Spectrum analysis

Name

Institution of affiliation

**Spectrum Analysis**

The sweeping of radio-frequency (FT) front end, is not needed in the spectrum analyzers that are based on Fast Fourier Transform (FFT). Instead, FFT achieves the conversion to the frequency domain from the time domain. A short series of events happens, first and foremost, the memory servers as storage and stores a batch of samples. The samples that represent time domain are then decoded into the spectrum information. The frequency span of the analyzer that is based on FFT depends on the sample rate. The term ‘sweep time’ is inherited in this case to describe the time that is spent between two consecutive Fast Fourier Transform results, although no sweeping is actually done. In other incidences, spectrum analyzers tend to join or combine the FFT mode and the swept mode. In the end, one sweep results to a combination of several other FFT shots that are got or rather obtained from different frequency centers. This, in other words, is termed as the swept Fast Fourier Transformation mode. The FFT-based analyzer has one main advantage; one operation can enable you to look at a spectrum on a broader range. However, the acquisition of a batch of samples followed by a step that involves processing is required in FFT. The analyzer in turn misses the events that subsequently happen in the acquisition phase. This problem can be solved if the analyzer meets some conditions that include:

* The speed used in processing should be faster than the speed used in acquisition
* The sample acquisition process and the sample process should occur or happen in parallel.

Spectrum analyzers that have the capability to present seamless measurements are called the real-time spectrum analyzers (Wei Liu\*, 2013). The type of device determines the exact features of real time analyzers. It can be illustrated in an event that involves two specific spectrum analyzers by applying FFT. This event can be described in detail as follows: the FSVR series of ROHDE and the SCHWARZ come first, followed by the RSA series of Tektronix. At this point we only focus on the FFT mode, despite the fact that swept mode is used in the modern spectrum analyzers to increase the range of the frequency. The below discussion emphasizes and focuses on the processing mechanism accompanied by the whole underlying process, and how much flexibility the end users enjoy, rather than focusing or including the implementation details involved.

* **ROHDE AND SCHWARZ FSVR**

The FSVR is one of the most well-known series that originates from R&S. The well-designed machine has the capability to perform 250,000 times 1,024-point Fast Fourier Transform per second. This means that for every 4µs, one FFT shot is produced. Some users tend to configure the frequency span which can otherwise be referred as the sample rate, and this automatically leads to adjustment in the percentage of overlapping of samples between the adjacent FFT frames.

 1,024/Fs × (1-x) = 4µs

The FFT shot that is obtained cannot be directly displayed because the number of FFT bins is greater than the amount of pixels on the screen.

**Sensing Solution Overview**

Spectrum analyzers are some of the high-cost solutions that are usually over-kill for the applications that are targeted i.e. most functionalities that are built in the spectrum analyzers tend to be redundant for the mere reason of channel assessment. Moreover, this devises lack the capability to record seamlessly, long-term and also faster transfer of data, on the other hand, the low-cost devices are flexible, they have less bandwidth and they have limited processing power. Designing a low-cost solution that has the capability to record seamlessly, and is sufficiently flexible is the only way the situation can be remedied. The table below shows an overview of existing solutions

Table 1 Overview of existing sensing solutions.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Device name** | **Flexibility** | **Seamless capturing** | **Long-term recording** | **Cost** |
| Spectrum analyzer | High | yes | no | high |
| USB sensing devices | Medium | no | yes | medium |
| Sensor | Low | no | yes | low |
| Our target solution | High | yes | yes | low |

The following are the design goals for the solution

* The direct access to the IQ samples.
* The sufficient rate of sample.
* Flexibility.
* Ease of developing.
* Platform independence.

**The hardware platform**

Software defined radio platforms tend to allow basic and traditional radio functions which include encoding and decoding in order to be transferred from hardware to software. The SDRs can be divided or categorized depending on the processor type used in processing signal. The Universal Software Radio Peripheral (USRP) developed formally by Ettus Research lies in the first category. It is the software defined radio platform that employs general purpose processors commercially and consists of two parts. These parts include a fixed motherboard and a plug-in daughterboard. Among the things that the motherboard consist is, a field-programmable gate array (FPGA), analogue to digital converter (ADC), digital to analogue converter (DAC).

