1. Introduction

Sensor network system is a system that has many sensor nodes cover inspecting area. Each node of sensor has to be small and wireless data transfer ability between nodes. Thus, the sensor nodes are required to integrate RF transceiver with low power consumption. Since the placement of each sensor node cannot be distantly separate, the nodes distance will be very short in order of meters or less. Hence, long range RF transceiver is not necessary. Power consumption must be very small for long battery life time.

Some of medical instruments, such as Electroencephalograph (EEG), are also required to integrate RF transceiver for portable use. Although the longer communication range is needed in some applications, the short-range RF transceiver can be integrated and transfer data by hopping technique through sensor networks to achieve the required range.

In this report, the transceiver system is described in section 2. Section 3 states an example of integrated system for short-range RF transceiver, and the conclusion is in the last section.

2. UWB Transceiver systems

Ultra-wideband (UWB) is a communication scheme based on transmitting simple Gaussian pulses which are occupied very wide bandwidth. Signals will be called as UWB signal if and only if its bandwidth is over 1.5 GHz or the power spectrum density (PSD) satisfies Eq.(1) [1].

\[
\frac{\text{Bandwidth}}{\text{Center frequency}} \geq 0.25 \quad \text{Eq.(1)}
\]

The pulses can be easily generated by simple digital logic gate. This seems like UWB is a good choice for low-power short-range RF transceiver. Anyway, the most difficult point in UWB transceiver is the method to detect the pulse. According to part 15 of Federal Communication Commission (FCC) regulation, the transmitted bandwidth must not over 3.1-10.6 GHz and the power density must lower than -41.3 dBm/MHz [1]. Since only short period pulse is transmitted and the ultra wide bandwidth of this pulse, pulse detection in time domain is only one exist solution.

2.1 System architectures

A classic UWB receiver is shown in figure 1[2]. The correlator can be performed in both digital and analog domain. In case that digital correlator is chosen, the receiver side needs very high-speed analog-to-digital converter (ADC) that operate at frequency higher than twice of pulse bandwidth. For full-bandwidth UWB signal, ADC and digital correlator must operate at frequency higher than 22 GHz to satisfy Nyquist condition.

For analog correlator, the ideal pulse template generator is needed to detect the pulse which is very difficult to design. The easier way to detect the pulse is to feed the signal into a sense amplifier instead of a correlator.

2.2 Design limitations

There are many effects seem to be limitation of transmission performance. Ambient noises, wall-reflected signal, and path-loss attenuation are mainly points which will be concerned here.

Although the noise floor is higher than signal amplitude, the signal is still able to see in time-domain as shown in figure 2. From Hartley-Shannon’s equation [3], Eq.(2), maximum channel capacity (C) of UWB signal can be over 700 Mbps with Signal-to-Noise ratio (SNR) of 0.1 because of wide bandwidth (B). This can imply that ambient noise is not a big design issue for this case.

\[
C = B \log_2 (1 + \text{SNR}) \quad \text{Eq.(2)}
\]

Wall-reflected signal will be seen at receiver side when the signal is transmitted and reflects the wall. This signal will have lower amplitude and lag the main pulse in time-domain as shown in figure 2(d). Assuming the communication scheme is already synchronized, both correlator and sense amplifier technique can deal with the wall-reflected problem because the exact timing is already known. This point also is not a big design issue.

The path-loss (PL) equation is shown in Eq.(3) [4], where f is frequency in MHz unit, d is transmission range in meter unit, a is attenuation loss factor, \( G_t \) and \( G_r \) are antenna gain of transmitter side and receiver side respectively.

\[
\text{PL(dB)} = 20 \log \left( \frac{1}{a} \right) = 20 \log \left( \frac{f \cdot d \cdot 10^{\frac{-138}{G_t \cdot G_r}}}{} \right) \quad \text{Eq.(3)}
\]
From Eq.(3), the transmission range can be derived as shown in Eq.(4).

\[ d = \frac{G_r \cdot G_t \cdot 10^{1.38}}{a \cdot F} \quad \text{Eq.(4)} \]

Assuming that the good antenna is used, the antenna gains are 10 at both sides. The attenuation factor is determined by circuit performances such as amplifier gain, and noise figure.

The transmission range is checked by performing simulation and the results show that the transmission range of 3 meters can be reached with power consumption of 26 mW. The test system operates at 1.5 V supply voltage.

3. An example of transceiver application

The transceiver system can be embedded in many applications such as sensor nodes, pulse-rate monitoring system, etc. EEG system is a medical instrument that measures signal from human brain and reports to display panel. The measure system needs only amplifiers and ADC. So, this part could be small. The display panel is normally large and not movable. Separation of these two parts will make this instrument to be portable. This is convenient for the doctor to measure samples from patients from rural areas and stores data wirelessly at the local hospital. Figure 4 shows an example of EEG system with embedded UWB transceiver.

4. Conclusion

The UWB transceiver architecture and design issues those should be concerned are described. This system is suitable for low-power short-range wireless RF transceiver design. An example of integration in medical instrument like EEG system is also reported here.

References