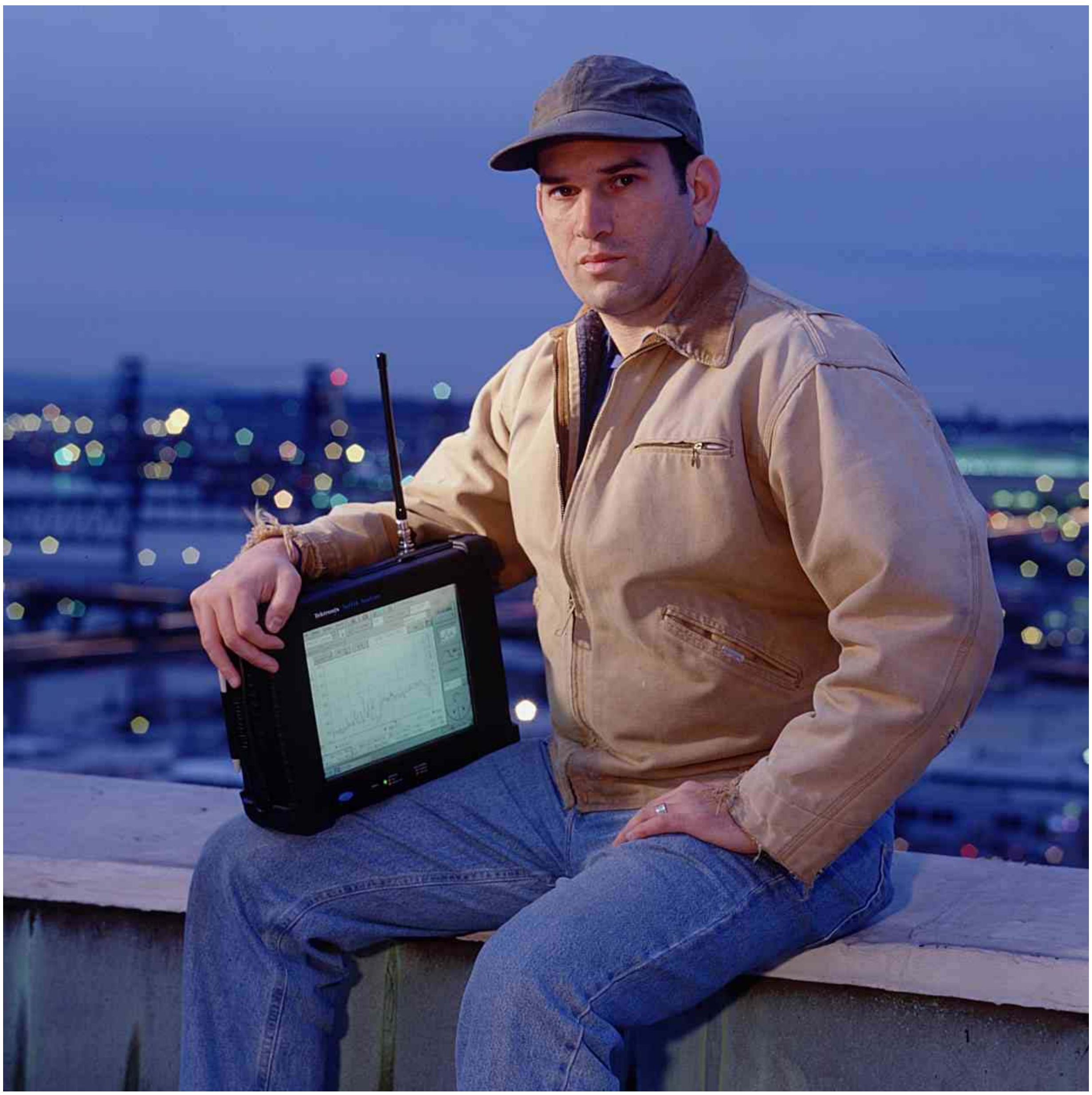
Module 3
GSM RF Background and Measurements



Overview

A Base Transceiver Station (BTS) consists of various devices, such as oscillators, mixers, amplifiers, and duplexers. Interference and transmitter-related problems may occur when these devices malfunction. You can troubleshoot these problems by using the results of a series of standard RF measurements using the YBT250.

This module covers the features and description of the RF components of a generic GSM BTS. This module also describes various GSM parameters that can be measured using the YBT250.

At the end of this module, you will be able to:

- Describe the RF components of a generic GSM BTS.
- Describe the GSM parameters that are measured using the YBT250.
- Identify the external and internal sources of interference.
- List the techniques used to troubleshoot a GSM BTS and apply them.
- List the basic techniques used to identify and locate various sources of interference and apply them.

Contents

3.1 Introduction to GSM Specific Measurements

A technician should be familiar with common BTS faults. This makes it easier to troubleshoot a BTS.

At the end of this section, you will be able to:

- Describe the parts that comprise the RF section of a generic GSM BTS.
- Understand and describe the GSM parameters that are measured with the YBT250.

3.1.1 RF Components of a Generic GSM BTS

Figure 3.1 is a generic block diagram of a GSM BTS. Although the blocks may not correspond to the replaceable units in a specific BTS, GSM base stations do contain these parts. Take a moment to study the block diagram and understand how it relates to familiar BTS models.

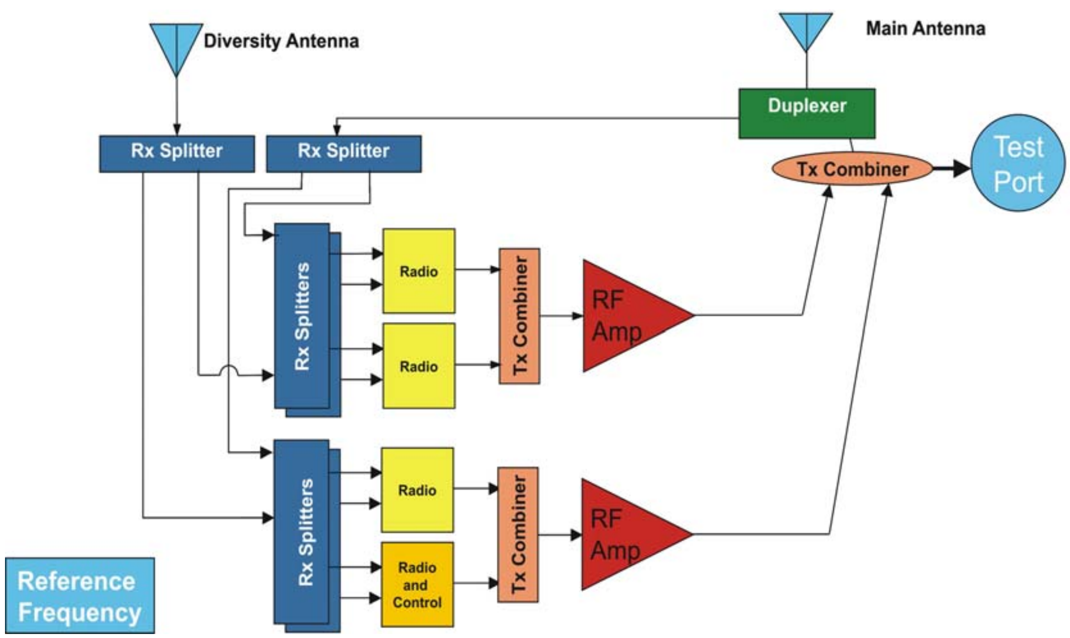


Figure 3.1: RF Section of a Generic GSM BTS

In the diagram, the Main Antenna and Diversity Antenna pick up the signal from a cell phone. The Diversity Antenna is a dedicated receive antenna while the Main Antenna receives and transmits signals.

On the receive side, the signal is picked up by the Main Antenna and the Diversity Antenna. The signal from the Main Antenna is routed through a duplexer to a splitter, then to further splitters, while the signal from the Diversity Antenna has it's own set of splitters. The signals from both the antennae then enter the receiver in the radio. The receiver then routes the signal on to the GSM system and ultimately, to the switch.

On the transmit side, signals from the switch are routed to radio units. The radio transmitter generates low-level RF signals, on specific carriers, or channels, that are amplified by the RF amplifier assigned to each radio. The amplified signals are then routed through combiners and a duplexer to the Main Antenna.

The control channel of a GSM BTS combines control data and some traffic. The control channel is always on. To make this happen, timeslots are occupied by dummy bursts in the absence of traffic. This is done so GSM phones will have a steady signal to measure when locating base stations. Pure traffic channels, on the other hand, only send data when calls are in progress.

The RF amplifier in a GSM BTS is linear, and may processes multiple RF carriers. If the amplifier is defective, it can cause Intermodulation Distortion (IMD). IMD will be discussed later in the module.

Parts of a BTS

The parts of a generic GSM BTS are:

- Radio unit
- Amplifier
- Duplexer
- Splitter
- Combiner

Let's take a look at each of these parts in detail.