**Configuration and Important features**

Various options can be used to configure the sensing engine software. Some of these options are described below.

* **Swept FFT mode vs continuous FFT mode.**

The front-end of USRP continuously samples out the wireless medium and stays at the same frequency in the continuous mode of FFT. On the other hand, the swept FFT mode has a maximum sample collection rate of 25Msps. The samples that are then collected at a particular or specific RF center frequency are referred to as a block while “one sweep” is the complete measurement across several RF center frequencies.

* **Measurement types**

When configured, the sensing engine can carry out different types of measurements, this includes:

* It can measure the PSD in the frequency range that is required and further determine the amount of energy detected in each specified channel. Therefore, this is referred to as the power spectral density measurement. It has three variants, maxhold, minhold and averaging.
* **Sensing efficiency**

A mentioned earlier, sensing capacity can be described as the ratio of the sampling time and the sum of the additional processing time and sampling time. In this case, the processing phase entirely happens in parallel with the processing phase. The swept FFT mode sensing efficiency can be defined as

 ƛ= sampling time/ (Sampling time + Channel switching)

* **Output format**

The sensing engine output contains the following components.

1. Usrpid
2. Energy or duty cycle array
3. Timestamp
* **Resolution bandwidth and FFT size**

The RBW of the spectrum analyzer that is based on FFT is calculated as the sample rate over FFT size.

Just like with the Tektronix analyzer, users here can specify the sample rate and the size of the FFT independently. The channel’s bandwidth and the number of channels define the final frequency resolution.

* **Comparison of the performance with existing sensing solutions.**

This is the comparison of the performance of the spectrum and analyzing solutions with the already available devices. It involves comparing a broad range of devices. Fixing of parameters and observing the remaining parameters needs to be done in order to have a fair comparison. The other point is that the performance of the parameters is not independent completely. When configuring a parameter, you mark it with a lowercase letter ‘a’ that is a superscript.The two separate entries of the USRP sensing engine that are listed include the continuous FFT and the swept FFT mode. The setting that is listed in the table is the closest to the Air magnet, when certain settings are not available for a specific device.

**THE ADVENT OF DESKTOP SDR**

There has been great enthusiasm on the prospect of software radios by the digital signal processing (DSP), RF/radio sector and digital communications over the past twenty years. The term software defined radio (SDR), in recent years, has somehow diverged to different engineering groups. The DSP community has many people that SDR was in effect the engineering of radio stations that are DSP-enabled, by virtue of DACs (digital to analogue converters) and ADCs that are designed to have very high speed. In other communication systems of the engineering domains, SDR refers to the middleware, which in real sense is the software that could define the radio and provide the framework for the deployment of software objects over networks and between devices in the radio software (Stewart, 2015). Both the SDR interpretations are closely related i.e. the middleware and the radio that is DSP enabled, had a promise and concept that was easy to understand, but the software and hardware that 20 years was mostly needed or required, was really expensive and not affordable to many. However, Moore’s law at list, so far, hasn’t failed, or rather is yet to fail. Therefore affording the SDR technologies is a reality that is definitely here and within us.

SDR in the middleware and the radio that is DSP enabled category, in the past five years or less, has been achieved in the laboratory and at a very reasonable and fair cost, the area of around $1500 or less for a hardware with ADC and DAC that is enabled by FPGA. Some products, for example the URSP, which is a product of SDR, has been used on many occasions to stream samples down-converted RF signals to the desktop where they input to software such as MATLAB and Simulink for real-time processing or recorded off-line for off-line use (Stewart, 2015). In addition to this, a real-time DSP software algorithm could be easily implemented in situations where the required drivers were available and the desktop itself was a platform that was high speed. SDR is in this time and day established in a number of institutions if not most of them, as a part of the curriculum.

References

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