation $\Delta f = 4$ rad					
	$f_{mod} = 300$ Hz		-	...	0.1	%
	= 1 kHz		-	...	0.1	%
	= 20 kHz		-	...	0.1	%

*) plus peak residual φM

Pos.	Feature	To be measured acc. to section	min	actual	max	Unit
7.	AM	3.2.7.	-		-	
7.1.	AM < 3.5 MHz	3.2.7.1.	-		-	
7.1.1.	Accuracy f_{RF} = 3.0 MHz 100 mV	3.2.7.1.1.	-		-	
	m = 5 % f_{mod} = 30 Hz		4.9	...	5.1	% AM
	= 1 kHz		4.9	...	5.1	% AM
	= 10 kHz		4.9	...	5.1	% AM
	m = 80 % f_{mod} = 30 Hz		78.4	...	81.6	% AM
	= 1 kHz		78.4	...	81.6	% AM
	= 10 kHz		78.4	...	81.6	% AM
	m = 100 % f_{mod} = 1 kHz		95	...	105	% AM
7.1.2.	AM distortion factor f_{RF} = 3 MHz 100 mV	3.2.7.1.2.	-		-	
	m = 40 % f_{mod} = 5 kHz		-	...	0.2	%
	m = 80 % f_{mod} = 5 kHz		-	...	0.4	%
7.1.3.	Inherent spurious AM f_{RF} = 3 MHz 250 mV	3.2.7.1.3.	-		-	
	CCITT		-	...	0.01	% AM
	30 Hz to 20 kHz		-	...	0.05	% AM
	CCIR		-	...	0.05	% AM
7.2.	AM > 3.5 MHz	3.2.7.2.	-		-	
7.2.1	AM accuracy f_{RF} = 10 MHz 100 mV	3.2.7.2.1.	-		-	
	m = 5 % f_{mod} = 30 Hz		4.9*	...	5.1*	% AM
	= 1 kHz		4.9*	...	5.1*	% AM
	= 60 kHz		4.9*	...	5.1*	% AM
	= 100 kHz		4.8*	...	5.2*	% AM
	m = 80 % f_{mod} = 1 kHz		78.4*	...	81.6*	% AM
	= 60 kHz		78.4*	...	81.6*	% AM
	= 100 kHz		76.8*	...	83.2*	% AM
	m = 100 % f_{mod} = 1 kHz		95 *	...	105 *	% AM

*) + inherent peak residual AM

Pos.	Feature	To be measured acc. to section	min	actual	min	Unit
7.2.2.	AM distortion factor	3.2.7.2.2.	-		-	
	f_{RF} = 10 MHz					
	m = 40 % f_{mod} = 1 kHz		-	...	0.2	%
	= 20 kHz		-	...	0.2	%
	m = 80 % f_{mod} = 1 kHz		-	...	0.4	%
	= 20 kHz		-	...	0.4	%
	f_{RF} = 200 MHz					
	m = 40 % f_{mod} = 1 kHz		-	...	0.4	%
	= 20 kHz		-	...	0.4	%
	m = 80 % f_{mod} = 1 kHz		-	...	0.6	%
	= 20 kHz		-	...	0.6	%
7.2.3.	Inherent spurious AM	3.2.7.2.3.	-		-	
	f_{RF} = 3.5 MHz					
	CCITT		-	...	0.01	% AM
	30 Hz to 20 kHz		-	...	0.05	% AM
	CCIR		-	...	0.05	% AM
	f_{RF} = 120 MHz					
	CCITT		-	...	0.01	% AM
	30 Hz to 20 kHz		-	...	0.05	% AM
	CCIR		-	...	0.05	% AM
	with option B2					
	f_{RF} = 550 MHz					
	CCITT		-	...	0.01	% AM
	30 Hz to 20 kHz		-	...	0.05	% AM
	CCIR		-	...	0.05	% AM
	f_{RF} = 1360 MHz					
	CCITT		-	...	0.02	% AM
	30 Hz to 20 kHz		-	...	0.05	% AM
	CCIR		-	...	0.1	% AM
7.2.4.	Check synchronous AM	3.2.7.2.4.	-		-	
	f_{RF} = 100 MHz 100 mV		-	...	0.1	% AM

Pos.	Feature	To be measured acc. to section	min	actual	max	Unit
8	Check audio filter	3.2.8	-		-	
8.1	Check TP 200 kHz f_{mod} = 200 kHz attenuation in reference to 1 kHz FM: AM:	3.2.8.2	- 1 1		- 3 3	 dB dB
8.2	CCITT-Filter Option B6 attenuation at 800 Hz in reference to HP 10 Hz, LP 200 kHz check the nominal filter response	3.2.8.3	- -1.5 -	 ... 	- +1.5 -	 %
8.3	CCIR-Filter Option B7	3.2.8.4	-		-	
8.3.1	CCIR-Filter Gain at 6.3 kHz referred to HP 10 kHz LP 20 kHz check the nominal filter response	3.2.8.4.1	- 12.0 -	 ... 	- 12.4 -	 dB
8.3.2	CCIR detector 0.775 V, 1 kHz Overshoot, 0.775 V = 0 dB Single pulse check Dynamic range check, max. deviation from set attenuation Pulse sequence check, deviation from continuous sinusoidal signal at pulse rep. freq. 2 Hz: 10 Hz: 100 Hz: Polarity error	3.2.8.4 B)	- 763 - -1 -7.3 -2.9 -0.5 -0.5		- 787 +0.3 - +1 -5.5 -1.7 0 +0.5	 mV dB dB dB dB dB dB
9	Check audio outputs Δf = 40 kHz, FM-Stereo-MPX m = 100%, AM output	3.2.9 3.2.9.2 3.9.3	- 1.506 950		- 1.584 1010	 V mV
10	Check IEC bus	3.2.10	-	...	-	

Pos.	Feature	To be measured acc. to section	min	actual	max	Unit
11	Check DIST and SINAD meter	3.2.11	-		-	
11.1	Check minimum detectable distortion factor Test frequencies: 30, 40 to 90 Hz ± 3% 100, 200 to 900 Hz ± 3% 1, 2 to 9 kHz ± 3% 10 kHz, 12.5 kHz, 15 kHz, 17.5 kHz, 20 kHz ± 3%	3.2.11.1		... ...	0.1 0.1 0.1 0.1	% % % %
11.2	Check indication accuracy Applied distortion factor: 0.1% 0.3% 1 % 3 % 10 %	3.2.11.2	 0.08 0.26 0.9 2.7 9		 0.12 0.34 1.1 3.3 11	 % % % % %

4.   Functional Description

(refer to circuit schematic 334.2015.01 S)

4.1.   General Function

The Modulation Analyzer FAM is divided into the RF-, IF-Audio- and Computer Control section. (Fig. 4-1). In the RF section, a counter is measuring the frequency of the input signal, the signal voltage is automatically controlled and the signal is converted to the IF frequency. The IF section includes the FM- and AM demodulators, the audio section evaluates the demodulated signal. The computer control supervises all settings, data acquisitions, inputs and outputs of the keyboard and the indicator panel, respectively.
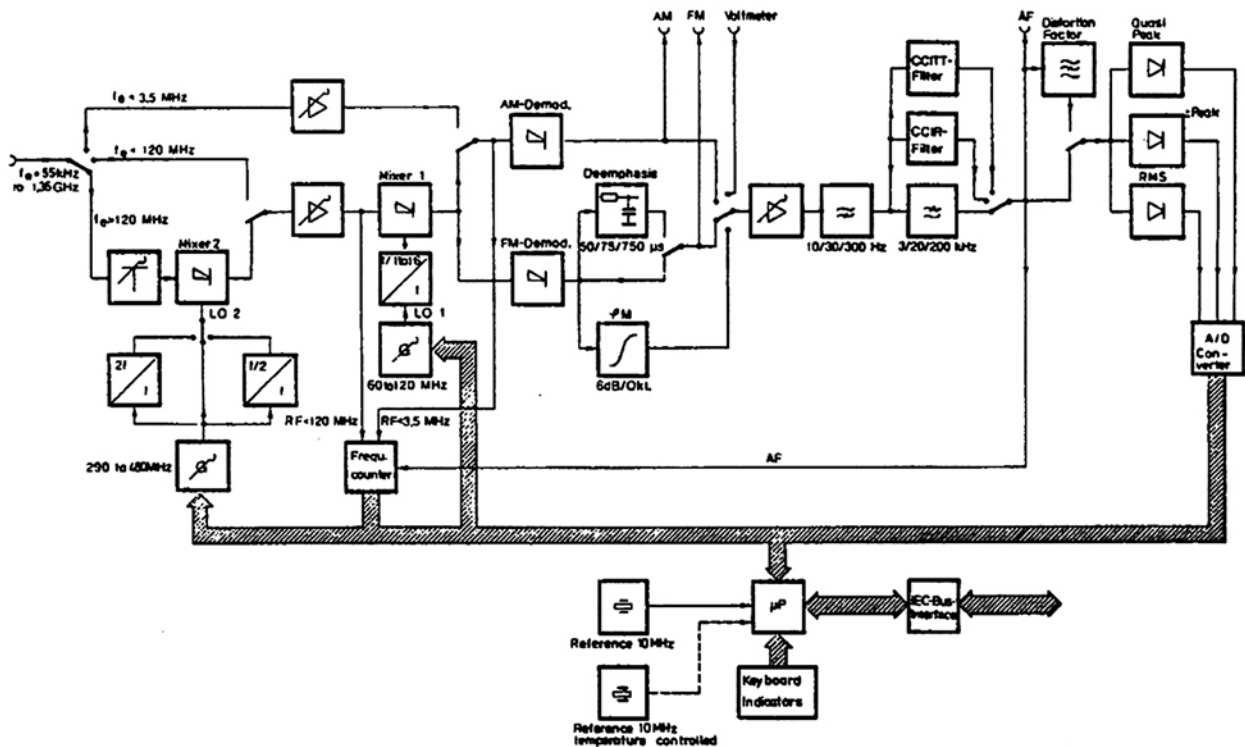
Fig. 4-1   General Circuit Modulation Analyzer FAM (including options)

4.1.1.   RF Section

The input frequency range of the basic 120 MHz-Version of the FAM is divided
into two parts: input frequencies between 55 kHz and 3.5 MHz are directly fed
to the IF section, frequencies between 3.5 MHz and 120 MHz are converted to
this range. With the 1.36 GHz frequency range extension option, a third range
from 120 to 1360 MHz is added. This uses double frequency conversion.
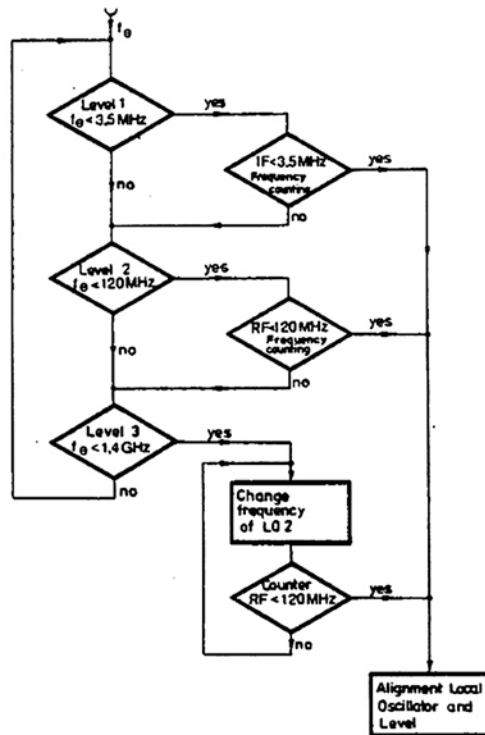
Fig. 4-2   Simplified flow chart of frequency scanning mode in the
Modulation Analyzer FAM
(with Option 1.36 GHz frequency range expansion)

In the scanning mode (Fig. 4-2), the microprocessor senses an input signal using level indicators in the RF- and IF sections, and a frequency counter. It computes the correct adjustment for the first mixer-oscillator and performs the RF level alignment. The maximum range of the input signal is between 10 mV and 3 V. In the option 1.36 GHz, all input signals above 120 MHz are converted to the range below 120 MHz by the second mixer oscillator. The computer will vary the frequency of the mixer-oscillator LO2 in coarse increments as long as a mixer product in the range below 120 MHz is produced, which can be measured by the frequency counter. The further processing of the signal is the same as in the frequency range below 120 MHz. When the microprocessor knows the frequency of the mixer-oscillator LO2, it can compute and display the input frequency.

The unit does not have any preselection. A useable mixer frequency is produced not only for an input signal below the oscillator frequency but also for the reflection frequency. The position of a newly applied input signal is sensed by the microprocessor in the scanning mode.

The octave range oscillator LO1 (60 - 120 MHz) is tunable in four ranges in steps of 50 kHz by the means of a PLL circuit. A gain control circuit in the PLL loop eliminates the influences of the non-linear tuning characteristic of the oscillator and the variations of the devision factor. The frequency range of the oscillator is extended to input frequencies down to 3.5 MHz (AM) by means of a frequency divider.

When scanning in the extended frequency range up to 1.36 GHz, the oscillator LO2 has to step through many frequency settings. It has a broad-band control loop to keep the setting time short. The high spectral purity of the 10 MHz frequency reference together with the low dividing factor of the PLL loop determine the low spurious sideband noise and the low spurious inherent deviation of this oscillator. The frequency range is extended to lower frequencies by division, to higher frequencies the extension is made by doubling twice.

4.1.2   IF Section

Input AM frequencies below 3.5 MHz are demodulated by a broadband average-responsive detector. Input frequencies above 3.5 MHz are also demodulated by a parallel FM demodulating circuit. The optimum intermediate frequency (500 kHz or 1 MHz) for these demodulators is switched by the computer

depending upon the deviation of the FM signal. The FM demodulator circuit is of the pulse-counting type. The demodulated AM- and FM signals are available at sockets on the back panel of the FAM. The output of the FAM can be used for a stereo-decoder (for example a MSDC 2) too. Two selectable deemphasis of 50 μs and 75 μs comply with the different broadcast standards.

The deemphasis 750 μs can be used in addition to the mode φM for measurement of radio equipment with phase modulation.

4.1.3. Audio Section

AM-, FM- and φM signals and external audio signals can be weighted in the audio section with combinations of universal filters and different detectors. The resulting audio signal is fed to a frequency counter, measured and displayed. Weighting filters of the basic unit are high pass filters with cut-off frequencies of 10, 30 and 300 Hz and low pass filters with a high frequency cut-off of 3.20 or 200 kHz.

A telephone filter meeting the CCITT specification and a CCIR filter together with a quasi-peak detector to DIN 45405 are available as options.
This rectifier can be used in combination with all filters. The basic unit contains a peak detector (±peak) and a true RMS detector. The different values of rectification are led to an A/D-converter, depending upon the key selected. The output of the A/D-converter is sensed by the computer in cyclical order. The measured value of the peak detector is also used for the gain control in the audio circuit.

The audio distortion factor meter option has a hi-Q self-balancing notch-filter. Distortion factors down to below 0.1 % can be measured. Modulation distortion factor is indicated directly after pressing the appropriate keys.

4.1.4. Computer Control

One single chip microprocessor with external ROM performs all the control of the FAM, the data acquisition, the computation and output to the indicator unit and the scanning of the keyboard.

4.2. Level Control / Counter 120 MHz

(refer to schematic 334.4430 S)

4.2.1. Level Control

RF input signals in the frequency range 55 kHz to 120 MHz and in the voltage range 10 mV to 3 V are fed via ST20. Now the frequency of the signal is divided, and the signals in the range 55 kHz to 120 MHz are fed directly to the IF section via ST28 without mixing (The relay contact RS1 is closed). RS1 is switched on by the TTL-signal (L) and driven by transistor T15.

In the frequency range 3.5 - 120 MHz the RF input signal is led to an input attenuator, consisting of two functionally identical pads of 10 dB and 20 dB. The function of the attenuator is described for the first attenuator pad (10 dB). It consists of a feed-through network (GL2-GL4) for an attenuation of 0 dB and an attenuator R5-R6-R7 with switching diodes GL5-GL6. The TTL-switching signal for this network pin 5b is generated by comparators B31IV-B31III. With a logic LOW at terminal 5b the voltage at MP8 is about -12 V and at MP9 about +12 V due to B301; the attenuator is at 0 dB. With signal H at 5b the polarity is reversed: at MP 8 appr. + 12 V, at MP9 approx. - 12 V; the 10 dB attenuator is switched into the signal path.

Both legs of the 10 dB attenuator are switched into the high-impedance state by B30IV (output pin 11 low) at frequencies up to 3.5 MHz (relay RS1 closed). The voltage level at MP8 and MP9 is approx. - 12 V. Both attenuator pads are switched as a function of the input voltage, resulting in a RF voltage at MP1 of 30 mV to 100 mV for input voltages in the range of 30 mV to 3 V.

When the FAM-option B2 is installed, the switching voltage for the relay and the input attenuators is supplied via pins 4a to 7a and 8b by changing the connections of BU1, BU21-22, BU31-32, BU41-42, BU51-52. At the same time the input attenuator for 120 MHz is switched to 0 dB (fixed voltages at ST2 to ST5).

Amplifier I (ca. 10 dB) has a preamplifier stage T1 with very low noise and a separation amplifier stage T3. Transistor T2 guarantees a stable operating point for T1 in a common base circuit. The wide-band transformer TR1 together with the buffer stage T3 guarantee an input impedance of 50 Ω.

The amplifier II containing the level measuring point is loosely coupled to the output of T3. T30 compensates for the coupling losses, and T31 raises the signal to a level of 300 mV to 1 V (to 30 mV at 10 mV input voltage). The RF voltage is detected by GL40, which is biased with a small current via R138-L30 to detect small voltages. The positive detected voltage is applied to the differential amplifier B40II. For temperature compensation, a reference diode GL41 with bias current is provided at the inverting input of the amplifier. Differences between these two diodes are compensated by R193. The output voltage of the differential amplifier is therefore zero at 0 V input voltage. The maximum rectified voltage at pin 13b is adjusted to 1 V by R186. The time constant R184-C126 is chosen such that the detected voltage drop for an AM signal of 10 kHz is a maximum of 10%. At lower modulation frequencies the peak value of the AM-RF signal can be determined at the sampling speed of the A/D converter.

Three selectable, fixed attenuator pads with 8 dB (R41-R42-R43), 4 dB (R47-R48-R49) and 2 dB (R53-R54-R55) provide fine adjustment of the voltage level. Comparators B40I, B41II, B41I convert the TTL-control voltages at pins 6b, 7b, 8a to switching voltages +13 V (LOW; the corresponding attenuator has 0 dB) and -13 V (HIGH; the corresponding attenuator is switched into circuit). At MP3, the level differences are reduced to 2 dB by these attenuators.

Two stages of amplifier III (15 dB) together with attenuator II (1 dB) result in a desired signal level of 100 mV. A low pass filter with a cut-off frequency of 120 MHz eliminates unwanted spurious signals at frequencies above 120 MHz.

4.2.2. Frequency Counter
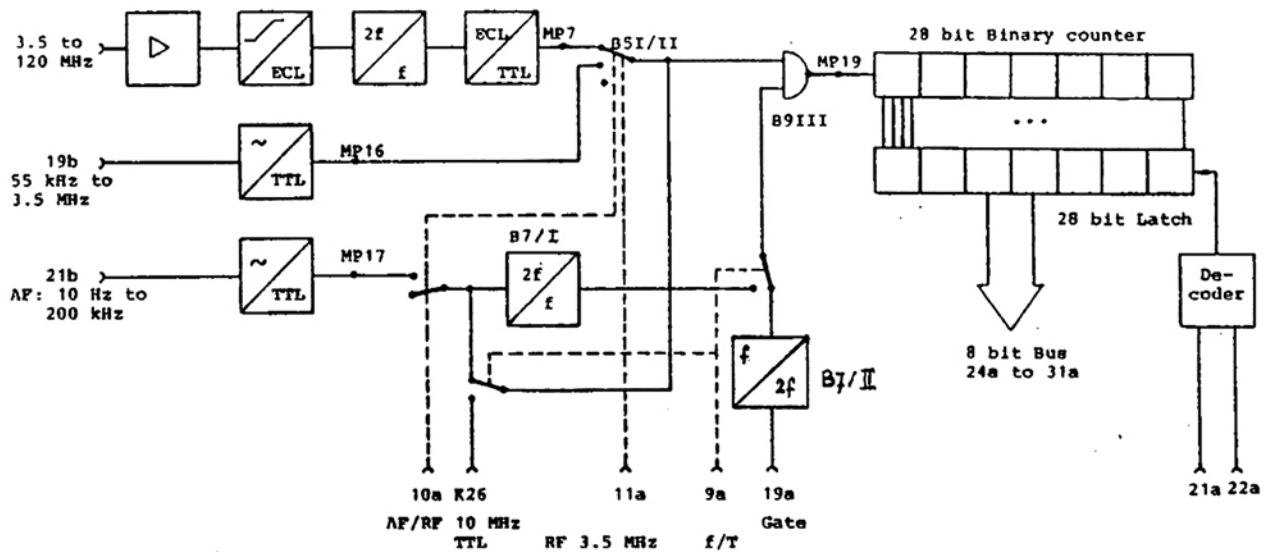
Fig. 4-3   Block Diagram: Frequency Counter

4.2.2.1. TTL-level-processing

All frequencies to be measured (low and high frequencies) are at first
processed as TTL-levels and then fed to the binary counter.
The audio signal at pin 21b (10 Hz to 200 kHz, 1 V $\pm$ 6 dB) is processed to
TTL-level by comparator B11 (MP 17). The reference voltage of the comparator
is 120 mV and well above the noise level.

The RF-signal 55 kHz to 3.5 MHz, range to be measured 100 mV to 400 mV at
pin 19b is processed to TTL-level by comparator B10. (MP 16).

The input of amplifier IV is high-impedance coupled to the IF output for
frequencies in the range 55 kHz to 3.5 MHz. The signal is amplified by T8-T9
to 2.5 V (MP5), to enable measurements of 90 % AM-modulated RF signals.
The limiter circuit provides an ECL-level for the driver stages B1I to III
using a superimposed bias of 2 V at MP18. (Adjust using R92 without RF signal).
As the binary frequency counter cannot count frequencies above 120 MHz,
these frequencies are subdivided with B21 and processed to TTL-levels using
T10 (MP7).

4.2.2.2. Frequency Counter Control Circuit

The counter control circuit provides the frequency to be measured to the binary counter.

RF up to 120 MHz: A HIGH signal at pin 11a enables gate B5I, RF is led to the gate B9III via B5III. The gate time is controlled by the microprocessor via pin 19a with the pulse shaping occurring in B7/II.
RF up to 3.5 MHz: LOW at pin 11a disables B5I. B5II provides control of voltage at MP16 to gate B9III via inverter B9IV. At the same time, relay BS1 will be activated by the same control line via B9IV.

