5. Alignment and Testing

The MX800 test and alignment procedures are divided into two main sections. The first section is a transceiver level procedure which assumes that the radio is fitted with working modules. The second section contains the individual module test procedures.

5.1. Transceiver Setup, Calibration and Alignment

This section explains how to setup, calibrate and align the complete MX800 Base Station.

A number of procedures are required to fully initialise the MX800. The following test equipment will be needed:

1.0 MXTOOLS (MX800 Base Station Programming Utility)
2.0 MXTOOLS User Manual
3.0 RF Test Set (HP 8920) or equivalent
4.0 CRO (Cathode Ray Oscilloscope)
5.0 RF Power Meter (Watts)
6.0 RF Signal Generator
7.0 Multimeter
8.0 +13.8 VDC @ 15 amp power supply

The order of some, but not all, of the procedures is important to ensure correct setup of the radio. The order of the procedures as described is recommended and those that are critical are mentioned. If the radio has been previously setup and the dealer intends to recalibrate and align the radio then steps 5.1.1, 5.1.2 and 5.1.3 can be ignored as the model number, serial number, configuration and channel information will have already been loaded.

5.1.1. Sending Model Number and Serial Number to the Radio

The model number is entered or updated using MXTOOLS. To edit the model number select 'Radio Model Number', under the 'Setup' menu. This brings up a dialog box that the dealer can then enter the model number, according to the configuration of the radio.

(Refer to the *MXTOOLS User Manual* for additional help)

The dealer cannot alter the serial number as this is factory set.

5.1.2. Sending Configuration Information

Firstly the configuration file for the radio needs to be setup. Using MXTOOLS the configuration information needs to be filled out on the Configuration Screen. This information needs to be saved to a configuration file. If an existing radio already contains the desired configuration then this configuration can be downloaded and saved. This configuration information then needs to be 'Sent to the MX800'. (Refer to the *MXTOOLS User Manual* for additional help) A warning message will appear that indicates that the MX800 Base Station has not yet been calibrated, this may be ignored.

Once the configuration information has been sent then all of the programmable parameters within the MX800 Base Station are initialized.

5.1.3. Sending Channel Information

The channel information setup is similar to that of the configuration. The channel frequencies, subtones and other parameters are setup in the Channel Screen in

MXTOOLS. At this stage it is not necessary to set the values of the digital potentiometers. This will be done in the following procedures. After entering in the channel details this information then needs to be saved to a file. If another radio already contains the desired frequencies then these can be downloaded from that radio and saved to a file. The digital potentiometer values from one radio to the next will differ so it is advisable to save the information in a new channel file and not save over the top of any backup copies of existing radios. The saved channel information is then sent to the MX800. (Refer to the *MXTOOLS User Manual* for additional help)

After sending the configuration and channel information the MX800 is fully programmed and will now operate. Without sending both the configuration and channel information the radio will not function, and thus the following procedures will not be able to **be** completed.

Note: The buttons for sending and loading of channel information may be disabled if MXTOOLS did not successfully 'Connect to MX800'. If this is the case simply choose to 'Connect to the Radio' after the configuration information is sent.

5.1.4. Setting Alignment Channel

When setting up the radio it is recommended that all measurement and adjustments are done on a channel that is in the center of the frequency spread of the channels. This minimizes any errors due to frequency changing. Alternatively if the frequency spread of

the channels is too large then you may wish to calibrate and align every channel. (In most cases this will not be necessary.) Both individual and group alignment will be covered.

The channel may be selected via the Channel Screen in MXTOOLS using the software channel select or in hardware via the internal channel dip switch or via the rear channel select. (Refer to section 2.2.2.3 for additional help.) This channel will then be used when performing the following procedures.

5.1.5. Power Calibration

Power calibration affects the forward and reflected power meters on the Diagnostics Screen as well as the low forward power trip point for the MX800. This procedure requires a power meter and the relevant leads to connect the transmitter output to the meter. Power calibration is done using MXTOOLS via the Calibration Screen. To complete the power calibration follow the instructions that MXTOOLS provides. (Refer to the *MXTOOLS User Manual* for additional help.)

Once power calibration has been completed the configuration information must be sent again. Check that the low forward power trip point is set correctly. The calibration affects the low forward power trip point and thus the configuration information must be sent to update it according to the new calibration information.

