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A Intelligence Approach of Analog to Digital Converter using Software Defined Radio Technique

L S P Sairam Nadipalli[1], Sarat K Kotamraju[2], P Kanakaraja[3], Aswin Kumer S V[4], K.Ch Sri Kavya[5]

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Abstract: Analog to Digital Converters are universal basic blocks of SDR (Software Defined Ratio) transmission management Architectures. Analog-to-digital converters are explained in this study, which includes converter characteristics and components often used in the field. The opening jitter that caused this paper's vulnerability might be linked to it. Because the speed of the SDR technology is limited by the ambiguity of the comparator, it is also a constraint for ADCs operating at Gs/S rates. Various uncertain ADC designs and circuit advancements have been suggested and implemented in an effort to push back these cut-off points. Lower power dissipation is brought about by a shift toward single-chip ADCs. Sampling rate has additionally been introduced, giving an understanding into their weaknesses. With the beginning of another thousand years, track down ourselves one stage before the development of the third era 3G versatile interchanges frameworks on the planet market. The execution of the 3G and moreover 4G versatile interchanges frameworks is incorporated inside the aims of the purported programming characterized radio (SDR) frameworks. The plan, improvement and the execution of SDR frameworks depend on a mix and development of innovations and methods including for the most part, brilliant receiving wires, radio frequency (RF) down/up converters, simple to computerized converters (ADCs) and advanced to simple converters (DACs), Digital Signal processors (DSPs), demonstrating and framework portrayal dialects. In this paper a quantitative investigation of the essential boundaries of one of the main fragments of a SDR recipient, an ADC is introduced. ADCs of the most recent innovation and their essential details are additionally added.

Keywords: *SDR, ADC, DAC, Signal to Noise Ratio, DSPs, Thermal Noise, Jitter Noise*

1. Introduction

The design and application of Software Defined Radio is a huge topic, so in this paper will focus on just the receiver [1][2]. Cover the several topics like an over view of SDR, Fundamentals of Analog to Digital Converter and its Specifications [3][4]. How analog to digital converter parameters impact Software Defined Radio system design and, a small form factor real world implementation [5][6]. The transmitter will include a high performance, here many of the same concepts apply even though in this paper will not directly address them in this topic [7][8]. Paper starts by looking at the INDIA allocation chart. The RF spectrum is vast, currently covering 8 decades of sequencies (9 kHzto400GHz) as shown in figure 1. The amount of spectrum that has been allocated has been increase in overtime and some of the allocation shave changed [7][8]. A various needs come and go, some bands are allocated, unallocated, and then reallocated [9][10].

1.1 What is SDR Analog

Customary receivers just cover a solitary divert in a predetermined number of groups since they are made with devoted equipment for a particular sign or waveform [11][12]. Even signals in adjacent bands may require multiple receivers leading to increased size, weight and power.

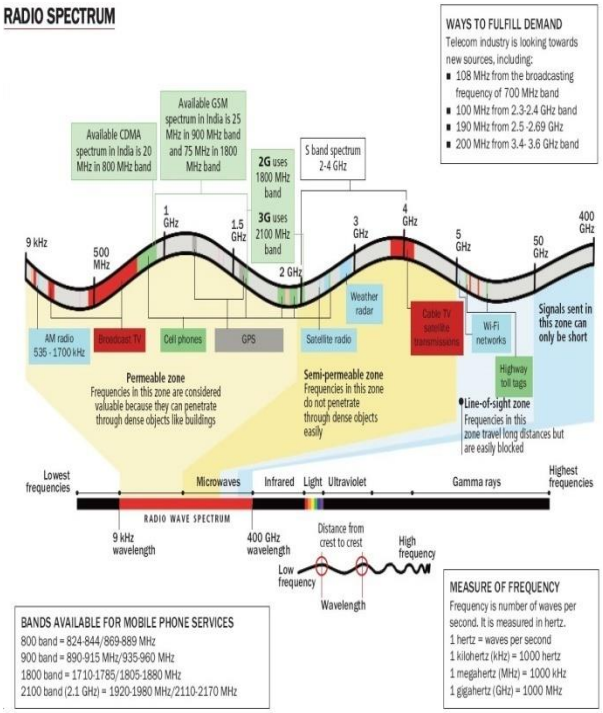

Figure -1 Radio Spectrum in India

A SDR is a Radio where it is digitalization the signal transmission permits hardware recently carried out in

[1, 2, 3, 4]*Department of Electronics and Communication Engineering, Koneru Lakshmaiah Education Foundation, Greenfields, Vaddeswaram, A.P, India, 522502*
[1]*sai.nadipalli@gmail.com* ,[2]*kksarat@gmail.com* ,
[3]*pamarthikanakaraja407@gmail.com*, [4]*svaswin@gmail.com*,
[5]*kavya@kluniversity.in*

committed equipment to be moved into the advanced area as shown in Figure -2.