Radio Unit

The radio unit consists of:

- Receiver
- Modulator
- Up-Converter
- Pre-Amplifier

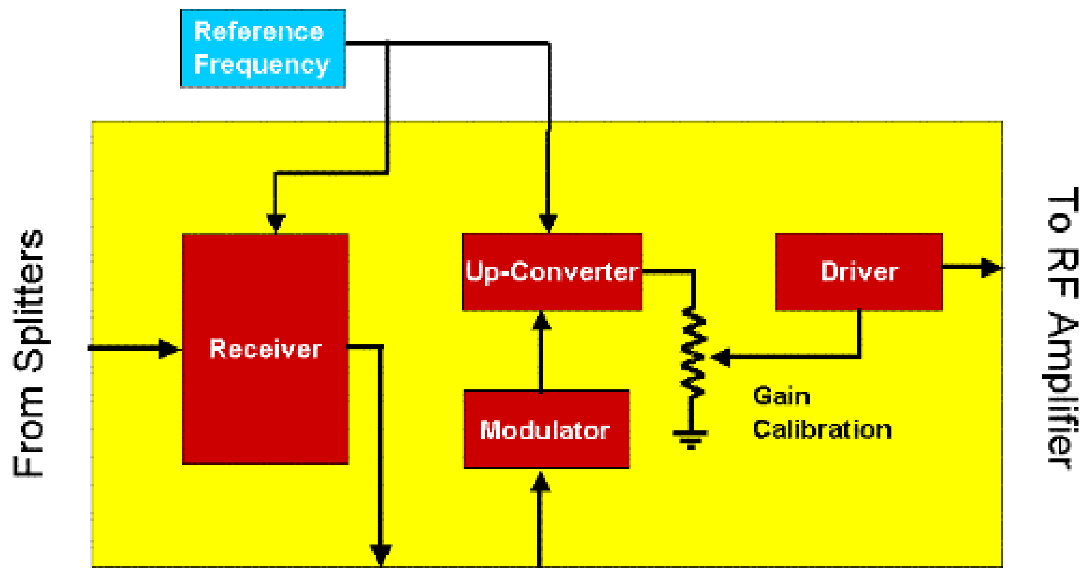


Figure 3.2: Radio Unit

On the receive side of the radio unit, signals from the Main and Diversity antennae are routed through combiners, to the receiver, and finally to the switch. The other side of the conversation is routed from the switch to the radio's modulator, which applies a GSMK modulation to the information. The modulated signal is then up-converted and at the RF frequency, ran through a driver and on to the rest of the BTS. The gain of the driver is normally adjusted to account for losses in the signal path and the radio. The driver gain should be reset whenever any component of the transmitted signal path is changed. Let's now look at the up-converter in detail.

Up-Converter The IF signal reaches the up-converter after being modulated. Up-converters change the IF frequency to the RF channel frequency by multiplying the IF input with the Local Oscillator (LO) frequency.

An up-converter is composed of a:

- Local oscillator
- Mixer
- Bandpass filter

A local oscillator (LO) produces a clean sine wave. The mixer multiplies the modulated IF input signal with the local oscillator signal. Two of the resultant frequencies are the original frequencies and two more are the sum and difference of the original frequencies. In addition, many different harmonic products are produced. Many of these frequencies now contain the modulation information. The bandpass filter is chosen to allow the appropriate resultant frequency to continue. The bandpass filter rejects other frequencies.

By choosing an appropriate frequency for the bandpass filter, up-converters or down-converters can be created. Up-converters are used in the Tx side of the base station while down-converters are used in the Rx side of the base station.

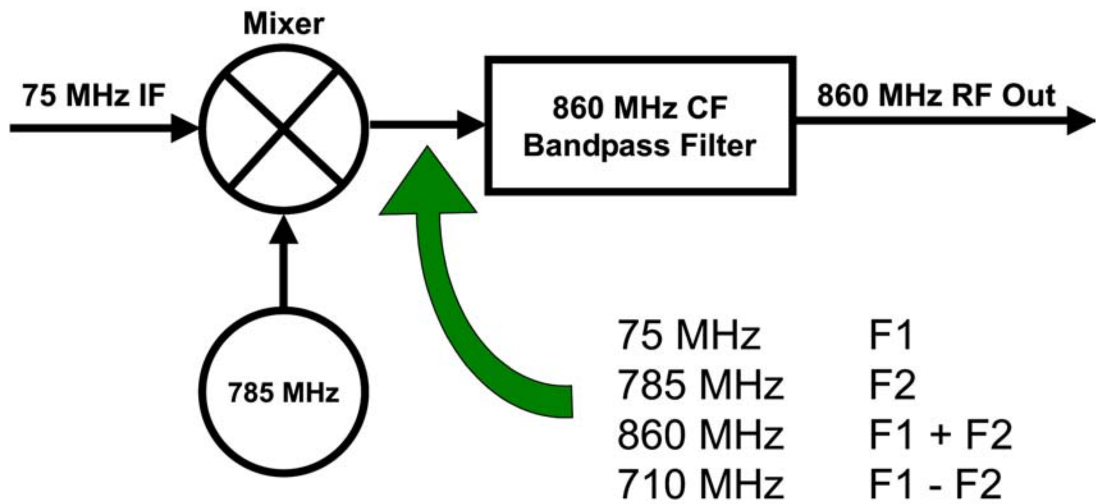


Figure 3.3: Example of an Up-converter

In Figure 3.3, an IF frequency of 75 MHz originates from the channel cards and enters the mixer. The IF frequency then mixes with the 785 MHz LO frequency. This mixing action produces a sum frequency at 860 MHz and a difference frequency at 710 MHz. A wide variety of other mixing products are also created. The bandpass filter, centered at 860 MHz, allows only the sum of the two original signals to pass and rejects the unwanted frequencies and their harmonics. So, 860 MHz is passed by the bandpass filter and becomes the 860 MHz RF Out.

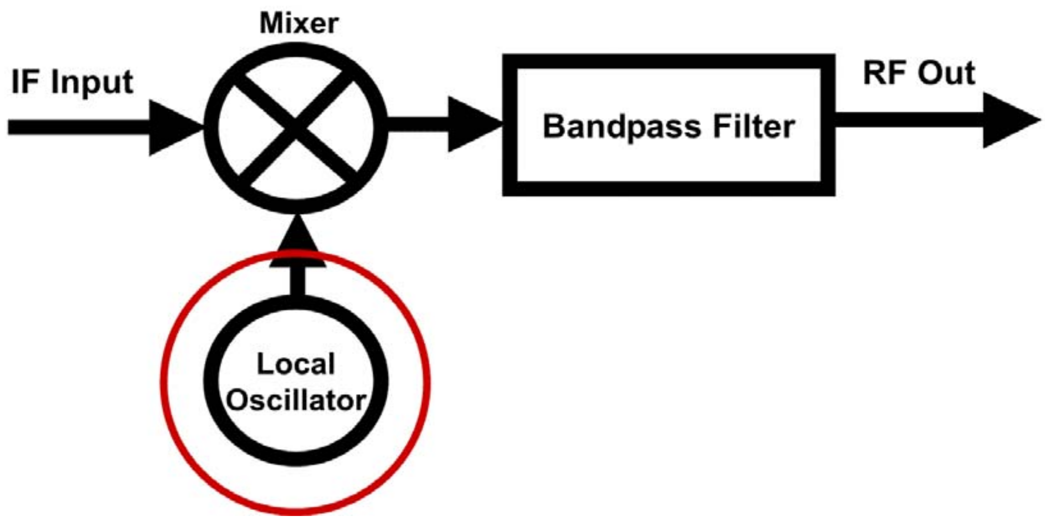


Figure 3.4: Local Oscillator

As mentioned above, local oscillators provide a clean sine wave of the required frequency and power. Any change in the frequency of the local oscillator leads to a change in the output of the mixer. Common local oscillator faults include frequency drift and phase errors. These errors distort the output of up-converters and down converters.

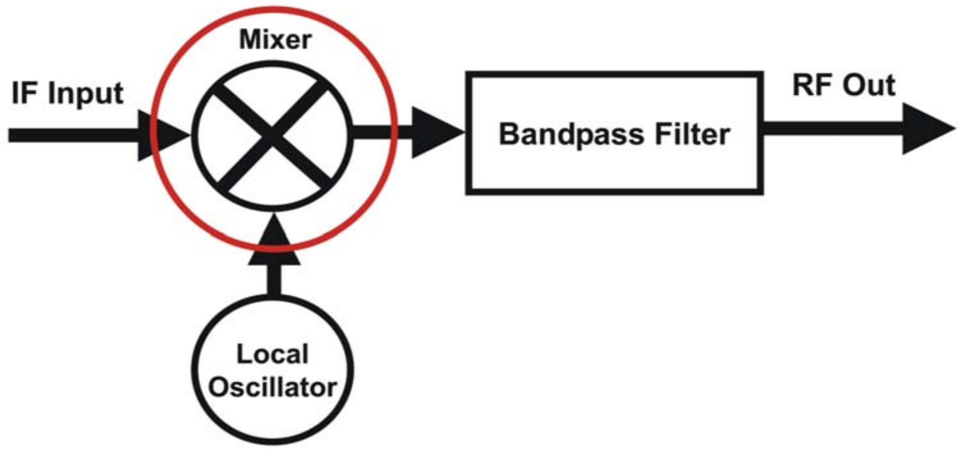


Figure 3.5: Mixer

Figure 3.5 illustrates a mixer. A mixer is composed mostly of diodes and transformers that are used to convert the IF Input signals into RF signals. The circuit is designed so that the local oscillator signal causes the diodes to change the polarity of the IF signal at the local oscillator rate. This action is equivalent to multiplying the two signals. The result of this process is many different signals that are the product of the LO and IF signals and their harmonics. This includes the sum and difference frequencies mentioned earlier.

Common mixer faults center around Intermodulation Distortion (IM). All mixers have a certain level of IM. If the level is high, IM interferes with the reception of the base station signal by the mobile phone. One mechanism of this degraded reception is lowered signal quality. Extensive IM will cause the transmitter to use a wider frequency band than intended, causing Occupied Bandwidth violations and possible interference with reception on adjacent channels. Occupied Bandwidth measurements indicate the extent of Intermodulation Distortion, among other faults.

