SERVICE INSTRUCTIONS

Synthesizer 1

342.5410.12

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5. Service Instructions for Synthesizer 1

(See circuit diagram 342.5410 S and block diagram Fig. 1)

5.1 Circuit Description

The synthesizer board 1 consists of the following functional groups:

- pulse generator n x 100 MHz;
- two VCOs for generation of frequencies n x 100 MHz comprising loop amplifier, lock-in identification and search generator;
- first oscillator comprising loop amplifier, lock-in identification and search generator;
- buffer amplifier for the first oscillator;
- mixer for mixing the output of the n x 100-MHz synthesizer and the first oscillator;
- 110.7-to-210.7-MHz filter and amplification section;
- mixer N5 acting as a phase comparator and finally
- logic circuit which selects the appropriate oscillator range from the control signals.

The block diagram of synthesizer 1 is shown in Fig. 1.

5.1.1 Auxiliary Synthesizer n x 100 MHz

The control signal 100 MHz (3 dBm) is applied to the pulse generator via X153. V1 boosts the power to 15 dBm. The required high-power pulse is produced in the step-recovery diode V2. C7, L3, C8 and L4 act as impedance transformer to the low internal impedance of the diode. The operating point of V2 is set with R900. The spectrum is attenuated by 10 dB and is available at X152 for measuring purposes. The high-pass filter consisting of C10, L5, C11, L6 and C12 has a cut-off frequency of 500 MHz and attenuates the first four insignificant spectral lines which keeps the load on the following mixer N1 low.

The auxiliary synthesizer frequency n x 100 MHz is produced in two oscillators covering the ranges 700 to 800 MHz and 900 to 1200 MHz. The oscillators are connected in a Colpitts circuit with V24 and V31 as active elements. They are switched on by means of V25 and V26 or V32 and V33, respectively. V22, V23, V29 and V30 act as tuning diodes. The oscillator power is brought out via two coupling loops per oscillator i.e. one for synchronization of the oscillators and one for down-conversion of the frequency of the first oscillator. The coupling loops are switched over by means of the switching diodes V20, V21, V27 and V28.

The gain of the buffer amplifier connected between X4 and X2 is 0 dB. The reverse transmission is < 30 dB. RF amplification is accomplished by V16 and V35 whose frequency response compensation is ensured by C39 and C154.

The ring mixer N1 functions as a phase comparator. The mixer is match-terminated with C27, C25, L13, L14 and R22 for high frequencies.

The low-noise loop amplifier N6 provides an oscillator signal of high spectral purity. The PIP controller N6 features a DC voltage gain of 33. The output voltage at pin 6 is applied via R20 to the varicaps of the oscillators. V17 with the dropping resistor R20 prevents the varicaps from being connected with the wrong·polarity. The bandwidth of the PLL is about 1 MHz.

Normally a VCO is not at the desired nominal frequency at switch-on. Since the phase comparator N1 is only phase-selective but not frequency-selective first a search action of the oscillator must be initiated. This is accomplished by beating the DC tuning voltage at the oscillators with a 200-Hz AC search voltage. The 200-Hz generator is a FET oscillator with double T feedback. The search voltage is added at contact 2 of N6. The criterion for switching on the search generator is derived from the presence of an AC voltage of up to 50 MHz at the IF port of N1. The AC output voltage of N1 is boosted in V11 which is followed by a low-pass filter with a cut-off frequency of 50 MHz. V13 detects the signal and the resulting DC voltage is applied to the comparator N3. If the oscillator is out of lock, N3 switches on the search generator via V3 and pin a20 open-collector output of X151 is taken to ground via V14.

For pretuning of the VCOs, a DC voltage is used which is added at N6, pin 2. A potentiometer with associated switching transistor V53 to V58 is provided for each frequency range between 700 MHz and 1200 MHz in steps of 100 MHz for frequency presetting of the VCOs. The signal of the n x 100-MHz synthesizer is applied via a high-pass filter with a cut-off frequency of 500 MHz to the mixer N2.