Audio Frequency/Period: For both RF ranges, B5I/II will be inhibited by a LOW signal at pin 10a. The measuring frequency is led to the gate via B9II, B8I, B8II. B7 is inhibited. Audio frequencies below 10 kHz are determined by measuring the duration of one period to achieve a better resolution and to speed up the measurement. In the time of one period the number of 10 MHz-oscillations of the crystal standard are counted (input at K26). The output of B9II is fed to the divider 2 : 1 (B7), which, enabled via pin 10 b, will deliver the periods of the audio signal. A HIGH signal at pin 9a inhibits B8I and switches the 10 MHz crystal reference frequency via B8III, B8II to the gate. The signal at the output of B7 (pin 9b) will inform the micro-processor at the end of one period (LOW). B7 will be immediately inhibited. The gate is now enabled during one full audio frequency period.

The frequency to be measured at MP19 is now applied to the binary counter (28 bit), consisting of B15-B17-B18I/II-B22I/II-B25. It is reset at the start of a measuring cycle by the reset signal at pin 20b. The outputs of the binary counter lead to the signal memories B16-B18-B20-B21-B23-B24-B26, which are connected to the data bus. Two signal memories, respectively, are combined to one byte (8 bit) and they are read with the aid of the decoder B28.

4.3. Mixer 120 MHz

(see schematic 334.3811 S)

The printed circuit board "120-MHz-Mischer" (120 MHz Mixer) converts the RF input signals 3.5 to 120 MHz to the corresponding IF (500, 1000 kHz).

When the option B2 "1.36 GHz Frequenzerweiterung" (Range Expansion to 1.36 GHz) is installed, RF frequencies above 120 MHz are converted to the range 3.5 to 120 MHz and will be processed by the assembly "Mischer 120 MHz". RF frequencies in the range 3.5 to 120 MHz are converted in the double-balanced mixer B27 by the signal of the local oscillator (B27, PIN1) which is generated on the same board, and its frequency shifted by the frequency of the IF.

The relation is $f_{LO} = f_{RF} - f_{IF}$.
The intermediate frequency signal is led from the separating filter at the IF output of B27 (PIN3,7) to the two stage amplifier T20, T21.
With a gain of 22 dB the IF is led to the assembly "Demodulator" via K31.

The local oscillator frequencies are generated by oscillator 1 (60 to 90 MHz) or oscillator 2 (90 to 120 MHz).

Lower LO-frequencies are generated in the output frequency divider circuit B22, B23, B24 and B25 by successive division 1:2.

This provides for a continuous LO-frequency range of 3.75 to 120 MHz.

Both oscillator circuits are of the negative impedance conversion type. The active component is a field-effect-transistor (FET). The inductance of the coil at the gate-pin of the FET (T1, T2) is selectable by T5 and GL3 (oscillator 1) or GL6 (oscillator 2) and will be tuned by two varactor diodes in parallel, respectively.
The oscillators are tunable in the following frequency ranges:

	Range I	Range II
Oscillator I	60 to 74	74 to 90 MHz
Oscillator II	90 to 104	104 to 120 MHz

The oscillators I and II are switched by T3 and T4. The drain current of the oscillator transistors is stabilized by a current source T15 to approx. 7 mA.

The oscillators are tuned to the desired frequency by a phase locked loop.

A small part of the oscillator's signal is used to control the frequency divider (B1 to B6) of the PLL-circuit via resistor devider R48 to R51.

The frequency divider circuit has a settable prescaler B1, that can be switched to a dividing ratio of 1 : 33 and 1 : 32, and two auxiliary dividers, the A-divider (B3-B4) and the N-divider (B5-B6). The A-divider controls the division 1 : 33 / 1 : 32, while the N-divider cares for the reset of the prescaler and both the auxiliary dividers and delivers the divided frequency f osc/ n at the carry-output (MP30).

The reference frequency of 50 kHz for the PLL-circuit is directed to the phase discriminator B8 via K32 and the Schmitt trigger B9 . The PLL-frequency divider is settable to division ratios of 1 : 1200..2420 in units steps. This divided oscillator signal f osc/ n is also directed to the phase discriminator via the monostable circuit B7. As long as the phase synchronisation of oscillator and reference frequence is not reached, the phase discriminator will deliver positive or negative pulses at the tristate output. These pulses are integrated at B10 and the resulting tuning voltage will vary the frequency of the oscillator by the tuning diodes GL1, 2 and GL4,5 respectively.

In the locked condition, the oscillator frequency will be

$f_{osc} = n \cdot f_{ref}$ with n = 1200, 1201 to 2420

$f_{ref} = 50$ kHz

The oscillator frequency is tunable in 50 kHz-increments of the reference frequency. The divisor is applied as a binary coded bit pattern to the control inputs A0, A1 to N7 of the A- or N-divider.

The gain control at B11 to B13 compensates to a great part for the characteristic of amplitude variations of the oscillators and also for the variations of the gain in the PLL-loop dependant upon the division n. The purpose of this circuit is to reach an optimum dynamic characteristic of the PLL-loop.

To achieve a tuning range of ca. 3 to 19 V, an appropriate DC-voltage is applied to B11/PIN 3 by B14.

The oscillator signal is taken to MP21 via amplifier B22I and Schmitt-trigger B22III, via Schmitt-trigger B23II to the flip-flop divider circuit, so that finally

f_{osc}, $f_{osc}/2$, $f_{osc}/4$, $f_{osc}/8$ or $f_{osc}/16$

are available at MP 21.

To get a signal of + 7 dBm at the LO-input of the Mixer B27, the signal is amplified in T9.

The complete logic control, dividing factor of the PLL-loop, oscillator- and amplifier switching and dividing factor for the LO-signal is controlled by the I/O-expander B19 (4 bits to 16 bits) with additional signal memory B18. Altogether 20 control bits are possible. An RF frequency signal < 3.5 MHz is fed to the "Demodulator" assembly without any conversion. In this case, a separate control line at ST5/7 disables both oscillators with LOW.

4.4. Demodulator
(refer to schematic 334.4453 S)

The task of the assembly "Demodulator" is to demodulate the intermediate frequencies 500 or 1000 kHz coming from the 120 MHz mixer assembly to ST31 and, too, the RF signal below 3.5 MHz at K28.

In the IF range, AM- and FM demodulators are operating in parallel, but RF signals < 3.5 MHz are AM demodulated only.

4.4.1. FM Demodulator

The filter at the input of the IF section containing L1 and L2 has a Bessel-response, the cut-off frequency is located at 1.6 MHz.

The IF signal is amplified and limited in B5. The comparator B10 shifts the signal to TTL-level. A switching signal can be set at B5/10 with R16 so that without an FAM input signal, gate B13 is inhibited via T9.

The TTL-IF signal is led to gate B12II and also to flip-flop B11. The flip-flop is enabled in case the IF is 1 MHz and will divide the IF (and the deviation of the IF, too) by 2.

Flip-flop B11 is enabled via control line ST6/Pin 8.

B16 and B18 are triggered by the falling edge of the corresponding input signal, B17 and B19 are triggered by the leading edge. The TTL-voltage at the Q-outputs of B16 to B19 is increased to approx. 10 V_s by T25, T26 or T20, T21. T27 or T22 serve as impedance converters to get low impedance output feed for the IF filters.

If the measured FM deviation is approximately < 8 kHz and LP 200 kHz has not been selected, a pole at about 500 kHz is switched in, also to improve the IF suppression. At the same time, the bandwidth of the following active LP filter is reduced to 30 kHz (switches B26I and IV closed) and the gain of B32 increased by two.

The different intermediate frequencies 500 and 1000 kHz are selected according to the frequency deviation to be measured.
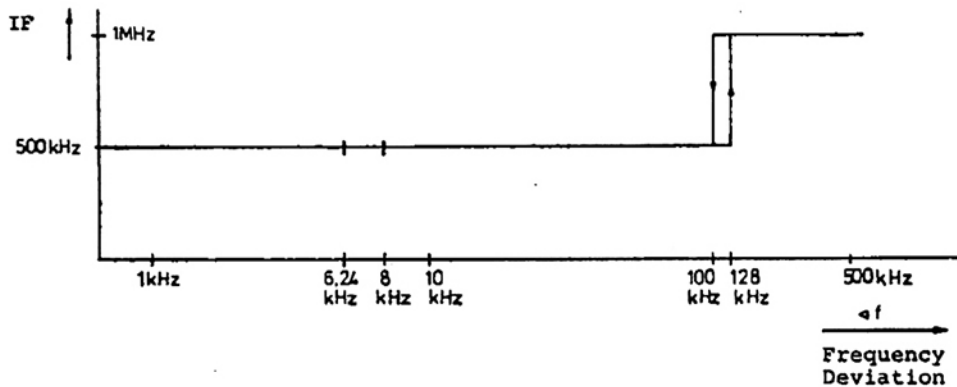
Fig. 4-4   Selection of intermediate frequency as a function of
            the frequency deviation of the input signal

Together with the change-over of the intermediate frequency from 500 kHz to 1000 kHz, the audio level will be reduced (at MP10) by a factor of 2.

The DC offset at the output of B22, appearing together with the IF signal, is compensated by the retriggerable monostable B20. The pulse width is so long, that its output will remain a constant LOW and a DC voltage to B22/3 is generated by T29.

This DC voltage is adjustable (by R96) for optimum transient response. In the subsequent active filter, the intermediate frequency is further attenuated.

After shipment BU5 is connected in such a way, that the deemphases are effective for the stereo-capable output ST6/31 and also for the output ST6/29, leading to the assembly "Filter-Gleichrichter" (filter-detector).

The deemphases, switched at ST6/29, are ineffective if BU5 is connected between ST5/2 and ST5/1 (except for the output ST6/31). B26II is connected through in case of an IF of 1000 kHz, reducing the gain of B31 by a factor of 2.

At IF = 1000 kHz, the output voltage per frequency deviation at stereo-MPX output is reduced by a factor of 4 in total (because of division of frequency and deviation in B11).

The reference voltage 5.000 V derived from diode GL30 is applied to the assembly "Microprocessor" via ST6/21. This diode together with B21I/II defines the voltage of the supply to T20, T21 or T25, T26 resp., and also the amplitude and stability of the demodulated FM deviation. The adjustment of the deviation is accomplished with R70.

4.4.2.   Phase Demodulator

The phase demodulation is executed in the filter circuitry associated with B28I/II where the signal coming from the FM demodulator at MP10 is converted to a phase demodulated signal (see filter response Fig. 2-9), concerning modulation frequencies < 300 Hz.

The phase-demodulated audio signal is fed to the assembly "NF-Filter-Gleichrichter" (audio filter/detector) via MP 12.

4.4.3. AM Demodulator

FAM-RF signals with a frequency < 3.5 MHz are directly fed to the "Demodulator" assembly via K28. The attenuator at the input is adjustable in steps of 3 dB. The input amplifier B1 is switched in by T5 and T6 for RF input voltages < 200 mV. At higher input voltages, T5 and T7 are inhibited and the signal is passed via T6 and ST1 directly to the AM demodulator B40 itself. It contains an active full-wave mean value detector. The detected voltage at GL40 and GL41 is summed by B41 and B47.

The rectifier circuit can be balanced using R158. Radio frequency components contained in the demodulated signal are eliminated in the low-pass filter subsequent to B41, B47. The DC- and audio components of the signal are amplified in B42.

The subsequent active low-pass filter is switched into circuit for FAM-input frequencies < 3.5 MHz. B231/IV generates poles in the passive low-pass filter. The overall audio bandwidth for AM-frequencies < 3.5 MHz is limited to 30 kHz (-3 dB), measured at MP18 (and AM output).

The DC component of the signal is blocked by C121. The low-pass filter with B431/II (cutt-off frequency 3 Hz) will let only the DC-component of the AM-demodulated signal pass.

In this equipment the AM-modulation factor is computed using the demodulated audio voltage (MP18) and the mean value of the carrier voltage (MP17). The calibration of the AM-modulation indicator is done with R182.

FAM-input frequencies > 3.5 MHz are converted in the "Mischer 120 MHz" (120 MHz Mixer) assembly to an intermediate frequency of constant 500 kHz, in the AM mode. This IF is fed to the "Demodulator" assembly via ST31.

Spurious mixture products are filtered out by the Tchebycheff-filter (cut-off frequency 1.6 MHz). The signal is then amplified (B8) by 2.7 dB and fed to the AM demodulator (with B40) via T8 and ST1.

4.5. Audio Filter & Detector

(refer to schematic 334.4418 S)

It is the task of the "NF-Filter-Gleichrichter" assembly (audio filter & detector), to rectify the filter-weighted audio signals, that are delivered by the voltmeter input or by the FM-, φM and AM-demodulators. The resulting DC voltages are then input to the A/D-converter (ST7/26b) at the assembly "Microprocessor". By B1, one of these audio signals (FM, AM, φM, VOLT) is switched to MP1.

The maximum voltage at MP1 is 2.62 V.

Audio voltages between 2.56 mV and 2.62 V are amplified or attenuated to a maximum voltage of 0.6554 V using amplifier- and voltage divider circuitry B2, B3, B4, B5, B6. The gain/attenuation is selected in steps of s^n, ($n = +8, +7, +6, +5, +4, +3, +2, +1, 0, -1, -2$).

The individual amplifier and attenuator stages are switched as shown in the following diagram:
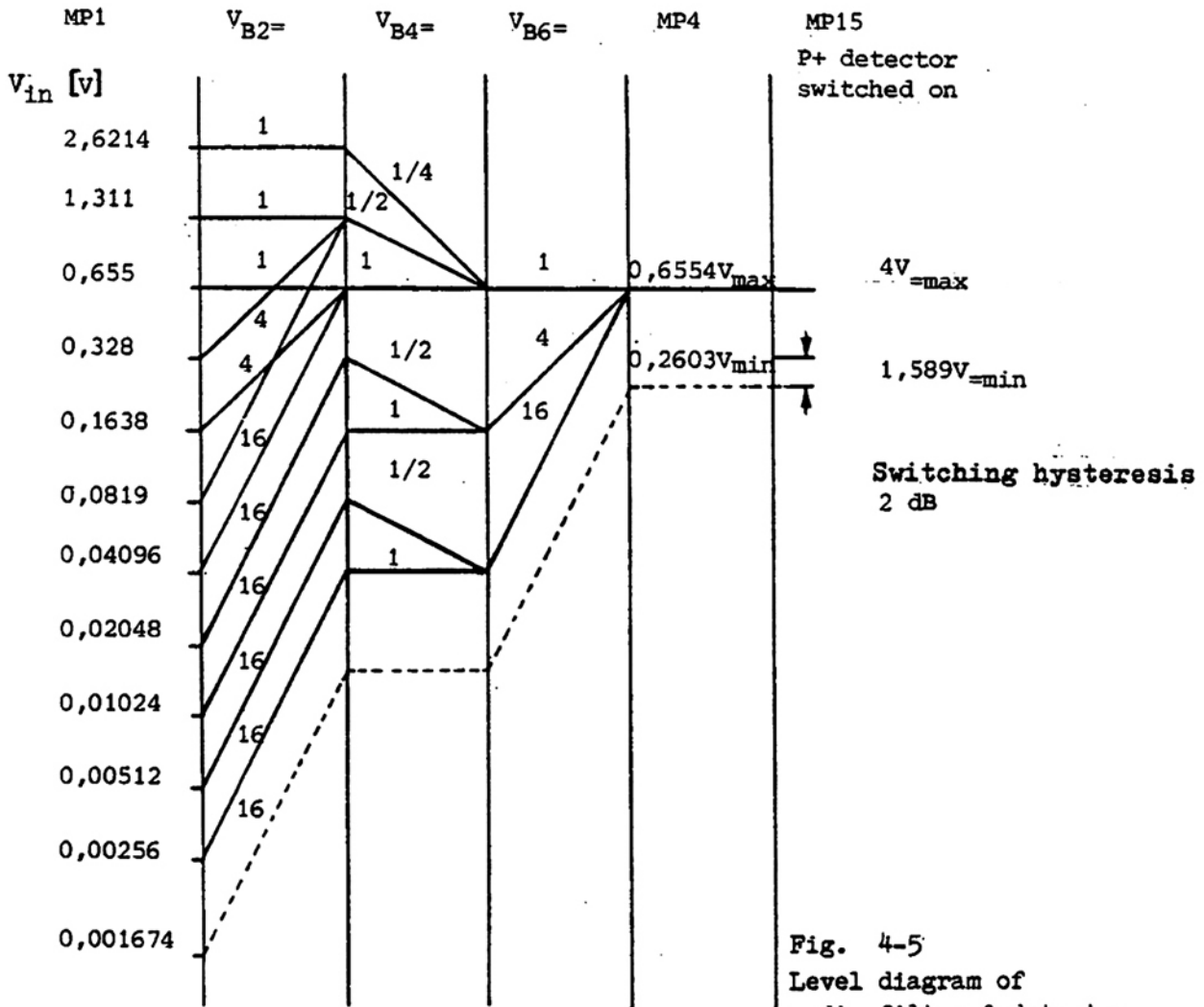
Fig. 4-5
Level diagram of
audio filter & detector

The amount of switching hysteresis is 2 dB.

The high-pass filter (B9) can be switched to 3 different cut-off frequencies: 10 Hz, 30 Hz, and 300 Hz (resp.) at -1 dB. The high-pass filter can be jumpered out, the lower cut-off frequency up to the AF output ST7/23b is then limited to 2 Hz (-3 dB). The low-pass filters (B15/B16) show a cut-off frequency of 3 kHz and 20 kHz, respectively, the skirt selectivity is 24 dB/octave in each case. In addition to these filters, optional CCITT- or CCIR-filters can be used alternatively. Switching of the direct path or of any one of these filters is done with the analog switch B17.

At MP10, there is a level regulated and filter-weighted audio signal, that is now directed to the assembly "Pegelregelung/Zähler" (level control/counter), via B18II to be frequency measured. Via B18II the signal reaches the AF output (11). The voltage of the audio signal at MP10 (max. 0.6554 V) is amplified in B20 up to 6.28 V. B21 inverts the signal.

The analog switch B22 can switch the inverted audio signal to B23, the active peak detector (-Peak, +Peak). Transistor T2 is under control of the "Microprocessor" assembly; it discharges the capacitor of the peak detector, C4. This resets the detector circuit. The calibration of the detector is achieved by R75 and with R97 the offset is adjusted.

The audio voltage level of max. 0.6554 V at MP10 is raised to 4.192 V by B14. This is the input signal of the RMS-detector B25, and (with the CCIR filter option) to the Quasi-peak detector (pin 10) and the optional "Klirrfaktormesser" assembly (audio distortion meter).

The calibration of the RMS-detector is done with R80. The offset of this detector is nulled out with R83.

Voltage levels at the input of the multiplexer B27:

Audio peak value (P+, P-):	pin 15
Audio RMS value:	pin 12
Audio Quasi-Peak value:	pin 13
AM carrier mean value:	pin 1
RF level at 120 MHz:	pin 5
RF level at 1.36 GHz:	pin 4

These voltages will be applied as selected to the A/D-converter located at the assembly "Microprocessor" under control of the same unit.

The level setting in the audio section is always based on the measured value of the peak detector:

Selected detector	Level setting based on
P+	positive peak value
P-	negative peak value
$\frac{P+P}{2}$	larger of the two peak values
RMS, RMS· 2, CCIR	peak detector last switched-in

Therefore, signals with a high crest factor cannot overdrive the audio section.

The I/O-expander B12 is responsible for the complete logical control of the "NF-Filter-Gleichrichter"(AF Filter/Detector) assembly, for selecting the input signal, setting the voltage attenuator, selecting the weighting filter and the measured value from the detector.

4.6.   Microprocessor (with reference oscillator)

(refer to schematic 334.2880 S)

This printed circuit board carries not only the microprocessor, but also the optional board "IEC-Bus" FAM-B4 and the 10 MHz-reference oscillator (optional the SMS-B1, "Referenzoszillator temperaturgeregelt" (reference oscillator temperature-controlled)), serving the CPU 8039 (B4) with the 5 MHz clock frequency. The bus is 8 bits wide (DB0 to DB7) and carries all the data- and address traffic to and from the EPROMs B8 and B9, to and from the keyboard/ display interface 8279, the IEC-bus and via the motherboard between the different boards.

The pins P10·to P15 will deliver the code for the RF- and audio attenuators, the pin P16 serves the discharge pulsing for the rectifier.

The program memory consists of a 2-K-EPROM B8 with two additional program memories B1 and B9 on the board "Memory Adapter". The CPU 8039 can address only 4K of memory, so it switches between the EPROMs B9 and B1. Selecting the chips is done by port P72 of B11 via K100 and B3. The selected EPROM is enabled via P23 of the microprocessor. An address-latch B2 serves for the addressing of B1; it is enabled by the line ALE.

The 12-bit data word output of the A/D converter B6 is applied to the input ports PA0 to PA7 and PB0 to PB3 of B8. The test signals representing the options FAM-B2, -B6, -B7, -B8 are present at PB4 to PB7.

The PB-port of B9 is the output for the IEC-bus. The ports are selected by DB0 and DB1, input- and output-control is managed by $\overline{RO}$ with P17, $\overline{WR}$ and $\overline{PSEN}$.

The 2K-program memory is controlled by the address bus DB0 to DB7 and P20 to P22 and via the control lines $\overline{PSEN}$, ALE and P23 (chip select). Data is read by R0.

There are four I/O expander, enabled by P24 to P27 under control of $\overline{CS}$: B10, B11 and one more at the printed circuit boards "120-MHz-Mischer" and "NF-Filter-Gleichrichter". P20 to P23 and PROG control the output and the 4-bit ports. Output ports B10 and B11 have control of the different functions on the printed circuit board and also on the IEC-bus component B16 (P5 and P6 of B11).

The microprocessor will read data out of the keyboard interface via the bus when signal $\overline{INT}$ is present.

The corresponding measurement values (selected from multiplexer B27 on sub-assembly AF-Filter/Detector) are fed via ST1/A19 to the 12-bit A/D converter B6. The offset of the A/D converter is adjusted with R38.

4.6.1. Function of the Reference Oscillator

The 10-MHz reference crystal oscillator generates the necessary reference frequency for the FAM. Reference element is a crystal with a fundamental frequency of 10 MHz, tunable to the exact frequency by C3 with T1 as oscillator transistor. This reference frequency at ST26 is fed to the "1.36-GHz Oszillator" (Option B2) via T5 to T7 and via ST26 to the printed circuit board "120-MHz-Pegelregelung-Zähler". The crystal frequency is divided by 2 (B1, pin 9) to get the clock frequency needed for the microprocessor. The frequency is further divided by B2 and B3 to give a frequency of 50 kHz. This frequency is needed as reference at the "120-MHz-Mischer" board (ST32). The output 29 on the back panel of the FAM is supplied with the 10 MHz signal via emitter follower T9 and ST40.

4.7. Keyboard and Display Unit

(refer to schematic 334.2215 S)

The interface between the microprocessor and the display unit/keyboard is realized with the circuit 8279 (B20). The microprocessor delivers display information to the display RAM of B20 using its data bus DB0 to DB7 and control lines $\overline{WR}$, $\overline{CS}$, C/D. Control of output to the multiplexed display panels and the display itself is done by unit B20.

The binary coded control signal at output SL0 to SL3 of B20 is applied to both BCD-decimal decoders B22/B23. Drivers B25 to B27 periodically switch the display panel and the lines of the LED-matrix. Display information for the number display panels is put out synchronously to SL0 to SL3 at the data outputs A0 to A3 of B20 via the seven segment decoder B24. The row information of the LED-matrix is supplied by data outputs B0 to B3 synchronously to SL0 to SL3.