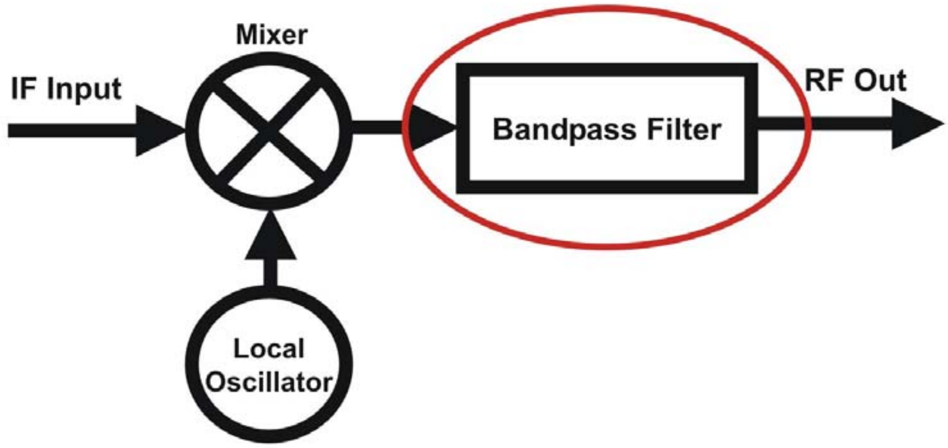


Figure 3.6: Bandpass Filter

A bandpass filter is shown in Figure 3.6. It is a device that allows a specific range of frequencies to pass and rejects other frequencies. It is chosen to allow specific mixing product to pass through it. Bandpass filters are also used in the channel filter or duplexer between the antenna and base station. Common bandpass filter faults include:

- Distortion of Signals
- Excessive Amplitude Loss
- Passband Tilt
- Ripple in Passband

Distortion of Signals A bandpass filter can delay the various frequencies of the signal by different amounts. This is known as “Envelope Delay.”

Excessive Amplitude Loss While all filters will cause some amplitude loss (insertion loss), a defective bandpass filter can cause an excessive loss in the signal passing through it. In the worst case, a broken filter can even prevent the signal from passing.

Passband Tilt A bandpass filter can have more loss on one side of the passband than the other. In the case of a duplexer, where the filter is as wide as the Rx or Tx band for the cellular service, excessive tilt may cause problems when leveling the amplitude of multiple RF channels. In the case of a bandpass filter at the output of a mixer, tilt can cause distortion of the modulated signal.

Ripple in Passband This is another way in which the response of a filter can vary with frequency. A bandpass filter can have ripple in its passband. This means that even if the signal is in the passband, the amplitude of the signal can change depending on its location within the passband. Ripple is different from tilt. Ripple causes the amplitude to increase and decrease at several places in the passband. However, tilt causes the amplitude to change from one side to another. Despite the differences in ripple and tilt, faults caused by ripple will be similar to those caused by tilt.

Amplifier An amplifier is a device that boosts the power level of a signal. It reproduces an input signal at a higher power level. RF amplifiers are normally meant to produce a fixed gain. The RF amplifier, depicted in Figure 3.7, is set at a gain of 10 dB.

When the power level of an input signal increases, an RF amplifier may not be able to reproduce the signal. This can be due to the limitations of the amplifier's power supply or limits on the power rating of the amplifier. Often, the maximum intended output power is set lower than the maximum rating of the amplifiers to avoid these limits. This difference between the maximum output rating of the amplifier and the maximum intended output is called headroom.

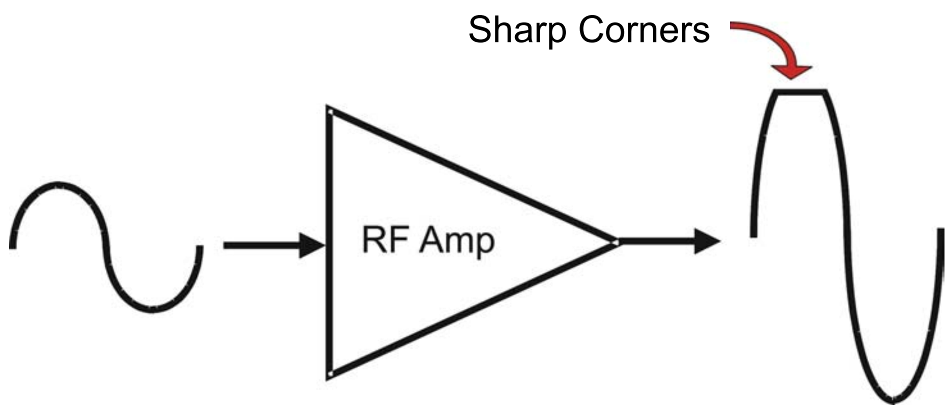


Figure 3.7 RF Amplifier

In GSM systems, multiple carriers may enter the amplifier. The main criteria for selecting an RF amplifier for GSM systems are linearity, headroom, low IM, and appropriate input power.

Common errors introduced by an amplifier are:

- Clipping
- Compression
- Power level drift

Clipping The output signal is clipped when it exceeds the available amplifier headroom. Clipping produces sharp corners in the waveform as shown in Figure 3.8.

A clipped waveform is composed of a series of harmonics similar to a square wave. The more a signal is clipped, the more it resembles a square wave. So, clipping leads to the generation of harmonics, which result in power loss. Harmonics that are not passed by the duplexer are often reflected back to the amplifier. This may result in Intermodulation Distortion.

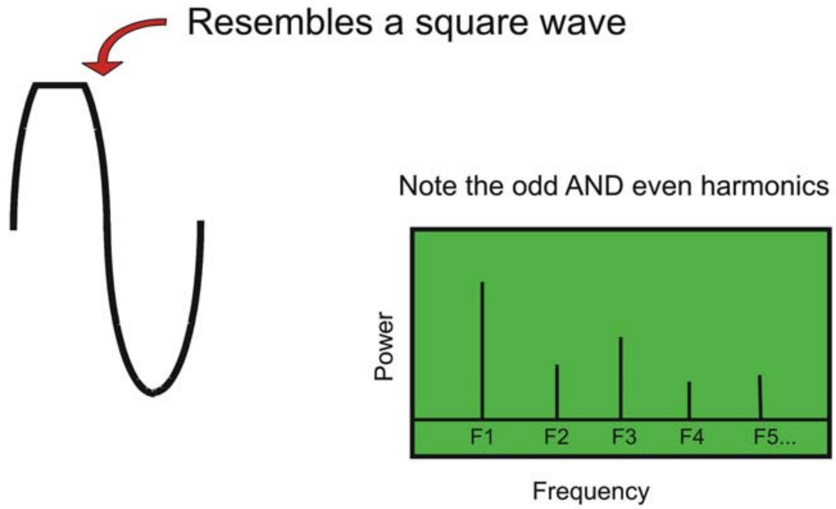


Figure 3.8: Simulated display of clipping

Figure 3.8 depicts the frequency components of a clipped carrier. A clipped carrier is composed of signals at the fundamental frequency and at multiples of the fundamental frequency. In the case of clipping, the harmonics may be even or odd. Odd harmonics occur if each polarity of the signal is clipped. Even harmonics occur if one polarity is clipped more than another. These harmonics continue indefinitely but their amplitude reduces so that they are eventually lost in the noise. As the clipping increases, the power level of the higher order harmonics also increase.

Compression A compressed waveform is shown in Figure 3.9. To better understand compression consider this example. If a 10-dB amplifier can accept a 5-dBm signal and produce a 15-dBm signal, it is working normally. If it accepts a 9-dBm signal and produces an 18.0-dBm output, it is in compression. These numbers imply that the gain is now 9.0 dB and the compression is 1.0 dB. This illustrates a common measure of compression called the "One dB Compression Point." Compression also produces harmonics but to a lesser extent than harmonics produced by clipping. If the input power of the amplifier is too high, the output signal may be compressed.

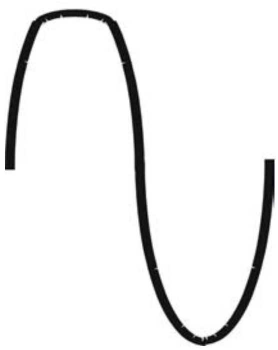


Figure 3.9: Compression

In a GSM system, multiple RF signals may be routed through the RF amplifier. If the input power of the amplifier is too high due to these signals, the output signal will be compressed.

Power Level Drift The gain of an amplifier changes gradually over time. This change may be caused by heat, dust, moisture, or aging components. This gradual change in gain, or power output, over time is known as drift. Amplifiers are calibrated at scheduled intervals to correct power drift. Amplifier gain can also change suddenly when faults occur.

Another gain issue is the response of the amplifier to power control loop commands and the power level switching that happens at the start and end of timeslots. TDMA/GSM RF amplifiers need to be able to accept sudden changes in their input signal without distortion

Many amplifier faults can be checked while the BTS is in service. If there is a test port on the duplexer, and the loss at the test port is known, amplifier power levels can be accurately checked at the test port while the BTS is in service.

Gain Calibration The gain of the amplifier, or perhaps the pre-amplifier, is calibrated to adjust the power level of the transmitted signal. The amplifier must be calibrated accurately, because the gain affects the coverage of the BTS, and the signal quality.

If the power level is set too high, the transmitted signal may be compressed and the base station coverage area is certainly increased. When this happens, the faulty base station may take more calls than it should, possibly causing it to be overloaded with calls as shown in figure 3.10.

