

4.5.1 Amplifier Failure

Exciter SV700 feeds the DVB-T signal to the power splitter that drives the power amplifiers. These are designed as twin amplifiers. The amplifier output stages, likewise designed as twin stages, are LDMOS power transistors. Depending on the required transmitter power, a number of amplifiers operate in parallel. Two amplifiers are combined via a coupler in each case. The coupler output signal is bandpass-filtered to increase the shoulder distance and taken to the transmitting antenna. Depending on the degree of suppression in the stopband of the bandpass filter, an extra filter may be required to suppress local oscillator harmonics.

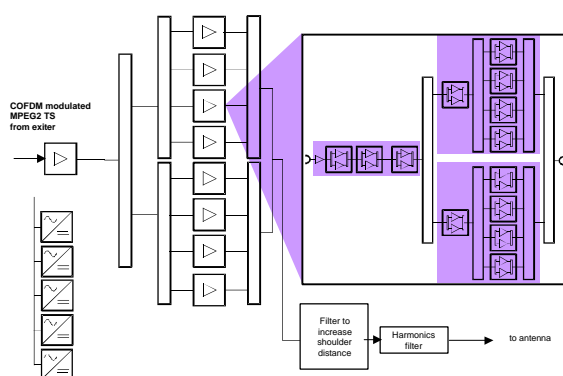


Fig. 4.36 Block diagram of power amplifier



Fig. 4.37 Power amplifier

4.5.1.1 Output Power in Event of Amplifier Failure

As mentioned above, twin amplifiers are used. Two amplifiers or, within one amplifier, two power transistors are combined via a coupler. If one of the *twins* fails, half of the power of the other twin is terminated by an absorber. Thanks to the absorber's very efficient cooling, overheating is prevented in the event of a failure. The following equation expresses the residual

output power of a transmitter in the event of amplifier failure:

$$P_{\text{out}} = P_{\text{nominal}} * \left(\frac{m-n}{m} \right)^2$$

P_{out} = real output power
 P_{nominal} = nominal output power
 m = number of amplifiers fitted
 n = number of defective amplifiers



DVB-T Transmitter NV 7250, 2.5 kW, band IV/V

Condensed data of NV/NH 7xxx

| | |
|---------------------|---|
| Frequency range | 470 MHz to 860 MHz |
| RF output power | 0.4 kW to 5 kW (DVB-T) 2 kW to 40 kW (analog TV) |
| Interfaces | RS232C and RS485 parallel interface (for messages and commands) |
| Option | |
| TV standards | DVB-T, ATSC |
| Digital | B, G, D, K, M, N, I |
| Analog | PAL, NTSC, SECAM |
| Colour transmission | dual-sound coding to IRT (-13 dB/-20 dB) or FM 1 sound (10 dB) and NICAM728 |
| Sound transmission | |

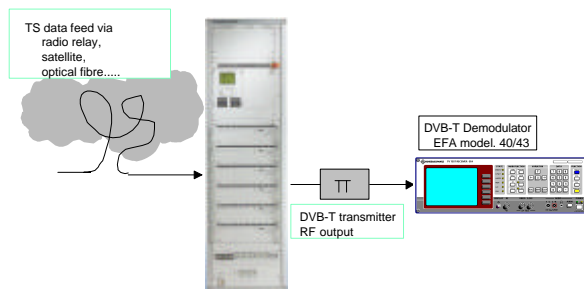
Example:

In a 2.5 kW DVB-T transmitter with a total of six amplifiers, one amplifier has failed. The transmitter continues operation with reduced power as follows:

$$P_{\text{out}} = 0.694 \times P_{\text{nominal}} \quad \text{with } m = 6 \text{ and } n = 1$$

If an amplifier fails, transmitter power is reduced but the characteristic remains the same. The latter is merely shifted – parallel to the previous characteristic – towards the lower power value. This also means that all quality parameters (except reduced power) remain in compliance with specifications. This also applies if individual power transistors of an amplifier fail. As an important prerequisite, however, any overloading of an amplifier or power transistors must be prevented. The MTBF of the operational elements is not affected by this condition.