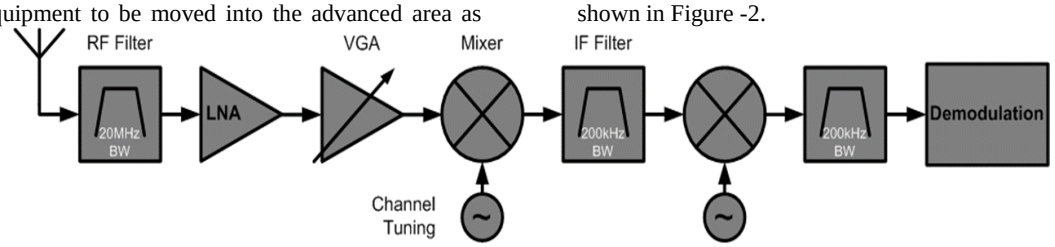

Figure -2 Block Diagram of typical SDR

Unfortunately, ADCs don't have boundless powerful reach or endless information transfer speed so extra parts like amplifiers, mixers and filters are as yet needed to control the input signal of the ADC [13][14]. After the signal is digitalized, programming can manage the channel recurrence, data transmission and regulation configuration. Putting the analog to digital converter as near the receiving Antenna as shown in Figure -3 conceivable gives the most adaptability however should be compromised against execution limits [15][16]. In a perfect world, an ADC could straightforwardly test the sign from the receiving Antenna [17][18].

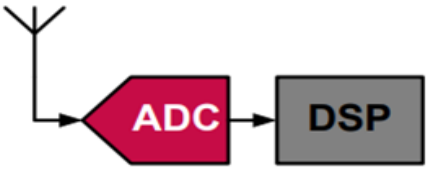

Figure -3 ADC with Antenna

2. ADC Fundamentals

Start with a basic illustration of analog to digital conversion. The ADC or our Analog to Digital Converter Is controlled by a clock signal known as sample or which sets the example stretch the examining system presents incidental effects which add commotion or contort the information signal the exhibition of the inspecting system is determined by its effect on Noise–reported as Signal-to-Noise Ratio (SNR) and Distortion–reported as Spurious Free Dynamic Range (SFDR), THD (Total Harmonic Distortion), INL (Integral Non-Linearity). An ADC converts an infinite range of analog into a limited number of digital output values. This means that there will be distortion because all the necessary digital output values do not exist [19][20]. Additionally, the ADC has non-ideal performance so even more distortion can be introduced [21][22]. Noise is another problem since the ADC will have a limited range from the largest signal to its noise floor. In the figure removal of high-frequency noise with an anti-aliasing filter followed by the conversion to a digital signal [23][24]. The 3-bitconverter will have 2^3 or 8 possible output values (also known as codes). Each input clock causes the analog input to be quantized into 1 of these 8 possible digital outputs. Any undesired input signals must be removed by a filter or they will also be digitized. After we talk about the performance metrics we will come back to aliasing [25].

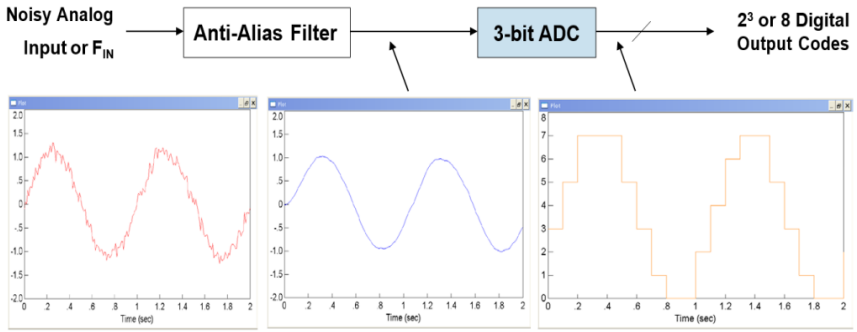

Figure -4 Sampling Process

ADCs are typically characterized with a single frequency sine wave input. This is the most difficult case for an ADC since wideband signals with multiple frequencies tend to randomize any linearity errors in the ADC giving better results as shown in figure 4 & 5. It is also easier (or more consistent) to process a fast Fourier transform (FFT) result with a single sine wave input. There are different Types of ADCs available in the market, for each type of ADC having unique properties like Resolution, Sample rate, Merits, Demerits & applications, all of them are listed in below table-1.