If the power level of the channel is set too low, the coverage area is reduced, leaving some calls to adjacent base stations. This can cause the adjacent base stations to be overloaded and also lead to gaps in coverage.

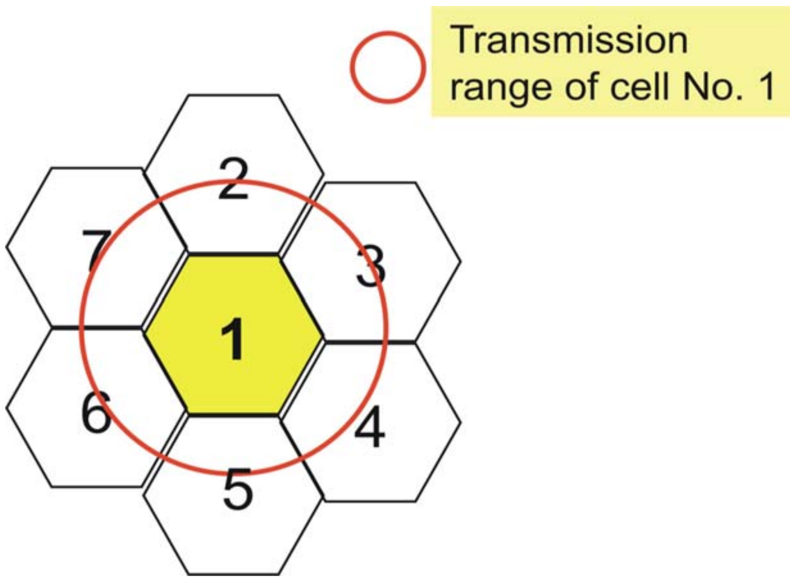


Figure 3.10: Increase in coverage due to a high input signal

Duplexer A duplexer is illustrated in Figure 3.11. A duplexer contains a pair of bandpass filters placed between the transmitter, receiver and the antenna. One bandpass filter is tuned to the transmit band and the other to the receive band. Duplexers allow the transmitter and the receiver to share an antenna without degrading receiver performance. Duplexers also limit transmitted and received signals to the intended bands. Duplexers have the same faults as bandpass filters. Some base stations do not use duplexers but instead, use independent bandpass filters, known as channel filters in this application.

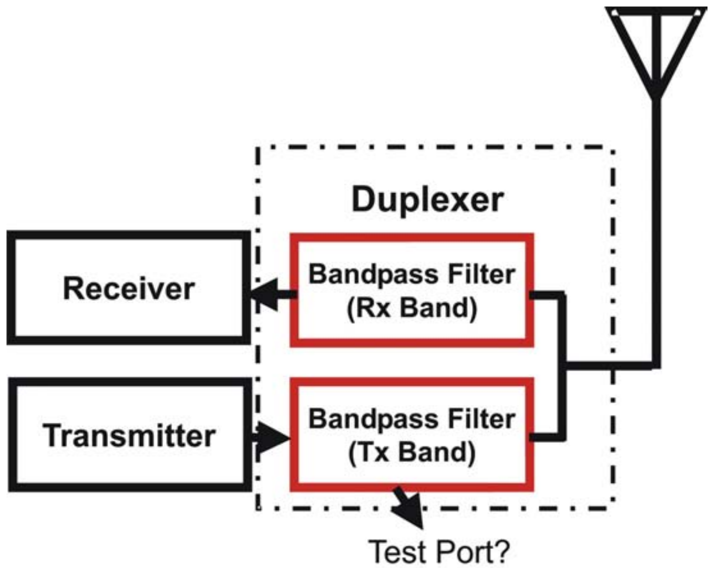


Figure 3.11: Duplexer

Power Splitter A splitter is illustrated in Figure 3.12a. Splitters divide signals, allowing one signal to drive two or more loads while matching impedances so that reflections are eliminated

Wilkinson passive splitters, often used in base stations, are passive devices that have low loss. They incorporate quarter wave transmission lines into their internal design. When used on the Rx side of the base station, they normally include pre-amplification stages. Without pre-amplification, they normally have a 3 to 4 dB loss for every two splits. When used with a built in pre-amplifier they may have gain.

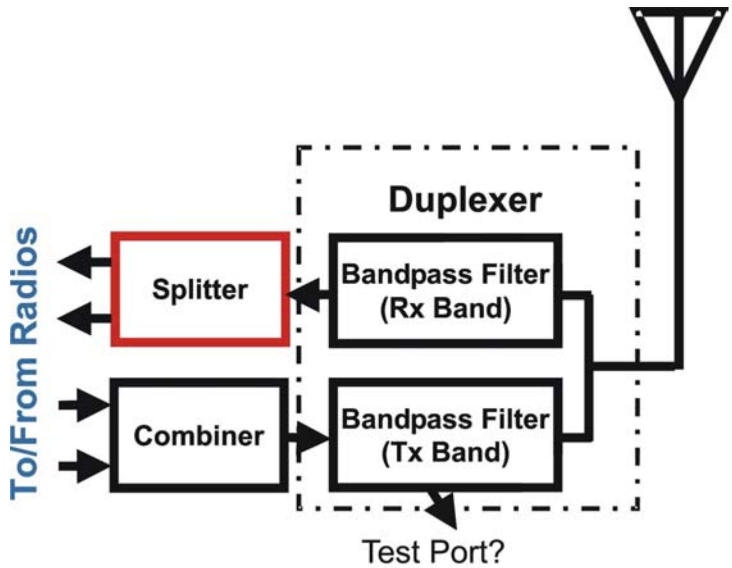


Figure 3.12a: Power Splitter

Common power splitter faults include:

- Amplifier faults, if amplified
- Impedance mismatches
- Lack of isolation, which allows signals to mix, causing Intermodulation Distortion. This can be caused by damage to a terminating resistor.
- Dirty connectors and bad cables that lead to:
    - Power loss
    - Incorrect frequency response
    - Intermodulation Distortion

Power Combiners A power combiner is illustrated in Figure 3.12b. A combiner is the opposite of a splitter. While matching impedances, they combine two RF signals to form a single signal path. AMPS, IS-136, or GSM base stations often use combiners on the transmit side, allowing transmitters to share antennae. It is interesting to note that a passive combiner and a passive splitter may be the same device, used in a different application. Wilkinson combiners, like splitters, produce a 3 to 4 dB loss per two combined signals. Combiners used on the Tx side of a base station do not normally include amplification.

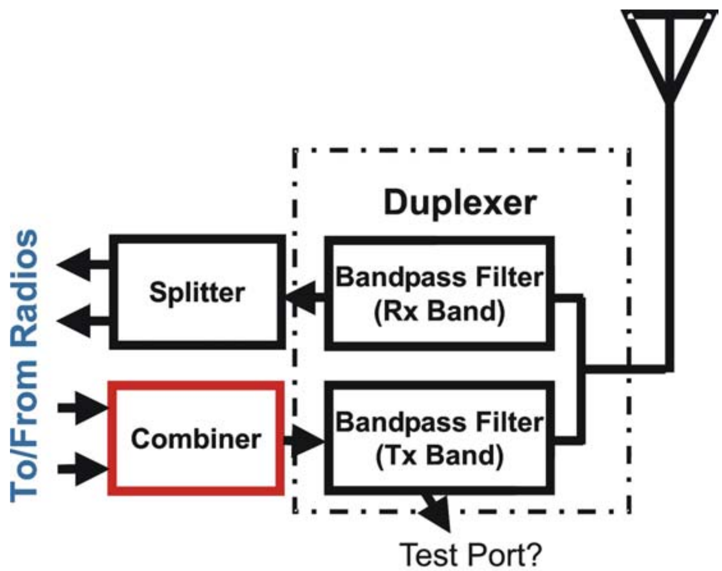


Figure 3.12b: Power Combiner

Common power combiner faults include:

- Impedance mismatches
- Lack of isolation, which allows signals to mix, causing Intermodulation Distortion. This can be caused by damage to a terminating resistor.
- Dirty connectors and bad cables that lead to:
    - Power loss
    - Incorrect frequency response
    - Intermodulation Distortion

Intermodulation Distortion

A common problem that affects base stations is Intermodulation Distortion (IMD). When two or more signals are in the presence of a non-linear device such as a diode, transistor, or rust, which creates IM products, mixing can occur. One common cause of IMD is overloaded amplifiers, which create harmonics. Since the harmonics are already in the presence of non-linear devices, such as transistors and diodes, IMD can easily be created. Overdriven mixers also exhibit excessive IM. Corrosion or rust can create crystals, which act as diodes, and so may cause unintentional mixing if two or more RF signals are present.

Unintentional mixing can occur wherever a diode, which is formed by crystals, and two RF signals are found. Examples of unintentional mixers include corroded connectors, rusty fences, rusty roofs, and even the transistors at the output of an RF amplifier. A crystal and two RF signals can cause unintentional mixing.