Control outputs SL0 to SL3 serve decoder B21, too. The lines of the keyboard matrix get a periodic scanning pulse out of B21. When a key is depressed, a scanning pulse is switched to one of the return lines RL0 to RL7. B20 recognizes the key depressed because of two informations received: control lines SL0 to SL2 and return lines RL0 to RL7. The position code is stored in B20, until the information is read by the microprocessor.

When pressing a key, B20 delivers an interrupt signal to the microprocessor. The microprocessor now reads data from the FIFO-RAM of the interface system B20 via the bus DB0 to DB7.

The "Tastatur-Anzeige-Einheit" printed circuit board carries the floating input circuit of the voltmeter. The signal is applied to the insulated BNC Socket on the front panel and to the impedance converter B351/II via K22. The outputs are combined in the subtracting circuit B36 and this output now is fed to the "NF-Filter-Gleichrichter" printed circuit board via K 24.

4.8. Power Supply

(refer to schematics 334.2515 S and 334.2715 S)

The power supply circuit delivers the four stabilized DC voltages:
+5 V, +15 V, -15 V, +24 V.

The circuit for the +15 V unregulated DC voltage employs a full-wave rectifier GL4-GL6 and C3-C4 and this voltage is stabilized with an integrated voltage regulator B3 to +15 V.

A similar circuit is provided for the -15 V supply, using an integrated voltage regulator B4 and a full-wave rectifier GL3-GL5 plus C5.

The +5 V and +24 V supplies use an integrated precision voltage regulator each (B1, B5). The current needed is supplied by a set of power transistors (T4, +24 V and T1 - T2, +5 V). The voltage regulators used (B1, B5, Type μA 723) shows a very low temperature drift, small quiescent current consumption and a high ripple suppression (typically 74 dB).

The contain a stable, temperature compensated voltage reference with a voltage reference amplifier delivering 7.15 V at the output pin 6. A differential amplifier (inverting input pin 4, non-inverting input pin 5) drives a transistor-circuit representing a voltage controlled resistor (input pin 11, output pin 10). The output current can be limited via pin 2. The current limiting circuit pro-vides a foldback-characteristic, i.e., the output current will be limited to safe values in case of an overload.

The current limiter of the supply +5 V is controlled by a comparator circuit B21. The input senses the unbalance voltage of a bridge consisting of R9-R8-R11 and the load circuit. In the normal condition, when the output current is smaller than the maximum current, the voltage at the inverting input of B2I is higher than the voltage at the non-inverting input because of the high load resistance. The current limiter of B1 will not operate, as the output voltage of the comparator is negative. At a very low output resistance (overload condition), the voltage at the inverting input of B2I is now smaller than the voltage at the non-inverting input. The output of the comparator is driven positive and the current limiting circuit is switched into operation. The regulated output voltage is applied to the inverting input of the internal differential amplifier of B1 via R13, R6. The internal reference voltage is divided by the variable resistor network R1-R2-R3 and part of it is applied to the non-inverting input of the differential amplifier. The difference between this voltage and the output voltage is reduced to zero by regulation. C22 smooths out the ripple voltage.

The unregulated input voltage for the transistor T1 acting as a series resistor is delivered by the balanced rectifier GL1-GL2 and C1-C2. The regulated output voltage of B1 is lower than its input voltage; therefore it will be supplied by +15 V.

The keyboard-display unit has a separate +5 V supply B2II and T3. The reference voltage for the non-inverting input of the differential amplifier B2II is the regulated +5 V. Because of its open loop gain, the series transistor T3 is regulated to make the output voltage equal to the reference voltage.

T3 has the same unregulated supply as T1. This voltage is not short-circuit proof as the other supplies are. Current limiting is provided by R14.

Series transistor T4 in the +24 V supply circuit is connected to an unregulated input voltage via bridge rectifier GL7 and C6. The reference voltage at the non-inverting input of the internal differential amplifier of B5 is applied through R21. The inverting input is connected to a resistor divider network R17-R18-R19 for the output voltage. The voltage drop in R18 is compared with the internal reference voltage, the difference is zeroed out by regulation. Resistors R22-R23 serve as current limiters for B5.

The nominal value of the output voltage is adjusted with potentiometers R2 (+5 V) and R18 (+24 V).

4.9.   Option Extended Frequency Range FAM - B2

4.9.1. Mixer / Frequency Doubler

(refer to circuit 334.5214 S)

In the frequency range 55 kHz to 1360 MHz and in the voltage range 10 mV to 3 V the input signal is fed in via ST21. Input frequencies in the range 55 kHz to 3.5 MHz are brought to the connector ST29 via closed relay contact (RS1), and to the printed circuit board "120-MHz-Pegelregelung/Zähler".
Detector diode GL2 is coupled to the wide-band circuit (3.5 to 1360 MHz) by R2-C1. Its positive detection voltage is applied to the differential amplifier B2. GL4 serves as temperature compensating element. When Pin 3 is HIGH, both diodes receive a negative bias from output B1. The output of the differential amplifier can be tuned to zero for 0 V input voltage using R19 to compensate for component tolerances. To avoid additional attenuation in the signal path, GL2 can be cut off (positive output voltage of B1, LOW at pin 3). Sensing the signal level

at this point should avoid overdriving the mixer and the preamplifier at large input voltages. At the maximum permissible voltage of 3 V at the RF input, the detected voltage at pin 13 is adjusted to ca. 1 V, using R11.

Both selectable attenuator pads with 10 dB (R21 to R23) and 20 dB (R27 to R30) achieve a rough level control for the mixer B20. The switching voltages are derived, as for the relay RS1, from the "120-MHz-Pegelregelung-Zähler" printed circuit board via pins 4 to 7 or 8 (see description "120-MHz-Pegelregelung/ Zähler"). Input signals in the frequency range 3.5 MHz to 120 MHz by-pass the mixer B20 via the open diode switches GL22 - GL26 (positive output voltage at B5II) and are fed to the 120 MHz low-pass filter. Higher frequencies are passed to the wide-band amplifier T1. GL22-GL26 are now cut off, while GL20-21 are conducting, under control of B3. The input of the mixer is decoupled from the RF input by T1 together with attenuator R45 to R47, which circuit also serves as an additional attenuation for the LO-signal against the RF input (especially at high frequencies).

The input signal, converted to the IF 5 to 120 MHz, is available at output X of the mixer circuit B20 with the oscillator signal at input L. This IF reaches the amplifier stage T2-T4 via frequency separating circuit L28I to L28III, C31 to C33 with wide-band matching.

Input frequencies in the range 120 to 420 MHz are converted to maximum IF of 35 MHz. The signal is directed to the 35 MHz low-pass filter C44 to C47, L36 to L38 (switched into circuit with diodes GL29 to GL30 conducting) and also to the low-pass filter 120 MHz. The maximum intermediate frequency at higher input frequencies is 120 MHz, this IF is applied to the band-limiting low-pass filter 120 MHz with diode switches GL31-GL33 open.

The oscillator signal from the "1.36 GHz Oszillator" printed circuit board is unsatisfactory for the mixer B20, both in frequency and voltage. This signal must be further processed in three frequency ranges.

Range I: direct branch 145 to 480 MHz

In the frequency range 145 MHz to 480 MHz, the oscillator signal with -14 dB is applied to amplifier B10 via ST27, which raises the level to ca. +7 dBm. For input frequencies from 120 to 540 MHz, this signal serves as LO-signal for the mixer directly (via GL100-GL122 under control of B21, and GL138). All other branches are inhibited.

Range II: Frequency doubling 580 to 960 MHz

The direct path is inhibited by GL100 - GL122. The oscillator signals 290 to
320 MHz and 420 to 480 MHz are fed via the switching diodes GL101-GL102 to
the frequency doubler. The 50 Ω-coaxial transformer TR2 - TR3 effectively
push-pull drives the two diode branches GL105I-GL108I, GL105II - GL108II
which perform full wave rectification. To improve the efficiency a bias current
is fed through these diodes by R105 - R106, R108. The resistor R107 is used to
set the quiescent current for the best suppression of odd harmonics and also
of the fundamental. B11 compensates for losses due to the doubler (level at
MP11 approx. +9 dB). The LO (local oscillator) signal at 840 MHz to 960 MHz
(oscillator frequency at ST27: 420 MHz to 480 MHz) is fed to the mixer via
GL115 - GL121 - GL138; whereas the LO signal 580 MHz to 640 MHz (oscillator
signal at ST27: 290 MHz to 320 MHz) is transferred to the mixer input via the
580 MHz high-pass filter C124 to C126, L114I - II and the switching diodes
GL116 - GL117, GL118 - GL119, GL138 in order to improve the decoupling of the
fundamental in the frequency doubler.

Range III: Quadrupler 1080 MHz to 1280 MHz

Oscillator frequencies 290 to 320 MHz are doubled to 580 to 640 MHz and the
fundamental frequency is suppressed. This signal at MP12 is passed to the
second doubling stage via diode switches GL109-GL110 with diode switches
GL115-GL121, GL118-GL119 cut-off. The operation of this doubler is the same
as described before under "Range II". The LO signal is amplified in T10-T11,
the output of the doubler stage is at MP13. This signal is fed to the L-input
of the mixer "B20" via diode switches GL135-GL136 with GL138 cut off.

All diode switches receive their control signals from the microprocessor's
data bus. The "interface" is set up with two CMOS signal memories B15 - B16.

4.9.2.   Oscillator 1.36 GHz
(refer to circuit 334.4930 S)

This unit "1,36 GHz Oszillator" provides the necessary LO signal for the
"Mischer-Verdoppler" assembly at FAM input frequencies > 120 MHz.

At RF input frequencies > 120 MHz, one of the oscillators at this assembly
is in operation. At RF input frequencies < 120 MHz, both oscillators are
switched off. The frequency range is 290 to 320 MHz for oscillator I and
420 to 480 MHz for oscillator II.

Both oscillator outputs are connected by switching diodes GL2 or GL3, respectively.

Both oscillator circuits are of the negative impedance converter type, and have a field-effect transistor (T5 or T1) as active element. A coil (L12, L3) is connected in parallel to the gate and the resonance is formed by a tuned varactor diode (GL5, GL1). The oscillation characteristic of the circuit depends upon the drain current. The optimum operating point is adjusted by means of trimmer resistors R31 and R2. The oscillator signal is output inductively via coils L15, L5. Two successive amplifier stages raise the level of the oscillator signal to approx. 4 dBm. Power supply +15 V for these two oscillators is switched via transistors T7 and T3. Both oscillators are phase locked via a PLL-circuit to the reference frequency of 10 MHz from the "Mikroprozessor/Referenzoszillator" assembly via K25.

From oscillator 1, part of the oscillator signal is fed out via R61 and applied to an attenuator, the switching diodes GL11, GL13 and the input of amplifier B2.

The subsequent frequency divider (B6 - B10) divides the oscillator signal (Osc 1) by 1/29, 1/30, 1/31, 1/32 resp. The signal is passed to the phase discriminator B5.

The output pulses of B5 are integrated in B4 to obtain a control voltage.

In case of phase synchronisation of both input signals at B5, the frequencies of Osc 1 are: 290, 300, 310, 320 MHz. A part of the output signal of the oscillators is coupled to an attenuator and amplifier B1 via R61 and fed to the frequency divider 2/1 (B3).

For oscillator 2, the divided signal of B3 is fed to amplifier B2 via GL22, GL14.

If the PLL-frequency divider is set to 1/21, 1/22, 1/23, 1/24, the phase synchronized frequencies of Osc 2 are: 420, 440, 460, 480 MHz.

The PLL-frequency divider has a prescaler B6 that can be switched to division ratios of 1/6 and 1/5 depending upon the control inputs to PE1 and PE2.

The programmable divider B8 controls the change-over of the division ratio at B6 with the aid of a latch flip-flop B10. B7 cares for the reset of B6, B7 and B8 after one divide cycle and sends the signal, divided by n, to the phase discriminator B5. n is the preset division ratio.

The division ratio n is determined by logic levels of the inputs D0, D1, D2 to dividers B7 and B8, following the appended table: (ECL-levels)

Table 4-1

Osc. Frequency	Division ratio	B7			B8		
		D2	D1	D0	D2	D1	D0
290	1/29	1	0	1	1	0	1
300	1/30	1	0	1	1	1	0
310	1/31	1	1	0	0	0	1
320	1/32	1	1	0	0	1	0
420	1/21	1	0	0	0	0	1
440	1/22	1	0	0	0	1	1
460	1/23	1	0	0	1	0	0
480	1/24	1	0	0	1	0	1

The assembly "Mischer/Verdoppler" receives the oscillator signal either directly via attenuator R62-R63-R64 and GL7, K27, or via B3, GL20, GL8 divided by 2. Switching diodes shut off the other branch. Concerning the assembly "Mischer/Verdoppler", the resulting mixer frequencies are:

145, 150, 155, 160, 210, 220, 230, 240 and
290, 300, 310, 320, 420, 440, 460, 480 MHz.

Data signals from the microprocessor data bus are stored in B14 and B15 and serve as logic control for the "1.36-GHz-Oscillator" assembly. These signals are static at the outputs of the signal memories.

4.10.   "IEC Bus"

(refer to schematic 334.5914 S)

The IEC 625-1 interface of the FAM consists of the following interface
functions:

AH1 Acceptor Handshake
T4   Talker
L2   Listener
RL1 Remote/local
DC1 Device clear

Two ribbon cables with 16 poles interconnect the IEC-connector (24 poles) on
the instrument's chassis with the printed circuit board. All IEC functions
are executed under control of the IEC-interface circuit HEF 4738 (B15). Shift
registers B13, B14 read the addressing (A1 to A5), IEC-signals RSV and RTL
(return to load, HIGH, if local key is depressed) at the input Jsr of B16.

With remote control, the output Oloc is LOW, with automatic control, Oloc is
HIGH. This information is read by the microprocessor via P62 of B11.
The handshake between the IEC-interface for data input and output of the
IEC-bus data lines DIO1 to DIO7 is under control of the microprocessor with
the aid of the output ports P52, P53, P60, P61 of B11.

a) Listener

   When there is a LOW on the line Irdy, the microprocessor is ready to accept
   a new data byte. B15 will send a HIGH signal on the line dvd, if there is
   a data byte on the IEC-data bus lines. The microprocessor will now enable
   the buffer B23 and the data byte is read in. The timing is shown in Fig. 4-6.

Data

Bus handshake

Microprocessor interface
4738 handshake
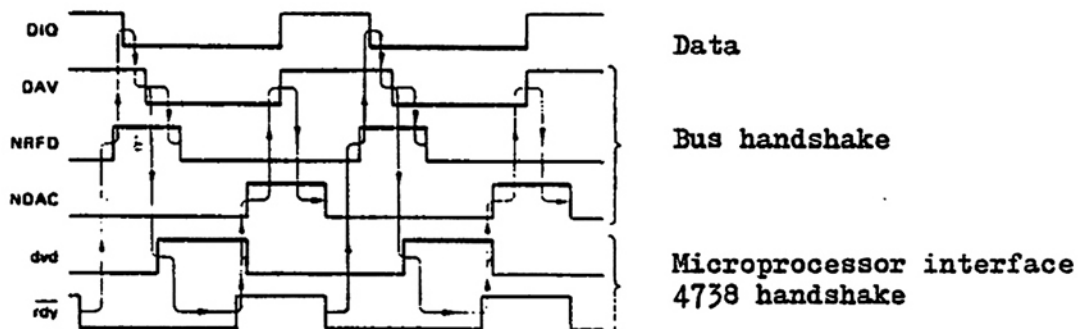
Fig. 4-6   Handshake-timing of the listener function

b) Talker

With data output, the microprocessor puts a LOW signal onto the line nba. If the controller is ready to read a new data byte (response signal NRFD), the interface B15 will set output line dcd to HIGH. This signal to the microprocessor indicates the transfer of data that must not be altered during this time. The handshake timing diagram is shown in Fig. 4-7.
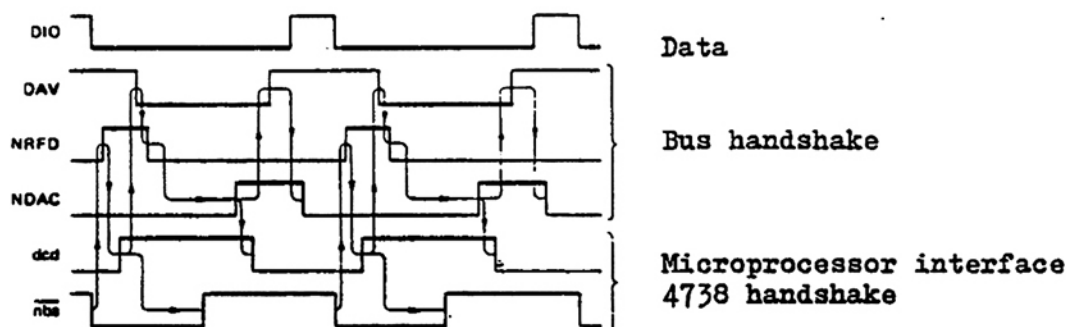
Fig. 4 - 7   Handshake-timing of talker function

Output 0clr of B15 is HIGH, if the interface is in the state dcas (device clear active state). B12II/III generates a reset pulse, starting the microprocessor from the beginning.

4.11.   "Reference Oscillator" Option SMS-B1

(refer to circuit 302.8918 S)

The "Reference Oscillator" option is a plug-in unit. Four connectors A, B, C and D establish electrical connection to the "Microprocessor" printed circuit board. If the "Reference Oscillator" option is installed later, the jumpers BU2 and BU3 must be removed from the "Microprocessor" printed circuit board.

The crystal oscillator in the "Reference oscillator" unit has a crystal Q1, an oscillator transistor T16 and a resonant circuit TR1, C56, C57, C58. C57 serves as temperature compensation to transformer TR1. The exact frequency is tuned by C53. Transistor T13 is an impedance converter.

The oscillator transistor and the crystal are housed in an oven for temperature stabilization. Thermistor R60 serves as temperature sensor and transistor T15 as heater. The required temperature is adjusted with the trimmer R52. Differential amplifier T10, T11 together with T12 form a regulator amplifier. The heater transistor is current-limited by R58, GL10, T12.

4.12. "CCIR-Filter / Detector" Option FAM-B7

a) Psophometric filter to CCIR Rec. 468
   (Filter characteristics see Fig. 2-10 in Appendix)

This is a passive filter with components CL to C5, L1/L2 input resistor R1 and output resistor R2. B1I serves for isolating the input and B6II isolates the output. The necessary gain is achieved with a feedback of B6II.

The filter is switched into circuit, if there is a HIGH at pin 4 and both FETs, T1 and T2, are on. A LOW at pin 4 switches the filter off the input and output, the gate voltage of T1 and T2 is ca. -15 V.

b) Quasi-peak detector

The input signal at pin 10 is rectified with two active detector circuits: one for the positive signal peaks (B4-GL10-T10) and the other for the negative signal peaks (B3-B2-GL11-T11). The higher peak value of both negative and positive peaks is applied to the CCIR-RC-network R21-R22-C11 and R23-C12 representing a dynamic characteristic for the peak measurement to the CCIR-specification. The maximum peak value within one measurement cycle is stored in C13, as the microprocessor does a cyclic interpretation of the signal. A discharge of C13 is prevented by T13-B5/II and the transistor T14 (LOW at pin 3), which is cut-off. When a certain maximum voltage at the output is reached, the limiter transistor will become conductive and prevents an overdrive.

After the voltage at pin 5 has been checked by the microprocessor, a short HIGH pulse at pin 3 discharges condenser C13 via T14.

4.13. "CCITT-Filter" Option FAM - B6

The telephone filter to CCITT Rec.P. 53A is on active filter (filter characteristics see Fig. 2-10).

The filter can be adjusted with R47 to 0 dB attenuation at 800 Hz.

4.14   DIST and SINAD Meter Option FAM-B8

With the aid of the DIST and SINAD Meter FAM-B8 distortion and SINAD values can be measured in the range from 30 Hz to 20 kHz at 30 fixed frequencies. The distortion factor can be measured in the modes AM, FM and φM as well as in voltage measurements.

The DIST and SINAD Meter FAM-B8 mainly consists of a tunable stopband filter in the form of a bridged RC filter network (see Fig. 4-8).

The stopband filter is preset depending on the value measured by the AF frequency counter of the FAM basic unit; fine tuning is effected with the aid of two control circuits.

The signal at MP5 (harmonics + noise) without fundamental is applied to the rms rectifier B15 after adequate amplification by B11, B13. The rectified voltage V_{dist} is then applied via K82 to the multiplexer B27 on the AF filter/ rectifier board. When measurements are made in the DIST or SINAD mode, the microprocessor calculates the value to be indicated from the result of the periodic AF level measurements (V_{AF}) and from the measurement of V_{dist} of the distortion factor circuit according to the following formula:

DIST measurement

$$ k\left[\%\right] = \frac{V_{dist}}{V_{AF}} \times 100 $$

SINAD measurement

$$ SINAD\,(dB) = -20 \times \log \frac{V_{dist}}{V_{AF}} $$

whereby V_{AF} = rms value of total signal

V_{dist} = rms value of total signal less fundamental

Presetting of Stopband Filter

The information from the data bus is fed to latches B51 and B2. Operating as quadruple comparator B41 controls the analog switches B3, B4, B5 and B18 in the binary code. The filter capacitances in "decade" step arrangement are switched via B40 with the binary BCD decoder (analog switch B2, B6 or B19). The phase shifter for the phase-error correction circuit (B18, B19, B21) is controlled at the same time.
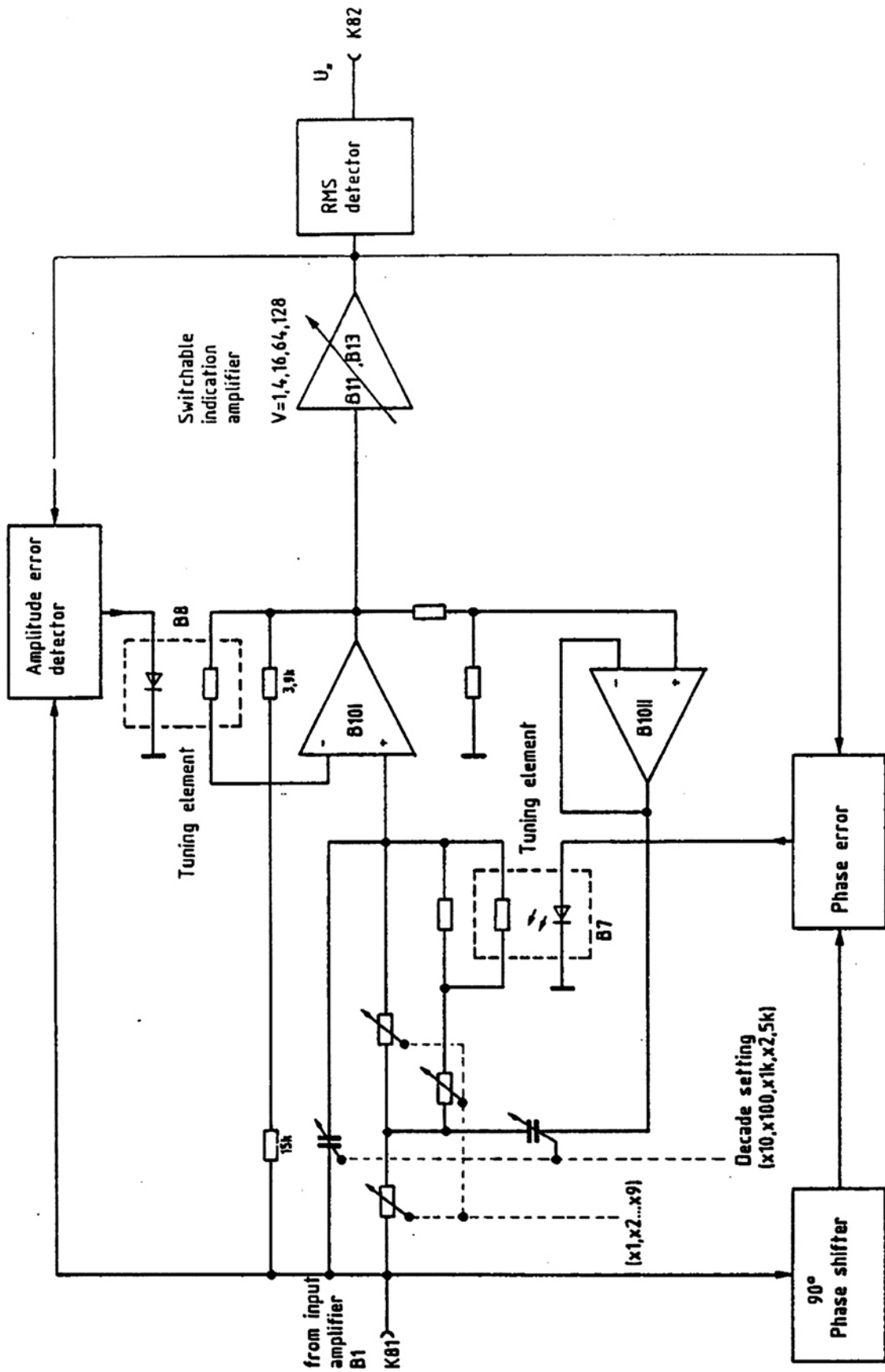
Fig. 4-8   Block diagram of DIST and SINAD Meter FAM-B8

Fine Adjustment of Stopband Filter

Amplitude error correction circuit

The amplitude error correction circuit is used for controlling part of the feedback signal of the "bridged T-RC filter network" in order to optimize the attenuation of the notch filter.