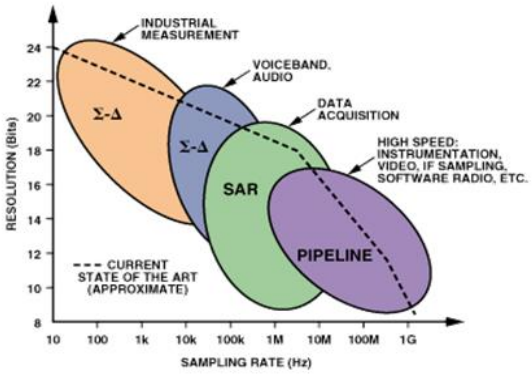

Figure -5 ADCs with Sampling Rate

Table -1 Comparison of ADCs

Type of ADC	Merit	Demerits	Maximum Resolution	Maximum Sample rate	Applications
SAR	Good Speed	no protection for anti aliasing	18bit	10 MHz	Data Acquisition
ΔΣ Delta Sigma	High Performance	Signal Hysteresis	32bits	1 MHz	Audio& Vibration
Pipelined	Very fast	Limited Resolution	16bits	1GHz	Oscilloscope
Dual Scope	Inexpensive, accurate	Low Speed	20bits	10Hz	Voltmeters
Flash	Fastest	Low bit Resolution	12bits	10GHz	Oscilloscope

Now, look at SNR (or Signal to Noise Figure which is the amount of all power aside from DC, the principal (or essential info signal) and the initial ten music, comparative with the full power (measured in dBFS) or relative to the power of the signal (measured in dBc which refers to dB relative to the carrier). The SNR contributors are shown in redin the example spectrum plot. The ADC's SNR is set by four factors, quantization noise (from the number of bits), thermal noise (from the ADC input), higher order harmonics due to DNL errors and clock jitter noise. The first three are set by the ADC's design and are relatively fixed. The jitter noise is influenced by external factors including clock jitter, input frequency and input amplitude. Next, we'll look at the effect of jittering more detail.

3. Importance of SNR in SDR

Excludes the power at DC, the fundamental power and the power of the first ten harmonics, Includes thermal noise, quantization noise, aperture jitter and higher order harmonics due to DNL (differential non-linearity)SNR is usually measured with respect to full scale amplitude (dBFS). All of these effects are primarily white, and spread across the entire digitized band width these three components are summed as a root-sum-of-squares (RSS) to get the

Total SNR = SQRT [(SNR_thermal^2) + (SNR_quantization^2) + (SNR_jitter^2) + (DNL_noise^2)]

Note: These noise contributors and the noise power in the FFT must be summed in voltage rather than dB Thermal noise (Johnson-Nyquist noise)

Due to kTC in the sampler an sub sequent ADC pipeline stages

Thermal noise = Vn =SQRT (Kb*T / C)

Quantization noise. Due to limited number of bits in the quantizer SNR _quantization = 1.76 + (6.02 * Num_bits)

Aperture jitter. The jitter added in the clock receiver

Performance impact of jitter added scales with input frequency

SNR_jitter=20*LOG10 (1/(2*pi*f*Tj))

DNL noise is the error between the idea land actual ADC outputs for each code. These errors create higher order harmonics (above H10) that is summed into the noise power.

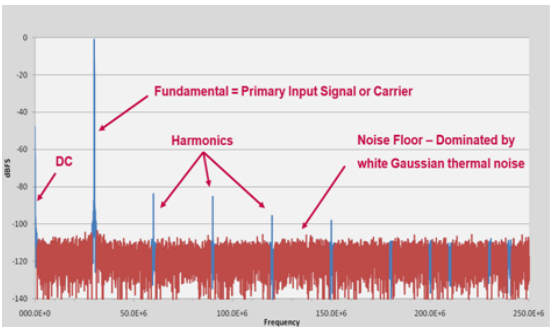

Figure -6 Signals to Noise Ratio

Clock jitter is variation or uncertainty relative to an ideal clock. If there is an error in sample time caused by clock jitter there will be an error in the sampled voltage, relative to the voltage at the expected sample time. This error will create higher level of broad band noise at the ADC's output leading to reduced SNR. For small input signals the ADC's thermal noise will determine the SNR but, as the signal input amplitude increases noise due to clock jitter can determine the SNR as shown in figure 6. This is especially true at higher input frequencies.

