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APPLICATION NOTE 6061

GOLF OFFERS INSIGHT TO WEARABLE IOT TECHNOLOGY TRENDS

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Abstract: The game of golf provides a unique perspective of wearable Internet-of-Things (IoT) technology trends over the next 3 to 5 years.

A recent survey by Forrester Research shows that 36% of European consumers are interested in a wristband as a wearable sensor device (**Figure 1**)¹. A market study by IHS Technology forecasts an 18% six-year CAGR for wearable devices, reaching 135 million units in 2019.² In addition, the 2014 Cisco VNI report on mobile data traffic estimates there will be 177 million Internet-connected wearables in 2018.³

Clearly, market indicators point to consumer readiness for wristband wearable devices and convergence with the Internet of Things (IoT). What trends can we expect for wearables? Surprisingly, the game of golf provides a unique perspective of wearable IoT technology trends over the next 3 to 5 years.

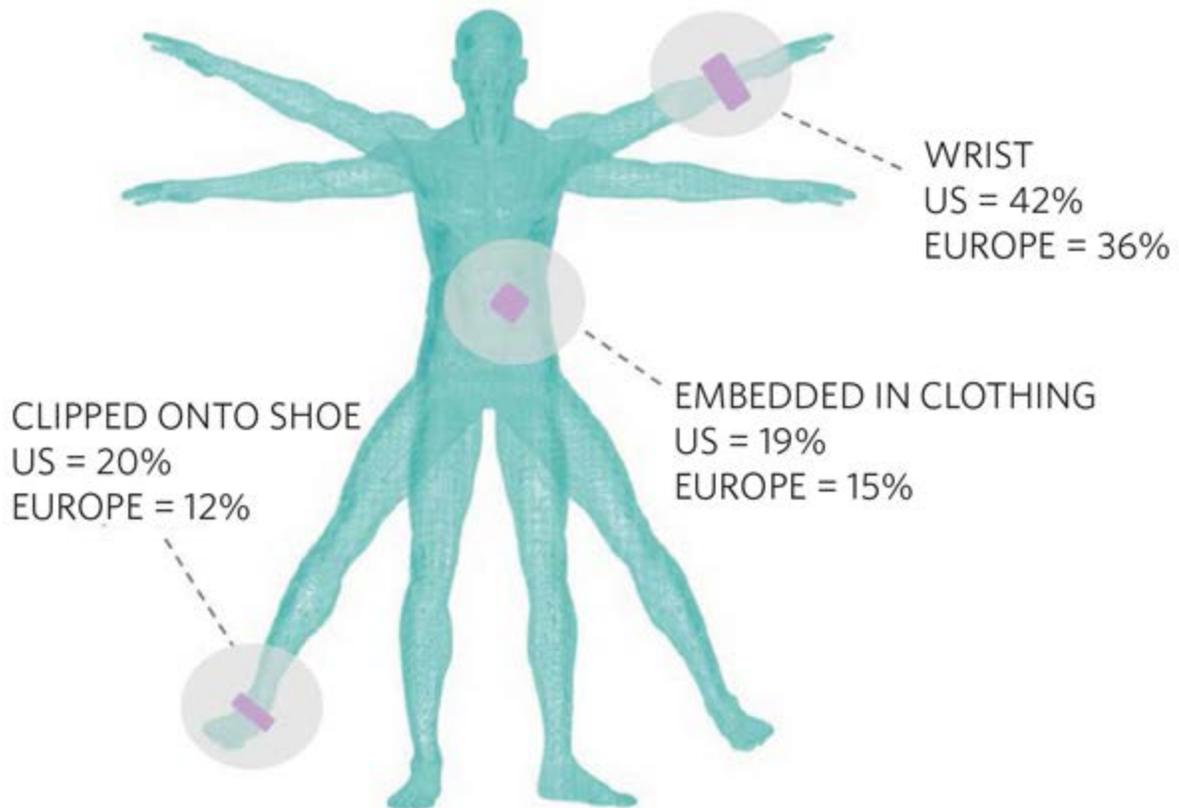


Figure 1. European and U.S. consumer interest level is highest for sensor-based wristband wearables.