4.5.1.2 Amplifier Replacement



Longterm measurements with
Test Receiver EFA model 40/43

Fig. 4.38 Longterm measurement of transmitter power

A defective amplifier can easily be identified, also in remote monitoring, from the transmitter power histogram displayed on Test Receiver EFA model 40/43. If, in the case of DVB-T Transmitter NV 7250, transmitter power is reduced by a constant 1.59 dB, this means that one of the six amplifiers has failed. At higher transmitter powers the difference is smaller but still clearly identifiable from the histogram. The power drop can in any case be calculated with the above equation.

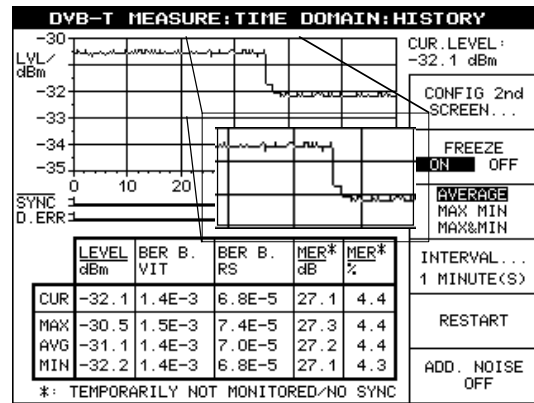


Fig. 4.39 Histogram generated by Test Receiver EFA model 40/43

What should be done if an amplifier fails?

First, remove the defective amplifier plug-in from the transmitter rack (also during operation) and insert a replacement.

Match the level and phase of the replacement amplifier to that of its twin amplifier. To do this, use a Spectrum Analyzer FSEx or FSP or a Test Receiver EFA 40/43 as employed in DVB-T transmitter monitoring. With optimally matched phase, the transmitter will output maximum power. The procedure is consequently very simple: adjust the phase until the instrument indicates maximum transmitter output power.

4.5.2 END Measurement

Each unit of a transmission chain contributes to degradation of the S/N ratio of the transmit signal. END (equivalent noise degradation) is a measure of the deterioration of signal quality. To determine END, another parameter, i.e. BER, is used. If the S/N ratio of a DVB signal decreases, BER increases. By adding white noise to the transmit signal before and after the device under test, signal characteristics can be degraded to the point where BER reaches a value of 2×10^{-4} after Viterbi decoding (or before Reed-Solomon decoding). Reed-Solomon forward error correction is capable of correcting BER of 2×10^{-4} to obtain a quasi-error-free (QEF) transport stream with $\text{BER} \sim 1 \times 10^{-11}$.

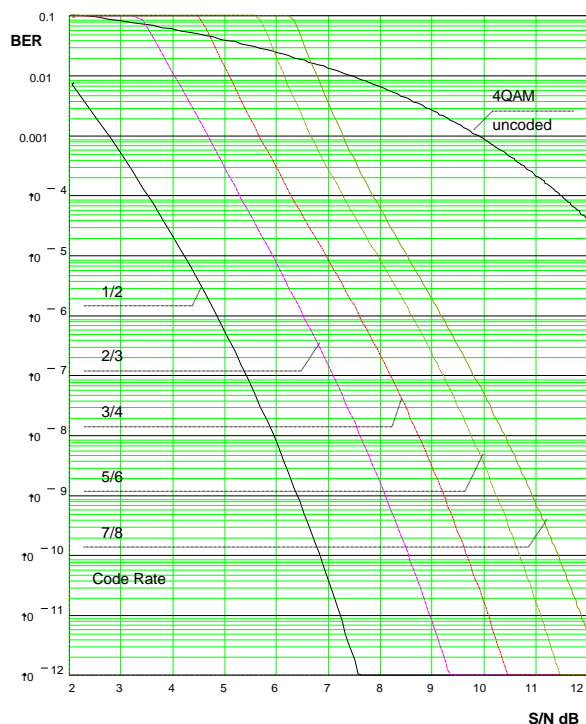


Fig. 4.40 BER (S/N) for QPSK modulation

The difference between the noise levels ahead and after the device under test for which BER of 2×10^{-4} is reached after Viterbi is the wanted END.

From the QPSK modulation diagram (Fig. 4.40) it can be seen that the curve for BER versus S/N (signal to noise) is very steep at BER = 2×10^{-4} . This is because Viterbi error correction has already been performed at this point. Minor errors in determining S/N therefore lead to strong variations of BER. Moreover, END values of < 0.3 dB should be measurable too. These requirements can be met only if S/N is determined with an accuracy of < 0.1 dB.