5.1.6. RSSI Calibration

The RSSI calibration is used to calibrate the RSSI meter on the MXTOOLS Diagnostics Screen. The procedure requires an RF signal generator and the relevant leads to connect the signal generator to the RF input of the MX800 Base Station. RSSI calibration is done via the MXTOOLS Calibration Screen. To complete the RSSI calibration follow the instructions that MXTOOLS provides. (Refer to the *MXTOOLS User Manual* for additional help.)

5.1.7. Temperature Calibration

The temperature calibration is used to calibrate the temperature meter on the MXTOOLS Diagnostics Screen and the temperature controlled switch/alarm points. The procedure requires dummy cable for SKB on the micro controller having a 2045 ohm resistor between pins 4 and 6 of this connector on the MX800 Base Station. Temperature calibration is done via the MXTOOLS Calibration Screen. To complete the temperature calibration follow the instructions that MXTOOLS provides. (Refer to the *MXTOOLS User Manual* for additional help.)

5.1.8. TX Power Setup

The transmitter power setup is used to set the correct power for each channel. This can be done on a per channel basis or all channels can be set at once. Power setup is done using the Channel Screen in MXTOOLS. To complete this test the transmitter output needs to be connected to a power meter.

To set all channels **at** once select the 'Lock Data' option on the Channel Screen. Click On the alignment channel to bring up the Channel Edit Screen and allow editing of the channel parameters,
Note.' If the 'Lock Data' option is selected then any changes made to the current channel are duplicated on all channels.

Select the 'Continuous Update' option on the Channel Edit Screen. This allows real time updating of the potentiometer values to the radio. Thus any changes made will be immediately reflected in the radio. Alter the Transmit Power potentiometer until the power meter reads the required output power. Choose 'OK' to accept the changes made and then from the Channel Screen choose 'Send Data to MX800'. This then saves the changes that you have made to the radio.

To calibrate each channel individually make sure the 'Lock Data' option is not selected and repeat the above procedure for each channel.

5.1.9. Peak Deviation and Modulation Balance Alignment

This procedure is used to set the peak deviation and modulation balance for each channel.

This can be done on a per channel basis or all channels can be set at once. The alignment done using the Channel Screen in MXTOOLS. To carry out this procedure the demodulated output of the transmitter output needs to be connected to a CRO or some other piece of equipment giving a visual display of the demodulated output. IF Bandwidth of the RF test set should be set at 20kHz or greater (230kHz on the HP 8920) and deemphasis should be off. The audio filters should be set at <20Hz HPF and 15kHz LPF.

To alter all channels at once use the 'Lock Data' option as described in the power setup procedure. The correct peak deviation is dependent on whether the radio is narrow, medium or wide band and also whether the CTCSS option is installed. The following table specifies the peak deviation in each case.

Bandwidth	CTCSS Option	Peak Deviation (Hz)
narrow (12.SkHz spacing)	YES	2150
	NO	2400
medium (20kHz spacing-US)	YES	4300
	NO	4800
wide (25kHz spacing)	YES	4300
	NO	4800

Table 1 - Peak Deviation Settings

The setting of the peak deviation is done at 1 kHz for the standard build and 400Hz for the E1A build. If the board is an EIA build this is noted on the motherboard. The modulation balance for both builds is done at 400Hz. The transmitter modulating audio for this test is connected to the WB/DC-FM input with JMP8 set to I-2. This input is located on the rear of the MX800, on the Line I/O connector pin 13 of the DB15F connector. (Refer to section 6.1.1 for additional help.)

Procedure

i) Disable the CTCSS if present. This is either done through the digital input port at the rear or temporarily disabling it in the Channel Information Screen.

ii) PTT transmitter.

iii) Set the transmitter modulation frequency to lkHz, +10dBm, injected in through the WB/DCFM input with JMP8 set to 1-2.

iv) Adjust the VCO Deviation digital potentiometer using MXTOOLS until the correct deviation is obtained. (See Table 1- Peak Deviation)

v) Set the transmitter modulation frequency to 400Hz, +10dBm, injected in through the WB/DCFM input.

vi) Adjust the Reference Deviation digital potentiometer until the top of the waveform is flat. If the waveform top droops increase the level (see Figure 1) and if it peaks reduce the level (see Figure 2).

vii) Set the transmitter modulation frequency to either 400Hz / lkHz depending on the build, +10dBm, injected in through the WB/DCFM input.

viii) Repeat steps iv) through to vii) until the correct peak deviation and modulation balance is obtained.