5.1.2 Main Synthesizer

Like in the n x 100-MHz synthesizer, the frequency range of the first oscillator is covered by two oscillators. The Colpitts oscillator V106 acts as active element over the range from 690 MHz to 1010 MHz. Over the range 1010 MHz to 1330 MHz, the Colpitts oscillator V102 acts as active element. The oscillators are switched on by the transistors V103 and V230 or V107 and V231, respectively. V100 and V101 or V104 and V105, respectively, act as tuning diodes. The oscillator power of 3 dBm is brought out via a coupling loop which is terminated with R222.

The following two-stage buffer amplifier V69 and V71 can be disconnected by removing the link X10. The amplifier features a broadband constant gain of 17 dB over the frequency range from 680 MHz to 1350 MHz.

The oscillator signal is available at the output X155 with a level of 17 dBm via a high-pass filter with a cut-off frequency of 650 MHz and a low-pass filter with a cut-off frequency of 1350 MHz as well as a 3-dB attenuator. At X156 the signal of the first oscillator attenuated by 32 dB is available.

The signal of the first oscillator attenuated by 33 dB through R135, R139, R138, R137,R140 and R149 is coupled out at the input of the 3-dB attenuator for down-conversion. This is followed by a further two-stage buffer amplifier V67, V65. V66 and V64 stabilize again the operating point of V67 and V65. The amplifier features a broadband constant gain of 16 dB over the frequency range 680 to 1350 MHz.
The oscillator signal is applied with a level of -20 dBm via an adjustable attenuator R426, R427, V72(-8 to -12 dB) for the phase control at phase discriminator N5 and a fixed attenuator R125 to R127(-10 dB) to the mixer N2 where it is down-converted with the signal of the auxiliary n x 100-MHz synthesizer to 110.7 to 210.7 MHz.

The filter following the IF gate of the mixer N2 can be disconnected by removing the link X8. Termination for high frequencies is provided by R107, R108 and C160. Signals with frequencies below 230 MHz are applied to X9 via a low-pass filter. This is followed by a two-stage buffer amplifier with V61 and V63. Broadband frequency response compensation is ensured by C70, R114 and C161, R106. The high-pass filter C162, L37 and C71 features a cut-off frequency of 100 MHz determining the lower frequency limit of the 110.7-to-210.7-MHz amplifier.

Following the amplifier V63, a part of the signal is coupled out with a high impedance and rectified with V59. The rectified voltage thus obtained is buffered by N11/I and compared with the reference voltage at pin 5 of N11/I. The control amplifier N11/II sets the attenuation of the attenuator R426/427, V72 by the current injection of the PIN diode so that the level of the 110.7 to 210.7-MHz signal at the phase discriminator N5 remains constant (-12±3 dBm) for all frequencies of the 1 st oscillator. A 3-dB attenuator and another 100-MHz high-pass filter are connected between V63 and X11. The overall gain of the 110.7-to-210.7-MHz section is 16 dB.

A frequency between 110.7 MHz and 210.7 MHz depending on the desired first oscillator frequency is fed into X154. This frequency is down-converted to 0 in N5 with the signal from the 110.7-to-210.7-MHz amplification section. The IF port of N5 is match-terminated with C103 and R160 for high frequencies. The low-frequency or DC voltage component is applied via X15 to the loop amplifier N7. The low-noise loop amplifier ensures a signal of the first oscillator of high spectral purity. The PIP controller N7 features a DC voltage gain of 55. The output voltage at pin 6 is applied via R182 to the varicaps of the oscillators. V120 with the dropping resistor R182 prevents the varicaps from being connected with the wrong polarity. The bandwidth of the PLL is about 2 MHz.

Normally a VCO is not at the desired nominal frequency at switch-on. Since the phase comparator N5 is only phase-selective but not frequency-selective first a search action of the oscillator must be initiated. This is accomplished by beating the tuning voltage at the oscillators with a 200-Hz AC search voltage. The 200-Hz generator is a FET oscillator with double T feedback. The search voltage is added at contact 2 of N7.

