Don't Forget That Test Point!

In recent years, software defined or digital programmable radios have found renewed opportunity in the cellular field. Developed originally for military applications, these radios first found their home in cellular base stations. Now as these are heading for deployment, the new frontier will be handsets and terminals. Getting to this point has required many advancements. With many recent advances in digital programmable radios, a few thoughts about designing for test are merited.

In order that these radio architectures become a reality, several key technologies must be in place. First, general radio components have both improved in performance and cost. Recent advances in both GaAs and Si technologies have driven NF down and IP3 up, both improving potential receiver performance. Likewise, data converter technologies have improved with smaller devices, higher sample rates and wider analog bandwidths. Today, many low cost converters are available that can accurately sample analog signals as high as 250 MHz, high enough to capture the first IF in many receiver designs allowing the elimination of 1 or more down conversion stages. Following the ADC is a digital receive signal processor. This chip provides for interfacing between the high sample rate of the ADC and the relatively slow input rates available on a DSP. The use of a RSP greatly reduces the computational load from the general purpose DSP and at the same time provides tuning and filtering flexibility to the input signal. Finally, the DSP provides the 'soft' in software radio. DSP advancements have largely been the result of improved architectures such as the Harvard Architecture, built in accelerators and reduced geometry’s.

Figure 1) Block Diagram of a Software Radio

As any receiver (or any other circuit for that matter) is architected, it is all too easy to omit vital test points. For example, in a traditional analog receiver, test points may be located at the output of the LNA’s, local oscillators, mixer outputs and detector outputs for the sole purpose of observing spectrums, envelopes and signal levels. However, in an IF sampling digital radio, these same test points may not be available. This is not to say that the information is not important nor available, it is just in a different form than in a traditional receiver. That is to say, once the signal has been sampled, all test points become digital. If a path is not provided for this information to exit the system, critical information may go un-probed.

In a global sense, digital radios can easily be tested using loop back techniques as is widely common throughout the industry. However, these test only tell if the receivers are functional or not. Often, they can provide some form of diagnostic information, however, when performing the initial debug on a receiver design, nothing suffices like access to key signals throughout the design. Remembering back to college theory, the Heisenberg uncertainty principle comes to mind. It states that when observing a particle, both the position and momentum of a particle can not be know for certain. For if the momentum is measured, then its position is changed and likewise, if its position measured, then its momentum changes. The same is true for analog test points. If a probe is placed on a node, the signal characteristics can and will change. However with a digital test point, as long as the timing for that signal is robust enough, it will not change when probed.

In the beginning there was digital...

The first digital test point is the ADC output. The ADC output can provide a wide variety of basic information about the signal. Among the information available at this point is signal level, envelop and spectrum including the entire band if wideband sampling is employed. From this vantage point, many key measurements may be made. For example conversion gain of the front end may be determined. Since the data converter has a know full scale, a known input signal will produce a determinable response within the ADC. If the input signal frequency is swept across the band, the bandwidth and pass band ripple of the front end can easily be measured. Likewise, image and stop band measurements can be made by selecting the appropriate input signal conditions.

