Next-Generation Wireless Sensing is Moving Forward

With the integration of MEMS technology in the remote, motion signatures can be digitized for the game control.

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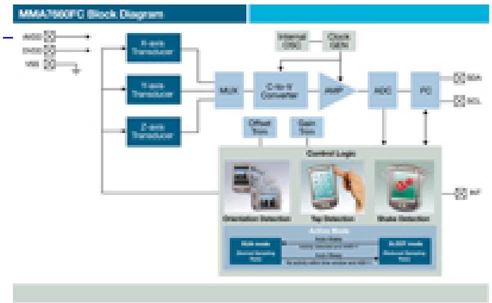
Consider the gaming industry and you will find motion sensing at the forefront. The leading gaming platform today (and subsequent aftermarket equivalents) consists of a wireless sensing handheld remote. This motion sensing remote can be used to represent various real life action equipment such as a tennis racket, a sword, and a steering wheel. The motion detection capability in the remote was a gigantic step toward more life-like human interaction in games. However, there is another big step coming. MEMS accelerometers, one of the key enabling technologies for the motion detection of the remotes today, are now being offered at lower costs with higher integration and accuracy. In parallel, the knowledge of the true capability of accelerometers is being realized. With lower costs, gaming manufacturers can now consider adding multiple wireless sensors to a wearable gaming system, enabling a broader sensor measurement. With integrated wireless sensing, actions of the player's entire body can be detected for next generation gaming.

The Wireless Sensing Remotes of Today

The motion sensing capability built into motion game controllers of today allow infrared LEDs to work with the optical sensor on the remote so it can be used as an accurate pointing device (up to 5 meters). The controller requires two AA batteries, as a power source, lasting 60 hours while operating the accelerometer and 25 hours while operating both accelerometer and pointer functionality. The accelerometers in the remotes are analog output with sensitivity of &plusmn2g and &plusmn3g. Motion is detected by the accelerometer; and a voltage output is sent to an on board processor and digitized and then sent out on a Bluetooth protocol to achieve low power and low input latency for significantly less delay between motion control and game response.

MEMS Sensors of Today

The MEMS accelerometers are the sensing technology measure static (due to constant force of gravity) and dynamic (due to motion or vibration) acceleration, replacing buttons for control of the previous generation game hardware. Accelerometers sensing capability is enabled by its g-cell, a mechanical structure formed from semiconductor materials (polysilicon) using semiconductor processes (masking and etching). It can be modeled as a set of beams attached to a moveable central mass that moves from their rest position when subjected to acceleration.



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Freescale's MMA7660FC block diagram shows the internal signal conversion to voltage, amplification and digitization to work with embedded control logic designed for mobile gaming and handheld motion detection.

An ASIC is paired with the g-cell to perform signal amplification, calibration and filtering to provide an output proportional to acceleration. With the integration of MEMS technology in the remote, motion signatures can be digitized for the game control. The g-cell of accelerometers has gone through an evolution in the last few years. It is designed to be more sensitive to acceleration changes and less sensitive to package stress that can occur during board mounting in the printed circuit board (PCB) assembly process. In addition, the design has gone through various structure changes. For example, as Freescale developed its single axis accelerometer with a g-cell structure of a trampoline that would deflect like a trampoline when exerted with acceleration to an X- and Y-axis g-cell, the structure was designed as inter-digitated fingers that would move to sense X- and Y-axis accelerations.

Finally, the g-cell design has changed to a single mass XYZ-axis sensing structure where a mass of interdigitated fingers sense X- and Y-axis acceleration and the entire mass teeter totters for Z-axis sensing. This evolution to the single mass XYZ axis sensing solution has allowed Freescale to continue to increase performance while still reducing power consumption, cost and size.