The criterion for switching on the search generator is derived from the presence of an AC voltage of up to 100 MHz at the IF port of N5. The AC output voltage of N5 is boosted in V79 which is followed by a low-pass filter with a cut-off frequency of 100 MHz. V82 detects the signal and the resulting DC voltage is applied to the comparator via V85 and pin b20 open-collector output of X151 is taken to ground via V83.

For pretuning of the VCOs, a DC voltage is used which is added at N7, pin 2. A potentiometer (R903, R910 to R917) with associated switching transistor (V52, V92 to V99) is provided for each of the 100-MHz ranges (see Table 1) for frequency presetting of the VCOs.

The digital chip N8 and a switching diode array decode the BCD information present at X151, pins b27 to b30 into the decimal equivalent for controlling the oscillators. N9 is a full adder which adds 0 to the 100-MHz digit applied at b27 to b30 if a19 of X151 is at high level or 5 if a19 of X151 is at low level. With a30 being at high, N8 is disabled and the frequency information must be applied via a/b8 to a/b10.

All RF connections to and in the synthesizer 1 are of 50-Ω design facilitating adjustment of the synthesizer 1 with standard measuring instruments.

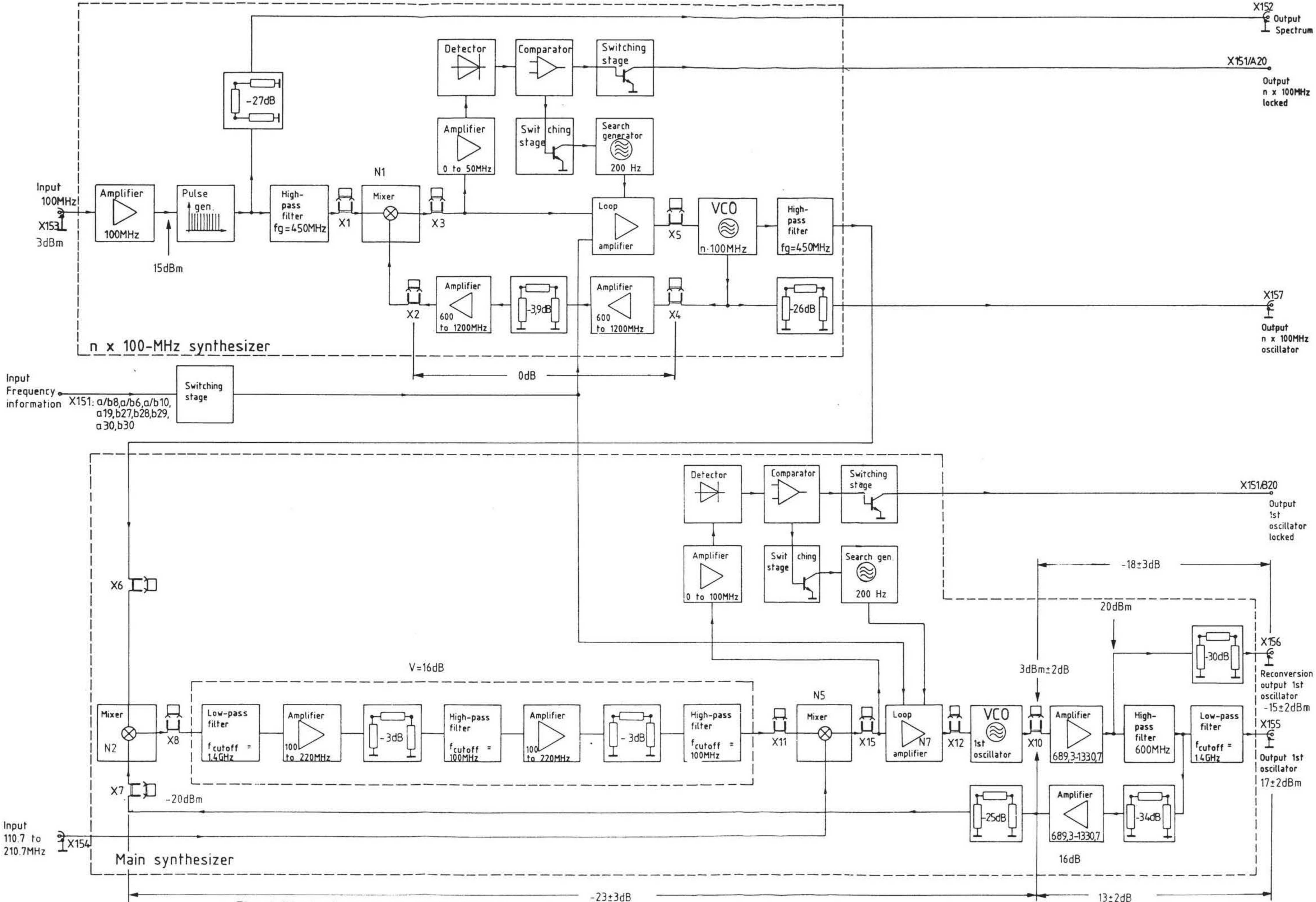


Fig. 1 Block diagram of synthesizer 1

5.2.4.1 700-to-800-MHz Oscillator

- a19 of X151 at high level.

Adjust the series inductance of V22 and V23 such that the frequency range 550 to 950 MHz can be covered with R904. Subsequently adjust the coupling loop between V21 and R45 such that the level over the frequency range 700 to 800 MHz is 2 dBm ±2 dB.

5.2.4.2 900-to-1200-MHz Oscillator

- a19 of X151 at high level.
- b28 of X151 at high level.

Adjust the series inductance of V29 to V30 such that the frequency range 800 to 1300 MHz can be covered with R906.