Examples of incorrect, observed waveforms are as follows:

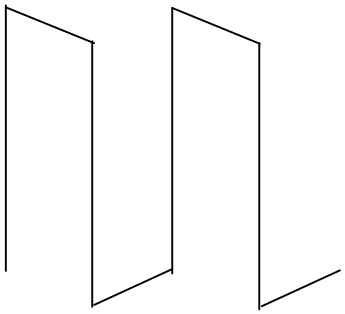

Figure 5-1 - Under (increase level)

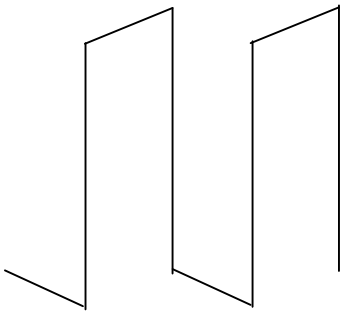

Figure 2 -Over (decrease level)

The waveform when correctly aligned should look as follows:

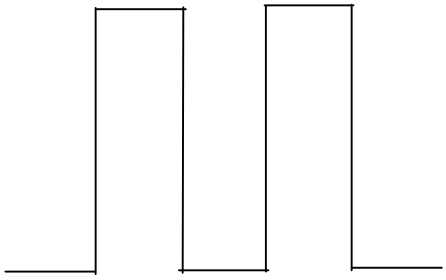

Figure 3 - Correctly Aligned Waveform

Choose 'OK' to accept the changes made and then from the Channel Screen choose 'Send Data to MX800'. This then saves the changes that you have made to the radio.

After balancing and setting the correct peak deviation is necessary to align the reference oscillator and re-check the deviation alignment, as the reference oscillator alignment affects the deviation. This may require running through the deviation alignment again after the oscillator alignment procedure.

5.1.10. TX Center Frequency Alignment

The reference oscillator alignment is used to set the correct center frequency for each channel. This can be done on a per channel basis or all channels can be set at once.

Oscillator alignment is done using a digital potentiometer adjustment through the Channel Screen in MXTOOLS. To carry out this procedure the transmitter output needs to be

connected to a RF test set displaying the frequency error. This procedure should be done after the deviation alignment procedure has been done. Transmitter modulation should be disabled.

To alter all channels at once use the 'Lock Data'•ption as described in the power setup procedure. Alter the Reference Oscillator Frequency potentiometer until the channel is "on frequency". Choose 'OK' to accept the changes made and then from the Channel Screen choose 'Send Data to MX800'. This then saves the changes that you have made to the radio.

To calibrate each channel individually make sure the 'Lock Data' option is not selected and repeat the above procedure for each channel.

5.1.11.TX Line Input Level and Nominal Deviation Alignment

There are three manual potentiometers associated with the TX deviation on the motherboard. These are set by injecting the correct audio levels and adjusting the potentiometers. The transmitter modulating audio is to be connected to either the WB/DC-FM input or the TX VF input as described in the procedures.

The required nominal deviation is dependent on whether the radio is narrow, medium or wide. The following table lists the required level for each case:

Bandwidth	**FM Deviation** (kHz)
narrow (12.5kHz spacing)	1.5
medium (20kHz spacing-US)	3.0
wide (25kHz spacing)	3.0

Table 2 - Nominal Deviation

The first potentiometer sets the TX Limiter Gain. The transmitter modulating audio for this test is connected to the WB/DC-FM input with JMP8 set to 1-2. This input is located on the rear of the MX800, on the Line I/O connector pin 13 of the DB 15F connector.

(Refer section 6.1,1 for additional help,)

Procedure

i) PTT the transmitter.

ii) Set the transmitter modulation frequency to lkHz, at 1V pk-pk injected in the WB/DC-FM input.

iii) Adjust TX Limiter gain RV2 to obtain to obtain the nominaI deviation. (See .Table 2 - Nominal Deviation)

The second potentiometer sets the TX VF line input level. The transmitter modulating audio for this test is connected to the TX VF input. This input is located on the rear of the MX800, on the Line I/O connector pin 9 of the DB15F connector. (Refer section 5.1.I for additional help.)