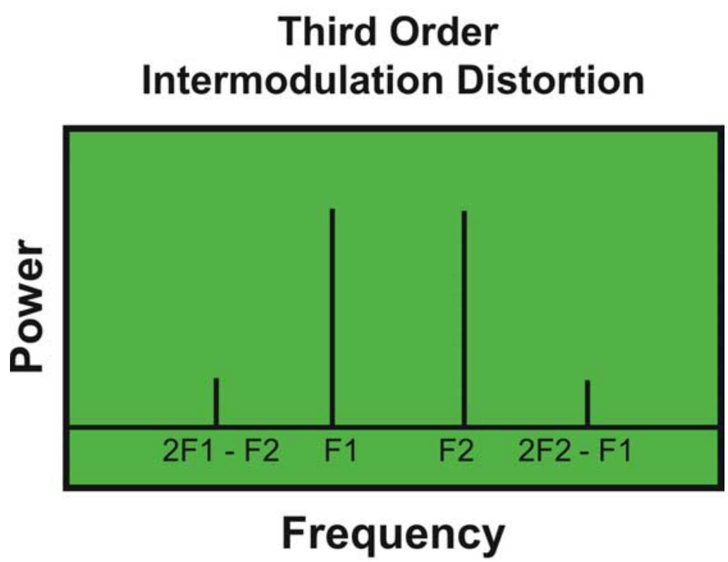


Figure 3.13: Intermodulation Distortion

It is only fair to note that IM due to corroded connectors or other rust is only common in areas that combine high humidity with salt air. Oil platforms in the Gulf of Mexico are an excellent example of a geographic area particularly susceptible to this “rusty bolt” phenomena.

Spectral regrowth is a term used for a specific type of Intermodulation Distortion. When a broadband or digitally modulated signal experiences IM it is known as spectral regrowth. Spectral regrowth occurs in the skirt areas as shown in Figure 3.14. This type of distortion originates from mixers or even from unintentional mixers.

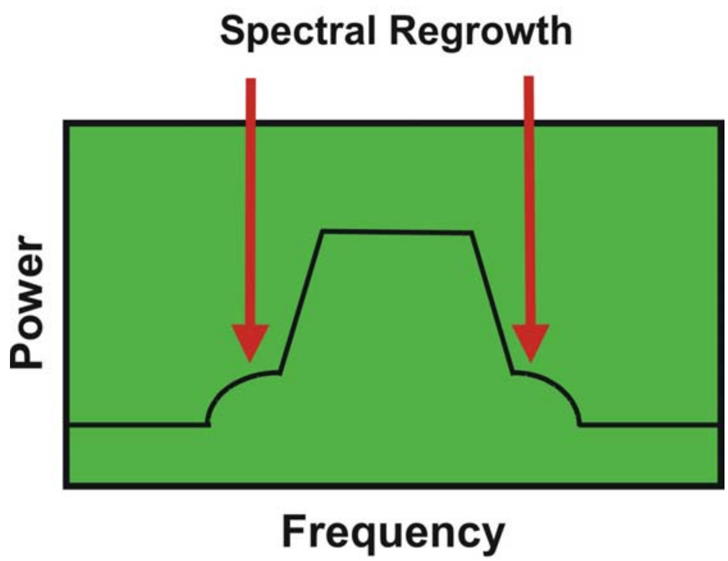


Figure 3.14: Spectral Regrowth

Section Summary In this section, we looked at the various RF components of a generic BTS. Up-converters change the IF frequency to RF channel frequency. An up-converter consists of a mixer, an LO, and a bandpass filter. An amplifier boosts the power level of the signal. Duplexers allow the transmitter and the receiver to share an antenna without damaging the receiver. Duplexers also limit transmitted and received signals to the intended bands. Splitters divide signals, allowing one signal to drive two loads while matching impedances. This ensures that reflections are eliminated. Splitters are of two types, active and passive. Combiners combine two RF signals to form one signal path.

3.1.2 Measured Parameters of a GSM Signal

The YBT250 is used to troubleshoot interference and transmitter-related problems in a BTS. Troubleshooting involves measuring various parameters of the transmitted signal and making decisions based on those measurements.

The parameters that are measured in a GSM BTS are:

- RF Channel Power
- Carrier Frequency Error
- Occupied Bandwidth

In this section, each measurement is discussed and defined. In addition, common guidelines for error limits are given, the consequences of exceeding the limits are explored, and common results of limit violations are given.

Before measuring the GSM parameters, the YBT250 measurement limits should be enabled and set up. The proper screen can be reached by either pressing the measurement readout and the Change button or by pressing the Edit button and then the Limit tab.

After the measurement limits are enabled, limit violations are identified with an audible beep and red arrows. This beep can be turned off on the limits screen, if required.

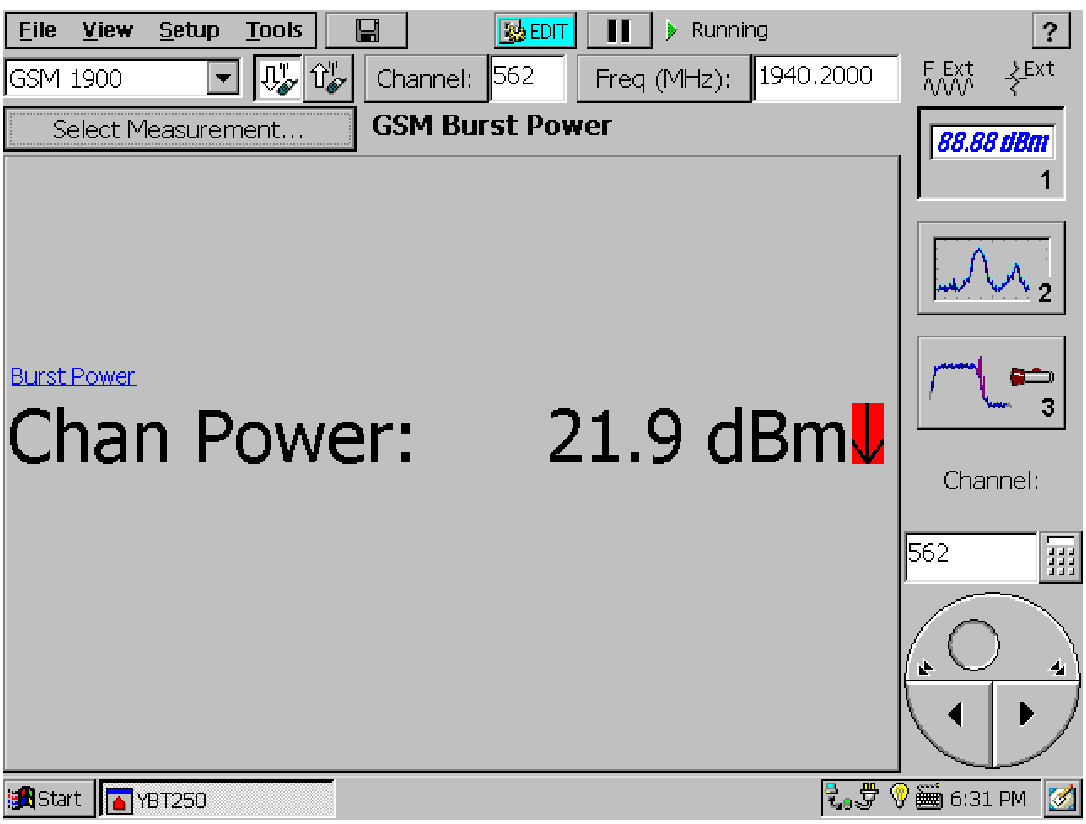


Figure 3.15: Setting Up the YBT250

RF Channel Power

Definition Channel power is measured during a timeslot (or burst) of the BTS. The YBT250 prefers to measure GSM power during a burst. In the absence of bursts, the YBT250 measures the average power of a signal transmitted by the BTS and puts a message on the screen stating that it could not find a burst. This message may show up if measuring a GSM control channel, which is not required to burst. It is a good idea to measure power with a known signal.

Guideline Channel power should be set up as specified in the base station RF calibration procedure.

Consequences Compression and other distortions are caused when the channel power exceeds the specified limits. Coverage area is reduced when the channel power drops below the specified limits.

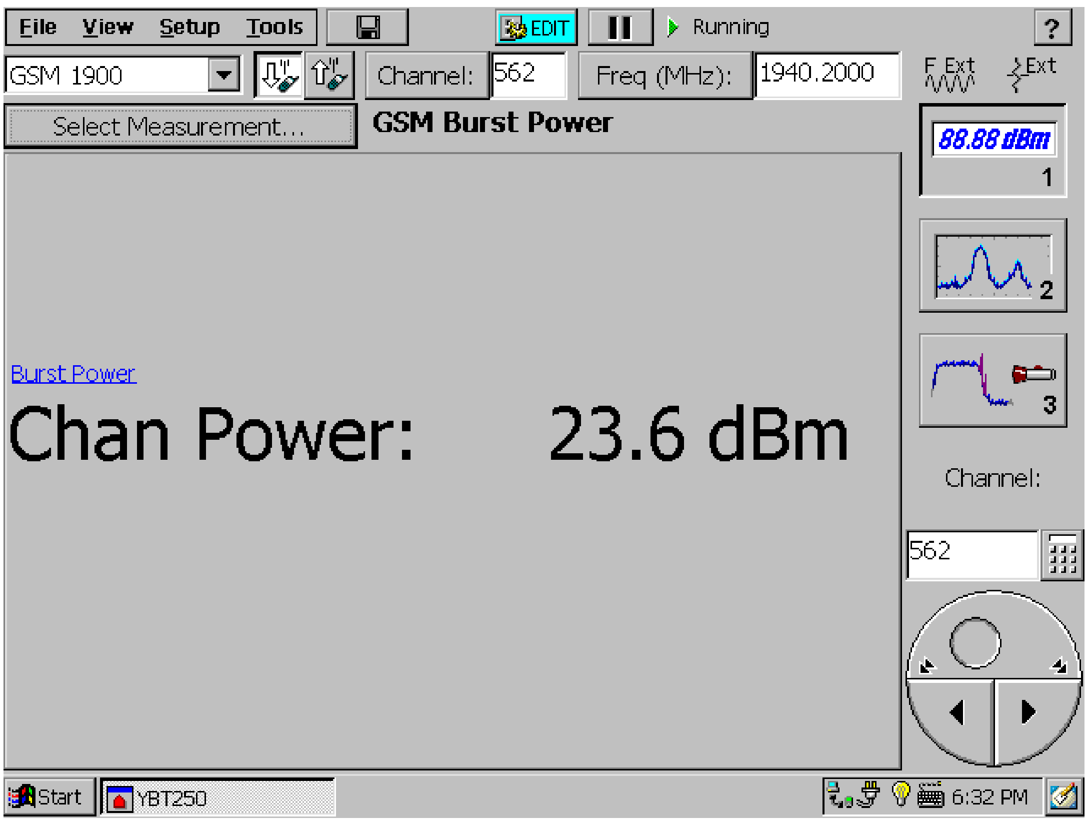


Figure 3.16: RF Channel Power

Common Faults

- An error in RF amplifier gain calibration: The amplifier gain calibration needs to be accurate.
- Cable faults. Cables can cause losses if they are corroded, kinked or compressed, or are improperly attached.