Subsequently adjust the coupling loop between V28 and R51 such that the level over the frequency range 900 to 1200 MHz is 2 dBm ±2 dB.

5.2.5 Adjustment of the Main Coupling Loops of the n x 100-MHz Oscillators

Remove the link X6 and connect a spectrum analyzer to the oscillator output of X6.

5.2.5.1 Coupling Loop at the 700-to-800-MHz Oscillator

- a19 of X151 at high level.

Adjust the coupling loop between V20 and R43 such that the level over the frequency range 700 to 800 MHz is 2 dBm ±2 dB.

5.2.5.2 Coupling Loop at the 900-to-1200-MHz Oscillator

- a19 of X151 at high level.
- b28 of X151 at high level.

Adjust the coupling loop between V27 and R58 such that the level over the frequency range 900 to 1200 MHz is 2 dBm ±2 dB.

5.2.6 Checking the Buffer Amplifier in the n x 100-MHz Synthesizer

- Remove the links X2 and X4.
- Connect a network analyzer to X4 and X2 such that the signal is fed into X4.

Gain over the frequency range 650 to 1250 MHz .... 0 ±2 dB

5.2.7 Checking the Loop Amplifier, the Lock-in Identification and the Search Generator in the n x 100-MHz Synthesizer

- Remove the link X6 and connect a spectrum analyzer to A1 of X6.
- X153 must be left free.
- a19 of X151 at high level.
- Tune oscillator frequency to 700 MHz by means of R904.

5.2.7.1 Checking the Search Generator

Connect pins 1 and 2 at X13.
Oscillator sweep width .... ±35 MHz

5.2.7.2 Checking the Lock-in Identification

Feed 100-MHz signal with a level of 3 dBm into X153.
The oscillator should lock at 700 MHz.

5.2.8 Frequency Adjustment of n x 100-MHz Synthesizer

- Feed 95-MHz signal with a level of 3 dBm into X153.
- a19 of X151 at high level
- Remove the link X6 and connect a spectrum analyzer to A1 of X6.
- Apply a high signal in BCD format according to the desired frequency to b27 to b30 of X151.

Adjust the n x100-MHz oscillators by means of R904 to R909 such that a balanced sweep width is produced about the desired n x 100-MHz frequency.