Clock uncertainty -> Sample time uncertainty

Outcomes: Errors of output voltage

- Thermal noise or jitter noise might dominate the Signal to Noise Ratio.
- The jitter noise is proportional to the magnitude of the inputs.
- The noise of a huge signal may obscure a smaller signal.
- A lower jitter in the clock might result in a greater level of sensitivity.

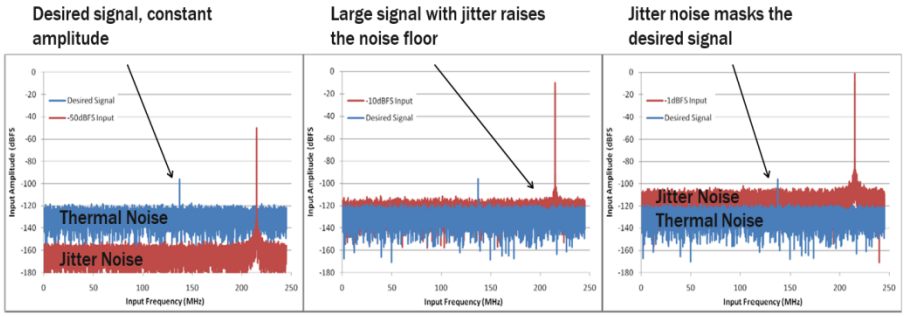

Figure -7 SNR dominates Jitter Noise & Thermal Noise

Jitter noise is independent of sample rate, only the input frequency's slew rate and the amount of jitter determine the jitter noise. This is because the voltage error will be greater with a higher slew rate and the slew rate increases with frequency and amplitude as depicted by figure 7. This is important in a Software Defined Radio because jitter can reduce the sensitivity of the receiver when a large signal sampled with too much jitter raises the entire noise floor as shown in the following illustration. The plot on the left shows the desired small signal with enough SNR relative to the thermal noise to be recovered (all in blue). The jitter noise and a large interfering signal are shown in red. The centre plot shows that as the large interfering signal, sometimes called a blocker, increases, the jitter noise floor increases with it reducing the total SNR. The plot on the above shows the point where increasing amplitude of the interferer has raised the jitter noise causing the desired signal to be lost. Clock jitter will also degrade the SNR of higher input frequencies leading to lower dynamic range in direct RF sampling applications. The negative effects of jitter noise on receiver sensitivity can be reduced by using a low jitter clock and an ADC with low internal aperture jitter. In a traditional receiver, the interfering signal would be removed by a filter. Since SDR processes a wider range of frequencies this is not practical–need more dynamic range to handle both signals.

Table -2 Lowest Noise Figure in SDRs

Device	Lowest Noise Figure (dB)					
	145 MHz	437 MHz	1.28 GHz	2.25 GHz	2.425 GHz	5.83 GHz
RTL-SDR	5.8	5.4	11.9	-	-	-
Airspy Mini	7.1	7.4	10.7	-	-	-
SDRplay RSPduo	2.1	2.5	5.4	-	-	-
LimeSDR Mini	11.1	13.8	15.6	-	-	-
BladeRF 2.0 micro	5.0	4.9	7.4	9.0	9.5	15.8
USRP B210	5.5	4.4	5.7	4.8	6.3	9.6
PlutoSDR	6.2	6.1	4.1	4.7	5.0	9.3

There are different types of SDRs available in the market to tune various frequency ranges depends up on application are listed above table-2 with their SNRs.

4. Harmonic Distortion (THD, SFDR)

dBc is a unit of measurement often used to express the total amount of HD (harmonic distortion) in a transmission, abbreviated as THD. Spurious Free Dynamic Range (SFDR or SFDR) is defined as the ratio between the input signals and the highest spur excluding DC. Generally the SFDR is set by a harmonic of the fundamental but this is not always the case. For example, uncorrected mismatch when interleaving multiple ADCs to obtain higher sample rates can lead to spurious signals that will dominate SFDR if not corrected. Advanced ADCs are interleaved 500MSPS14-bit ADC that provides automatic calibration that typically keeps the interleaving spursbelow-95dBFS as shown in figure 8.