Procedure

i) PTT the transmitter.

ii) Set the transmitter modulation frequency to lkHz, at nominal line input level (-10dBm is default level) injected **in** through the TX VF input.

iii) Adjust TX VF gain RV4 to obtain to obtain the nominal deviation. (See Table 2 - Nominal Deviation.)

The third potentiometer sets the TTR Gain.

Procedure

i) Remove TX PTT.

ii) Enable the repeater. The repeater may be enabled by turning on switch 4, of DIP2, inside the radio. Alternatively the repeater may be enabled/disabled via the repeater enable pin 8 of the Line I/O connector. The polarity of the repeater enable function is dependent on how the internal LIFUISEN jumper is set (JMP9).

iii) Set the receiver modulation frequency to I kHz and the FM deviation to that specified in Table 2 - Nominal Deviation, for the particular RF receive frequency of the test channel.

iv) Adjust TTR Deviation RV3 to obtain to obtain the same deviation as input to the RX. (See Table 2 - Nominal Deviation.)

Note: The test channel must be programmed as a repeater channel so this potentiometer can be setup. If not then temporarily alter the channel settings using the Channel Edit Screen in MXTOOLS.

5.l.l2 RX Line Output Level Adjustment

The fourth potentiometer sets the RX Line output level.

Procedure

i) Disable the repeater (switch SW4/DIP2 OFF).

ii) Using a 600ohm termination monitor RX line output level. Tl•is output is located on the rear of the MX800, on the Line I/O connector pin 9 of the DBI 5F.

iii) Set the receiver modulation frequency to I kHz and the FM deviation to nominal for the particular RF receive frequency of the test channel.

iv) Adjust Line Output level RV5 to obtain nominal line output level (-10dBm is the default level).

5.1.12.TX VF Loop Back Level

Under control of the TX VF Loopback Control line (LIFUSEN) the TX line input may be looped back to the RX Line output. The fifth potentiometer sets the loop-back level.

Procedure

Enable the TX VF loopback using JMP9.

Set the transmitter modulation frequency to lkHz, -10dBm, injected in through the TX VF input.

Adjust RV7 to obtain a RX Line output level of-10dBm.

Resore JMP9

5.1.13.Mute Threshold Setting

The Mute Threshold Setting is used to set the level at which the mute opens.

- Force the mute open using the Remote Screen in MXTOOLS.
- Inject the correct RF frequency into the receiver for the test channel.
- Set the receiver modulation frequency to I kHz at nominal deviation.
- Alter the amplitude of the RF signal until the RX audio has an 8dB SINAD.
- Set the mute back to normal using the Remote Screen in MXTOOLS.
- Adjust the mute level potentiometer, RV6, until the mute opens then wind it back until it just closes.

5.2. Module Level Test Procedures

The following alignment and testing procedures are based upon using a working transceiver as the test environment. It is also assumed that test fixtures to the radio are available to exercise control lines and monitor outputs and that a PC with MXTOOLS is connected to the radio.

There are four modules in the Mxg00 - the Exciter, Receiver, Power Amplifier and Micro Controller. The Exciter and the Receiver have VCO daughter boards. Receiver and Exciter VCOs are identical.

5.2.1. Exciter Module

Test Equipment:

- Tested MX800 with Exciter **removed**
- Tested TX VCO board (in wanted band)
- PC with MXTOOLS software
- RF Communications test set
- Multimeter
- Oscilloscope
- +13.8VDC power supply

Preliminaries:

* Program upper, middle and lower frequencies of band (refer section 5.4 for band split details) into 3 channels in MXTOOLS channel screen (Note that 'Continuous Update Enabled' on the MXTOOLS channel screen should be ticked for these tests).

– Remove top cover from Exciter module under test and fit known working VCO

tuned for the band to be tested.

– Connect Exciter to working Micro Controller via 16-way ribbon cable.

– Disconnect Exciter RF drive output CN 1 from PA.

Procedure:
1. Switch DC power on and check that the output voltage on pin 1 of IC5 is 5V +/- 0.2V and that the output voltage on pin 1 of IC3 and IC8 is 8V +/-0.2V. Assert PTT and check that the 8V is switched through to SKU-3.

2. Check reference oscillator signal on center pin pad of CN3 is > 3V pk-pk.

3. Select mid channel. Connect comms test set RF input port to CN 1. Assert PTT and check that Lock Detect (LD) on SKD-16 goes high indicating that the loop is locked.