Carrier Frequency Error

Definition Carrier Frequency Error is the difference between the specified and the actual center frequency. The Carrier Frequency Error screen is shown in Figure 3.17.

Guideline 0.05 ppm, or approximately 98 Hz for GSM1900.

Consequences Carrier Frequency Error reduces the quality of service. It also pollutes adjacent RF channels.

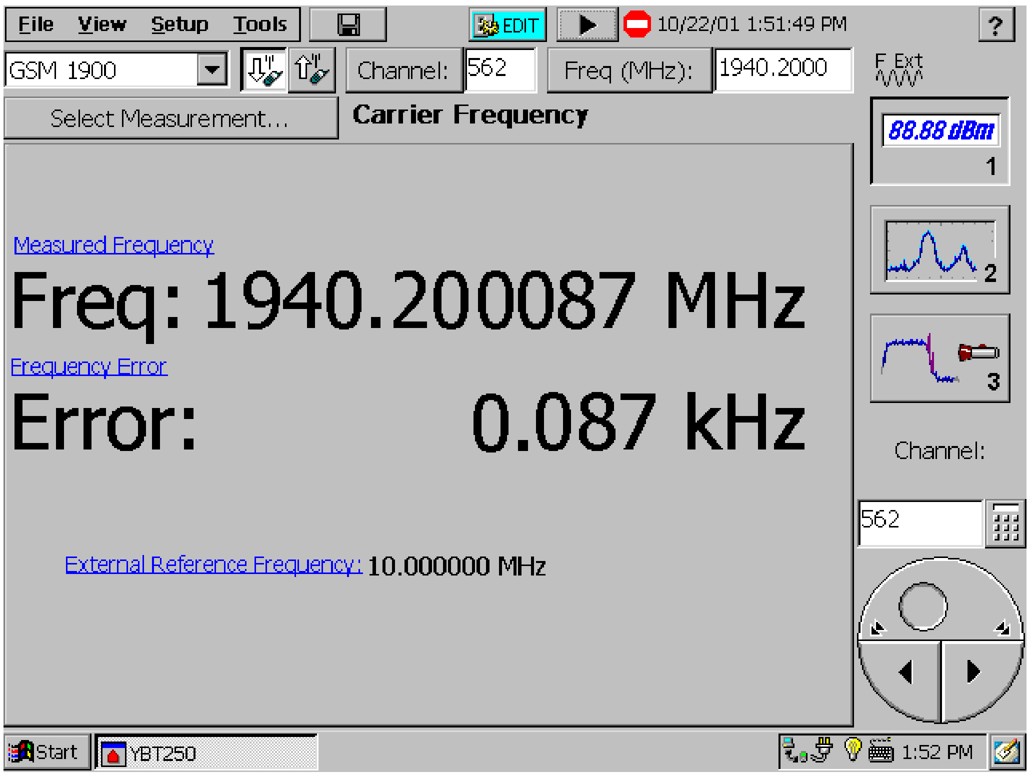


Figure 3.17: Carrier Frequency Error

Common Fault Carrier frequency error may be caused by an inaccurate BTS frequency reference or a local oscillator referenced to the frequency reference. While the frequency reference may not always be brought out to an external jack on GSM base stations, it may be accessible in other ways.

Errors in the YBT250's reference frequency can be corrected by using the Frequency Correction utility, as explained below. By comparing the carrier frequency error measured when using the BTS reference frequency and the measurement made when using the YBT's internal corrected reference values, inferences can be made regarding the accuracy of the BTS reference.

Frequency Correction

A high-accuracy frequency reference source may not be available at all sites, or may be of questionable accuracy. To ensure accuracy in frequency measurements, custom correction factors for the YBT250’s internal reference can be created using the Frequency Correction utility. This utility compares the YBT250 internal frequency reference to a known good external reference and then calculates correction values to align the internal frequency standard with the external reference.

The Frequency Correction utility should be run only if a high-quality frequency reference source is available for use. The reference source frequency accuracy directly affects the accuracy of the frequency correction values. A poorly calibrated reference source can significantly degrade measurement results.

The Frequency Correction menu offers the option of choosing either the newly generated correction values or the original factory-generated values. Corrected values can be very useful when at a remote site.

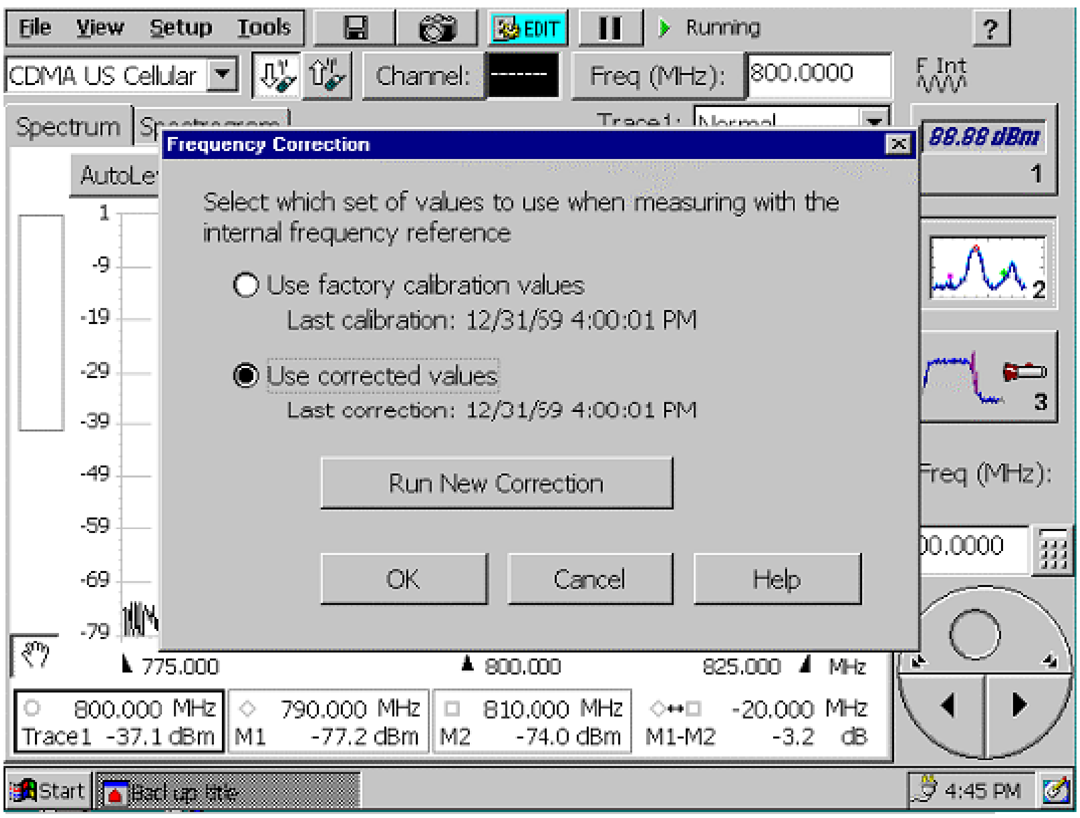


Figure 3.18: Frequency Correction Utility

To run the Frequency Correction utility:

1. Connect a frequency reference signal to the frequency reference input.
2. Allow the YBT250 to warm up for at least 10 minutes, preferably longer.
3. Follow warm up directions for the frequency reference.
4. Select **Tools->Frequency Correction**. This displays the Frequency Correction dialog box.
5. To calculate new frequency correction values, tap **Run New Correction**. This displays another dialog box.
   - If the reference frequency is detected, the frequency appears in the dialog box.
   - If the reference frequency is not detected, "--" will appear instead of a frequency.
     - If the reference frequency is not displayed, check the connection to the external frequency reference.
6. If the reference frequency is detected, tap **Finish** to calculate new frequency correction values.

   If the calculation of new frequency correction values is successful, a dialog box appears stating that new values were calculated and saved.
7. Tap **Close**. This will display the **Frequency Correction** dialog box again.

To use the new frequency correction values, select **Use Corrected Values**, and then tap **OK**.

Frequency Correction will allow the YBT250 to be accurate to ±10 Hz plus the error of the reference used for the calibration under warmup and ambient temperature conditions similar to those at the time the correction was taken. Consideration also must be given to drift due to ageing, which is less than 1 ppm per year, or 2.5 Hz per day at 900 MHz.

Occupied Bandwidth

Definition Occupied Bandwidth is the RF bandwidth used by the transmission.

Guideline 99 percent of the power should be within 200 kHz to 300 kHz bandwidth.

