SEMI-AUTOMATIC TESTING OF A MICROWAVE RADIO FRONT END

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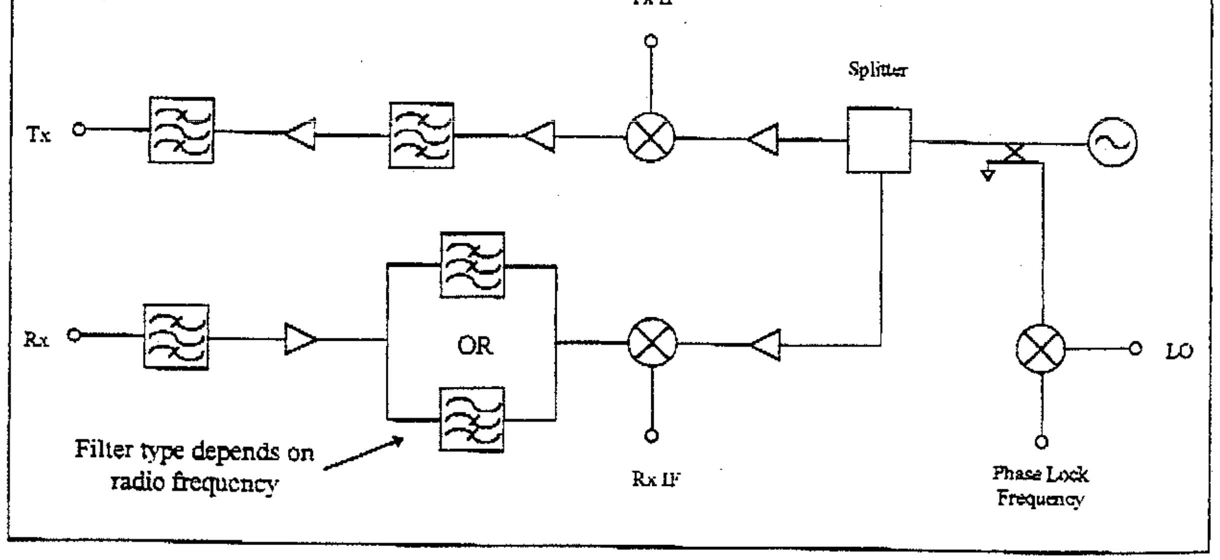
ABSTRACT

The first section of this paper gives a brief description of the architecture of the microwave front ends used in the Nera radios. This is followed by a section detailing the measurement philosophies which were used originally, and later adapted, in the developing test system. These philosophies have helped to ensure that the units being tested were specification compliant. A description of the test software used followed by proposed future test developments concludes the paper.

THE RADIO FRONT END

The microwave front ends are, essentially, high frequency up and down converters. Half of the assembly provides the main transmit, Tx, output whilst the other half forms the first stage of the receive, Rx, down conversion chain. Referred to as Microwave Integrated Circuits, MICs, these front ends currently cover 17 to 40GHz in various bands, 17.7 to 19.7GHz, 21 to 24GHz etc., with Tx powers up to +23dBm. These MICs form part of the Nera Accesslink radio which comprises a complete Tx and Rx module and all the necessary control functions. Both the Rx output and Tx input are signals in the range 1 to 3GHz, IFs, see Figure 1. The actual values of the IFs are fixed for each type and frequency of radio and depend on the radio architecture. The MIC also generates a DC output voltage from a detector which is proportional to the level of the Tx power and is used to set the transmit level in the complete radio.