In the example below, the END measurement is described for a DVB-T transmitter amplifier. Fig. 4.41 illustrates the test setup:

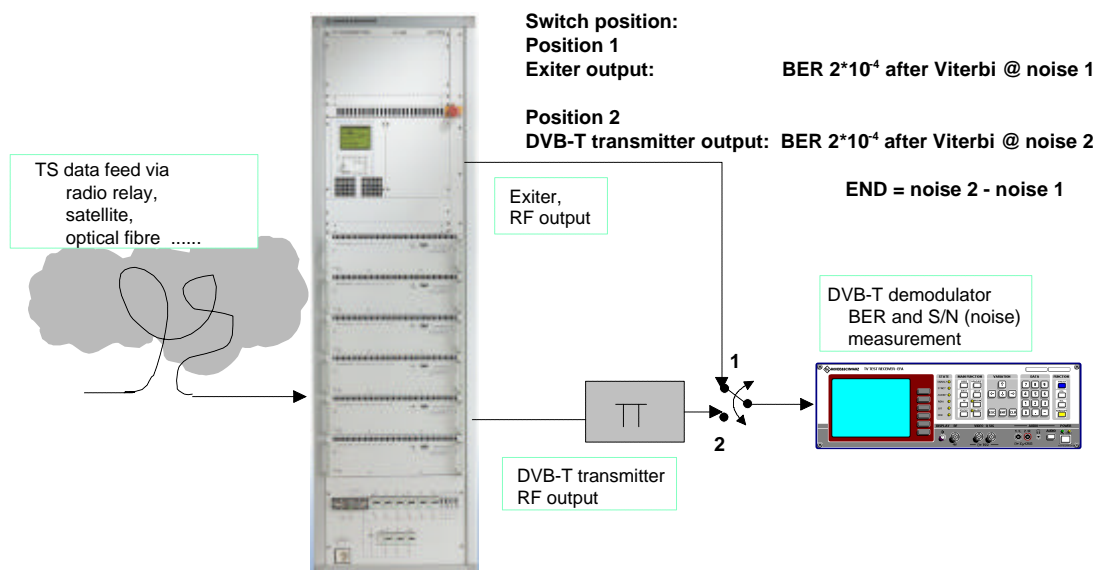


Fig. 4.41 Test setup for END measurement on solid-state transmitter amplifiers

The transport stream is fed to the exciter input and directly converted to the RF. Test Receiver EFA 40/43 demodulates the signal at the SV700 monitoring output and measures BER. In the demodulator, the signal is converted to the IF at 36 MHz and, with EFA's built-in noise generator, white noise is added until BER = 2×10^{-4} . Read this first C/N ratio – $(C/N)_1$ – from the EFA display.

Next, feed the transmitter output signal to the EFA RF input via a coupler and an attenuator. Adjust the input level via the coupler and the attenuator, so that a value identical with the first measurement is obtained, so establishing the conditions of reception existing at the exciter output. Again, add white noise with EFA's noise generator until BER = 2×10^{-4} is displayed. Read the second C/N ratio – $(C/N)_2$ – from the display.

The END for the transmitter amplifiers is calculated as follows:

$$\text{END} = (C/N)_2 - (C/N)_1 \text{ dB}$$

High-quality amplifiers should have an END not exceeding 0.4 dB. For this range, the 0.1 dB accuracy and 0.1 dB resolution of the EFA noise generator are sufficient.

Where more stringent demands have to be met, the C/N ratio has to be determined with much higher absolute accuracy. Application Note 7BM03_2E (see Annex 4C) describes how to do this. The method discussed there allows C/N ratio measurement with absolute accuracy better than 0.1 dB. The accuracy for END measurement is likewise typically 0.1 dB.

4.6 BER Measurement

Bit error ratio is the most important figure of merit in digital video broadcasting. In DVB-T, BER is measured at three points after demodulation:

- immediately after demodulation before any error correction, i.e. the raw-bit error ratio, generally referred to as "BER before Viterbi" (inner FEC);
- after the first error correction, generally referred to as "BER after Viterbi" or "BER before RS" (outer FEC);
- after the second error correction, generally referred to as "BER after RS" (outer FEC).