Then feed 100-MHz signal with a level of 3 dBm into X153. The oscillators should now lock at n x 100 MHz.

5.2.9 Checking and Adjustment of the 110.7-to-210.7-MHz Amplification Section

5.2.9.1 Adjustment of the 220-MHz Low-pass Filter

- Remove the links X8 and X9.
- Connect a network analyzer to X8 and X9.

Adjust L32 to L36 for uniform return loss over the range 100 to 220 MHz.

5.2.9.2 Checking the Gain of the 110.7-to-210.7-MHz Section

- Remove the links X8 and X11 and link A1 and B1 at X9.
- Connect a network analyzer to X8 and X11 such that the signal is fed into X8.

Gain over the frequency range 110.7 to 210.7 MHz .... 16 ±2 dB

5.2.10 Frequency and Level Adjustment of the First Oscillator

Remove the link X10 and connect a spectrum analyzer to A1 of X10.

5.2.10.1 689-to-1010-MHz Oscillator

- a19 of X151 at high level.

Adjust the series inductance of V104 and V105 such that the frequency range 650 to 1100 MHz can be covered with a voltage of 3 to 24 V at X12.

5.2.10.2 1010-to-1330-MHz Oscillator

- a19 and b28 of X151 at high level.

Adjust the series inductance of V100 and V101 such that the frequency range 950 to 1400 MHz can be covered with a voltage of 3 to 24 V at X12.

5.2.10.3 Level Adjustment in the Frequency Range 689 to 1330 MHz

Adjust the coupling loop between R222 and X10 such that the level over the frequency range 650 to 1010 MHz and 1010 to 1400 MHz is 3 dBm ±2 dB.

5.2.11 Adjustment of the Output High-pass and Low-pass Filters and Checking the Gain of the Oscillator Amplifier

- Remove the link X10.
- Connect a network analyzer to X10 and X155 such that the signal is fed into X10/B1.
- Adjust the high-pass filter by means of L45 and L46 such that a flat frequency response is obtained especially over the frequency range 680 to 900 MHz.
- Adjust the low-pass filter by means of L160 to L162 such that a flat frequency response is obtained especially over the frequency range 900 to 1350 MHz.
- Cut-off frequency of the low-pass filter .... 1350 MHz
- Gain .... 13 ±2 dB

5.2.12 Checking the Gain at the Reconversion Output and at the Buffer Amplifier Output

- Remove the link X10.
- Connect a network analyzer to X10 and X156 such that the signal is fed into X10/B1.
- Terminate X155 with 50 Ω.
- Remove the link X7.

Attenuation over the frequency range 650 to 1350 MHz .... −18 ±3 dB

5.2.13 Checking the Loop Amplifier, the Lock-in Identification and the Search Generator in the Main Synthesizer

- Connect a spectrum analyzer to X155.
- a19 of X151 at high level.
- Tune the oscillator frequency to 860 MHz by means of R910.
- Feed 160-MHz signal with a level of 3 dBm into X154.
- Put the n x 100-MHz synthesizer into operation.

5.2.13.1 Checking the Search Generator

- Connect an oscilloscope to R169.

- Link 1 and 2 at X14.

A search voltage with a frequency of 200 Hz ±30% and a voltage of approximately 5 V_{pp} should be measured with the oscilloscope.

5.2.13.2 Checking the Loop Amplifier and the Lock-in Identification

- Remove the link X14.

Vary the frequency of the signal fed in at X154 until the oscillator goes out of lock. Then sweep the oscillator with a sweep width of approximately 75 MHz about its centre frequency.

5.2.14 Frequency Adjustment of the Main Synthesizer

- Put the n x 100-MHz synthesizer into operation.
- Connect a spectrum analyzer to X155.
- a19 of X151 at high level.
- Apply a high signal to pins b27 to b30 of X151 or low signal to ab8 to ab10 of X151 according to the desired frequency.
- X154 must be left free.