There are about 80 million golfers worldwide,⁴ and in 2016 golf will be an official Olympic sport with international participation. Golf serves as a good case study for anticipating wearable tech trends because the market potential is large, the consumer base is global, and golfers are avid users of wristband wearable devices. Popular demand for GPS golf watches like the one shown in **Figure 2** confirm that golfers embrace wearable technology. Familiarity with the games' key attributes can reveal valuable insight to wearable technology trends.



Figure 2. The GPS golf watch is a popular consumer wearable (Image courtesy of Garmin Ltd., Approach S6).

The game of golf demands analysis of many sensory inputs, making analog sensor integration an important trend for GPS golf watches. Sensors can provide a golfer with knowledge of environmental conditions and swing mechanics, leading to better golf scores. Environmental conditions affect ball flight, shot accuracy, and distance control. Some relevant environmental parameters are ambient temperature, wind direction, wind speed, altitude, elevation, and distance. Golf swing mechanics can be improved with metrics of swing tempo, timing, and power. Swing metrics are acquired by processing multiple degrees of freedom using MEMS inertial sensors. Moreover, sensors are useful for monitoring a golfer's physical condition.

Golf is an outdoor sport played in moderately cold-to-hot weather conditions, and a game that can be walked, making it a healthy activity. Walking an 18-hole round of golf is equivalent to a 3.5 mile run and burns up to 2,000 calories.⁵ For the avid walker, strength and endurance are requisites to scoring well. Consequently, sensory information of the body's exposure to the elements and physiological condition are important wearable features. Some useful physiological parameters are heart rate, body temperature, and hydration level. A continuous heart-rate monitor, based on photoplethysmography using reflectance-mode optical sensors, can alert a golfer to fatigue or overexertion.

Armed with insight to key attributes of the game, the major trends in GPS sports watch technology can be anticipated:

- Physiological sensor array integration
- Environmental sensor array integration
- Power-management integration
- Cloud-connectivity integration

Figure 3 summarizes technology trends, product features, and user benefits of IoT sport wearables. Noteworthy is the trend toward dense sensor integration.

IoT Sport Wearable Trends 			
Integration Trend	Sensor	Feature	Benefit
Physiological Sensors	Optical Reflectance	Continuous heart rate monitor Pulse oximetry	Optimize exercise intensity High altitude O2 saturation Alert/prevent over exertion
	Biopotential Electrode	Galvanic skin response	Hydration level Alert/prevent dehydration
	Resistance Temperature Detector	Core and skin temperature	Alert/prevent heat stroke
Environmental Sensors	MEMS Gyroscope	9-Axis sensor fusion 6 Degrees-of-Freedom(DOF)	Golf swing training metrics: <ul style="list-style-type: none"> • tempo, strength Activity tracker Orientation, motion
	MEMS Accelerometer		
	Magnetometer		
	Pressure	Altimeter	Compensate golf ball travel distance Track/monitor altitude performance
	Infrared Light Photo Detector	Ultraviolet radiation monitor	Sun screen reminder Alert/prevent sun overexposure
	Visible Light Photo Detector	Ambient light sensing	Optimize display backlight setting
	Resistance Temperature Detector	Ambient temperature	Compensate golf ball travel distance
Integration Trend	Application	Feature	Benefit
Power Management	Power SoC	Efficient DC-DC conversion	Extend operating time Optimize battery capacity Device miniaturization
	Battery Management	Accurate fuel gauge, charging	
	Energy Harvesting	Ambient energy conversion	
Cloud Connectivity	Bluetooth	Wireless connectivity	Access content Share content
	Universal Serial Bus	Wired connectivity	
	Global Navigation	Location and ranging	Accurate distance measurement

Figure 3. Dense sensor integration is a key technology trend anticipated in next-generation IoT sport wearables.

The trend of dense sensor integration in sport wearables will require analog semiconductor solutions that faithfully capture and interpret real-world analog signals such as temperature, light, heart rate, motion, and orientation. Furthermore, consumers expect the longest possible operating time before battery charging. A GPS golf watch must operate at ultra-low power with accurate battery management to ensure continuous operation beyond 10 hours in activity mode and 30 weeks in watch mode. As wearable devices trend toward more compact, lightweight, and comfortable form factors, they will need power-efficient and highly integrated analog semiconductor solutions that occupy the smallest possible area. **Figure 4** illustrates the many analog functions packed into a GPS sport wearable typically measuring 5cm x 5cm x 1.5cm.