Motion Sensors are Moving toward Higher Integration

MEMS accelerometers were originally developed for automotive applications where very high acceleration/deceleration detection was needed to detect a crash signature. It was not until the technology was designed to provide higher sensitivity to detect lower acceleration ranges (lower g-ranges) that human interface applications were apparent. During the last decade, design specifications have been targeting the consumer market for small form factor, low power, higher feature integration, and lower cost. This trend is continuing as the form factor is now in 3x3mm packaging and features such as auto-wake, auto-sleep, threshold, pulse and fall detect are now wide spread through product offerings. Freescale's MMA7660FC is an example of that trend. For example, configuration registers for detection tap and pulse detect allow customers to specify a threshold level, a time duration, and a debounce filter. This integration of features into the sensor allows customers to quickly implement the solution on their hardware, with minimal effort for algorithm development. This also reduces the processing required on the system controller.

Enabling More with Wireless

As sensor features and intelligence increase, so are the features of radios. A great example of this is Freescale's MC13224V which includes a 32-bit ARM7 microcontroller running at 26 MHz, two 12-bit analog-to-digital converters, an on-chip IEEE® 802.15.4 transceiver, flash memory, RAM, ROM and all necessary RF matching components. What is needed for all that processing power you may wonder? Many wireless sensor applications require a smarter network for data transfer and analysis. All the motion processing should be done on the controller, so that the only information that is sent to the console is position and motion vectors, thus dramatically reducing the load on the network, which is extremely important for latency critical applications like gaming.

Freescale's MMA73xx analog output 3-axis accelerometer family has a broad offering of g-ranges accommodating various game controllers of today.

For example, in the game of tennis, current gaming platforms sense the motion in the racket or the hand holding the controller that would be moved with the motion signature of a racket. However, in a real game of tennis, a good swing is dependent on much more than the racket. With a sensor network, a sensor node on the racket can measure the motion of the racquet as it "moves towards the ball on the screen," but it can also talk to a sensor node on the gamers' forearm and upper arm to monitor that the gamer is not bending or straightening their arm or moving their wrists. Sensor nodes on the shoulders can monitor that the gamer rotates their shoulders while sensor nodes on the gamers' head can monitor that the head stays forward to "keep their eye on the ball". All the sensor nodes would continue to monitor the gamer as they "make contact" with the ball when the "face" of the racquet should be square to the ball. And monitor the shoulders as they should rotate through contact. The multiple sensor nodes on each limb can work as simple nodes where acceleration data is sent to a main node for processing. Or, the multiple sensor nodes can each do a certain level of motion processing and then send that compiled information to the main processor.

Human Body Sensor Network is the Missing Link

In order for a gaming system to recognize full body motion, it will require gaming hardware to go beyond the handheld controller; therefore, requiring a wireless sensing network on each player for gaming control. Sensors mounted on the arms, legs, torso, and head will enable full range of motion detection. The motion of the human body is limited by the joints of the body, but even with this limitation, there seems to be limitless motions possible. Accelerometer measurement data, such as motion and tilt of one limb, can be transmitted to another limb that is also measuring motion and tilt. Each sensor could act as a data node measuring data and sending it to a node cluster master to then determine the motion as a whole. This wireless cluster master would be equipped with processing power to do analysis of the motion of a section of body or the entire body. This master could also be equipped with a higher bandwidth radio using a protocol like Wireless LAN (IEEE 802.11) or Bluetooth® Protocol (IEEE 802.15.1) to send the information to the controller. Since the Bluetooth protocol allows for up to only 7 Bluetooth-capable devices, it works best for the main processing node to send the total motion signature for the player to the console, but not for the 10+ nodes on each player.

The ZigBee® Protocol was designed for applications where multiple radios could be enabled in a given area and need to automatically form a network without user intervention. This would be ideal for gaming controllers, where the controllers could be turned on and a new player can be detected and brought into the game. Because the ZigBee protocol was designed for low-power applications, it fits well into game controllers where reliability, battery life, and versatility are important.

Conclusion

With motion detection capability on Freescale's MMA7660FC and processing and wireless capability on Freescale's MC13224V, a hardware solution for each individual sensor node is available today. A Human Body Sensor Network protocol is not defined by any standard yet. However, with the hardware available today, with motion algorithm development continuing, and with an obvious trend of higher accuracy motion detection for consumer gaming, gaming manufacturers may develop their own way to make this data transmission and sensor data fusion possible.

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