Adjust the frequencies to the centre values of the various ranges according to Table 1 using R903 and R910 to R917. After feeding 160 MHz with 3 dBm into X154, the oscillators in every range should lock. Subsequently check the tuning range. To this end, tune through the frequency range of the signal applied to X154 from 100 to 220 MHz. The first oscillator must remain locked. An exception is the range from 1310.7 to 1330.7 MHz in which the signal applied to X154 need only be tuned through the frequency range 100 to 150 MHz.

If one of the tuning subranges cannot be obtained without the first oscillator going out of lock, slightly readjust R903 and R910 to R917.

5.2.15 Checking the Oscillator Output Power

- Connect a power meter to X155.

Check the output power over the frequency range 689.3 to 1330.7 MHz (frequency setting according to Table 1).

- Oscillator output power at X155 .... 17 ±2 dBm

If necessary, readjust coupling loop between R222 and X10 as well as L45, L46 and L162 of the output high-pass and low-pass filters.

5.2.16 Checking the Level at the Phase Discriminator

Connect a spectrum analyzer(110-211 MHz) to X16. The level of the 1st oscillator is checked in the frequency range 689.3 to 1330.7 MHz.

Level at X16......................................-38 ± 3 dBm

Possible corrections:

Overall level too high or too low:

- Check reference voltage at pin 5 of N11(can be corrected for by trimming resistor R301(threshold value)between 274 and 475Ω).
- The overall level is decreased by varying R126 and R426(100 to 150Ω).
- The overall level is increased by removing R139.

Frequency response is not flat enough:

- The level is increased in the upper frequency range by removing C93.

5.2.17 Checking the Power at the Oscillator Reconversion Output

- Connect a power meter to X156.

Output power over the frequency range 689.3 to 1330.7 MHz .... 15 $^{+2}_{-3}$ dBm

If necessary, the output power can be adjusted via the coupling loop between R441 and X156.

5.2.18 Checking the Sideband Noise of the First Oscillator

- Apply a low-noise crystal signal (100 MHz/3 dBm) to X153.
- Apply a low-noise signal with the frequencies 110.7 MHz, 160 MHz and 210.7 MHz according to the test frequency to X154.
- Connect a sideband noise meter to X155.

Check the sideband noise at three points in every range according to Table 1 (except for range 1310 to 1330 MHz where only one point need be checked and range 830.7 to 910 MHz where checking is required at two points).
Fig. 2 shows the typical characteristic of the sideband noise.