Check that the power control volts on SKD-4 is > 10V ancl that the RF output on CN 1 is >300roW. In the channel screen on MXTOOLS adjust the power digipotentiometer slider to 0 and check that the power control volts on SKD-4 goes to 0 and that the RF power out drops to <lmW. Set digipotentiometer slider back to mid position.

4. Select lowest channel. Assert PTT, check that LD goes high and check that the VCO tuning volts on SKD-14 is > 2V. Select highest channel. Assert PTT, check that LD goes high and check that the VCO tuning volts on SKD-14 is <18V. Check that RF output is >300mW in both cases.

5. Select mid channel. Assert PTT, note RF output carrier frequency and check that by adjusting the Reference Oscillator Frequency digipotentiometer slider on the MXTOOLS channel screen that the carrier frequency can be adjusted + and - 3ppm of the nominal frequency.

6. Select mid channel. Assert PTT carry out steps 4.2.1.1 and 4.2.1.2 of the TX VF alignment procedure below to check the function of the VCO and Reference oscillator modulation inputs.

5.2.2. Receiver Module

Test Equipment:

- Tested MX800 with Receiver removed
- Tested RX VCO board (in wanted band)
- PC with MXTOOLS software
- RF Communications test set
- Spectrum analyser with tracking generator
- Multimeter
- High frequency (89.545MHz) pick up loop.

- Oscilloscope
- +13.8VDC power supply

Preliminaries:

– Program upper, middle and lower frequencies of band (refer section 5.4 for band split details) into 3 channels in MXTOOLS channel screen (Note that 'Continuous Update Enabled' on the MXTOOLS channel screen should be ticked for these tests).

– Remove top cover from Receiver module under test and fit known working VCO tuned for the band to be tested (refer section 4.5).

– Connect Receiver to working Micro Controller via 16-way ribbon cable.

Procedure:

The test procedure for the Receiver is divided into the front end alignment and the IF alignment procedures

Front End Alignment:

I. Switch DC power on. Check that the output voltage on pin I of IC8 is 5V +/- 0.2V, on pin 1 oflC2 is 8V +/-0.2V, on output of IC9 (on C66) is 8V +/- 0.2V and on pin 1 oflC3 is 9V +/- 0.2V.

2. Remove jumper E and D. Install jumper C. Connect tracking generator output to CN1 and spectrum analyser input to CN4. Set tracking generator to sweep the band.

Adjust A4, A 10 and A 16 for a symmetrical passband around the band center frequency. Check that the gain over the band is 12dB and that the ripple is <+/- 1.5dB. Check that the attenuation at the first IF image is >50dB.

3. Remove jumper C and I. Install jumper E and H. Connect tracking generator output to CN4 and spectrum analyser input to CN5. Set tracking generator to sweep the band. Adjust B4, B10 and B16 for a symmetrical passband around the band center frequency. Check that the maximum loss over the band is < 3dB and that the attenuation at the first IF image is >50dB.

4. Remove jumper E. Install jumper D. Connect spectrum analyser input to CN5 and tracking generator output to CN1. Set tracking generator to sweep the band. Check for symmetrical passband around band center frequency. Check that the gain over the band is 10dB and that the ripple is <l.5dB. Remove Jumper H. Install Jumper J.

IF Alignment:

1. Select the mid channel. Check that LD on SKD-16 goes high indicating that the synthesizer is in lock. Remove S3 (0gl local oscillator connection to mixer) and solder a 500 coax test lead across C60 position (note C60 position is near a retaining

screw and C60 is not fitted). Connect a comms test set to this lead and check that RF local oscillator power is +17dBm +/- 2dB. Measure local oscillator frequency, this should be Frx-90MHz(45 MHz for A2,A3 modules). Using a non metallic trimmer tool carefully adjust the TCXO (X2) frequency until the correct frequency is obtained. Remove the test lead and solder S3 back in position.

2. Place the high frequency pick up loop in close proximity. to IC1 in order to pick up the second IF oscillator frequency (note do not probe directly on the chip as test lead capacitance will affect oscillator frequency). Adjust CT1 for 89.545MHz (44.545 MHz for A2,A3 models).

3. Inject an RF signal at -80dBm (unmodulated) at Frx into CN5 (Jumper I out, Jumper J in). Measure DC voltage at VF output SKD-3, adjust L14 for 2.5VDC on this point.