Test Receiver EFA 40/43 measures BER at these points during normal operation. The three values are displayed together in the MEASURE menu. To speed up display, a number of data blocks are selected for evaluation, each block comprising 10^7 bits. While BER calculated from these blocks is usually displayed with low resolution, e.g. 0.0E-5, the result is available immediately. EFA then performs *sliding* BER calculation until – after a corresponding waiting time – the result is obtained with the final accuracy. In the example shown in Fig. 4.42, the measurement before Viterbi starts with 10 data blocks. The corresponding 10×10^7 bits have already been processed, and the result is 2.0E-4. For BER before RS, sliding calculation is already active. Here, a total of 10000 blocks has to be checked, of which 881 have been processed so far.

| DVB-T MEASURE | | | |
|-----------------------------|--------------------|---------------|-------------------------|
| SET RF (8MHz) | | ATTEN : 15 dB | |
| 474.000 MHz | | -35.9 dBm | |
| FREQUENCY/BER: | | | CONSTELL DIAGRAM... |
| FREQUENCY OFFSET | 0.133 kHz | | |
| BITRATE OFFSET | -11.8 ppm | | |
| BER BEFORE VIT | 2.0E-4 (10/10) | | FREQUENCY DOMAIN... |
| BER BEFORE RS | 0.0E-10 (881/10K0) | | |
| BER AFTER RS | 0.0E-9 (2K62/10K0) | | |
| OFDM/CODE RATE: | | | TIME DOMAIN... |
| FFT MODE | 2K (TPS: 2K) | | |
| GUARD INTERVAL | 1/32 (TPS: 1/32) | | |
| ORDER OF QAM | 64 (TPS: 64) | | OFDM PARA- METERS... |
| ALPHA | 1 NH (TPS: 1 NH) | | |
| CODE RATE | 2/3 (TPS: 2/3) | | |
| TPS RESERVED | 0000 (HEX) | | |
| NET BITRATE 24.12834 MBit/s | | | RESET BER |
| | | | ADD. NOISE OFF |

Fig. 4.42 MEASURE menu of EFA

This example shows the efficiency of Viterbi FEC: at a code rate of 2/3, it corrects BER of 2.0E-4 to 0.0E-10 before RS FEC. This value is very close to the QEF value, which is obtained after RS FEC.

For hierarchical modulation, Test Receiver EFA 40/43 can measure BER separately for the high-priority and the low-priority data stream. The path currently measured is indicated by the information "HP" (high priority) or "LP" (low priority) below the heading FREQUENCY/BER.

We again refer you to the note on page 6:

BER of 2×10^{-4} before RS FEC is the reference value in all measurements of transmission quality.



4.7 Other Measurements of MEASURE Menu

4.7.1 Measurement of Frequency Offset

In the status line of the MEASURE menu, the input level, the manually set channel center frequency (see also 4.4.5 Center Frequencies of UHF Channels) and the used channel bandwidth are displayed. The center frequency of the input signal is compared with the set frequency and the difference indicated under FREQUENCY OFFSET. The highly accurate, oven-controlled crystal used as a reference allows offset display down to 1 Hz. Test Receiver EFA 40/43, therefore, also replaces an extra frequency counter on the DVB-T transmitter.

4.7.2 Measurement of Data Rate Offset

DVB-T data rates are defined for each modulation mode (QPSK, 16QAM or 64QAM), guard interval and puncturing rate. Deviations from specified data rates have an effect on the DVB-T spectrum. The deviation from the specified data rate must therefore be known. On EFA, it is indicated in ppm under BITRATE OFFSET. The corresponding net data rate is displayed in the bottom line.

| DVB-T MEASURE | | | |
|-------------------------------------|--|-----------------------------------|-------------------------|
| SET RF <8MHz> 474.000 MHz | | ATTEN : 15 dB -35.9 dBm | |
| FREQUENCY/BER: | | | CONSTELL DIAGRAM... |
| FREQUENCY OFFSET 0.133 kHz | | | FREQUENCY DOMAIN... |
| BITRATE OFFSET -11.8 ppm | | | TIME DOMAIN... |
| BER BEFORE VIT 2.0E-4 <10/10> | | | OFDM PARA- METERS... |
| BER BEFORE RS 0.0E-10 <881/10K0> | | | RESET BER |
| BER AFTER RS 0.0E-9 <2K62/10K0> | | | ADD. NOISE OFF |
| OFDM/CODE RATE: | | | |
| FFT MODE 2K <TPS: 2K> | | | |
| GUARD INTERVAL 1/32 <TPS: 1/32> | | | |
| ORDER OF QAM 64 <TPS: 64> | | | |
| ALPHA 1 NH <TPS: 1 NH> | | | |
| CODE RATE 2/3 <TPS: 2/3> | | | |
| TPS RESERVED 0000 <HEX> | | | |
| NET BITRATE 24.12834 Mbit/s | | | |