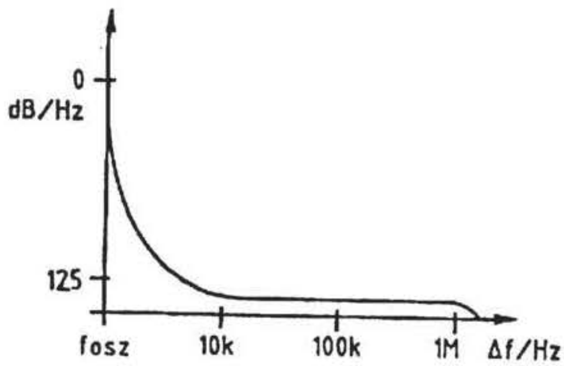
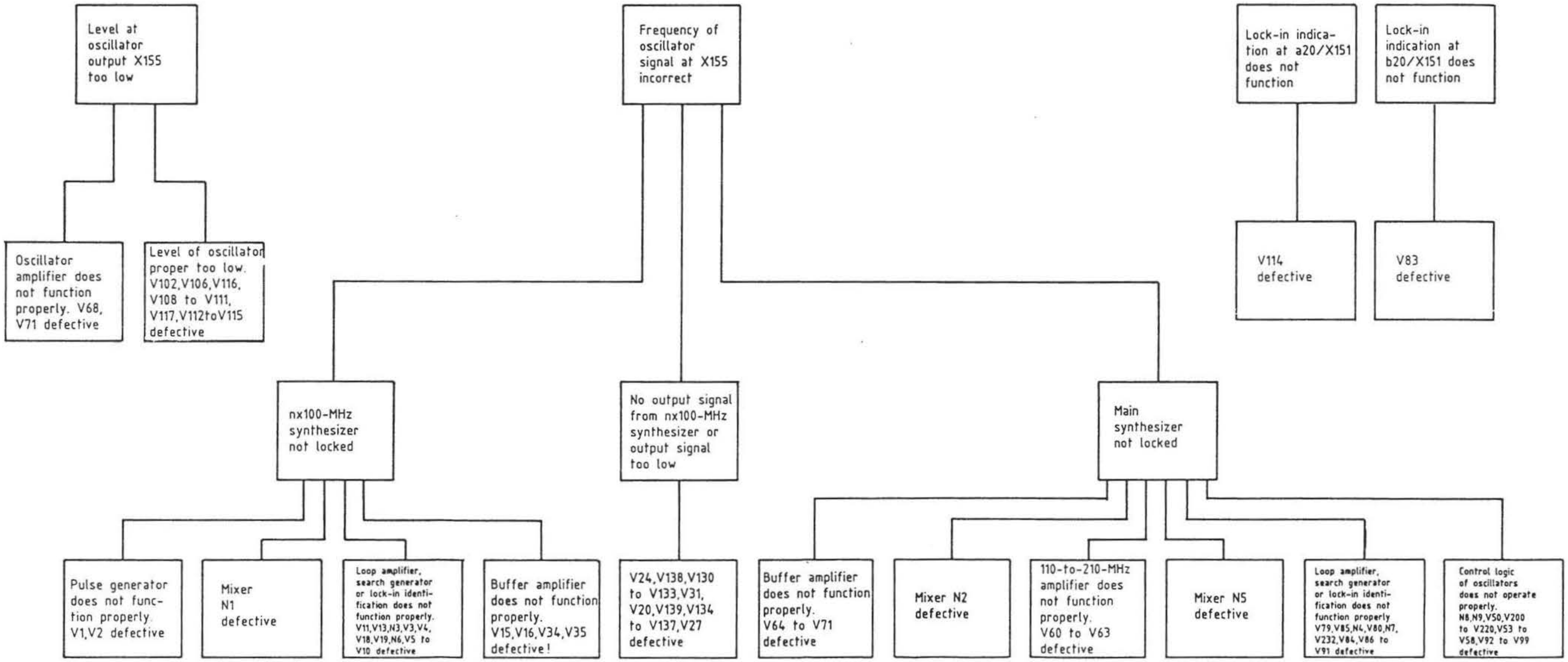


Fig. 2 Characteristic of typical sideband noise level of the first oscillator


Level at oscillator output X155 too low
Oscillator amplifier does not function properly. V68, V71 defective
Level of oscillator proper too low. V102,V106,V116, V108 to V111, V117,V112toV115 defective
Frequency of oscillator signal at X155 incorrect
nx100-MHz synthesizer not locked
Pulse generator does not function properly. V1,V2 defective
Mixer N1 defective
Loop amplifier, search generator or lock-in identification does not function properly. V11,V13,N3,V3,V4, V18,V19,N6,V5 to V10 defective
Buffer amplifier does not function properly. V15,V16,V34,V35 defective!
No output signal from nx100-MHz synthesizer or output signal too low
V24,V138,V130 to V133,V31, V20,V139,V134 to V137,V27 defective
Main synthesizer not locked
Buffer amplifier does not function properly. V64 to V71 defective
Mixer N2 defective
110-to-210-MHz amplifier does not function properly. V60 to V63 defective
Mixer N5 defective
Loop amplifier, search generator or lock-in identification does not function properly V79,V85,N4,V80,N7, V232,V84,V86 to V91 defective
Control logic of oscillators does not operate properly. N8,N9,V50,V200 to V220,V53 to V58,V92 to V99 defective
Lock-in indication at a20/X151 does not function
V114 defective
Lock-in indication at b20/X151 does not function
V83 defective