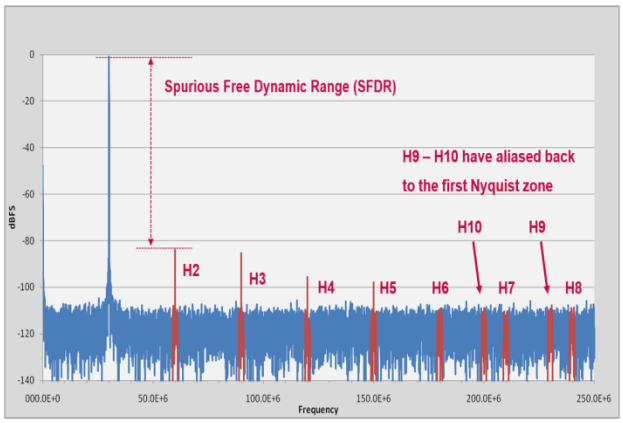

Figure -8 Aliases of the Harmonics

5. ADC Condition for SDR

5.1 Noise Distortion

Controls the smallest signals that can be digitalized and drives the receiving sensitivities.

Linearity (Distortion) Distortion can mask desired signals. Linearity translates to freedom from Distortion, as distortion is caused by non-linearity. Distortion can mask desired signals and prevent accurate recovery of signals. Lower distortion reduces the interaction between multiple signals, improving dynamic range. Resolution sets the quantization noise, and is generally expressed by the number of bits. As the other factors of noise and distortion improve, resolution ultimately becomes the limiting factor on performance. The Instantaneous Dynamic Range ties noise, linearity and resolution together. It's the distinction in signal strength between the most grounded and most vulnerable signs can effectively get simultaneously.

5.2 Instantaneous Dynamic Range

The greatest information level less the commotion and mutilation. Basic for multichannel wideband SDR beneficiaries. It's the greatest information level less the commotion and mutilation level (in dBs) in the receiver and call it INSTANTANEOUS dynamic range, as it excludes any variable gain (such as Automatic Gain Control or AGC). Dynamic range is critical for a wideband SDR receiver. In an SDR, often want to digitize a wider bandwidth, rather than having, say, a narrow analog IF bandwidth, like the 25 kHz used in many legacy VHF and UHF radios. With a wider bandwidth, there's a higher probability that have a strong interfering signal in-band along with the desired signal. Dynamic range is also key for multi-carrier receivers, as digitizing more signals requires the input level for each signal to be reduced to maintain the overall power. So part of the price is to pay for having wide bandwidth is that ALSO need

to have a wide dynamic range to accommodate the signals that appear within that bandwidth.

5.3 Sample Rate

The ideal SDR has a higher sampling rate. Flexibility frequencies plan is set possible by high sample rates, which raises SNR in the target channel.

5.4 Trade off: Resolution Vs Sample Rate

In general, a higher sample rate moves us closer to the ideal SDR. It determines how much bandwidth can be digitized, allowing more flexible signal processing. A high sample rate enables flexible frequency planning, by moving aliases farther apart, including the aliases of the harmonics as shown in Figure -7. A high sample rate can also increase the SNR in the desired channel, with oversampling gain.

There is generally a trade-off between the maximum sampling rate that an ADC can achieve, and its resolution. For example, MCP33141-10 ADCs 12-bit ADC, which runs at 1MSPS, is the fastest one currently available at that resolution. Faster ADCs are available, but they have a resolution of 12 bits or less. The amount of power the ADC draws will also impact on SDR system performance.

5.5 Power Consumption

It affects battery life in portable applications. It affects reliability, as higher power consumption results in a higher temperature. The ADC is often one of the hotter components on the board. It likewise restricts the quantity of ADCs & can accommodate in high-density systems. There is a trade off between dynamic range, sample rate and power consumption. A higher dynamic range and sample rate also often mean a higher power consumption.

6. Conclusion

In current SDRs each square is significant to convey a superior item for different applications. In this paper especially centred on the ADC and their speciation's. While planning a SDR simple to advanced converter is assumes a crucial part. Every single SDR, particular references are significant for uncertain Designing.

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