Fig. 4-9 shows a simplified diagram of this circuit. The input signal of the stopband filter is used as reference signal for the amplitude detector B31, while the output of the stopband filter provides the control signal. Amplifier chain B11, B13 and B20 provides the necessary dynamic range for achieving an attenuation of 80 dB. The product of both input signals is available at the output of amplitude detector B31. The voltage difference at the output of B31 is taken to earth potential by B32I.

For sinewave control the following formulae apply:

Reference signal	Control signal
$V_R = A_1 \times \cos \omega t$	$V_K = A_2 \times \cos(\omega t + \varphi)$

Product signal (error signal) at MP17:

$$V_0 = K \times A_1 \times \cos \omega t \times A_2 \times \cos(\omega t + \varphi) \qquad K = \text{constant}$$

After conversion via relation:

$$\cos \alpha \times \cos \beta = 1/2 \left(\cos(\alpha + \beta) + \cos(\alpha - \beta) \right)$$

the following formula is obtained:

$$V_0 = \frac{K \times A_1 \times A_2}{2} \left(\cos \varphi + \cos(2\omega t - \varphi) \right)$$

The integrator B32II operating as lowpass filter suppresses the component $\cos(2\omega t - \varphi)$.

Since the passband filter is coarsly adjusted to the fundamental, $\varphi = 0$, $\cos \varphi = 1$.

Thus the following value is obtained at the integrator output:

$$V_0 \approx \frac{K \times A_1 \times A_2}{2} \qquad \text{(DC signal)}$$

Since the input amplitude (reference signal) of the filter is constant, a change of the control signal A_2 causes a variation of the DC signal V_0.

The integrator output signal drives via the DC voltage converter B33I the tuning element B8 which adjusts the gain of B10 such that the error signal (and therefore the amplitude of the fundamental ω_1) is at a minimum.
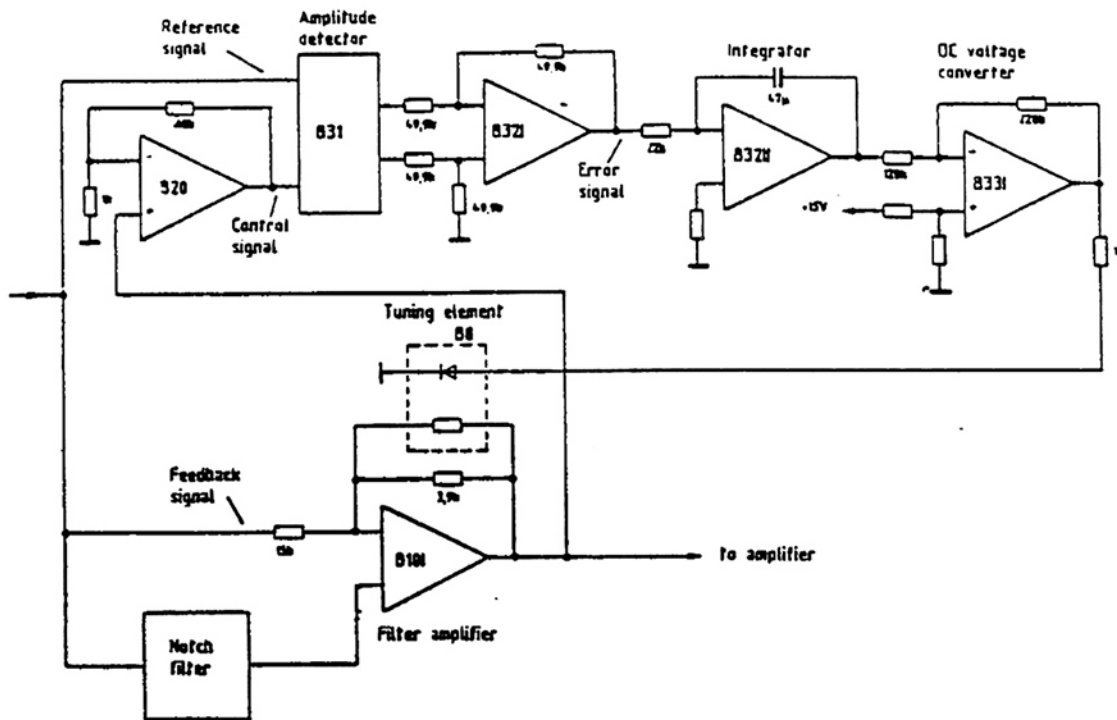
Fig. 4-9   Simplified circuit diagram of amplitude error detector
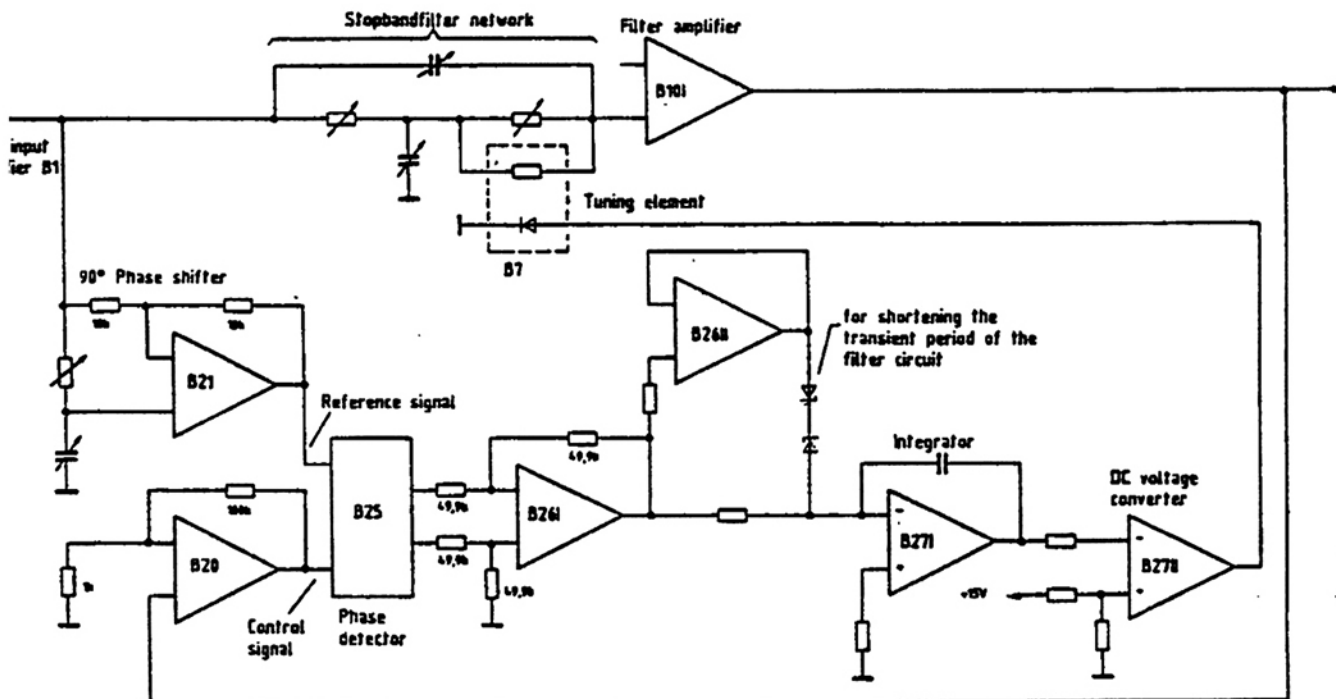
Fig. 4-10   Simplified circuit diagram of phase error detector

R 42219 - 4.32

Phase error correction circuit

The phase error correction circuit serves for fine tuning the stopband filter to the fundamental.

Fig. 4-10 shows a simplified diagram of this control circuit.

The input signal of the stopband filter shifted by 90° in the phase shifter B21 is used as reference signal for the phase error detector B25.

Reference signal

$$V_R = A_1 \times \cos(\omega t - 90^\circ)$$

The output signal of the stopband filter amplified by B11, B13 and B20 serves as control signal for the phase detector B25:

Control signal

$$V_K = A_2 \times \cos(\omega t + \varphi)$$

The product signal at the output of B25 is taken to earth potential with B26I, so that the following formula is obtained at the output of B26I:

$$V_0 = K \times A_1 \times \cos(\omega t - 90^\circ) \times A_2 \times \cos(\omega t + \varphi) \qquad \text{whereby K is a constant.}$$

After conversion according to the formula

$$\cos\alpha \times \cos\beta = 1/2(\cos(\alpha + \beta) + \cos(\alpha - \beta))$$

the following is obtained: $\quad V_0 = \dfrac{K \times A_1 \times A_2}{2} \left[\sin(2\omega t + \varphi) - \sin\varphi\right].$

The integrator B27I operates as lowpass filter so that only the low-frequency component of the signal is present at MP 12. Thus the error signal at the integrator output has the formula:

$$V_0 = \frac{K \times A_1 \times A_2}{2} \times \sin\varphi$$

This error signal V_0 becomes 0 when $\varphi = 0^\circ$ ($\sin 0^\circ = 0$) i.e. a phase difference of 0° between filter input and output is brought about.

The time constant of the integrator B27I is determined by R190, C96. The amplifier B26II with Zener diodes GL65, GL66 causes the charge of the integrator to be changed more rapidly if the notch filter is heavily detuned. This circuit is ineffective for fine tuning.

The integrator output signal drives via the DC voltage converter B27I the tuning element B7 which changes the resonance frequency of the stopband filter.

5. Repair Instructions

5.1. Required Measuring Equipment and Accessories

See section 3.1.

5.2. Trouble Shooting (including hints on operator errors)

The flow charts below will be of help in identifying or locating errors, i.e., in identifying an operator error or in determining the faulty PC board in case of a real error or fault. The designations Y1,..., Y10 in the rest angular fields identify the PC board to be checked in the way, indicated in the adjacent field.

The code digits Y1,..., Y10 in the circular fields identify the PC board, where the fault must be sought, with the aid of section 5.2.8.

Before trouble shooting, check that all voltages have their nominal values. See section 5.3.1.

!! Shut off power before changing PC board !!

Index of printed circuit boards

No.	Denomination	Id.No.	Colour Code
Y1	Keyboard/display unit	334.2421	-
Y2	Microprocessor	334.2880	blue-red
Y3	Option FAM-B2 1.36-GHz Oscillator	334.4930	black-red
Y4	Option FAM-B2 1.36-GHz Mixer/ frequency doubler	334.5214	green-red
Y5	Level control/counter	334.4430	yellow-red
Y6	120-MHz Mixer	334.3811	black-blue
Y7	Demodulator	334.4453	green-blue
Y8	Audio filter/rectifier	334.4418	yellow-blue
Y9	Option FAM-B8	334.5714	grey-blue
Y10	Power supply	334.2515	-

Flowchart:

Input voltage, input frequency outside specification? — yes → operator error
↓ no

Input frequency < 3.5 MHz? — yes →
↓ no

Input frequency between 3.5 MHz and 120 MHz? — yes → Y5
↓ no

Input frequency between 120 MHz and 1.36 GHz and option B2 not installed? — yes → operator error
↓ no

Manual input of frequency
↓

Y4 Check RF 5 MHz to 120 MHz at K21? — yes → Y5
↓ no

Y3 Check LO signal at K27? — yes →
↓ no
Y3   Y4

(Right branch)
FM mode? — yes → operator error
↓ no

Input 3 MHz manually
↓

Option B2 installed? — yes →
↓ no

Y5 Check for input signal at ST28? — yes →
↓ no
Y5

Y4 Check for input signal at K28 — no → Y4

Y7 Check input frequency at ST7 — yes →
↓ no
Y7

Y7 DC voltage > 50 mV at ST6,24?
↓
Y5   Y7

```
                    ┌─────────────────────┐   yes
           ─────────│   Input signal with │──────────▶   not specified
                    │   m = > 80% ?       │
                    └─────────────────────┘
                              │ no
                              ▼
                    ┌─────────────────────┐   yes
                    │ More than one RF    │──────────▶   not specified
                    │ signal at RF input ?│
                    └─────────────────────┘
                              │ no
                              ▼
                    ┌─────────────────────┐   yes
                    │ 10-MHz reference    │──────────▶   (Y2)
                    │ frequency wrong? (29)│
                    └─────────────────────┘
                              │ no
                              ▼
          ┌─────────────────────┐  yes     ┌─────────────────────┐  yes
          │  RF frequency       │────────▶ │ Sufficient voltage  │──────┐
          │  55 kHz to 3.5 MHz ?│          │ at ST6/19 ?         │      │
          └─────────────────────┘          └─────────────────────┘      │
                    │ no                              │                  │
                    ▼                                 ▼                  ▼
   yes    ┌─────────────────────┐                   (Y7)              (Y5)
  ┌───────│  RF frequency       │
  │       │  3.5 MHz to 120 MHz ?│
  │       └─────────────────────┘
  ▼                 │ no
 (Y5)               ▼
          ┌─────────────────────┐
   yes    │ Input signals < 120 │
  ┌───────│ MHz being correctly │
  │       │ counted ?           │
  │       └─────────────────────┘
  ▼                 │ no
 (Y3/               ▼
  Y4)              (Y5)
```

5.2.3.   Dashes (periodically in RF Display in MAN Mode

One or more of the following causes may be responsible for
this error indication:

- AM > 80%, the RF-frequency counter cannot make a reliable count
  of this signal

- Excessive difference between input frequency and inserted frequency.

- There are two or more input signals, the counter cannot work properly.

5.2.4. Dashes in the Modulation Display

Instrument blocked measuring range* (S3) over- or underdriven by RF, IF, or audio level.

- switch briefly to AUTO mode before blocking again with "S3"

Instrument in S3 mode? — yes

FM, φ M, AM mode? — yes
no

VOLT mode Audio Level > 5.2 V? — yes → operator error
no

Audio signal in reject range of selected filter? — yes → operator error
no

RF signal at RF input? — yes → RF signal higher after changeover to NF? — yes → operator error
no   no

A/D-converter working properly? — yes → Y2
no
Y8

RF frequency <3.5 MHz and LP 200 kHz pressed — yes → operator error
no

Modulated signal in reject range of selected filter? — yes → operator error
no

Modulation greater than allowed? — yes → operator error
no

RF level no greater than allowed? — yes → operator error
no

VOLT mode working correctly? See 5.2.8.1. — yes → Y7
no

R 39242 - 5.5

```
                              │
                              ▼
          ┌─────────────────────────────────┐
          │      Modulated signal           │   yes
          │      in reject range of         │ ─────────▶  operator error
          │      selected filter ?          │
          └─────────────────────────────────┘
                              │ no
                              ▼
          ┌─────────────────────────────────┐
          │      Wrong rectifier            │   yes
          │      in circuit ?               │ ─────────▶  operator error
          │                                 │
          └─────────────────────────────────┘
                              │ no
                              ▼
          ┌─────────────────────────────────┐
          │      Input frequency            │   yes
          │      ≥ 3.5 MHz ?                 │ ─────────┐
          │                                 │          │
          └─────────────────────────────────┘          │
                              │ no                      │
                              ●◀────────────────┐       │
                              ▼                 │ yes   │
          ┌──────────────────────────┐   ┌──────────────────────────┐
     no   │  Audio voltmeter         │   │  250 kHz to 1 MHz        │
    ┌─────│  working correctly ?     │   │  IF present at           │
    │     │  See 5.2.8.1.            │   │  motherboard ST6/19 ?    │
    │     └──────────────────────────┘   └──────────────────────────┘
    │                 │ yes                          │
    ▼                 ▼                              ▼
  ( Y8 )            ( Y7 )                        ( Y7 )
                                                  ( Y6 )
```

R 42219 - 5.6

Audio signal in
reject range of
audio filter?

yes → operator error

no

A/D-converter
working properly?
See 5.3.2.3.

yes

no

(Y2)   (Y8)

R 42219 - 5.7

Wrong selection of
weighting filter or
rectifier ?
See specification

yes → operator error

no

Input frequency
> 120 MHz ?

yes →

Spurious deviation
in input range
61 to 120 MHz o.k. ?

yes

no

no

Spurious deviation 10 MHz,
Reference (29, Fig. 2-6)
excessive ?

yes →

no

Y6   Y7   Y3

R 42219 - 5.8

5.2.8. Functional Tests

5.2.8.1. Audio Filter/Rectifier Y8

5.2.8.1.1. Check Input Selector Switch B1

At ST7/29a, 27a, 25a or B1/10, the level of the modulated signals FM, φM, AM or VOLT must be the same as at MP1 after entering these signals on keyboard.

The test is made with an AC voltmeter or, with reduced accuracy, with an oscilloscope. The logical levels at B12 and B13II are:

Mode	B12		B13II			
	23	1	12	11	10	9
FM	L	L	H	L	L	L
φM	L	H	L	H	L	L
AM	H	L	L	L	H	L
VOLT	H	H	L	L	L	H

5.2.8.1.2. Check Switching of Gain and Divider

Mode: P+, VOLT, AUTO, HP 30 Hz, LP 20 kHz

Note: The test is performed at the upper hysteresis point. The voltage at the voltmeter input (19) must be increased in steps starting at 0 Volts, with a test signal of 1 kHz. Check that the level at the AF output is in all cases about 1 V.

V_{in} [mV]	V_{MP1} [V]	V_{MP2} [V]	B12				B30				
			5	4	3	2	4	5	6	7	11
3.535	0.0025	0.640	L	L	L	L	H	L	L	L	L
7.071	0.005	0.640	L	L	L	H	H	L	L	L	L
14.14	0.01	0.640	L	L	H	L	L	H	L	L	L
28.28	0.02	0.640	L	L	H	H	L	H	L	L	L
56.57	0.04	0.640	L	H	L	L	L	L	H	L	L
113.14	0.08	0.640	L	H	L	H	L	L	H	L	L
226.27	0.16	0.640	L	H	H	L	L	L	L	H	L
455.25	0.32	0.640	L	H	H	H	L	L	L	H	L
905.1	0.64	0.640	H	L	L	L	L	L	L	L	L
1810.2	1.28	0.640	H	L	L	H	L	L	L	L	L
3620.4	2.56	0.640	H	L	H	L	L	L	L	L	H

5.2.8.1.3. Check Audio Filter

For the test of the audio filter, see 5.3.3.5.

A) Check High-Pass Filters

As described in 5.3.3.5.1.

The 0-dB reference voltage at MP7 is 0.64 V.

	B12 21	22
HP 10 Hz	L	L
HP 30 Hz	L	H
HP 300 Hz	H	L

B) Check Low-Pass and (optional) CCITT and CCIR Filters

As described in 5.3.3.5.2.

The instrument must be blocked, with "S3", in the corresponding
filter position.

The 0-dB reference voltage is 0.64 V,

for:	at:
LP 200 kHz	MP7
LP 20 kHz	MP9
LP 3 kHz	MP8
CCITT	B17/3
CCIR	B14/3

C) Check Low-Pass Filter Switching

The audio signals corresponding to the different filters at the test points
listed above must also be observed at MP10.

	B12 18	19	20	B13I 4	5	6	7
LP 200 kHz	L	L	L	H	L	L	L
LP 20 kHz	L	L	H	L	H	L	L
LP 3 kHz	L	H	L	L	L	H	L
CCITT (optional)	L	H	H	L	L	L	H
CCIR (optional)	H	L	L	L	L	L	L

D) Check AF Output and Input of Audio Signal to Counter

See section 5.3.3.6.

E) Check Detector

a) Detector +peak / -peak

Apply 3620.4 mV, 1 kHz to voltmeter input
Remove T2 temporarily

Voltage at:

MP10	MP11	MP12	B27/15	Indication
0.640 V	6.14 V	8.69 V	1.96 V	5120 mV

The audio signal at MP11 must be inverse to the signal at MP10
when switching in the -peak detector.

The levels with reference to the +peak must not deviate by more than 0.4 %.

Replace T2.