Figure 1: MIC STRUCTURE

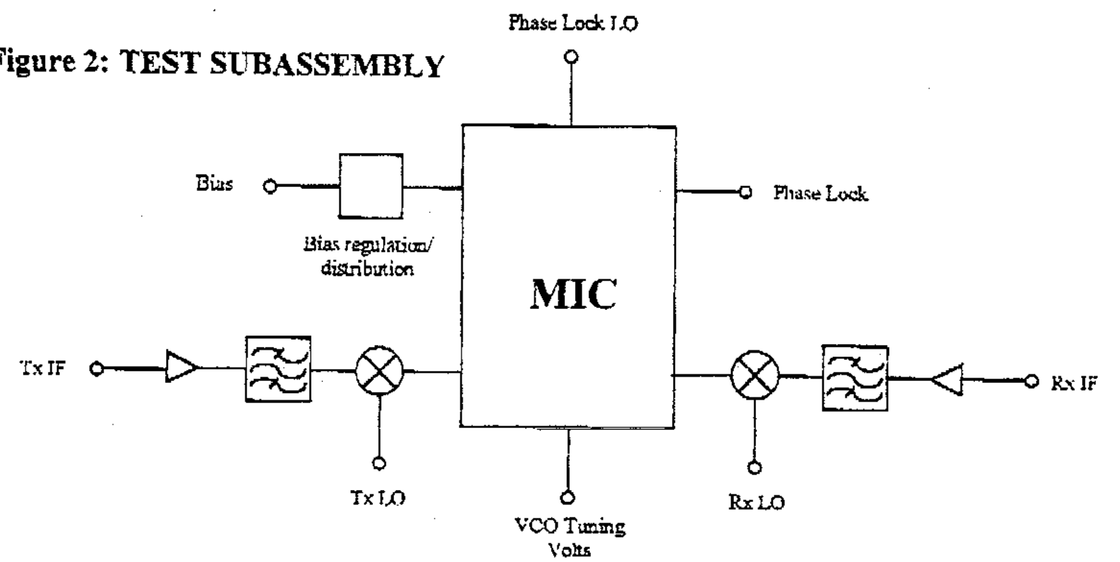


Also included in the MIC package is a high frequency Voltage Controlled Oscillator, VCO. The VCO output frequency mixes with the Rx input signal to produce the low frequency Rx IF output. The VCO output is also mixed with the Tx IF (upconverted) to produce the main Tx output frequency. A sample of the VCO is taken and mixed with a low frequency signal provided to the MIC. This produces a low frequency mixed output which is used to lock the VCO by comparing it with an accurate reference. The radio automatically adjusts a voltage to the VCO which alters it's frequency until the mixed frequency output is the same as the reference. This system of phase locking provides a very stable transmit frequency. Finally part of the Tx output is mixed with a fixed frequency external signal to produce a signal at the Rx frequency. This signal is then fed into the Rx chain and thus produces an Rx IF output signal. This provides a method of testing the function of the radio in the field by simultaneously checking the Tx and Rx chains not just of the MIC but the whole RF head.

TEST PHILOSOPHY

Testing of the MIC has been reduced to a minimum so that only those parameters which are likely to vary from radio to radio, or that need optimisation, are checked. Optimisation is usually required to reduce gain ripple due to the interaction of the various elements of the MIC. The MIC could be tested on it's own but this was found to be time consuming as some of the parameters being measured are at very low signal levels. Some signals are so low (<<-85dBm) that they originally and had to be measured on a spectrum analyser. This was because the signal levels were too low to be measured on a scalar analyser. The sensitivity of a spectrum analyser is very high but to achieve the required sensitivity meant slowing the sweep time right down. This led to a single result taking up to 5 minutes to form on the screen This was excessive and added significantly to the overall test time.

Figure 2: TEST SUBASSEMBLY



By testing the MIC along with the board into which it fits, as a subassembly, the testing time was dramatically reduced. This interfacing board provides high levels of gain, especially on the Rx side, boosting signals to manageable levels (>-40dBm). This increased signal level also meant that the assembly could be measured on a standard scalar analyser instead of more sensitive equipment. The biggest advantage of this was that a unit could be measured in real time (about 200msec), with no waiting for a trace to form. The interfacing board also provides all of the bias to the various active devices used on the MIC. Simple plug-in interfaces allow for rapid connection of the external power supply and low frequency feeds. See Figure 2

THE TEST SET-UP

When the first ever MICs were tested some years ago the test set up was very complex requiring several RF sources. These RF sources had to provide low frequency signals, <3GHz, and high frequency signals, up to 40GHz. More than one RF source was required as some tests required up to 3 different frequency inputs. In addition DMMs, a swept voltage source, a power meter, spectrum analyser and scalar analyser were also required. In total 10 pieces of test gear formed the test bench not including waveguide couplers, connectors etc. This made the test bench very complex and inefficient as it kept having to be swapped around to perform the various tests. Testing time was further increased by the fact that results had to be produced as hard copies via a pen plotter which was very laborious.

The second generation of test equipment reduced the list to a DMM (used only occasionally), an RF source box, a spectrum analyser and a scalar analyser. The RF source box is in-house manufactured and provides virtually all of the required low frequency signals to the MIC. These signals are mainly used to drive the mixers in the Tx and Rx chains. Most of the functions required by the large test bench are now provided by the Marconi Instruments, 6204, Microwave Test Set (MTS). The use of this test bench reduced the test time by 60% compared to the original test time. This saving was made due to the reduced complexity of the test bench and the ease of use and numerous functions of the MTS.