4. Inject an RF signal at -80dBm with standard modulation at Fe, x into CN5, monitor line RX out and adjust T1 and T2 for minimum distortion. Reduce RF signal level and check that sensitivity is better than -112dBm for 12dB SINAD.

5. Remove Jumper J and fit Jumper I. Inject an RF signal with standard modulation at Frx into CN 1, monitor line RX out and check that sensitivity is better than -117dBm for 12dB SINAD. Repeat test for band upper and lower frequencies.

5.2.3. Power Amplifier Module

Test Equipment:

- Tested MX800 with PA removed
- PC with MXTOOLS software
- RF Power Meter
- RF Signal Generator
- Multimeter
- +13.8VDC 15A power supply

Preliminaries:

* Program upper, middle and lower frequencies of band into 3 channels in MXTOOLS channel screen. Although the PA will function over a wider bandwidth, the nominal switching bandwidth of the PA is 10 MHz. The recommended procedure is to center this 10MHz around the center of the user frequencies. (Note that 'Continuous Update Enabled' on the MXTOOLS channel screen should be ticked for these tests)

– Do not connect Exciter RF drive output CN1 to PA.

Procedure:

1. Remove PA top cover. Measure resistance of thermistor between CN4-6 and CN4-4, this should be approximately 2kfL Connect DC power lead and 10-way connector

from MX800. Connect PA RF output to RS power meter and PA RF input (CNi) to RF signal generator.

2. Set signal generator to center frequency of PA under test and reduce RF drive level (from signal generator) to zero. Switch DC power on and check that supply is present on L9. Assert PTT (check that no output RF power is emitted from the PA) check that the 13.8V supply is switched through to the Hybrid on pin adjacent to RF input and that 5V is switched to the Hybrid on the next pin along (pins not numbered on Hybrid).

Slowly increase RF drive level from signal generator until RF power output is approximately 25W. Adjust trim caps CT1, CT2 and CT3 for maximum power output. Adjust RF drive level so that RF power output is 50W and fine tune the trim caps. Check during this process that supply current does not exceed 11A and that RF output power does not exceed 65W.

With PA transmitting at 50W into 50fl load measure DC volts FWD power sense CN4-8 and REFL power sense CN4-5. These voltages should be approx 2.8V and <450mV respectively. Reduce RF drive until PA output is 10W and disconnect PA RF output cable. Measure DC voltage on CN4-8 and CN4-5 again. These should now both read approximately 1VDC. Remove PTT.

5.2.4. VCO Board

Test Equipment:

- Tested MX800 with Exciter VCO removed
- PC with MXTOOLS software
- RF Communications test set
- Multimeter
- Oscilloscope
- +13.8VDC power supply

Preliminaries:

– Program upper, middle and lower frequencies of band (refer section 5.4 for band split details) into 3 channels in MXTOOLS channel screen. (Note that 'Continuous Update Enabled' on the MXTOOLS channel screen should be ticked for these tests)

– Remove top cover from Exciter module and fit VCO under test. As the TX and RX VCOs are identical the RX VCO may also be tested in an exciter. As the receiver VCO operates at Fp, x - 90MHz the frequencies

– Connect Exciter to working Micro Controller via 16-way ribbon cable.

– Disconnect Exciter RF drive output CN 1 from PA.

Procedure:
I. Select mid channel. Connect SKU from exciter to VCO, switch DC power on, assert PTY and measure RF output power on VCO SKT-6. This should be 0dBm to +3dBm.

Measure RF output level on SKU-1. This should be 0dBm to +3dBm (Note that if SKU-1 is disconnected from the exciter the loop will lose lock). Reconnect SKT and SKU to exciter.

2. Select lower channel. Assert PTT and check that loop is locked. Adjust trim cap CT1 on VCO for 3VDC (2VDC for N2 band) on SKT- 1. Select upper channel. Check that the loop is locked and that the voltage on SKT-1 is <18VDC.

3. The following test is not required for the RX VCO. Connect Exciter output to comms test set. Inject l kHz tone at nominal line input level and check that Exciter RF output is modulated and that the depth of modulation can be controlled through the MXTOOLS channel screen.

5.2.5. Micro Controller Module

Comprehensive testing of the Micro Controller can only be carried out at the Factory. The procedures in sections 5.1.10 to 5.1.13 provide alignment instructions for the workshop adjustable parameters.