Check the discharge curve of the peak detector at MP12 with an oscilloscope:

Signal pattern:
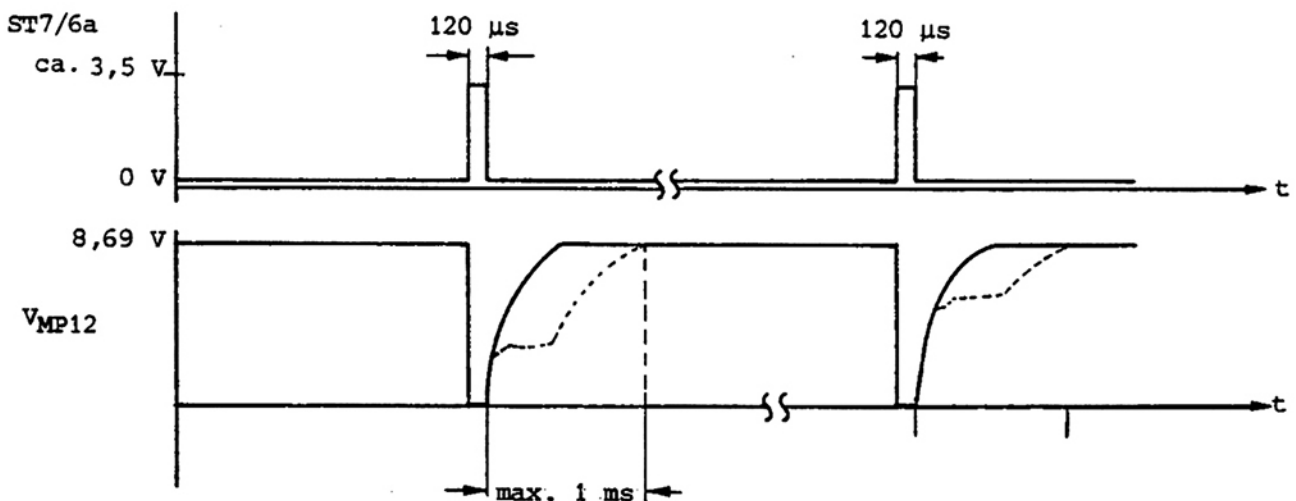
b) Check RMS Detector and (optional) Quasi-Peak Detector

Apply 3620.4 mV, 1 kHz to voltmeter input:

| Voltage at: | | | | | with: | |
MP10	B14/6	B25/6	MP13	B27/12	RMS indication	CCIR indication
0.640 V	4.07 V	4.07 V	1.384 V	1.38 V	3620 mV	3620 mV

F) Check Multiplexer B27

The different inputs of B27 will be connected to MP14 under control of the
Microprocessor PCB in cyclical order depending upon the mode, detector,
and options B2, B7, and B8 (if present).

The relations are as following:

P73	P72	P71	P70	Input B27 Pin	connected to MP14	max. DC voltage at MP14
X	L	L	L	13	CCIR detector	2 V
X	L	L	H	14	Dist./Sinad	2 V
L	L	H	L	15	+peak	2 V
H	L	H	L	15	-peak	2 V
X	L	H	H	12	RMS detector	2 V
X	H	L	L	1	Mean value of AM carrier	2 V
X	H	L	H	5	Test point < 120 MHz	1 V
X	H	H	L	2	-	
X	H	H	H	4	1.36-GHz test point	1 V

Note: B12 spans P73, P72, P71, P70.

5.2.8.2. 120-MHz Mixer Y6

a) Fault: no IF signal at K31.
   Check as described in 5.3.5.

   Help for trouble-shooting the mixer circuit:

Oscillator and selection of sensitivity						
Frequency range [MHz] (Oscillator frequency)	$\overline{Q4}$	$\overline{Q3}$	$\overline{Q2}$	$\overline{Q1}$	DC voltages refer to the frequencies at the low end of the range MP10 [V]	MP11 [V]
60 - 64 / 74 - 80	H	H	H	L	+ 4.1	3.65
64 - 67 / 80 - 85	H	H	L	H	+ 6.8	6.7
67 - 72 / 85 - 88	H	L	H	H	+ 9.6	9.5
72 - 74 / 88 - 90	H	H	H	H	+ 9.6	15.4
90 - 95 /104 - 108	L	H	H	L	+ 4.1	3.9
95 - 99 /108 - 115	L	H	L	H	+ 6.8	7.8
99 - 102 /115 - 118	L	L	H	H	+ 9.6	11.4
102 - 104/118 - 120	L	H	H	H	+ 9.6	15.1

Oscillator frequency range selector	Output frequency divider selector				
Frequency [MHz] BI/II/P43	Frequency MP22				
		P42	P41	P40	
Range I 60 - 74 L 90 -104		L	L	L	3.75 - 7.5 MHz
		L	L	H	7.5 - 15 MHz
Range II 74 - 90 H 104 -120		L	H	L	15 - 30 MHz
		L	H	H	30 - 60 MHz
		H	L	L	60 -120 MHz

b) Fault: Excessive spurious deviation of LO oscillator

In addition to the tests of 5.3.5. check following:

	DC voltage	Nominal value of (extraneous) noise voltage
MP35:	13.5 V ± 0.3 V	< 10 μV
MP1 :	7.5 V	< 15 μV ⎫
MP2 :	7.5 V	< 15 μV ⎬ if operational
MP12:	+10 V resp. -15 V	< 20 μV
MP9 :	+4 V ...+10 V	< 10 μV
MP10:	-10 V...+10 V	-
B13/3:	2.5 V ± 0.2 V	< 10 μV
Collector T15	-	< 10 μV

5.2.8.3. Demodulator Y7

5.2.8.3.1. Check +5.00-V Reference Voltage

Nominal value 5.00 V ± 5 mV.

5.2.8.3.2. Check Voltage and Frequency Response

As described in 5.3.5.2., check up to MP2 and ST1/1.
In addition check that 300 mV at ST31 gives 520 mV ± 50 mV (IF 500 kHz) at ST6/19.

5.2.8.3.3.   Check FM and φM Circuit

a) IF 500 kHz

Use a 100-MHz 100-mV signal, unmodulated, at RF jack, in the FM-mode, LP 20 kHz.

ST6/7:	H	B25/1:	14.5 V ± 1 V
ST6/8:	L	B26/5:	13.5 V ± 1 V
ST6/9:	H		

Residual IF voltage at MP10,11 < 2 mV.

R 42219 - 5.14
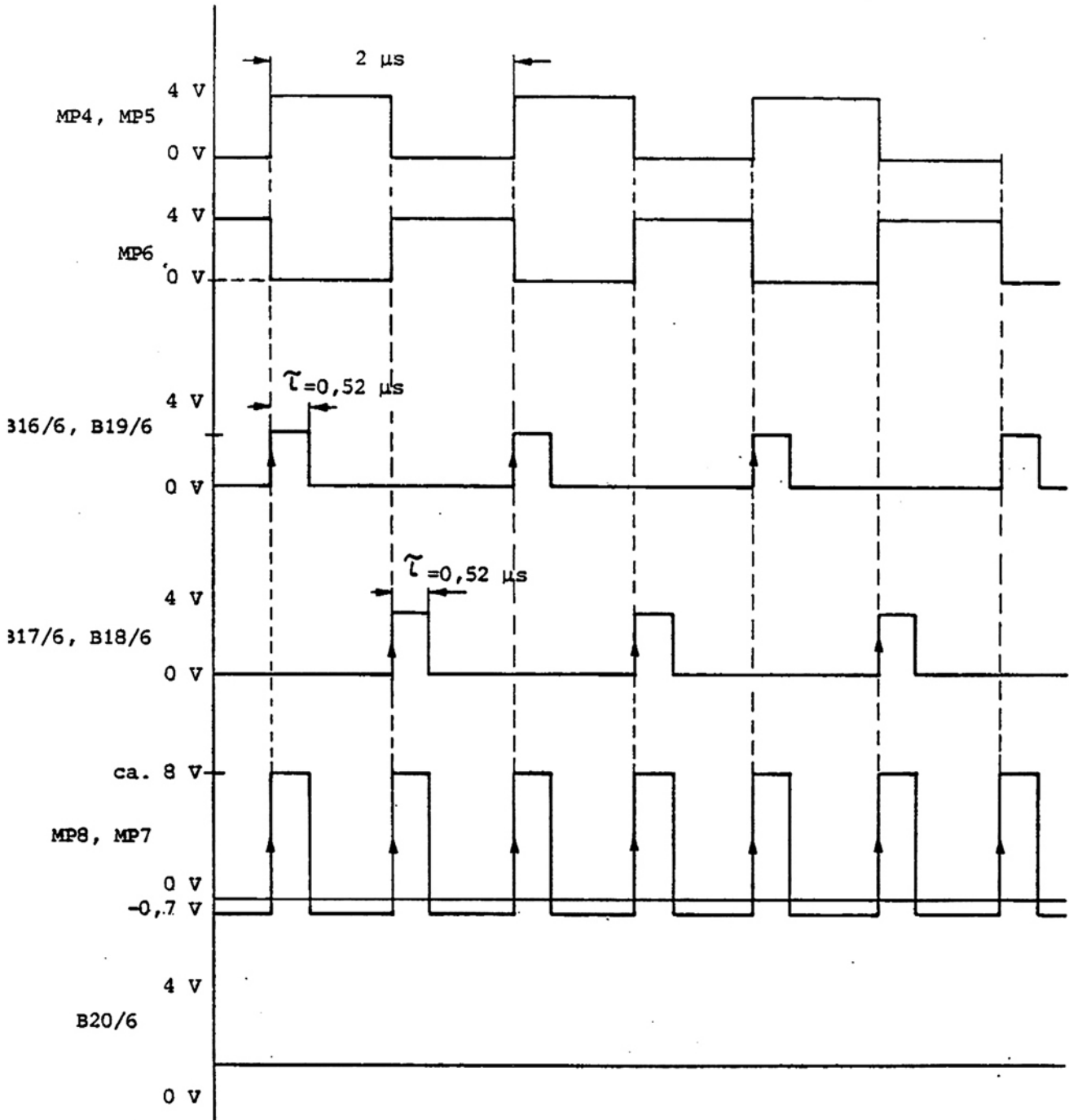
FAM: select LP 200 kHz

ST6/9: L
ST6/8: L

B25/1:   -14.5 $\pm$1 V

Residual IF voltage at MP10,11 < 2 mV.

b) IF 1 MHz

FAM: modulate 100 MHz signal with a deviation > 150 kHz, f_{mod} = 1 kHz.
Block FAM with "S3", switch test signal to "unmodulated".

B26/5:   +13.5 V $\pm$1 V
B12/8:   L
MP6:   H
MP5:   500-kHz TTL-signal

The TTL-signals at MP4, MP5, B18, B19/6, MP8 must be the same as with an
IF of 500 kHz.
(Frequency: 500 kHz)

c) Check Output Signal of FM Demodulator

As described in 5.3.6.4.

5.2.8.3.4.   Check AM Circuit

a) AM < 3.5 MHz

Adjust manually to 500 kHz, apply a 100 mV unmodulated signal to RF-jack (22), check with voltmeter or oscilloscope:

```
ST6/7 :   L
ST6/9 :   H
B3/7  :   -13.5 V
B3/15 :   -13.5 V
B3/9  :   +13.5 V
B25/1 :   +13.5 V
ST1/1 :   190 mV ± 20 mV
```
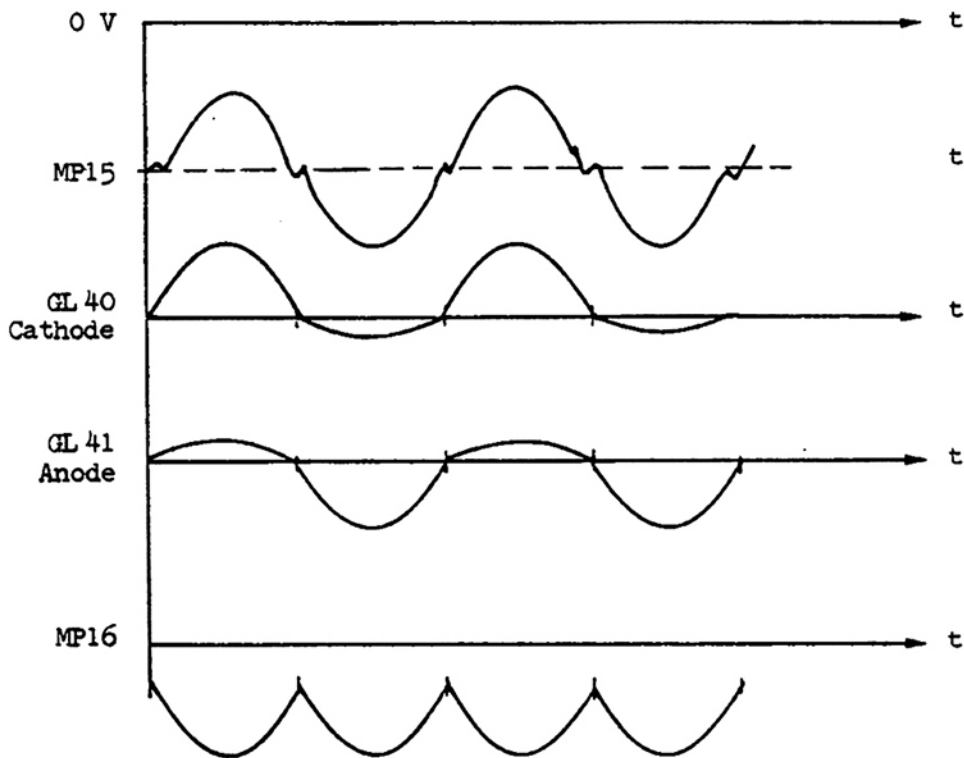

Adjust RF voltage for a DC level of 1.8 V ± 2 mV at MP17.

Modulate signal with 40% AM, f_{mod} = 1 kHz.

DC voltage at MP17 must not change !

Nominal (effective) voltage at MP18: 0.905 V ± 10 mV.

Check RF attenuator ($f_E < 3.5$ MHz)

Reduce RF level (without modulation) to 10 mV and increase slowly to 3 V.
At 2 V, in each case, the attenuator must be switched as follows:

V_{in} [mV]	a [dB]	ST6				B3		B2			
		3	4	5	6	15	1	1	7	9	15
10...											
ca. 30 mV	-24	L	L	L	L	-14 V	+14 V	-14	+14	+14	+14
	-21	L	L	L	H	"	"	-14	+14	+14	-14
	-18	L	L	H	L	"	"	-14	+14	-14	+14
	-15	L	L	H	H	"	"	-14	+14	-14	-14
	-12	L	H	L	L	"	"	+14	-14	+14	+14
	-9	L	H	L	H	"	"	+14	-14	+14	-14
	-6	L	H	H	L	"	"	+14	-14	-14	+14
	-3	L	H	H	H	"	"	+14	-14	-14	-14
	0	H	L	L	L	+14 V	-14 V				
	3	H	L	L	H	"	"				
	6	H	L	H	L	"	"				
	9	H	L	H	H	"	"		as above!		
	12	H	H	L	L	"	"				
	15	H	H	L	H	"	"				
	18	H	H	H	L	"	"				
...3 V	21	H	H	H	H						

b) AM > 3.5 MHz

In AM mode, insert 10 MHz manually.

Apply 10 MHz, 100 mV without modulation to RF jack.

Check the following DC voltages:

B3/7 :   +13.5 V
B3/15 : -13.5 V
B3/9 :   -13.5 V
B25/1 : -13.5 V
MP17 :   1500 mV ± 100 mV

Residual IF at MP18 and AM output must be ≤ 2 mV.

Block instrument with "S3".

Modulate test signal with 40% AM, f_{mod} = 1 kHz

Voltage at MP17 unchanged

Change RF level until a DC voltage of 1.8 V at MP17 is reached.

Nominal voltage at MP18: 0.905 V ± 10 mV.

5.2.8.4. Level Regulation / Frequency Counter Y5

a) No frequency indication in the range 55 kHz to 3.5 MHz
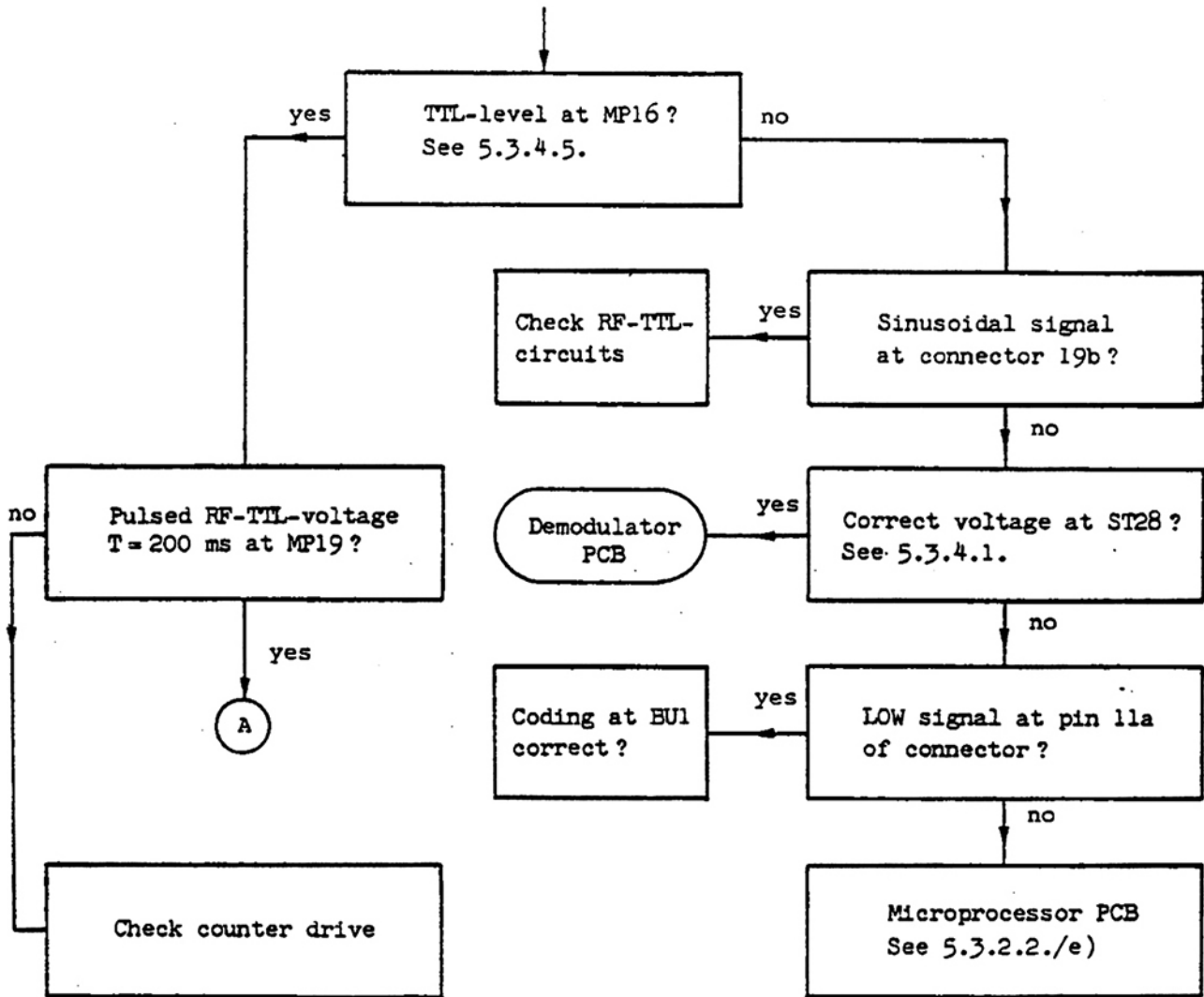
b) No frequency indication in the input frequency range 3.5 MHz to 120 MHz.

```
                  │
                  ▼
        ┌──────────────────────┐  yes
        │ TTL-level at MP7 ?    ├──────────────────────────┐
        │ See 5.3.4.5./a)       │                          │
        └──────────┬───────────┘                          │
                   │ no                                    ▼
                   │                           ┌──────────────────────┐
                   │         ┌─────────────┐   │ Pulsed RF voltage     │
                   │    yes  │ Check       │◄──┤ with T = 200 ms       │
                   │    ┌────┤ counter     │yes│ at MP19 ?             │
                   │    │    │ drive       │   └──────────┬───────────┘
                   ▼    │    └─────────────┘              │ no
        ┌──────────────────────┐                         │
   no   │ Correct IF voltage   │                         ▼
 (B)◄───┤ at ST30 ?            │              ┌──────────────────────┐
        │ See 5.3.4.3.         │         yes  │ TTL signals with      │
        └──────────┬───────────┘  (A)◄────────┤ T = 200 ms at        │
                   │ yes                       │ pin 19a ?            │
                   ▼                           └──────────┬───────────┘
        ┌──────────────────────┐                         │ no
        │ Check frequency      │                         ▼
        │ counter ICs.         │              ⟨ Microprocessor PCB ⟩
        └──────────────────────┘              ⟨ See 5.3.2.2./h)     ⟩
```

c) No IF voltage at ST30.

```
                  (B)
                   │
                   ▼
        ┌──────────────────────┐  no
        │ Alignment of PMS     ├──────────────────┐
        │ correct ?            │                   │
        │ See 5.3.4.2.         │                   ▼
        └──────────┬───────────┘        ┌──────────────────────┐
                   │ yes                 │ Coding of BU21 to BU52│
                   ▼                     │ correct ?            │
        ┌──────────────────────┐        └──────────────────────┘
        │ Check level regulation│
        │ according to 5.3.4.3. │
        └──────────────────────┘
```

d) No audio frequency indication

```
┌─────────────────────┐ yes                                      ┌──────────────────────┐
│ Audio frequency     │─────────────────────────────────────────│ Audio frequency      │
│ indication 10 Hz to 10 kHz │                                   │ indication           │
└─────────────────────┘                                          │ 10 kHz to 200 kHz    │
         │ no                                                     │ correct ?            │
         ▼                                                        └──────────────────────┘
                        ┌──────────────────────┐                           │ no
                        │ Check audio frequency │◄────                     │
                        │ indication            │                          ▼
                        └──────────────────────┘
```

Audio frequency indication 10 Hz to 10 kHz — yes → **Audio frequency indication 10 kHz to 200 kHz correct ?**

— no → **Check audio frequency indication** ◄── (from 10 kHz to 200 kHz box)

Audio frequency indication 10 Hz to 10 kHz — no ↓

10-MHz TTL signal present at B8III pin 10 ? — no → **Check reference 10-MHz oscillator**

— yes ↓

Pulsed 10-MHz TTL-signal with T = audio period at MP19 ? — no → ● ← no — **Pulsed audio TTL-signal with T = 1 ms at MP19 ?**

— yes ↓ **(A)**

Audio frequency indication 10 kHz to 200 kHz correct ? — no ↓ **Pulsed audio TTL-signal with T = 1 ms at MP19 ?** — yes ↓ **(A)**

● ↓ **TTL-level at MP17 ? See 5.3.4.5./c)**

— no → **Sinusoidal signal at connector pin 21b ?**

— yes ↓ **Check control lines Microprocessor PCB See 5.3.2.2./h)**

Sinusoidal signal at connector pin 21b ? — yes → (loop up)

