A low-power tunable telecommand receiver cum decoder

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We see a trend in the implementation of control applications with remote communication, which is getting increasing acceptance, as this technology can be easily adapted.

In engineering terms, Communication is the meaningful exchange of information between two systems. It requires a simple transmitter, a receiver and the information to be passed. When it comes to communication solutions in military terms, the entire equation changes. The military communication equipment needs are more than simple; they are required to survive and operate in some of the toughest environments; not just geographically but also in hostile territories like battlefields. In most of the cases, they are also built to encode and/or decode information and also use different frequency bands and modulation schemes to keep the information safe and secure till it reaches the right receiving end. As a result, military communication is more intense, complicated, and often motivates the development of advanced technology for remote, systems such as satellites, projectiles, aircrafts, both manned and unmanned.

What is a telecommand?

A telecommand is sent to control a remote system or systems not directly connected to the place from which the telecommand originates. This science is known as Telemetry. Most of these systems are onboard military aircrafts or ships and have to undergo stipulated certification before deployment. For a telecommand to be effective, it must be modulated onto a carrier wave, which is then transmitted with adequate power to the remote system. The remote system then demodulates the digital signal from the carrier, decodes the telecommand and then executes it.

Current coding/decoding methodology

In the present day scenario, the telecommand, which is in binary form, initially undergoes an FSK (Frequency Shift Keying), in which the binary/ digital information is transmitted through discrete frequency changes of a carrier wave. Further, this is frequency modulated (FM) by a high frequency carrier and transmitted using an antenna. The receiver needs to perform the reverse of this process to decode the telecommand. It has to perform an FM demodulation to obtain the FSK data which is again decoded through a Frequency-to-voltage conversion process to get the original binary data or command.

Design Considerations and Technology Aids

The front-end of the telecommand receiver is the most important section as it decides the sensitivity and the noise frequency rejection capability of the receiver. Added to this, the core component of the front-end decides the Noise Figure (NF) of the entire receiver. This demands an effective design taking all the parameters into considerations along with a careful

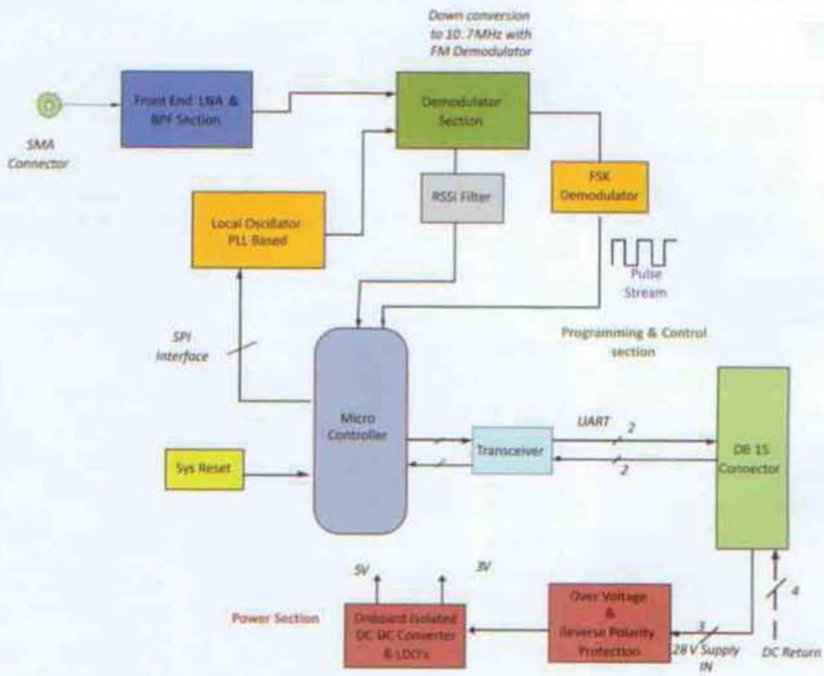

Figure 1:Architecture Block Diagram

selection of components.

Advanced filters like SAW / Ceramic filters can be chosen on the front-end as against traditional discrete filters, to achieve better noise rejection. They also provide advantages such as very low form factor, sharper response, lesser insertion loss and low temperature drift.

Selection of a front end filter with wider bandwidth makes the receiver tunable to various centre frequencies within it. This makes the communication more restricted and user can confine his program to the required frequency. Since most of the currently available receivers are of standard frequency, they can be easily jammed. Having a tunable range addresses this drawback.

Reduced component count, better MTBF

Readily available single chip FM demodulators makes the task of a designer much easier as these have a mixer, limiter and a quadrature detector with all the necessary circuitry in-built. Opting for such a single chip solution greatly reduces system cost, size, time-to-market and increases the performance and integrity of the system.

Highly stable, programmable PLL based local oscillators are desirable, as they provide greater flexibility by enabling the receiver to be tuned on the fly, to differeht carrier frequencies over a wide range, making it more versatile in military environments. They also help in maintaining secure communication as they can operate at different carrier frequencies.

Another important parameter of the receiver is RSSI (Receiver Signal Strength Indicator). This information is extracted by the demodulator and simply indicates the strength of the received signal. How it is treated and what decisions can be taken based on RSSI depends on the system designer. High dynamic range and linearity are the key parameters to be considered while using RSSI. Usually a small drift with respect to temperature is observed depending on the method of construction by the manufacturer. High-end receivers need to provide some kind of temperature compensation within the system to accurately determine the strength of the received signal. A simple look-up table implemented within a microcontroller along with a temperature sensor on-board can address this.

Adding a microcontroller along with UART lines makes the system an independent and standalone unit. The microcontroller is required to configure the on-board PLL and to measure the RSSI along with look-up table implemented. It can also be used to decode the received telecommand and provide a logical output to the next stage, which could drive a set of relays based on the command decoded.

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PCB Design Challenges

PCB design considerations are another important aspect, which designers have to address while designing a Telecommand system. Frequencies around 500MHz require a professional PCB design to get optimal results with special consideration given to component placement and layer stack-up.

A high receiver sensitivity of -115dBm means that the receiver is capable of detecting and recovering signals less than a Micro voltage (μV). To attain such high sensitivity, noise should be kept as low as possible throughout the system. Also, a good ground plane along with stitching vias is a must. Coplanar routing guide-lines and right selection of dielectric material is also essential.

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Implementing a highly sensitive RF circuitry and digital circuitry containing a microcontroller on a single PCB is a challenge. Care needs to be taken at all levels to minimize the switching noise by implementing an isolated ground plane for the RF and digital sections. Ferrite beads and common mode choke should be used where necessary. Proper de-coupling capacitors and their placement are important, along with the selection of Low Drop out regulators with very low noise and high PSRR. All through the RF path, proper impedance matching has to be maintained, especially on the signal path while connecting from one component to other. As stated by 'Maximum Power Transfer Theorem', even a small mismatch in the impedances leads to a great loss of an already weak signal.

Conclusion

The considerations defined above with a smaller form factor, ESD and transient protection, wide input supply range and rugged mechanicals can make the telecommand system easily adaptable for a wide range of platforms like short range wireless applications, commercial aircrafts, parachutes, etc. This is testimonial to the nature of technological advances in both the commercial as well as the military segment.