Consequences If this limit is exceeded, then the RF signal may interfere with the RF signals in adjacent RF channels. In addition, exceeding the occupied bandwidth reduces system capacity.

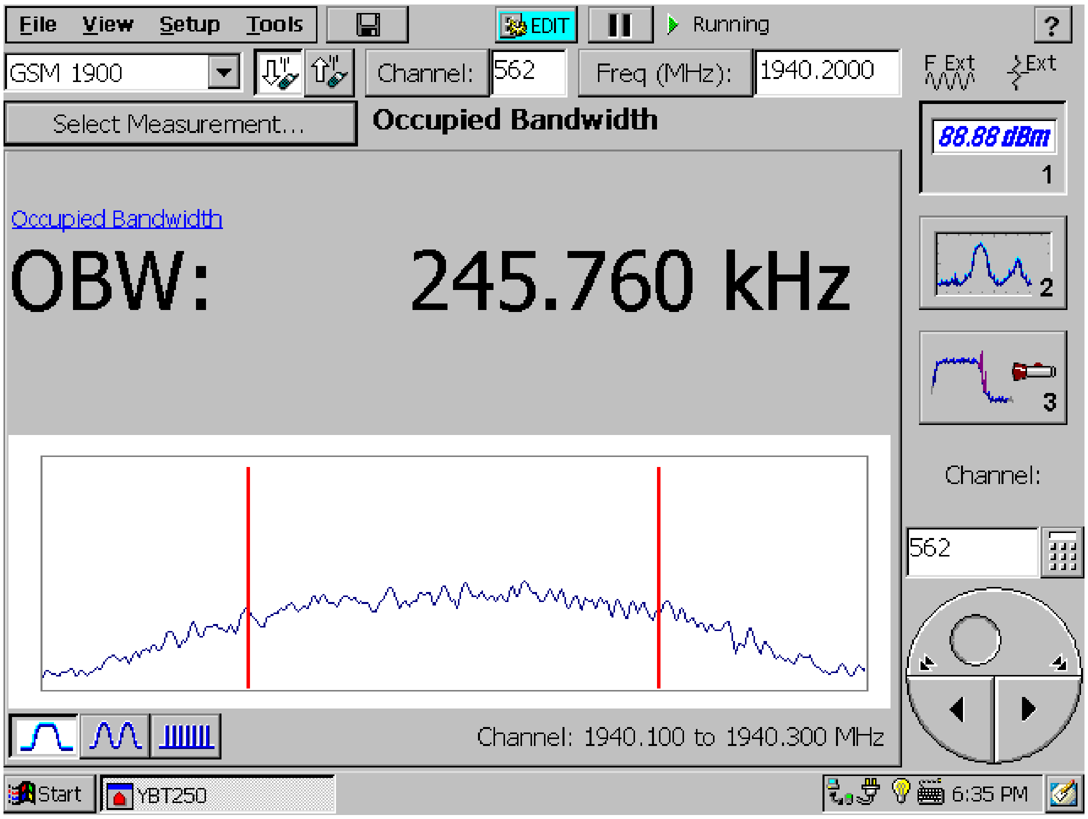


Figure 3.19: Occupied Bandwidth

Common Fault The common faults that cause the Occupied Bandwidth to exceed are:

- Faulty mixers
- Unintentional mixers

3.2 Spurious Signals Within Base Stations

Base station RF signals are processed by a variety of devices, such as mixers, bandpass filters, and RF amplifiers. When these devices malfunction, signals distort, which results in spurious signals within the base station. In addition, some spurious signals, or spurs, may have a source external to the base station. In this section, we will discuss how to locate spurs.

At the end of this section, you will be able to:

- Describe sources of spurs internal to base stations.
- Describe appropriate troubleshooting techniques to find these spurs.

3.2.1 Internal and External Sources of Spurious Signals

While it is not possible to develop a specific procedure for troubleshooting a generic base station, general guidelines can be developed. As part of the troubleshooting tool set, all the RF measurements that have been discussed so far can be used at different places throughout the RF path. This includes the top of an antenna tower, the base of a tower, the output of a splitter, near a duplexer, at a test port, the output of an RF amplifier, or an IF stage.

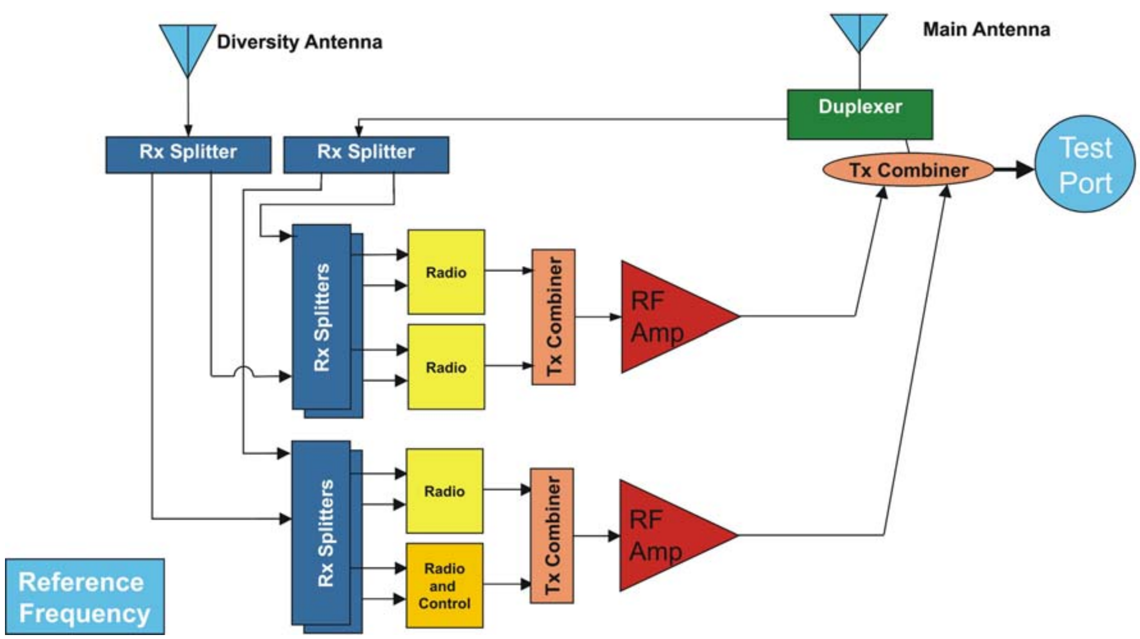


Figure 3.20: RF Section of a BTS

Spurious emission sources can be broadly categorized into:

- Sources internal to the base station
- Sources external to the base station

Internal Sources

Internal sources can be further classified into:

- Noise from a switching power supply
- Compression or clipping of IF signals
- Compression or clipping of RF signals
- Corroded connectors
- Faulty shielding
- Frequency reference instability
- Digital noise
- Phase noise
- Ground loops

Let's discuss each of these spur sources.

Noise from a switching power supply Interference from a switching power supply has a distinct signature. Switching power supply may switch between a 20 and 150 kHz rate. This will create strong harmonics at an interval that corresponds to the switching frequency, or twice the switching frequency. It is possible that this signal may leak out of the supply and into the IF or RF stages. The signature of this sort of problem is a distinctive set of harmonics at an interval of the switching frequency or twice the switching frequency.

Compression or clipping of IF signals Compression or clipping on an IF signal will generate a set of harmonics separated by the IF frequency or twice the IF frequency. While the harmonics will likely be filtered out, this will still lead to a loss of power in the IF stage. In addition, reflections from the filter may produce IM distortion. The distinctive signature of this sort of problem, when looking at an IF signal, is a set of harmonics spaced at the IF frequency or twice the IF frequency and the same spectral regrowth that happens at the output. When looking at the transmitter output the signature of this IF fault will be low power and spectral regrowth, which leads to occupied bandwidth violations.

Compression or clipping of RF signals Compression or clipping in an RF stage can generate a set of harmonics at even and/or odd multiples of the RF frequency. The distinctive signature of this fault, when measuring at the output of the RF amplifier, is the presence of harmonics that are multiples of the RF carrier frequency. If these harmonics get to the antenna, they are of interest to government regulatory agencies because they can interfere with other transmissions. If filtered out by a channel filter or duplexer, the rejected harmonics may only be evident from the spectral regrowth and increase in occupied bandwidth they cause.

Corroded connectors Corroded connectors that are internal to the base station can cause internal interference. As discussed in the section on unintentional mixing, corrosion can form crystals that may combine or mix two signals to produce a greater number of frequencies. To check for connector corrosion, disconnect the cable and then reattach it. If the connector is corroding, unfastening and reattaching the connector may cure the problem for a few months. If fiddling with cables corrects a problem, be suspicious of the cables. This problem is most prevalent in areas of high humidity with exposure to salt air.

Faulty shielding Another potential cause of interference is faulty shielding. You detect this by putting a sniffer antenna on the YBT250 and moving it around the base station. To make a sniffer antenna, cut one end from a piece of an old coaxial cable, separate the braid and core for about 4 centimeters, and make a loop of the two ends with a diameter of approximately 2 centimeters. Solder the braid and center conductor for best results.

Frequency reference instability Occasionally, frequency references experience instability, or loss of phase lock, which results in multiple "reference" signals at a variety of frequencies close to the nominal reference. The original reference may or may not be present. The signals resulting from this instability may become interference. Frequency reference instability will also affect the base station directly if the base station boards can no longer lock to the reference.