— no ↓ **Audio filter / rectifier PCB**

↓ **Check audio TTL-circuits**

R 42219 - 5.20

5.2.8.5.   1.36-MHz Mixer / Frequency Doubler FAM-B2 Y4

No IF voltage at ST20

```
                        │
                        ▼
  ┌─────────────────────────┐
  │ Voltage at ST20 in      │         no
  │ range 3.5 MHz to 120 MHz │──────────────────────────────┐
  │ correct ?               │                               │
  │ See 5.3.8.2.            │                               │
  └─────────────────────────┘                               │
                        │ yes                               │
                        ▼                                    ▼
  ┌─────────────────────────┐         ┌──────────────────────────────┐
  │ RF voltage at MP2 for   │   no    │ Check attenuator at MP1:      │
  │ input frequencies       │────────▶│ Coding of divider at          │
  │ > 120 MHz correct ?     │         │ 120-MHz Level control/        │
  │ See 5.3.8.4.            │         │ counter PCB correct ?         │
  └─────────────────────────┘         └──────────────────────────────┘
                        │ yes
                        ▼
  ┌─────────────────────────┐         ┌──────────────────────────────┐
  │ LO voltage at MP3       │   no    │                              │
  │ correct ?               │────────▶│ Check LO-level circuits       │
  │ See 5.3.8.1.            │         │                              │
  └─────────────────────────┘         └──────────────────────────────┘
                        │ yes
                        ▼
  ┌─────────────────────────┐
  │ Check IF circuits       │
  │ according to 5.3.8.5.   │
  └─────────────────────────┘
```
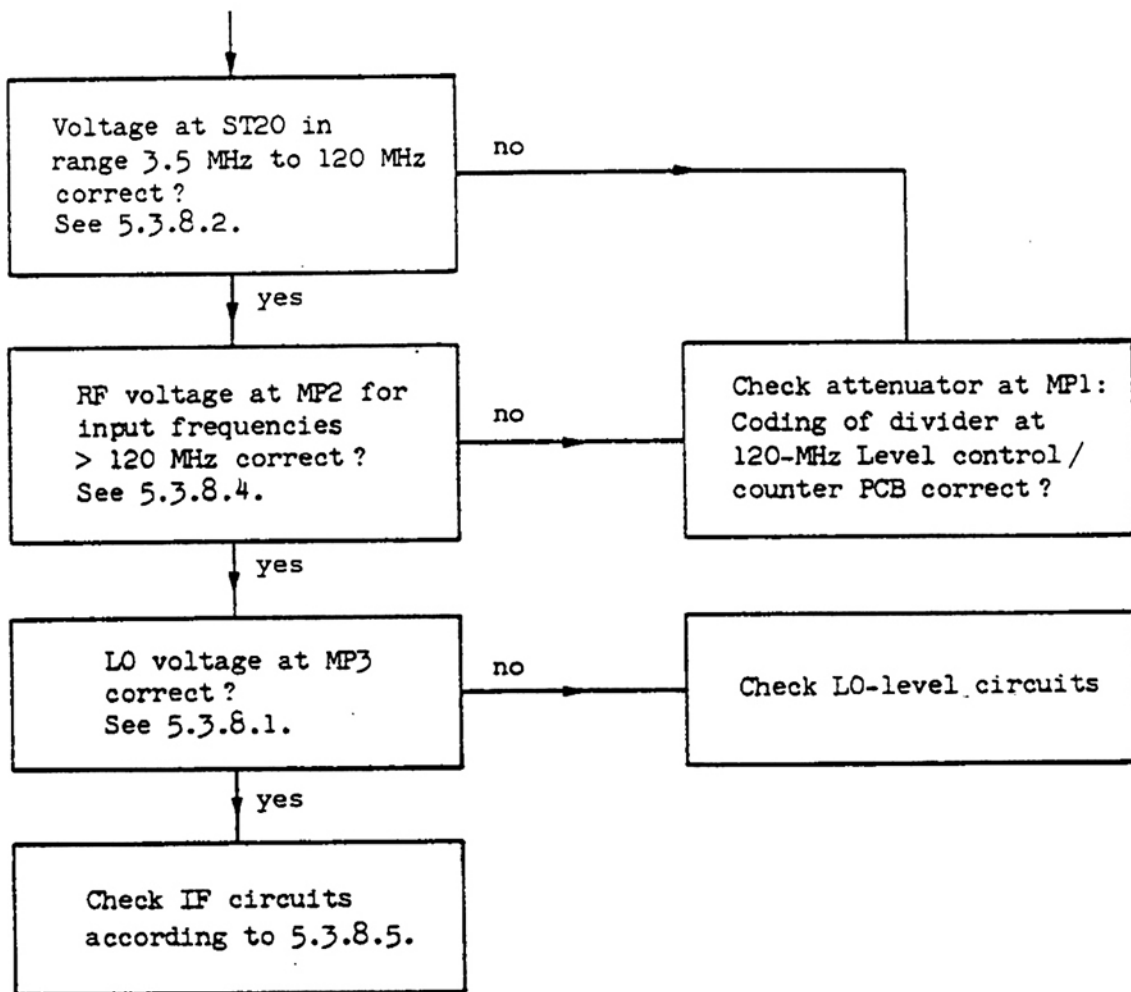
5.2.8.6.   1.36-GHz Oscillator FAM-B2

Fault: Wrong or no LO frequency at K27 for manual input of
        input frequencies 120.5 to 1360 MHz.

Check 10-MHz reference frequency and divided 10-MHz oscillator frequency:

MP19:   10-MHz ECL-signal (reference frequency)
MP18:   10-MHz ECL-signal (unsynchronized state)

In the synchronized state, the tuning at MP17 or ST2/6 must be within
the range +3 V to 14 V.

5.2.8.6.1. Check of Logical Control

Inserted frequency MHz	Nominal LO frequency K27 MHz	B15 1 11 10	B14 3 15 9 12 3	Divider ratio MP18 MP16	MP3	MP4	MP10	MP11	MP12	MP13	MP14
1000	480	L L L	H H H L L	1/24	ca. 0 V	+15 V	-15 V	-15 V	+15 V	-15 V	+5 V
960	440	L H L	H H H L L	1/22							
860	460	L H L	H H H L H	1/23							
800	420	L H L	H H H H L	1/21							
1320	320	L L H	L H L H H	1/32	+15 V	ca. 0 V	-15 V	+15 V	-15 V	+15 V	0 V
1200	310	L L H	L H L H L	1/31							
1280	300	L L H	H L L L H	1/30							
1100	290	L L H	H L H L L	1/29							
260	240	H H L	the same as at the double LO frequency	1/24	ca. 0 V	+15 V	+15 V	-15 V	+15 V	-15 V	5 V
200	210	H H L		1/22							
180	160	H L H	At the outputs of B12, the logical states must in each case be inverted!	1/32	15 V	ca. 0 V	+15 V	+15 V	-15 V	+15 V	5 V
125	145	H L H		1/29	"	"	"	"	"	"	"

5.2.8.6.2. Excessive Spurious Deviation of 1.36-GHz Oscillator

Insert test frequency manually and check level with RF-probe at:

K27 : -13.5 ±1 dBm

B3/1 : -4 ... +3 dBm

B6/1 : -4 ... +3 dBm

Check all ECL-voltages at B6, B7, B8, B9, B10, MP18, MP19, B5
with an oscilloscope.

Nominal value

4.16 V
permissible HIGH-range
3.95 V

3.51 V
permissible LOW-range
3.17 V

0 V

5.3.   Check and Alignment of Basic Instrument

5.3.1.   Supply Voltages

All printed circuit boards must be in place.

Apply a 10-MHz 100-mV signal from RF generator to RF input jack (22).

a) Measure voltages at test points on motherboard and
   adjust according to table 1.

Table 1

Voltage	Trimmer potentiometer at regulation circuit	Test point
+5.20 V ± 0.05 V	R2	+5 V Motherboard
+24 V ± 0.05 V	R18	+24 V "

Verify voltages according to table 2.

Table 2

Voltage	Tolerance	Test point
+15 V	±0.75 V	+15 V Motherboard
-15 V	±0.75 V	-15 V "
+5 V	±0.50 V	pin 8-9 at BU10

b) Press VOLT key

   Check voltage regulation for line voltage from 198 V to 242 V.
   Check noise voltages (RMS) with a millivoltmeter.

Table 3

Voltage	Variation	Noise voltage (mV)
+5.20 V	±0.01 V	< 0.5
+15 V	±0.05 V	< 1.5
-15 V	±0.05 V	< 1.5
+24 V	±0.01 V	< 0.3

c) Before switching on the power supply circuit for the first time
    (pre-adjustment of voltages according to table 1) make sure that
    ST17-ST18 is connected to the motherboard. Connect a dummy load to
    the test points of table 1 and 2, so that the currents of table 4
    are drawn. Check noise voltage according to (b).

Table 4

Voltage	Current	Noise voltage (mV)
+5.20 V	2.0 A	< 0.1
+15 V	1.5 A	< 1.5
-15 V	0.5 A	< 1.5
+24 V	0.1 A	< 0.3
+5 V	0.4 A	-

5.3.2.   Microprocessor with Keyboard/Display Unit

Plug the Microprocessor PCB into an adapter. Jumpers BR1 and BR4 must be
in place.

5.3.2.1.   Check and Adjustment of 10-MHz Reference Oscillator

Set the following jumpers:

BU2 at ST2

BU3 at ST3

BU4 at ST4 pin 1-2

BU5 at ST4 pin 3-4

Connect a frequency counter to reference output, close the cover and adjust
to 10.00000 MHz using C3 (TTL-level).

Check following frequencies and levels:

ST26	10.00000 MHz	TTL-signal
ST25	10.00000 MHz	> 3 V
ST32	50.000 kHz	TTL-signal
BU13/10	1.2500 MHz	" "
BU12/8	2.5000 MHz	" "
B4/2	5.0000 MHz	" "
B6/24	50.000 kHz	

5.3.2.2. Functional Test of Microprocessor

A) Check of basic mode   -   switch on FAM

After indication of a two-digit code number (indication of software version), all display positions must show zeros.

The following keys must be lighted:

AUTO, AM, AF-FREQ, HP 30 Hz, LP 20 kHz, P+

The unit "%" of the middle display and the unit "Hz" of the right-hand display and one LED of the analog display must be visible.

B) Check the key circuits

The following keys must light momentarily when pressed.
Only one key in one group may be lit, together with the corresponding unit:

Table 1

Group 1	Unit	Group 2	Group 3
AM	%	HP 300 Hz	LP 200 kHz
FM	Hz (kHz)	HP 30 Hz	LP 20 kHz
φM	RAD	HP 10 Hz	LP 3 kHz
VOLT	mV		

Group 4	Group 5		Group 6	Unit
P+	Deemph. 50 µs		REF	as Gr. 1
P-	" 75 µs		%	%
P±	" 750 µs		dB	dB
RMS	" OFF		OFF	as Gr. 1
RMS · √2				

The following keys of the basic instrument (without options FAM-B6, -B7, -B8) must not light when depressed: CCIR, CCITT, DIST, SINAD, PEAK CCIR.

C) Check manual entering of frequency and reference

Key in a frequency (unit MHz) in the range 0.055 MHz to 120 MHz and then press the MAN key.
The LED in the AUTO key must go off.
The frequency keyed in must appear on the display for about 3 ms and than go off.

Within group 1 enter a reference value via the keyboard (unit corresponding to the display) and press the REF key. (Note the input range.)

The reference value must be indicated in the display.
The OFF key extinguishes this display.

For the following checks can only be performed on the fully equipped instrument. The Microprocessor PCB is plugged into the adapter. When the FAM shows the right starting position (see 5.3.2.2.), check the control lines and port outputs:

a) Check of control lines RD-CS of A/D-converter B6 (ADC Start Convert) at output port P40 of B10 together with output port P17 (RE, read enable) of the microprocessor.

- apply a 20-MHz, 100-mV signal amplitude-modulated with 1 kHz at m = 50% from the RF generator to the RF input jack.

- press P+ key

- inhibit FAM with "S3"

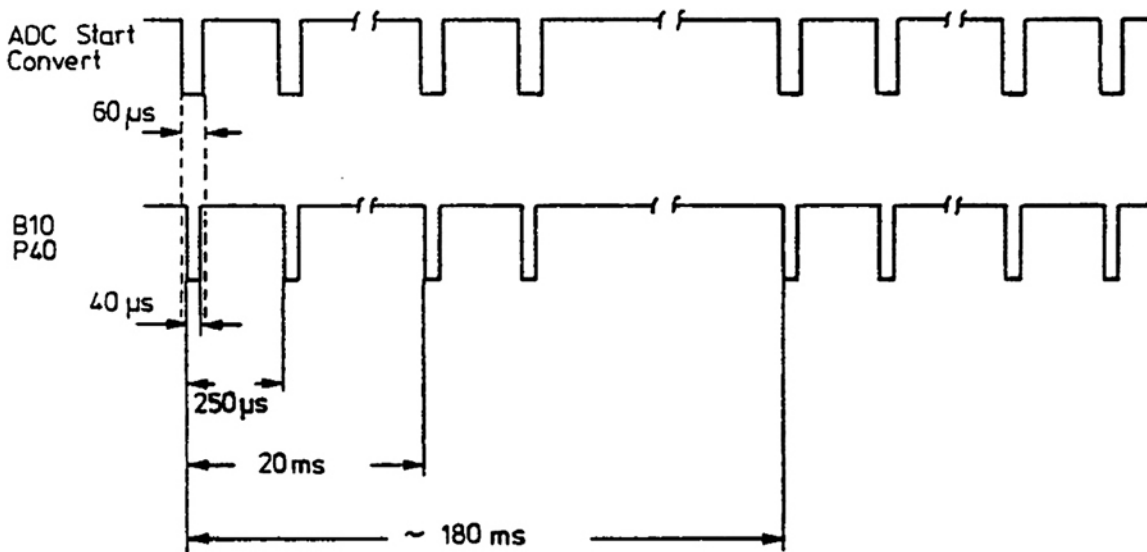Check TTL control signal at B4, P17 and B10, P40 (pin 2) against fig. 1

Fig. 1   TTL control signal

b) Check discharge pulse at output port P16 of microprocessor module B4 against fig. 2.

    - RF input voltage and FAM setting as in (a)

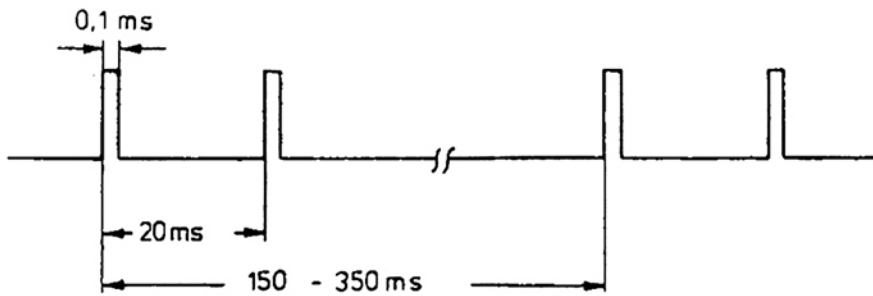Fig. 2   Discharge pulses

c) Check control signals for RF attenuator at P10, ..., P14 of microprocessor module B4.

    - Apply 20 MHz, unmodulated, voltage (V_E) as shown in table 2 below, to RF input.

    - Press AUTO key

    - Check B4 outputs P10,..., P14 against table-2 entries.

Table 2

RF attenuator	P10 (2dB)	P11 (4dB)	P12 (8dB)	P13 (10dB)	P14 (20dB)
V_{in}= 0 V	L	L	L	L	L
V_{in}= 3.0 V	H	H	H	H	H

d) Check test-lines at the B8 input ports PB4,..., PB7 against table 3, to verify presence of options.

Table 3

	PB4	PB5	PB6	PB7
without options FAM-B2, -B6, -B7, -B8	H	H	H	H
with option FAM-B2	L	H	H	H
" " FAM-B8	H	L	H	H
" " FAM-B6	H	H	L	H
" " FAM-B7	H	H	H	L

e) Check control signal for input frequencies $\geqslant$ 3.5 MHz at B11 port P70.

- Apply 100-mV signal, of frequency f_E of table 4 below, unmodulated, to the RF input jack

- press AM key

- press AUTO key

Table 4

	P70
$f_{in}=$ 2 MHz	L
$f_{in}=$ 20 MHz	H

f) Check control signal, when a deemphasis key is pressed, at B11 ports P40 and P41, against table 5.

- press AUTO key

- press FM key

Table 5

	P40	P41
Key 50 μs depressed	L	L
Key 75 μs depressed	L	H
Key 750 μs depressed	H	L
Key OFF depressed	H	H

g) Check control lines for IF:

250 kHz, 500 kHz, 1 MHz at B11 ports P42, P43

- Apply 20-MHz, 100-mV signal, FM-modulated with 1-kHz audio, deviation as in table 6, to RF input jack

- press AUTO key

Table 6

| Filter keys:			P42	P43	ZF
HP 30 Hz, LP 20 kHz	depressed				
" "	deviation:	5 kHz	H	L	250 kHz
" "	deviation:	20 kHz	L	L	500 MHz
" "	deviation:	200 kHz	L	H	1 kHz
LP 200 kHz	depressed		L	L	500 kHz
AM key depressed			L	L	500 kHz

h) Check of counter control circuit for measurement of frequency and period as in table 7.

- Apply 20-MHz, 100-mV signal, 50% AM with 1-kHz audio tone to RF input jack

- depress AUTO, AM, AF-FREQ, P+ keys

- inhibit FAM with "S3" after lock-in

<u>Table 7</u>   Counter control circuit (TTL level)

B11, P71
Change-over RF/Audio (Trigger signal for oscilloscope)
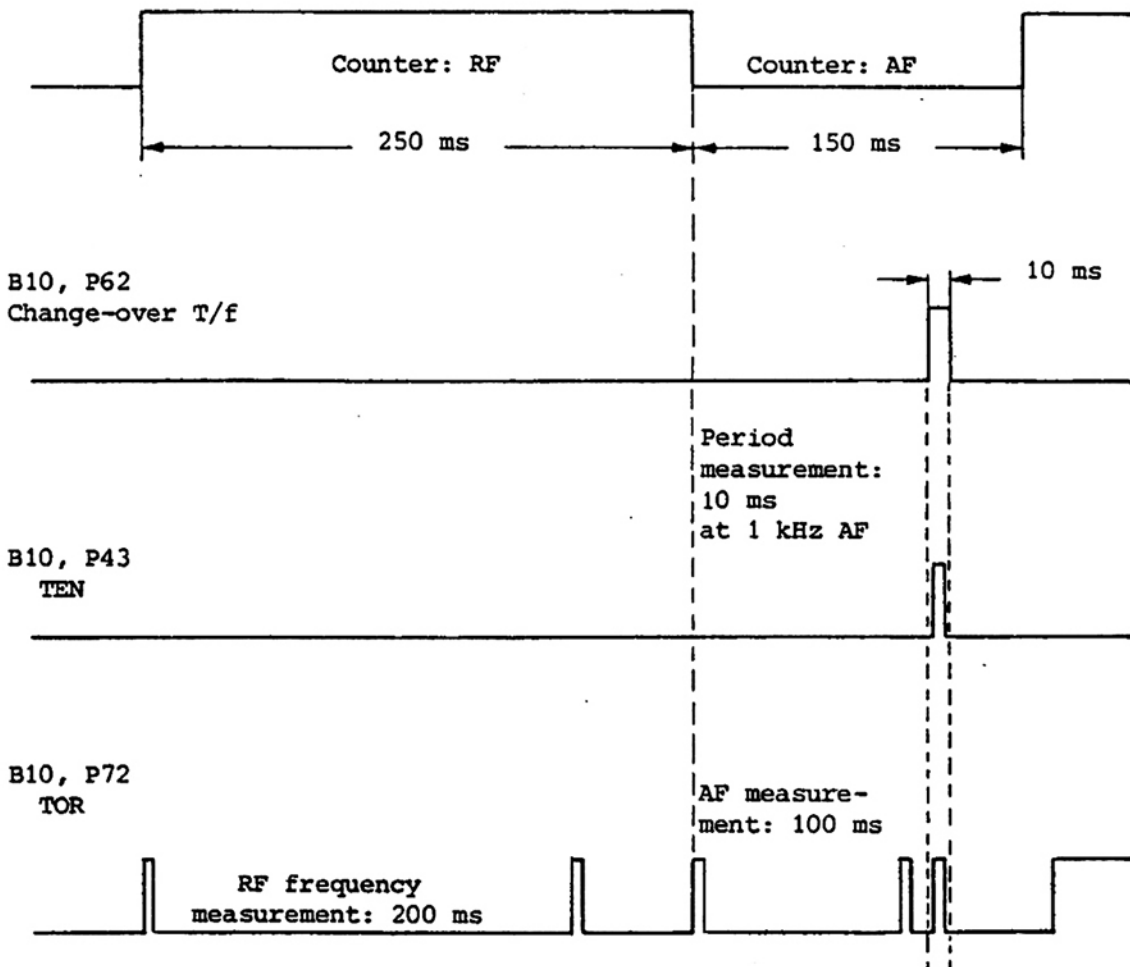
5.3.2.3.   Alignment and Check of the A/D Converter

Only the Microprocessor PCB should be plugged into the instrument, the other
PCBs must be removed.

Apply 5.000 V DC to pin ST6/pin 21 of motherboard (pin 32 is ground).
Connect a continuously variable DC power supply 0 to 6 V and a DC voltmeter
(accuracy better than 0.1%) to ST7/26b (pin 25b is ground). At the same
time, interconnect the chassis of the two DC voltage sources.

a) Voltage V at ST7/26b: V = 1.6 mV.
    - switch on FAM mode AM
    - manually enter 1 MHz
    - depress VOLT key
    - select P+ detector

    Adjust the display between 0.000 mV and 0.001 mV with R38 (display
    flickers).

b) Increase V to +6 V and decrease to 4.884 V after about 5 seconds.
    The display should show 5240 mV $\pm$ 10 mV.

5.3.2.4.   Voltmeter Input Amplifier

Plug K24 into ST24 (motherboard)
Plug K22 into ST22 (keyboard/display unit)

Connect audio generator ($R_i \leq 600\ \Omega$) to voltmeter input and apply 1 V at 1 kHz.
Turn R72 (keyboard/display) to mid-position.

Check gain and frequency response at ST24 with voltmeter:

Frequency kHz	1 Ref. value	20	60	100	200
V_{AF} V	1.000 $\pm$0.002	$\pm$0.002	$\pm$0.003	$\pm$0.003	$\pm$0.005

Adjusting the common-mode suppression of the voltmeter

Apply simultaneously a signal of 3 V, 50 Hz to the inner and outer conductors
of the voltmeter input socket. To this end, interconnect the inner and outer
conductors; chassis reference: K24 outer conductor. Check the voltage at ST24
with the voltmeter and adjust for minimum with R72.

Rated voltage: $\leq$ 300 μV

5.3.3.   Audio Filter/Detector

5.3.3.1.   Voltmeter Calibration, P+ and RMS

Setting: VOLT, 10 Hz to 200 kHz, P+

With special function S6, set AF level divider to maximum attenuation.
Key in: "1 2 S 6"

Voltage: apply 3.6204 V, 1 kHz to audio input.
Adjust level at MP1 to 2.560 V (error less than 0.1%) with R20.
Adjust to an indication of 5120 mV with R75.
Check level at MP15 with oscilloscope.

RMS adjustment

Adjust R80 to give an indication of 3620 mV

P+ adjustment
- Apply 362.04 mV, 1 kHz to audio jack.
- Adjust R97 to give an indication of 512 mV.
- Apply 3.6204 V 1 kHz to audio jack and check that indication is 5120 mV
  (if necessary, readjust with R75).
- Check symmetry at change-over between P+ and P-.

RMS adjustment

- Apply 362.04 mV to audio jack.
  Adjust to an indication of 362 mV with R83.
- Apply 3.6204 V to audio jack.
  Adjust to 3620 mV with R80.

Switch out special function S6 with "SØ".

5.3.3.2.   Check Audio Voltage Attenuator

Setting: P+, VOLT, HP 30 Hz, LP 20 kHz

- short circuit voltmeter input
- set DC voltage at MP2 to 0 V $\pm$1 mV with R100

Connect AF generator set to 1 kHz to voltmeter input and check the FAM
indications with the following generator levels:

Note: This check is performed at the upper hysteresis point. Increase voltage in steps, starting at 0 V.