SOFTWARE CONTROL

To further reduce testing time a number of macros were written on the MTS to semi-automate the testing. Macros are essentially software routines which mimic the pressing of the keys on the instrument. The use of macros speeds up testing as the time to change settings via a macro is a lot quicker than pressing the individual keys.

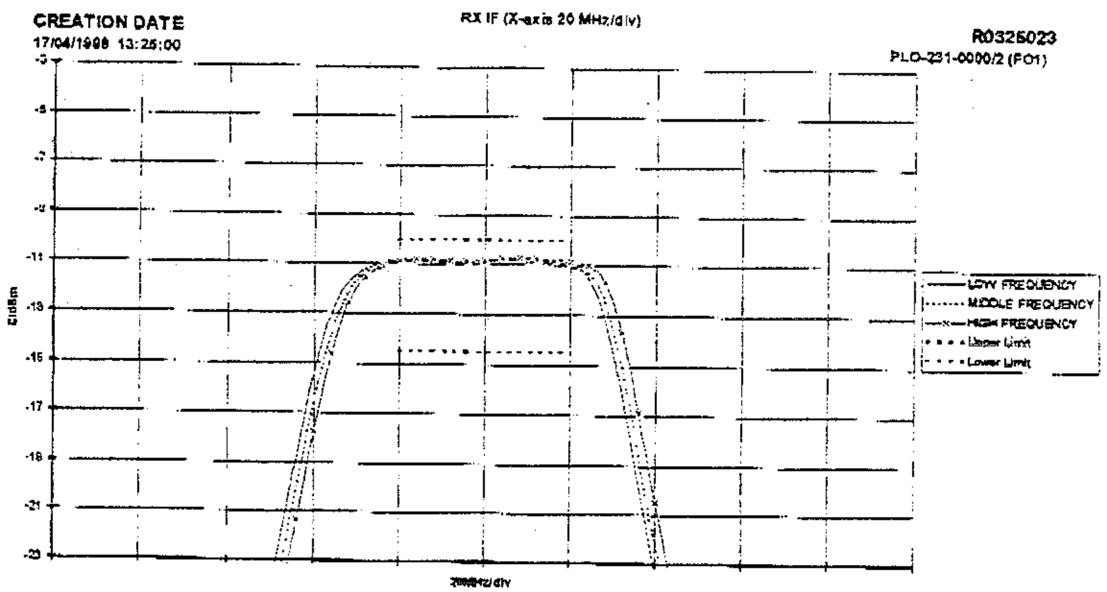


Figure 3: TYPICAL TEST BENCH OUTPUT

Testing is now done from an on screen menu on the MTS which allows the selection of any one of 10 tests. These tests include single functions like calibrating the VCO output frequency versus input voltage and more complex, interrelated, tests. The macros set up the analyser to the correct state, add in limit lines etc. and allow the user to toggle between different states, e.g. return loss and Tx power, just by the press of a button. Return loss and Tx power is an example of an interrelated test where tuning for one function can degrade the other. In addition the macros allow responses to be stored and prevent the user continuing until the parameter being tested passes the specification. A number of Visual Basic programs, on a computer, have also been written which control the storage of data and allow results to be plotted as hard copies if required, see Figure 3. All told this system allows 38 swept responses to be stored and even creates a results sheet with automatic entry of specification limits, required frequencies etc. Using this arrangement test time has been reduced still further to 20% of the original, manual, time.

FUTURE DEVELOPMENTS

A new generation of software is being planned which will be entirely computer based. The MTS and spectrum analyser will both be controlled from a computer so that the tests move even further towards becoming completely automated. Results can then be read directly off the test instrument and stored either as traces or as measurement points in a results sheet. The software will be written in Visual Basic as this has already been used to write the programs used to control the transfer of results, creation of results sheets and plotting of data. Some programs have already been transferred into alternative forms including on-line help and fault finding routines (menu driven) which have been re-written as Windows help files complete with hyperlinks. The first of the new generation of control software has been written, as a first draft, to control the calibration of the test benches. This new software has been found to reduce the calibration time from 30 minutes to 10 minutes per bench which is a considerable improvement. Such software provides full instructions to the user on what to do thus reducing the likelihood of human error.

CONCLUSION

It has been found that software control of instrumentation and the data it provides has helped to significantly reduce the test time for the radio front ends. Software also helps to eliminate the errors which can so easily occur in manually driven test systems. Software also ensures that all tests have been performed and that the unit is specification compliant before the operator can proceed. Further developments in software should reduce test times even further especially when coupled with ongoing work to improve a units performance, even before it reaches the test stations, thus eliminating any requirement for alignment.