Fig. 4.47 MEASURE menu with frequency offset and data rate offset

4.7.3 Display Zoom Function

The MEASURE menu uses a relatively small type and so can be recognized only at a short distance. To read results from the DVB-T transmitter at a greater distance, i.e. a few meters, the following parameters can be zoomed:

LEVEL

BER BEFORE VIT

BER BEFORE RS

BER AFTER RS

| DVB-T MEASURE | | | |
|---------------------------------------|--|----------------------------------|-------------------------|
| SET RF <8MHz> 330.000 MHz | | ATTEN : 0 dB 57.6 dBuV | |
| BER BEFORE RS 0.2E-9 | | | CONSTELL DIAGRAM... |
| BER: | | | FREQUENCY DOMAIN... |
| BER BEFORE VIT 3.6E-5 <10/10> | | | TIME DOMAIN... |
| BER BEFORE RS 0.2E-9 <1000/1K00> | | | OFDM PARA- METERS... |
| BER AFTER RS 0.3E-12 <156K/1M00> | | | RESET BER |
| OFDM: | | | ADD. NOISE OFF |
| FFT MODE 2K <TPS: 2K> | | | |
| GUARD INTERVAL 1/8 <TPS: 1/4> | | | |
| ORDER OF QAM 64 <TPS: 16> | | | |

Fig. 4.48 Display zoom function

In this case however, the following parameters are not displayed as they are superimposed with the zoomed parameter:

FREQUENCY OFFSET

BITRATE OFFSET

ALFA (degree of hierarchy)

CODE RATE

TPS RESERVED

4.7.3 Display of DVB-T Modulator Settings

The transmitter operator must know the exact setting of his DVB-T transmitter at any time. The data determining the operating mode are fed to the transmitter in three ways:

via the NIT table of the PSI,

via the MIP,

by manual settings.

Therefore, with control data fed by different sources, the transmitter's operating mode is not unambiguously defined.

Test Receiver EFA 40/43 finds the relevant settings in the AUTO mode of the OFDM/CODE RATE MODE of the STATUS menu. Apart from this, EFA can be configured via the TPS carriers inserted in the DVB-T modulator.

The measured and accepted DVB-T transmitter settings are listed in the MEASURE menu in addition to the decoded parameters assigned via the TPS carriers (TPS values in brackets).

If automatic setting or TPS decoding does not produce stable results, the settings can be made manually.

| DVB-T MEASURE | | | |
|-----------------------------|--------------------|---------------|-------------------------|
| SET RF (8MHz) | | ATTEN : 15 dB | |
| 474.000 MHz | | -35.9 dBm | |
| FREQUENCY/BER: | | | CONSTELL DIAGRAM... |
| FREQUENCY OFFSET | 0.133 kHz | | FREQUENCY DOMAIN... |
| BITRATE OFFSET | -11.8 ppm | | |
| BER BEFORE VIT | 2.0E-4 (10/10) | | |
| BER BEFORE RS | 0.0E-10 (881/10K0) | | |
| BER AFTER RS | 0.0E-9 (2K62/10K0) | | |
| OFDM/CODE RATE: | | | TIME DOMAIN... |
| FFT MODE | 2K | (TPS: 2K) | OFDM PARA- METERS... |
| GUARD INTERVAL | 1/32 | (TPS: 1/32) | |
| ORDER OF QAM | 64 | (TPS: 64) | |
| ALPHA | 1 NH | (TPS: 1 NH) | |
| CODE RATE | 2/3 | (TPS: 2/3) | |
| TPS RESERVED | 0000 | (HEX) | RESET BER |
| NET BITRATE 24.12834 MBit/s | | | ADD. NOISE OFF |

Fig. 4.49 MEASURE menu listing OFDM/CODE parameters

Test Receiver EFA 40/43 immediately tracks any change in configuration data, so keeping the transmitter operator informed at all times of current DVB-T transmitter status.