V_{AF} [mV]	Indication		
	Nominal [mV]	Minimum [mV]	Maximum [mV]
3.535	5.00	4.8	5.17
7.071	10.00	9.75	10.25
14.140	20.00	19.6	20.4
28.28	40.00	39.3	40.7
56.57	80.00	78.7	81.3
113.14	160.00	157.5	162.5
226.27	320.00	315.1	324.9
452.55	640.00	631.0	649.0
905.10	1280.00	1260.7	1299.3
1810.20	2560.00	2521.5	2598.5
3620.40	5120.00	5044.0	5196.0

5.3.3.3. Frequency Response, Peak Responding Rectifier P+ Selected

5.3.3.3.1. Maximum Level

Apply 3400 mV

Frequency [kHz]	0.03	0.1	1	10	60	100	200
Indication 4808 mV	±1.5%	±1.5%	±1.5%	±1.5%	±1.5%	±3%	±8%

5.3.3.3.2. Minimum Level

Inhibit FAM setting according to 5.3.3.3.1. with "S3"

Apply 1390 mV

Frequency [kHz]	0.03	0.1	1	10	60	100	200
Indication 1966 mV	±1.5%	±1.5%	±1.5%	±1.5%	±1,5%	±3%	±8%

5.3.3.3.3. Measurement of Frequency Response of Attenuator and Peak Detector P+

Frequency [kHz]		Indication mV				
		1	10	60	100	200
Level at volt-meter input mV	14.14 28.28 131.14 452.55	20 40 185.45 640.0 } +1.5%	+1.5%	+1.5%	+3%	+8%

5.3.3.3.4. Frequency Response of RMS Detector

Level at voltmeter input 3840 mV (min. detector level)

Frequency [kHz]	0.03	1.0	10	60	100	200
Deviation from reference value 3840 mV	+1.5%	+1.5%	+1.5%	+1,5%	+3%	+8%

Level at voltmeter input 1454 mV (max. detector level)

Frequency [kHz]	1.0	10	60	100	200
Deviation from reference value 1454 mV	+1.5%	+1.5%	+1.5%	+3%	+8%

5.3.3.4.   Check P+ Change-Over

Use a two-channel oscilloscope in chopped mode:

Connect channel 1 to MP11 (audio filter / detector)
connect channel 2 to AF output

With 3620 mV, 1 kHz at voltmeter input check that:

   P+:   channels 1 and 2 are in phase
   P-:   channels 1 and 2 are 180° out of phase
   P+:   apply measured value as reference
   P-:   maximum deviation 0.2%

The key P± will call the mean value of P+ and P-.
Error < 0.2%.

5.3.3.5.   Check Audio Filters

Apply 3620.4 mV 1 kHz to audio input, press P+.
Use 5120 mV as reference, press % or dB key.

5.3.3.5.1.   High-Pass Filters

10-Hz high-pass filter

Frequency [Hz]	10	15	30	60	200
Upper limit	-0.8 dB	+1.5%	+0.4%	+0.4%	+0.4%
Nominal value	-1 dB	-1.5%	0	0	0
Lower limit	-1,2 dB	-3%	-0.4%	-0.4%	-0.4%

press dB key ←⟶ press % key

30-Hz high-pass filter

Frequency [Hz]	10	20	31.5	60	90	500
Upper limit	-13.5 dB	2 dB	0	+1.5%	+1%	+0.4%
Nominal value	-14 dB	-3 dB	-2.5%	0	0	0
Lower limit	-14.5 dB	-4 dB	-5.9%	-0.4%	-0.4%	-0.4%

press dB key ←⟶ press % key

300-Hz high-pass filter

Frequency [Hz]	100	300	500	1000	5000
Upper limit	-13 dB	0	0	+0.4%	+0.4%
Nominal value	-14 dB	-0.5 dB	-1%	0	0
Lower limit	-15 dB	-1 dB	-2%	-0.4%	+0.4%

press dB key ←⟶ press % key

5.3.3.5.2. Low-Pass Filters

3-kHz low-pass filter

Frequency [kHz]	1	1.5	3	4	6
Upper limit	+0.4%	0%	-1 dB	-4 dB	-14 dB
Nominal value	0	-0.4%	-1.5 dB	-5 dB	-16 dB
Lower limit	-0.4%	-0.8%	-2 dB	-6 dB	-18 dB

press % key ←——→ press dB key

20-kHz-low-pass filter

Frequency [kHz]	1	8	12	16	22.4	50
Upper limit	+0.4%	+0.4%	+1%	+5%	-2.5 dB	-27 dB
Nominal value	0	0	0	0	-3.5 dB	-30 dB
Lower limit	-0.4%	-0.4%	-1%	-5%	-4.5 dB	-34 dB

press % key ←——→ press dB key

Remark:

Measuring attenuations > 20 dB:

Adjust frequency for a REF-indication of -20.0 dB.

- Inhibit FAM with "S3".

Connect an audio noise meter to the AF output (position RMS, 15 Hz to 100 kHz).
The readings of this instrument are then referenced to -20.0 dB.
At higher attenuations the filter response is then calculated as
(reading - reference) [dB] +20 dB.

5.3.3.6. Check AF Output and Audio Signal Counter Input

Apply 3620 mV, 1 kHz to audio voltmeter

- voltage at AF output: 1000 mV ± 50 mV
- voltage at ST7/19a: 2000 mV ± 5%

5.3.3.7 Overview of Analog-Digital Level-Matching Circuits

Audio filter/detector (334.4418)

Audio filter/ detector MP1		MP10	Input A/D MP15 Volts DC	Indication P+
FM:	V_{eff} = 2.621 V	0.6554 V	5 V	534.0 kHz
	V_{eff} = 2.5 V	0.625 V	4.68 V	500 kHz
φM:	2.621 V	0.65546 V	5 V	534.0 RAD
AM: Mean value carrier (Volts DC)	2 V	-	5 V	100%
AF:	2.5 V	0.625 V	4.77 V	
	(2.621 V	0.6554 V	5 V	104.9%)
Volt: 3.776 V	2.6214 V	0.65536 V	5 V P+:	5340 mV

5.3.4. 120-MHz Level Control / Counter

The PC board must be plugged into the adapter, the shielding must be removed.

The Audio filter/rectifier and Demodulator PCBs must be plugged in.

The IF output must be terminated with a 50 Ω resistor.

5.3.4.1. Check RF Output < 3.5 MHz (ST28)

From RF generator (R_o = 50 Ω), apply 3-MHz, 100 mV signal to RF input $\underline{22}$
- Press AM key.

Measure voltages at ST20 and ST28 with a RF millivoltmeter (with probe).
The voltage difference should be within 0.5 dB.

5.3.4.2. Adjustment of Level Measuring Point

Apply 5 MHz to RF input. (Harmonic distortion > 40 dB down).

a) Input voltage 0 V. Adjust DC voltage at pin 13b to 0 mV with R139

b) Input voltage 3.00 V (measured with RF probe at ST20).
   Adjust the DC voltage at pin 13b to 1.00 V±5 mV with R186.

5.3.4.3. Check Level Regulation

Connect RF generator 3.5 MHz to 120 MHz (R_o = 50 Ω), without modulation,
to the RF input. (Harmonic distortion > 40 dB down).
- Press FM key.

Measure the voltage at ST30 with a high impedance RF probe.

At 60 MHz, the input voltage is increased from 10 mV up to the point
where the first 2-dB attenuator switches.

The measured voltage should be 125 mV± 15%.

The input voltage is then increased in 0.5-dB steps up to 3 V and then
reduced again to 20 mV.

The maximum voltage difference at ST30 in the frequency range 3.5 MHz to 120 MHz
must be ⩽ 7 dB.

5.3.4.4. Adjustment of Limiter Circuit

Terminate RF input with a 50 Ω resistor.
With R92, adjust DC voltage at MP18 to 2 V ± 10 mV.

5.3.4.5. Check RF and Audio TTL Circuits

a) With RF generator apply 3.5 MHz to 120 MHz, 90 mV unmodulated
   to RF input.
   Check TTL-level from 1.75 MHz to 60 MHz at MP7 with an oscilloscope.

b) With RF generator apply 55 kHz to 3.5 MHz, 90 mV unmodulated
   to RF input.
   - press AM key
   Check TTL-level 55 kHz to 3.5 MHz at MP16.

c) With audio generator apply 10 Hz to 200 kHz, 1 V, to voltmeter
   input jack.
   - press VOLT key
   - press filter selector keys HP 10 Hz, LP 200 kHz
   Check TTL-level from 10 Hz to 200 kHz at MP17.

5.3.4.6. Check Frequency Counter and Display

For the input signals described in 5.3.4.5., check displayed frequency.
The maximum allowable difference between the display and the actual
frequency is ± 1 digit.

5.3.5.   120-MHz Mixer

Test conditions:

The Microprocessor, Keyboard / display unit, Audio filter / rectifier,
and Level control / counter PCBs must have been tested and be operational.
The associated cables, except K30 and K31, must be connected.

If the demodulator is out of service, apply 5.0 V DC to BU6/21 of motherboard.
- Set to AM mode.

5.3.5.1.   Insert following Frequencies via the Keyboard
            and MAN Key and Check Pin Levels

f_{in} [MHz]	TTL logic levels B19 Pin																B18 Pin				
	16	15	14	13	17	18	19	20	21	22	23	1	2	3	4	5	3	9	12	15	1
102.85	L	H	H	H	H	H	H	H	H	H	H	H	L	L	H	L	H	H	L	L	H
102.90	H	L	L	L	L	L	L	L	L	L	L	L	L	L	H	L	H	H	H	L	H

$f_{LO} = f_{in} - 500$ kHz

5.3.5.2.   Check Local Oscillator

- Enter the frequency f_{in} via the keyboard:

f_{in} [MHz]	LO frequency (MP4) PLL-loop synchronized	V [V]		V_{MP10} [V] +5%	V_{B13} [V] ± 1.5 V Pin			Tuning voltage [V] at MP11
		MP1	MP2		14	12	5	
74.5	74.0000	+7.5	1.25	9.6	-2	-2	+22	align to 18.5 V with L1/2
70.5	70.0000	+7.5	1.25	9.6	-2	+22	+22	+12.5
65.5	65.0000	+7.5	1.25	6.8	+22	-2	+22	+7.5
60.55	60.0500	+7.5	1.25	4.1	-	-	-	+2.5 to +4.5
74.75	74.2500	+7.5	1.25	4.1	-	-	-	+3.0 to +4.5
90.5	90.0000	+7.5	1.25	9.6	-2	-2	+22	+15 to +18
104.9	104.400	< +1	+7.5	-	-2	-2	-2	align to 19.0 V with L11/L12
90.65	90.150	+1	+7.5	-	-	-	-	+2.5 to +4.5
104.95	104.450	+1	+7.5	-	-	-	-	+2.5 to +4.5
120.25	120.0000	+1	+7.5	-	-	-	-	+13 to +17.5

5.3.5.3. Check LO Frequency and Voltage for the Mixer

Remove B27 and insert jumper between B27.1 and B27.8.

Connect RF voltmeter with insert probe and RF frequency counter (50 Ω) to K30.

Frequency entered via keyboard [MHz]	LO frequency at K30 [MHz]	Level at K30 [dBm]
120.00	119,5	+4 dBm 3 dBm -2 dBm
60.55	60.05	-"-
60.50	60.00	-"-
30.50	30.00	-"-
15.50	15.00	-"-
8.00	7.50	-"-
4.50	4.00	-"-

5.3.5.4. Check Mixer Frequency Response

- Reinsert B27
- Enter 10 MHz manually, generator 10-MHz to RF input.
- Connect insertion head of RF voltmeter between ST30 and K30.
- Connect RF voltmeter ($R_{in} \geqslant 1$ kΩ) and frequency counter ($R_0 \geqslant 1$ kΩ) to K31.
- Inhibit FAM with about 60 mV at RF input.

RF input frequency [MHz]	Keep level at ST30 constant to ±2 mV by varying input level	Level at K31 [mV]	Frequency at K31 [mV]
9.75	120	460 ± 30	250
10.0	120	460 ± 30	500
10.5	120	460 ± 30	1000
11.0	120	460 ± 60	1.5
12.5	120	ca. 150	3.0

5.3.6.   Demodulator

The Microprocessor, Keyboard/display unit, Level control/counter, 120-MHz Mixer, and Audio filter/rectifier PCBs must be aligned and operational.

5.3.6.1.   Check of 5.000-V Reference Voltage

Connect a digital voltmeter (error < 2.5 mV) between Microprocessor PCB pin 22a and ground and align with R110.

5.3.6.2.   Check Level and Frequency Response up to MP2

Apply a 100-mV 10.0-MHz signal to RF input.
Set instrument to FM and LP 200 kHz and inhibit in position "S3".
At an RF frequency of 9.6 MHz adjust to 600 mV at ST31 (increase input level).

RF input frequency [MHz]	Frequency ST31 [kHz]	Level B5/15 [mV]	Level ST1 [mV]
9.60	100 (600 mV)	400 +50 ref. value	200 +20 ref. value
9.75	250	Deviation 0 dB +0.2 dB −0.5 dB	Deviation 0 dB +0.2 dB −0.5 dB
10.00	500	−0.5 dB +0.5 dB	0 dB +0.5 dB
10.5	1000	−2.7 dB +0.8 dB	0 dB + 1 dB
11.5	2000	−14.5 dB + 2 dB	−24 dB + 4 dB

5.3.6.3.   Check and Adjust Limiter and TTL-Circuits

Apply 100 mV, 10.0 MHz to RF input.
FAM setting: FM, inhibit unit with S3.
Check level at MP5 with oscilloscope: 500 kHz TTL signal.

Reduce RF-input level to 0.5 mV.
Adjust R16 so that TTL signal is just present at MP5.
Switch RF level off: there should be no signal present at MP5.

5.3.6.4.   Check and Adjust FM Demodulator

Set FAM to AUTO.

5.3.6.4.1. 500-kHz IF

Apply a 10.000-MHz, 100 mV signal, frequency deviation 64.0 kHz, $f_{mod} = 11.594$ kHz ($n = 5.526$) from FM signal generator to the RF input of FAM. Check measuring signal with analyzer and adjust deviation for a carrier suppression > 60 dB. Set FAM to LP 200 kHz and, with the aid of R70, adjust:
(Check for upper hysteresis point at output RF: level = 954 mV $\pm$ 20 mV)

Measuring signal 10.000 MHz	Voltage at MP11	Stereo output voltage	FM-deviation indication
$\Delta f = 64$ kHz	0.64 V	2.48 $\pm$ 60 mV	64.00 kHz

5.3.6.4.2. Adjustment of DC Voltage at MP10

Check with a 10.000-MHz 100-mV unmodulated signal.
Set FAM to FM, LP 200 kHz
Switch off test signal, check DC voltage at MP10
(Nominal value: 0 $\pm$ 1 V) $\triangleq$ measuring value 1.

Switch on test signal, adjust to measuring value 1 with R96.
There is then no DC level jump when the carrier is added.

5.3.6.4.3. Check FM Demodulator 6.4 kHz Deviation

Apply 10.000 MHz, $\Delta f = 6.4$ kHz, $f_{mod} = 1.1594$ kHz from FM signal generator to RF input of FAM. Check measuring signal with analyzer and adjust frequency deviation to give a carrier suppression of more than 60 dB.

FAM: FM, LP 20 kHz

Measuring signal 10.000 MHz	Voltage at MP11	Stereo output voltage	FM-deviation indication
$\Delta f = 6.4$ kHz	128 mV	248 mV $\pm$ 10 mV	6.400 kHz $\pm$ 50 Hz

5.3.6.4.4. Check Modulation Frequency Response

Settings as in 5.3.6.4.1., enter measuring value of 64.0 kHz as reference
(REF key), set HP 10 Hz, LP 200 kHz.

f_{mod}	10 Hz	30 Hz	1 kHz	11.666 kHz	20 kHz	60 kHz	100 kHz	200 kHz
	deviation from measuring value			ref. value in each case	deviation from measuring value			
V_{MP11}	± 0	± 0.05 dB	± 0.05 dB	640 mV	± 0.05 dB	± 0.05 dB	± 0.1 dB	$^{+0}_{-3}$ dB
V_{MP23}	-1 dB	± 0.05 dB	± 0.05 dB	2.48 V	± 0.05 dB	± 0.05 dB	± 0.1 dB	$^{+0}_{-3}$ dB
indi-cation				64.00 kHz			$\pm 1.5\%$	$^{+0}_{-3}$ dB
	-1 dB	$\pm 1\%$	$\pm 1\%$	$\pm 1\%$	$\pm 1\%$	$\pm 1\%$	$\pm 2\%$	

With unmodulated carrier, the residual IF (and harmonics) at MP11 and stereo
output is < 4 mV.

$\Delta f = 6.4$ kHz: Settings as in 5.3.6.4.3.,

enter measuring value of 6.40 kHz as reference.

f_{mod}	1.166 kHz	5 kHz	16 kHz	20 kHz	100 kHz
	ref. value:				
V_{MP11}	128 mV	± 0.05 dB	± 0.1 dB	± 0.3 dB	
V_{MP23}	348 mV	± 0.05 dB	± 0.1 dB	± 0.3 dB	
indi-cation	6.400 kHz	$\pm 0.5\%$	$^{0}_{-5}\%$	$^{+10}_{-25}\%$	

With unmodulated carrier, the residual IF 500-kHz (and harmonics) at MP11 < 1 mV.

5.3.6.4.5. Check FM Demodulator IF 1 MHz

FM signal generator, 100.00 MHz, $\Delta f = 500$ kHz possible, 100 mV,
frequency deviation 64 kHz, $f_{mod} = 11.594$ kHz, external modulation
(calibration as in 5.3.6.4.1.).

Increase modulation voltage by four times (error below 0.1%) and check:

B12/Pin 8	MP5	MP6	MP11	Stereo output	Deviation indication
LOW	TTL signal	HIGH	1.280 V $\pm$ 25 mV	2.450 V $\pm$ 50 mV	256.0 kHz $\pm 3\%$

5.3.6.4.6.   Check Deemphasis and Phase Modulation

Settings as in 5.3.6.4.1. Set FAM to HP 10 Hz, LP 200 kHz,
enter frequency deviation as reference value and check at different
deemphasis settings:

Deemphasis:

f_{mod}	750 µs	75 µs	50 µs
30 Hz	-0.1 dB ±0.1 dB	0 dB ± 0.1 dB	0 dB ± 0.1 dB
210 Hz	-3 dB ±0.3 dB	—	-
2.1 kHz	-	-3 dB ± 0.3 dB	-
3.1 kHz	-	-	-3 dB ± 0.3 dB

Phase modulation:

Nominal filter response: 6 dB/oct from 300 Hz to 20 kHz
at 1 kHz: Deviation from FM: 0 dB ± 0.1 dB
                           Use measuring value as reference

f_{mod}	120 Hz	300 Hz	1 kHz	10 kHz
	0 dB ± 2 dB	+10.46 dB ± 0.3 dB	0 dB	-20 dB ± 0.3 dB

5.3.6.5.   Check and Adjustment of AM Demodulator

5.3.6.5.1.   Calibration of AM Demodulator ($f_{in} > 3.5$ MHz)

Connect signal generator to FAM, level 95 mV.

Set FAM to AM. Enter 120 MHz frequency manually. Connect DC voltmeter to demodulator, MP17, and an oscilloscope and audio voltmeter to MP18.
Set signal generator to 100% AM (check overdrive with oscilloscope)
and f_{mod} = 1 kHz. Adjust to minimum clipping of signal at MP18 using R158.

Set level at MP17 and MP18 to minimum by turning R178 to its stop.
Adjust indication to 100% with R182.
Set signal generator to unmodulated mode (level 95 mV):
nominal level at ST31: 530 mV ±10%.
Set voltage at MP17 to 1.8 V with R178.

(At different input levels and frequencies, the voltage at MP17 must not exceed 1.9 V).

Inhibit FAM using "S3"; set signal generator to maximum attenuation (level ≏ -100 dBm).
Adjust DC voltage at MP17 to 0 V ±1 mV using R210.
Set FAM to automatic mode using "S0".

Set signal generator to 40% AM (error ≤ 0.2%), f_{mod} = 1 kHz, and make fine adjustment of frequency deviation indication to 40 kHz with R182.

Nominal voltage at MP17 (for 1 V at MP18):   244.1 mV

(Note: The level regulation for input frequencies ≥ 3.5 MHz stabilizes
to the peak voltage of the input signal. At 100% AM, the maximum
level at ST31 and also at MP17 and MP18 is therefore 6 dB below
the maximum level for an unmodulated signal).

5.3.6.5.2.   Check AM Demodulator ($f_{in} < 3.5$ MHz)

Apply a signal of 1 MHz, 3 V to the RF input.
Inhibit FAM using "S3", voltage at MP17:   2.8 V ±0.2 V.
The DC voltage at MP17 must not exceed the above tolerance range of
1.8 V ±0.2 V over the frequency range 55 kHz to 3.5 MHz.

5.3.6.5.3.   Check AM Modulation Frequency Response   (IF 500 kHz)

Set to LP 200 kHz, set signal generator as before, enter 40% AM as reference value.

f_{mod}	30 Hz	1 kHz	20 kHz	60 kHz	100 kHz	200 kHz
V_{MP18}	±0.15 dB	244.1 mV	±0.1 dB	±0.15 dB	±0.2 dB	$^{+0}_{-3}$ dB
indication	±1.5%	40% ref. value	±1%	±1.5%	±3%	$^{+0}_{-3}$ dB

5.3.6.5.4.   Check IF Suppression ($f_{in} > 3.5$ MHz)

Apply 120 MHz, 100 mV, unmodulated, to RF input.

Connect audio voltmeter to output FAM-AM:

residual IF and noise voltage: $\leqslant 1$ mV.

5.3.7.   1.36-GHz Oscillator

5.3.7.1.   Adjust Oscillators

Oscillator I: frequency 290 to 320 MHz
Oscillator II: frequency 420 to 480 MHz

- **Connect RF analyzer and frequency counter to K27**
- Open BR1, apply 10 V
- Enter 300 MHz via keyboard
- Check voltage at MP3: 14.5 ± 0.5 V
- Adjust DC voltage at MP2 to **-9 V using R31**
- Perform frequency measurement of L12 at K27
- Adjust to 320 MHz ± 1 MHz (with cover closed) by adjusting
  the distance between windings of coil L12

- Enter 420 MHz via keyboard
- Check voltage at MP4: 14.5 V ± 0.5 V
- Adjust DC voltage at MP1 to -7.5 V **using R2**
- Adjust to 480 MHz ± 1 MHz (with cover closed) by adjusting
  the distance between windings of coil L3

- Reduce tuning voltage at oscillator I to adjust frequency to 290 MHz,
  nominal voltage for this frequency is 4 V± 0.5 V
  Nominal tuning voltage for oscillator-II frequency of 420 MHz
  is 4 V ± 0.5 V. In both cases with cover closed.

Adjust oscillator voltage:

- By bending L15 adjust level of oscillator-I output to -13.5 dBm ± 0.5 dBm
  at K27 in the frequency range 290 to 320 MHz.