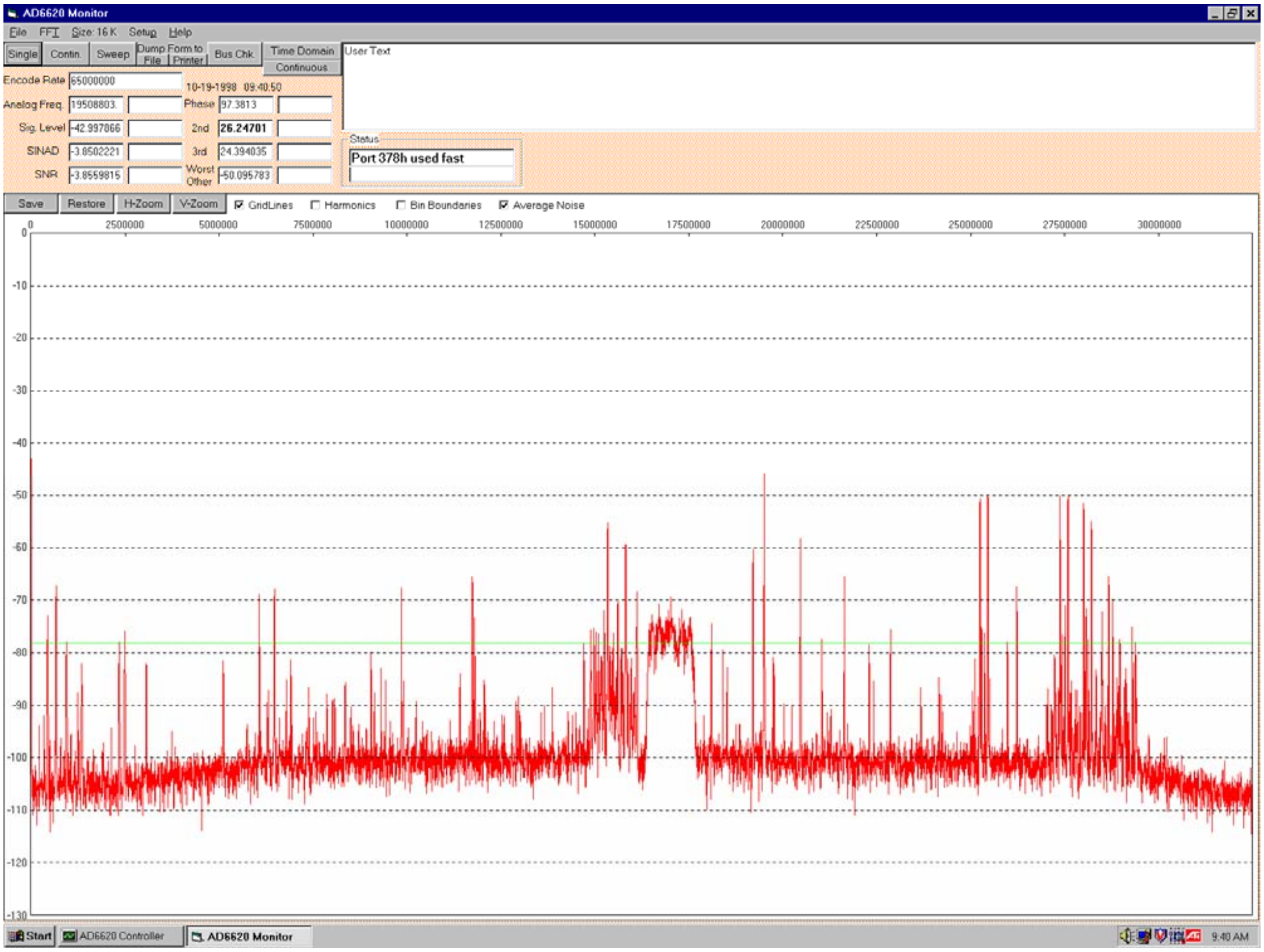

Figure 2) Direct ADC output of entire cellular band

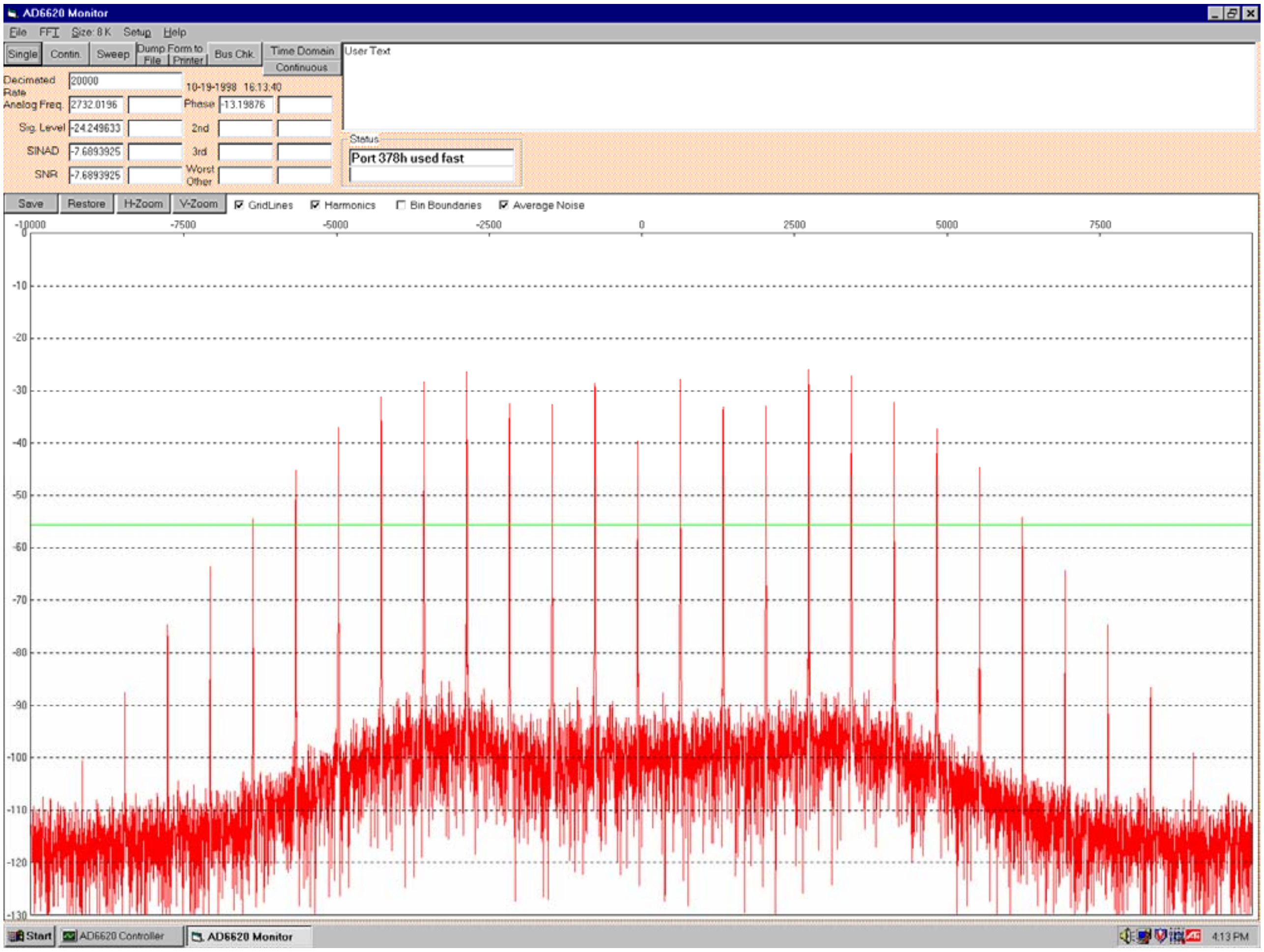

Figure 3) Tuned Single carrier output in the frequency domain

The next stage in the receiver is the digital receive signal processor. The purpose of this ASIC is to provide channel tuning, data rate decimation and channel filtering. This chip is also frequently used to perform quadrature demodulation. Therefore, the output of this chip can provide many useful views of the data. As with the ADC output direct, this output can provide signal power information, channel bandwidth information (stop band rejection and passband ripple). Also, since the output is complex, the constellation of the input data can be shown.

Figure 4) Constellation or 3-D phase plot

The final stage in this receiver is the DSP. Once the data is entered in the DSP, the hard part is done. The software can then be used to contrive a wide array of tests. However, software is 'soft' and can be changed much easier than the 'hard' in hardware. Therefore, diagnostic software can be loaded as needed.

Figure 5) Software Radio with Enhanced Digital Test Points

In conclusion, a little thought up front on placement of digital test points can go a long way in debugging that digital receiver. As these major building blocks of a modern receiver continue to be integrated, it will be even more important that these test point be accurately placed. Once a design is committed to silicon, it may be too late to add this functionality and diagnostic features.