Digital noise Digital signals containing a number of harmonics are present in a base station. These signals may cause spurs by entering the LOs, reference frequencies, and other RF sources. The signature of digital noise in an IF or RF signal is likely to be excessive phase noise. Phase noise looks a lot like spectral regrowth when viewing it with a spectrum analyzer, but it can occur on sine wave signals, not just broadband signals.

Local oscillator phase noise or instability Local oscillators can also produce interference. Local oscillators can generate phase noise, harmonics, or Intermodulation Distortion. Any of these faults may be passed on to the next RF stage. Local oscillators also can experience phase lock problems similar to the reference frequency problem described above.

Ground loops Ground loops are caused by a combination of resistance in the ground path and a magnetic field. When an induced signal flows through ground paths and meets with resistance, small voltages are created. These induced voltages can cause noise by influencing other circuits. This is why it is important to keep ground connections tight and free of corrosion. A common source of induced current is AC line voltage. This is known as 50 cycle or 60-cycle hum in some applications. AC hum is always a concern when the base station is located near a high voltage AC power transmission line, because of the strong magnetic fields that accompany power transmission.

External Sources

External sources of spurs can be further classified into:

- Power lines
- Co-located transmitters
- External corrosion
- Other Electro-Magnetic Interference sources (EMI)

Now, let's discuss each of these external interference sources.

Power lines High voltage power lines can be a source of induced currents. Currents through resistive, or poor grounds can generate spurs.

Co-located transmitters If co-located transmitter carriers or harmonics of those carriers are within the transmit band of the base station, another transmitter's signal can enter the transmit antenna of the base station. The interloping signal can then reach the transistors, diodes, or other non-linear devices in the output stage of the base station's RF power amplifier. When the spurious signal reaches a transistor junction, which is similar to a diode junction, unintentional mixing products can be generated.

External corrosion External corrosion, such as rusty wires, bolts, fences, or roofs can also cause unintentional mixing. For example, a pager operating at 931 MHz and a co-located cellular band transmitter operating at 890 MHz may mix with crystals formed by rust or corrosion to form a difference product at 849 MHz. 849MHz is within the upper range of the cellular base station receive band. It is important to be aware of the possibility of unintentional mixers when looking for interference. Areas with high humidity and salt air may experience this problem.

Other EMI sources EMI sources, such as lightening, harmonics of broadcast stations, and faulty automobile ignition systems, may cause interference.

3.2.2 Common Receive Path Troubleshooting Techniques

Two commonly used receive path troubleshooting techniques are:

- Receive channel signal tracing
- Rx noise floor check

Receive Channel Signal Tracing

It is possible to trace a signal through the receive channel. A safe signal, such as a –80 dBm sine wave at the receive frequency, may be injected at the antenna, or at a jumper at the base of the tower. This signal is traced through the combiners, duplexers, and other circuitry all the way to the receiver. If the power levels at various spots are known from prior measurements on a known good base station, this technique can be powerful.

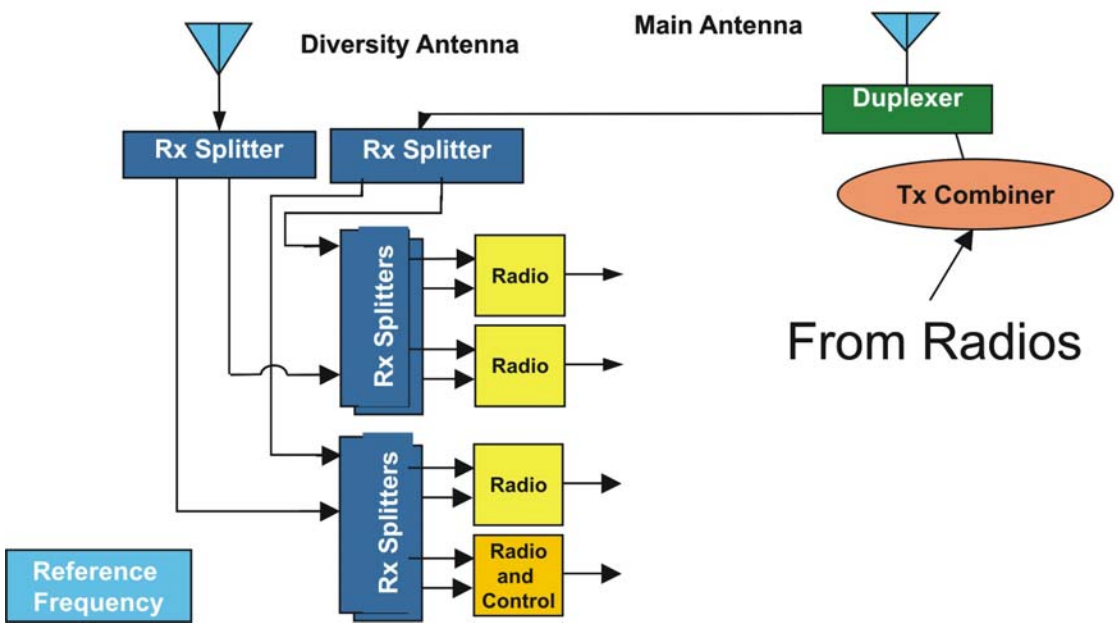


Figure 3.21: RF Receive Section of a BTS

Rx Noise Floor Check

The receive Noise Floor Check is performed to measure the noise level in the Rx environment. The Noise Floor Check is one of the signal identify screens, as shown in Figure 3.22.

This measurement is best made using the redundant receive antenna, if present, in the base station. The use of the receive antenna ensures that the noise floor measurement corresponds to the actual reception environment. –116 dBm indicates an ideal receive environment.

To make the most use of this measurement it is important to know the noise floor in good conditions. 3dB changes in the noise floor can make a significant difference in reception range.

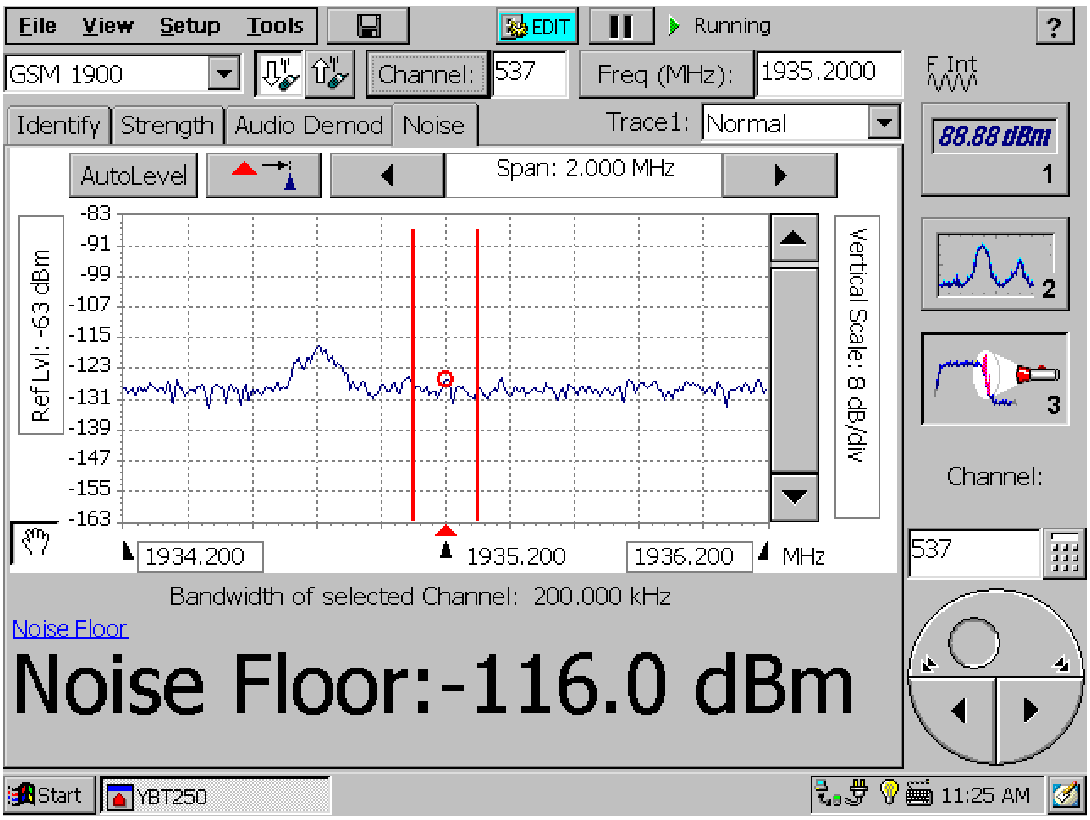


Figure 3.22: Noise Floor Screen

Summary

In this module, you learned that a BTS functional block diagram contains the following RF components.

- Radios that produce a low-level RF signal.
- Up-converters, which consist of:
  - Bandpass filters that allow only a specific set of frequencies to pass through.
  - Mixers that combine two frequencies to produce four frequencies, including the sum and difference frequencies.
  - Local Oscillators that provide one of the two frequencies to be combined.
- Amplifiers that increase the power of a signal.
- Duplexers that route, transmit, and receive signals.
- Splitters that allow signals to split into two or more paths.
- Combiners that combine signals from two or more paths into one path.

You also learned about various measurable parameters of a GSM BTS.

The parameters measured in a GSM BTS are:

- RF Channel Power, which is the average RF power in one slot of a GSM signal.
- Carrier Frequency Error, which measures the accuracy of the carrier frequency.
- Occupied Bandwidth, which measures the amount of RF bandwidth that the final signal uses.

All these tests and checks ensure that base stations have the highest quality of service and call capacity.

In addition, several possible sources of spurs, or interference, were discussed.