- By bending L5 adjust level of oscillator-II output to -13.5 dBm ± 0.5 dBm
  at K27 in the frequency range 420 to 480 MHz.
  (Cover must be closed for these level adjustments.)
- **The harmonic suppression of the oscillators should be >25 dB;
  readjust the oscillator operating point, if required, using R 31
  and R2.**

5.3.7.2.   Check of Frequency Synchronization and Mode Suppression

Close BR1.

Connect frequency counter to K27.

Supply a TTL reference signal of 10 MHz to K25.

A very high spectral purity is required!

Enter the following frequencies manually and check at K27:

Entered frequency [MHz]	LO frequency [MHz]	LO level [dBm]
1000	480	
850	460	
950	440	
800	420	-13.5 ± 2 dBm
1320	320	
1200	310	
1160	300	
1100	290	
260	240	
200	210	$-13.5 \, {}^{+1.0}_{-2}$ dBm
180	160	
125	145	

Check harmonic suppression:

Harmonics more than 20 dB at LO frequencies 290 to 480 MHz.
Typical value: 20 dB from 145 to 240 MHz LO frequency.

Check spurious response:

Check level of subharmonics and the possible combinations (f/2, 3f/2...)
at LO frequencies 420, 440, 460, 480 MHz.
Levels must be > 60 dB down.

Check for spurious modulation side bands at LO frequencies 420, 480,
290, 320, 145, 240 MHz.
Levels must be > 80 dB down.

5.3.8.   Mixer / Frequency Doubler 1.36-GHz

Plug the printed circuit board into the adapter and remove the shielding cover.
Besides the fully equipped basic instrument, a second optional board,
1.36-GHz Oscillator PCB, must be plugged in.

5.3.8.1.   Adjusting the Frequency Doubler

Open the printed conductor between MP3 and input L of mixer B20.
Connect a spectrum analyzer (up to 1.5 GHz) to MP3.
Good grounding is imperative.

The level and the spurious response of the LO is to be measured and
adjusted if required in the following frequency ranges:

Range I: Check LO level:

Manual entry of frequency	LO frequency	LO level at MP3
130 MHz	145 MHz	
260 MHz	240 MHz	
340 MHz	320 MHz	+7 dBm (±2 dB)
380 MHz	420 MHz	
440 MHz	480 MHz	

Range II: Check LO level and adjust for a maximum suppression
of spurious response, using R107, at the following frequencies:

Manual entry of frequency	LO frequency	LO level
560 MHz	580 MHz	
640 MHz	600 MHz	+7 dBm (+3 dB...−2 dB)
580 MHz	620 MHz	
680 MHz	640 MHz	

Typical values of spurious responses, referred to LO level, in the LO range 580 to 640 MHz:

Frequency of spurious response	$\dfrac{LO}{2}$	$\dfrac{3}{2} \cdot LO$	$2 \cdot LO$
Suppression of spurious response (adjust with R 107)	> 50 dB	> 25 dB	> 20 dB

Manual entry of frequency	LO frequency	LO level
800 MHz	840 MHz	
950 MHz	880 MHz	
970 MHz	920 MHz	+7 dBm (+4 dB...-1 dB)
1000 MHz	960 MHz	

Typical values of spurious-response suppression in the LO frequency range 840 MHz to 960 MHz:

Frequency of spurious response	$\dfrac{LO}{2}$	$\dfrac{3}{2} \cdot LO$	$2 \cdot LO$
Suppression of spurious response (adjust with R107)	> 20 dB	> 25 dB	> 20 dB

Range III: Check of LO level

Manual entry of frequency	LO frequency	LO level
1120 MHz	1160 MHz	
1170 MHz	1200 MHz	
1200 MHz	1240 MHz	+7 dBm (+4 dB...-3 dB)
1320 MHz	1280 MHz	

Using R127, adjust to a maximum suppression of spurious responses (referred to LO level).

Typical values:

Frequency of spurious response	$\dfrac{1}{4} \cdot LO$	$\dfrac{1}{2} \cdot LO$	$\dfrac{3}{4} \cdot LO$	$\dfrac{5}{4} \cdot LO$
Suppression of spurious response	> 30 dB	> 20 dB	> 30 dB	> 30 dB

Close the opened printed conductor.

5.3.8.2.   Check the Direct Circuit 55 kHz to 120 MHz

- Press key "SO"

  with signal generator apply 55 kHz to 3.5 MHz, 70 mV, unmodulated, to RF input jack.

a) In the range 55 kHz to 3.5 MHz this input voltage must be measurable at ST29.

b) In the frequency range 3.5 MHz to 120 MHz the voltage at ST20 should be measured.

  Maximum difference: 1 dB to 5 dB.

c) Check the rectified voltage V_r at an input voltage of 100 mV:

  V_r = 70 mV to 130 mV.

5.3.8.3   Adjustment of Level Measuring Point

Logic H level must be present at pin 3.

a) With 0 V input voltage adjust the DC voltage at pin 13 to 0 mV using R19.

b) Adjusting for maximum output voltage:

  Apply a signal of approx. 500 MHz, unmodulated, 1 V to the RF input socket.

  Adjust the DC voltage at pin 13 to 1.9 V using R11.

c) Check the rectified voltage V_r at 100 mV input voltage:

  V_r = 70 mV to 130 mV.

5.3.8.4. Check Attenuator Circuit

Apply 125 MHz, unmodulated to RF input jack. With RF probe check voltage V_A at MP2 in comparison with the input voltage V_{in}.

$$
\left.
\begin{array}{ll}
V_{in} = 60 \text{ mV} & V_A = \\
V_{in} + 10 \text{ dB} & V_A = \\
V_{in} + 20 \text{ dB} & V_A = \\
V_{in} + 30 \text{ dB} & V_A =
\end{array}
\right\} \; 30 \text{ mV } (\pm 1.5 \text{ dB})
$$

5.3.8.5. Check IF Circuit

Open BR1.

Apply 5 to 120 MHz, $V_{in} = 30$ mV, unmodulated, to the right-hand pin of BR1.
Measure voltage V_A at ST20, using 50 Ω insertion probe.

Manual entry of frequency	f_{in}	V_A
260 MHz	5... 35 MHz	$V_E + 12$ dB (± 1.5 dB)
400 MHz	5...120 MHz	

Close BR1 again.

5.3.8.6. Check Mixer

Apply 70 mV, unmodulated, to RF input jack (for f_E).
Measurement of IF levels at ST20, using 50-Ω terminating probe.

Manual entry of frequency	f_{in}	IF	IF level referred to input level
260 MHz	250...275 MHz	10...35 MHz	0...-4 dB
640 MHz	610...650 MHz	10...50 MHz	-1...-4 dB
800 MHz	760...830 MHz	80...10 MHz	-2...-6 dB
1300 MHz	1290...1360 MHz	10...80 MHz	-4...-8 dB

5.3.8.7 Adjustment of 100-MHz Trap at B20 using a Sweep Tester

- Connect sweep generator (50 to 150 MHz, 50 mV) to ST21.
- Set FAM manually to 740 MHz (K27 of 1.36-GHz Oscillator must be connected).
- Connect detector (50 Ω) to K21.
- Adjust to minimum level at 100.0 MHz with C18.
  Rated attenuation > 14 dB compared to that at 50 MHz.

5.3.9. Option "10-MHz Reference Oscillator"

- Connect a high-impedance DC voltmeter to test point MP1.
- Tune to minimum DC voltage, using TR1. This also tunes the resonant circuit.

Adjust the temperature inversion point of the crystal:

- Connect a frequency counter with a resolution better 10 Hz to REF.-FREQ. jack 10 MHz <u>29</u> (Fig. 2-6)
- Connect an ammeter into the +15 V line. When cold, the oven draws about 280 mA. The current becomes constant after 5 to 10 minutes.
- Vary the resistor R52 between 100 Ω and 500 Ω in steps of the E24 series; wait 5 minutes after each resistor change and read the frequency.
- Solder the resistor achieving the lowest frequency into the circuit.

5.3.10. CCITT Filter

All printed circuit boards of the basic instrument must be installed.
Plug the Audio filter PCB into the adapter.
Connect an audio generator 800 Hz ± 1 Hz to voltmeter jack, <u>19</u>.

- Press VOLT key
- Press P+ key
- Press filter keys HP 30 Hz and LP 20 kHz.

Adjust voltage at generator to give an audio voltmeter reading of 3000 mV.

- Press filter key CCITT.

Adjust indication to 3000 mV, using R47.

- Entry via keyboard: 3000
- Press REF key
- Press dB key

Adjust frequency of audio generator according to the following table
(frequency accurate to within 0.1%) and check the filter response.
The accuracy of the audio-generator signal level should be better than 0.1%.

<u>Remark</u>: The coils of the CCITT-filter are preadjusted, further adjustment is not provided for.

Measuring attenuation above 20 dB:

Adjust frequency for a REF-indication of -20.0 dB

- Inhibit FAM with "S3".

Connect an audio noise meter to the AF output (position RMS, 15 Hz to 100 kHz).
The readings of this instrument are then referenced to -20.0 dB.
At higher attenuations the filter response is then calculated as:
(reading - reference) [dB] + 20 dB.

Frequency response of the CCITT telephone filter

Frequency [Hz]	Attenuation [dB]	Allowable difference [dB]
50 100 150 200	-63.0 -41.0 -29.0 -21.0	± 2
300 400 500 600	-10.6 -6.3 -3.6 -2.0	± 1
800	0	0
1000 1200 1500 2000 2500 3000	+1.0 0 -1.3 -3.0 -4.2 -5.6	± 1
3500	-8.5	± 2
4000 5000	-15.0 -36.0	± 3
≥ 6000	< -43.0	--

5.3.11.   CCIR-Filter/Rectifier

All PC boards of the basic instrument must be installed.
The Audio-filter PCB must be plugged into the adapter.

5.3.11.1.   CCIR Filter

Apply 0.500 V, 6300 Hz ± 1 Hz from audio generator to audio voltmeter jack.

- Press VOLT key
- Press P+ key
- Press filter keys HP 10 Hz and LP 200 kHz

Enter the voltage displayed on the voltmeter via the keyboard.

- Press REF key
- Press dB key
- Press CCIR key.

Adjust indication to +12.2 dB with R36. Adjust frequency of audio generator (voltage: 0.5000 V) according to the table below and check filter response. Frequency accurate to 0.1%.

Remark: The coils of the CCIR filter are pre-adjusted. Further adjustment is not provided for.

Measuring attenuations > 20 dB:

Adjust frequency for a REF-indication of -20.0 dB.

- Inhibit FAM with "S3".

Connect an audio noise meter to the AF output (position RMS, 15 Hz to 100 kHz). The readings of this instrument are then referenced to -20.0 dB.

At higher attenuations the filter response is then calculated as (reading - reference) $[dB]$ + 20 dB.

Frequency response of the CCIR noise signal filter.

Frequency $[Hz]$	Attenuation $[dB]$	Allowable deviation $[dB]$
31.5	-29.9	±2.0
63	-23.9	±1.4
100	-19.8	±1.0
200	-13.8	±0.85
400	-7.8	±0.7
800	-1.9	±0.55
1000	0	±0.5
2000	+5.6	±0.5
3150	+9.0	±0.5
4000	+10.5	±0.5
5000	+11.7	±0.5
6300	+12.2	0
7100	+12.0	±0.2
8000	+11.4	±0.4
9000	+10.1	±0.6
10000	+8.1	±0.8
12500	0	±1.2
14000	-5.3	±1.4
16000	-11.7	±1.65
20000	-22.2	±2.0
31500	-42.7	$\begin{cases} ±2.8 \\ -\infty \end{cases}$

5.3.11.2.   Quasi-Peak Rectifier

- Press PEAK-CCIR key
- Press CCIR key

a) Adjustment of symmetry

Pre-adjustment: apply sinusoidal signal of 5000 Hz,
0.775 V (K < 0.3%) to audio voltmeter jack

- press VOLT key
- inhibit with "S3"

Remove BR2 and BR3,

Set R20 to maximum value, R22 to middle value,

Measure DC voltage at MP3 (high-impedance),
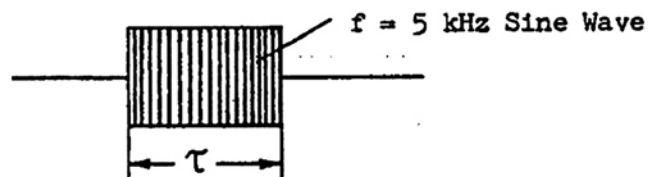
Close BR2,

Remove BR1,

Adjust to same voltage with R14,

Close BR1.

b) Single pulse indication

Pre-adjustment as in a).

Apply sinusoidal bursts of 5000 Hz, 0.775 V to the
audio voltmeter jack, according to picture below.

f = 5 kHz Sine Wave

Measure the transit response with an oscilloscope at MP3. Read the percentual
voltage reached after pulse duration τ (referred to a continuous signal),
for the values of τ in table.

The adjustment is made with R20; R22 should remain in a center position.

Pulse duration [*] in ms	1	2	5	10	20	50	100	200
Indication %	17.0	26.6	40	48	52	59	68	80
dB	-15.4	-11.5	-8.0	-6.4	-5.7	-4.6	-3.3	-1.9
Lower limit %	13.5	22.4	34	41	44	50	58	68
dB	-17.4	-13.0	-9.3	-7.7	-7.1	-6.0	-4.7	-3.3
Upper limit %	21.4	31.6	46	55	60	68	78	92
dB	-13.4	-10.0	-6.6	-5.2	-4.4	-3.3	-2.2	-0.7

[*]) The rise- and fall-time of the AC burst pulse should be shorter than 5 µs

c) Adjustment of RMS value

Apply sinusoidal signal of 5000 Hz, 0.5000 V to audio voltmeter jack.
Press AUTO key.
Check AC voltage at pin 10, high-impedance check of DC voltage at MP3,
adjust for equal reading with R22.

d) Calibration

Close BR3, turn R39 to centre of its range,
feed a sinusoidal signal of 1 kHz and 0.775 into FAM voltmeter input,
set FAM range to 940 mV (10S6),
adjust the display to 775 mV with R33.

e) Pulse sequence

Clear special function S6 (S∅),
Apply 5000 Hz, 0.5000 V to audio voltmeter jack.

- Press AUTO key.
- Inhibit with "S3".

Apply 5000 Hz, 0.5000 V in 5-ms bursts and repetition frequency of 10 Hz
to audio voltmeter jack.

The indication must be in the range -18% to -28%.

f) Polarity error

FAM setting: 30 Hz HP, 20 kHz LP, CCIR detector, S∅.
Apply a nonsymmetric squarewave pulse (pulse duration 1 ms,
pulse frequency 100 Hz) to the audio voltmeter jack.
Adjust amplitude to obtain a DC voltage of about 1.1 V at pin 5.
using an oscilloscope.

Enter the voltage indicated on the audio voltmeter via the keyboard.

- Press REF and dB keys.
- Inhibit instrument with "S3".

The change in the indication when the pulse polarity is changed from
positive to negative must not exceed ±0.5 dB.

g) Dynamic range (offset adjustment)

Measurement setup: connect sine-burst generator via the attenuator to
                    FAM voltmeter input.
FAM setting: VOLT, CCIR filter, CCIR detector, 10S6,
                    (set test range to 940 mV).

Set the level of the 5-kHz sinusoidal signal so that the FAM indicates 940 mV;
switch in a single sinusoidal burst of f = 5 kHz, pulse duration = 0.6 ms,
amplitude same as that of continuous sinusoidal signal. Take FAM display
value as reference value, switch to dB relative-value indication.

Switch in 20-dB attenuation with the attenuator and adjust the FAM display
to -20 dB with R39; repeat the calibration in section d).

5.3.12   DIST and SINAD Meter

- Set FAM to: VOLT, DIST, HP 10 Hz, LP 200 kHz
- Measurement setup: Connect the AF generator ($k \leq 0.02\%$) to the
                        voltmeter input (f = 1 kHz, 1 V)

5.3.12.1   Adjusting the Offset in the Amplifier Section

- Remove B1, B10
- Adjust DC voltage at MP 6 to 0 V $\pm$ 0.5 mV with R36
- Set R71 to centre position; adjust DC voltage at MP 8 to 0 V $\pm$ 0.1 mV
  with R58; nominal distortion factor indicated on the FAM: 0.00%
- Reinsert B1, B10

5.3.12.2   Adjusting the Amplitude and Phase Correction Circuit

- Adjust signal at MP 12 to $\leq$ 10 mV with R161
- Adjust signal at MP 17 to $\leq$ 10 mV with R246
- Clamp oscilloscope probe to MP 7 and adjust the fundamental
  of 1 kHz to minimum with R220 and R176.
  Nominal DC voltage at MP 8: $\leq$ 2 mV
  Nominal indication: $\leq$ 0.03%

5.3.12.3   Adjusting the Distortion Factor Meter

Measurement setup and FAM settings as under 3.2.11.2
- Set AF generator 1 to 1 V at 1 kHz
- Set AF generator 2 to 30 mV at 50 kHz
- Adjust a distortion factor of 3.00% on the meter with R71

5.3.12.4   Checking the Indication Accuracy

Measurement setup and check as described under 3.2.11.2.

5.3.13.   IEC Bus

Check the operation of the keyboard/display unit, as described in 5.3.2.2.

Connect FAM to a controller (for example, to R&S desk computer PPC), using an IEC connecting cable. Set to the correct address of the instrument.

Enter all control commands, one after the other, according to 2.4.2.1. and check for correct execution. Then check for the correct output of measurement data (FAM as TALKER), as described in 2.4.2.2.

5.4.   Later Installation of Options

5.4.1   Expansion of Frequency Range to 1.36 GHz

Free cables K20, K28, K30, K26 from subassembly level control/counter and remove the PCB. Pull off the nine sockets BU1 to BU42 from the upper side of the PCB, turn through 90° (as shown on upper cover of PCB) and push on again. Replace PCB and reconnect K30 and K26 as before.

Fit the two option PCBs

      1.36-GHz Oscillator   334.4930

      1.36-GHz Mixer/Doubler   334.5214

in accordance with the colour code on the extractor levers.

Connect the cables as follows:

K20 to ST21 of PCB "1.36-GHz Mixer/Doubler".
K28 from "Demodulator" to ST29 of "1.36-GHz Mixer/Doubler".
K27 from "1.36-GHz Oscillator" to ST27 of "1.36-GHz Mixer/Doubler".
K25 from "1.36-GHz Oscillator" to ST25 of PCB "Microprocessor".
K21 from "1.36-GHz Mixer/Doubler to ST20 of PCB "120-MHz Level control/Counter".

Exchange the frequency range sign "55 kHz - 120 MHz" for "55 kHz - 1360 MHz" as follows:

Remove the centre, upper fixing screw of the acrylic cover on the front panel.

Remove the adhesive from the cardboard sign with a sharp knife (razor blade) and slide it to the left until "55 kHz - 1360 MHz" appears. Retighten the fixing screw and glue the upper edge of the cardboard sign.

5.4.2   Reference Oscillator (Temperature-controlled)

Remove upper and lower cover plates. Remove cables K26, K32, K40
(K25 of option B2, if necessary) from under side of Microprocessor PCB and
remove ST11, ST12, ST15 and ST16 from upper side. Pull out the board and
remove shielding cover.

Remove jumpers BU2 and BU3. Plug Reference oscillator PCB onto free pins
(pin A, B, C, D, and 3 free pins). Secure board from the conductor side of
the Microprocessor PCB with three M2 screws. Be sure that the press-in nuts
of the option touch the printed circuit card.

Refasten the shielding cover and insert board in the instrument.
Connect ST11, ST12, ST15 and ST16. Screw in the subminax-cables K26, K32, K40
(K25 of option B2). Replace the cover plates of the instrument.

Remark: The option "Reference oscillator" is pre-aligned.

5.4.3   CCITT Filter

Remove upper cover plate. Pull out the Audio filter/rectifier PCB.
At the right side of the board (viewed from the front side) is printed
"FAM-B6 CCITT". Plug the option onto first of 5 upper and 5 lower pins,
so that this printing is fully covered. A reversed insertion is not possible
because of the position of these pins. Secure the option from the conductor
side of the Audio filter/rectifier PCB with 3 Phillips-head screws.
Reinsert the complete assembly on the motherboard.
Close the instrument.

5.4.4   CCIR Filter

Remove upper cover plate. Pull out Audio filter/rectifier PCB.
Note the printing "FAM-B7 CCIR" on the unoccupied right side of board
(viewed from the front). Plug the option onto the 5 upper and 5 lower pins
so that this printing is fully covered. A reversed insertion is impossible
because of the position of these pins. Secure this option from the conductor
side of the Audio filter/rectifier PCB, using 3 Phillips-head screws.
Connect the Audio filter/rectifier PCB via the FAM extender board to the
motherboard. Carry out the fine adjustments in section 5.3.11.2 g).
Replace the Audio filter/rectifier PCB on the motherboard.
Close the instrument.

5.4.5. Distortion Factor Meter

To install the Distortion Factor Meter option remove upper cover plate of instrument.

Pull out the Audio filter/detector PCB.

Plug in the Distortion Factor Meter. Install cables K81 and K82 with BU72 at ST72 (pin 1 to pin 1) coming from the Audio filter/rectifier. See illustration.

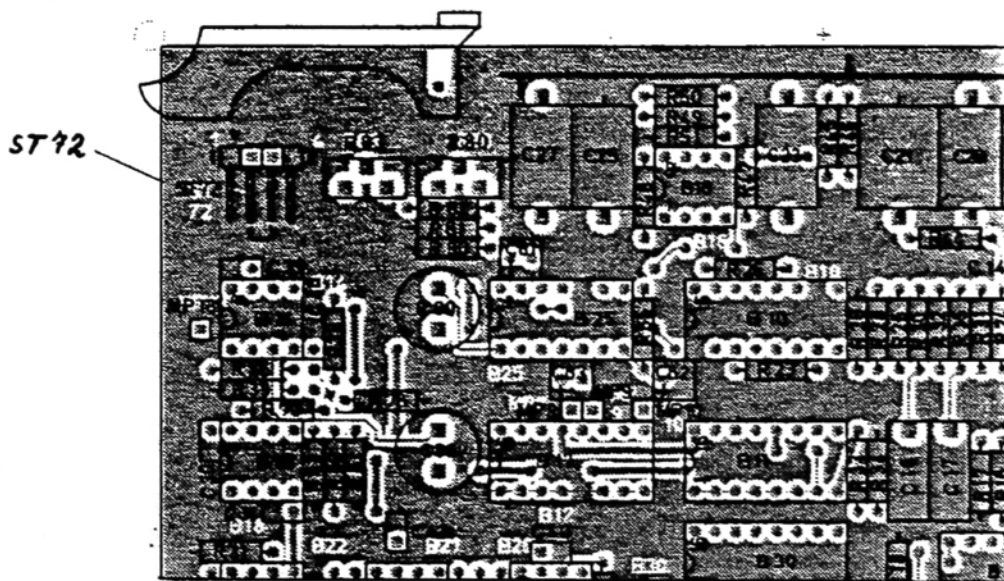Reinsert the Audio filter/rectifier PCB and replace instrument cover plate.

Fig. 5   Connection of option "Distortion factor meter" to Audio filter/rectifier PCB