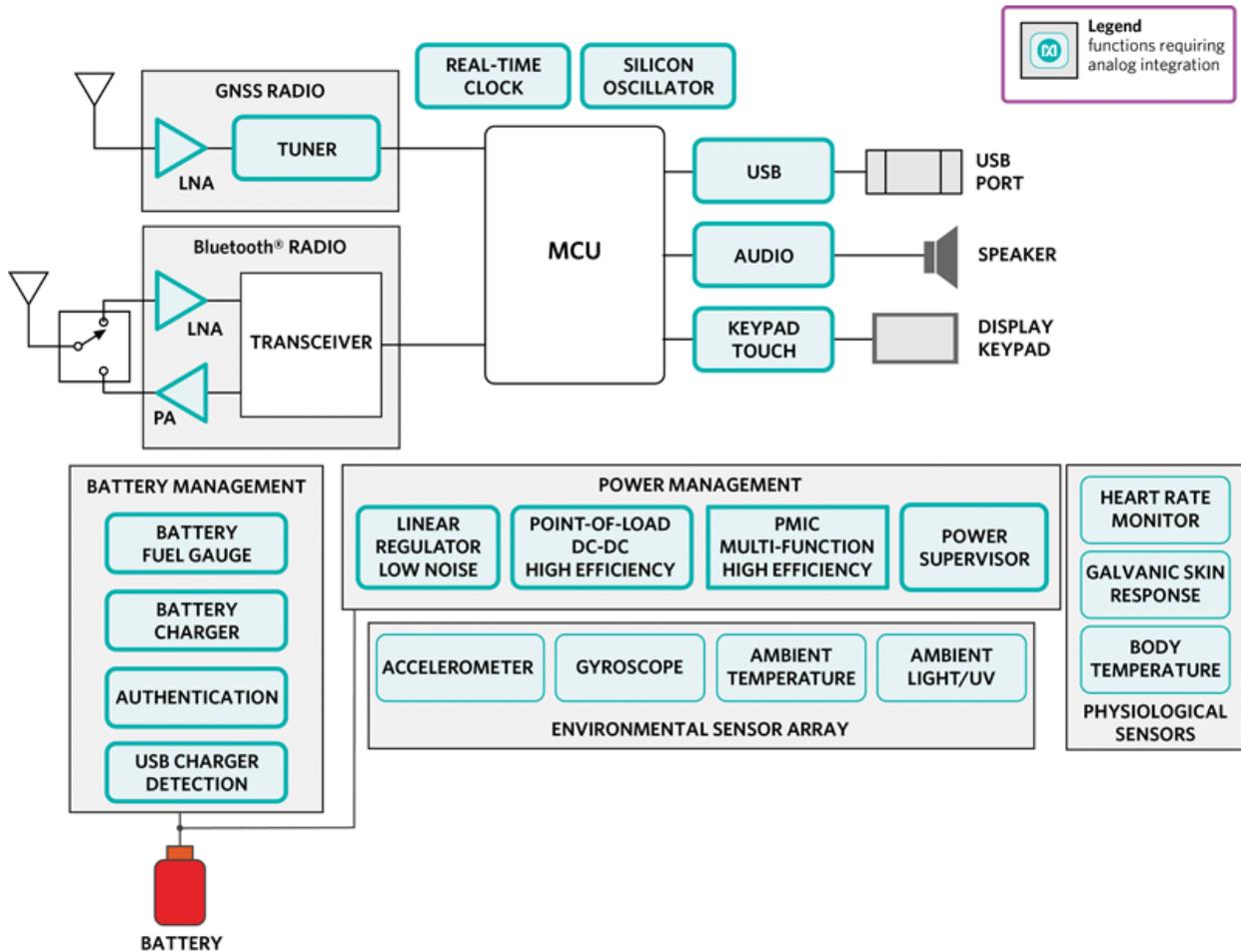


Figure 4. Analog integration plays a vital role in enabling a sport watch wearable with IoT connectivity and an array of sensory functions.

Companies like Maxim Integrated are addressing the next-generation analog integration requirements so that consumers can improve their game with wearable IoT innovations. And for all the golfers out there, expect to see more healthy players enjoying the game and posting better golf scores.

For more information on wearable fitness solutions, visit [our healthcare website](#).

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