A 110W 10Mb/s eTextiles transceiver for body area networks with remote battery power

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A 110µW 10Mb/s eTextiles Transceiver for Body Area Networks with Remote Battery Power

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Emerging sensor technologies are enabling low-cost ambulatory medical devices for remote patient monitoring. In order to replace traditional bulky wired links used to communicate data around and away from the body, recent work has proposed the use of wireless body area networks (BANs) and body-coupled communication (BCC) systems [1-3]. Although such links typically communicate over short distances, the human body presents significant path loss, requiring high TX output power or large RX amplification. Additionally, these inherently single-ended systems must tolerate significant interference from external sources and nearby users.

An emerging technique for conveying information around the human body uses electronics textiles (eTextiles) as a communication medium [4-5]. Figure 27.6.1 shows the implemented eTextiles system, where the medium consists of two electrically separate grids of conductive yarn. Sensor nodes physically connect to the shared medium using metallic button-snaps, and communicate via an eTextiles transceiver chip. Using a pair of physical low-impedance connections has the distinct advantage over wireless and/or BCC systems to be able to: 1) signal differentially, permitting energy-efficient amplitude-modulation schemes that tolerate coupled interference, and 2) power sensor nodes remotely from a local basestation (BS) at extremely high efficiency, minimizing the energy storage requirements on each node. In the proposed system, each sensor node is pre-programmed with a unique 5b ID code, enabling the BS to administer medium access using a TDMA scheme. New nodes added to the eTextiles network are dynamically recognized and added to the BS queue. Additionally, energy-expensive multi-user access and encryption operations can be delegated to the BS since the wired communication link is inherently secure.

A block diagram of the proposed eTextiles transceiver SoC, used in both sensor nodes and the BS, is shown in Fig. 27.6.2. The two main inputs, \( v_+ \) and \( v_- \), feed the RX front end (FE), and are the outputs of differential transmitters. Between packets, a fixed amount of time is allocated to activating transmitters M1 and M2 on all sensor nodes and the BS, directly connecting \( v_+ \) and \( v_- \) to the supply terminals of each chip. This permits the BS battery to remotely charge each node’s external super capacitor, which functions as each node’s energy supply.

Time-sharing of the eTextiles medium with remote charging circuitry forces the DC voltages on \( v_+ \) and \( v_- \) to be at opposite rails at the beginning of packet communication. To save the energy otherwise required to completely charge and discharge the primarily capacitive medium, the DC voltages are held constant by high impedance resistors, and transmitted signals are AC coupled onto the medium with supply-rail-coupled (SRC) differential transmitters (Fig. 27.6.3). High impedance resistors, and transmitted signals are AC coupled onto the eTextiles transceiver chip. Using a pair of physical low-impedance connections has the distinct advantage over wireless and/or BCC systems to be able to: 1) signal differentially, permitting energy-efficient amplitude-modulation schemes that tolerate coupled interference, and 2) power sensor nodes remotely from a local basestation (BS) at extremely high efficiency, minimizing the energy storage requirements on each node. In the proposed system, each sensor node is pre-programmed with a unique 5b ID code, enabling the BS to administer medium access using a TDMA scheme. New nodes added to the eTextiles network are dynamically recognized and added to the BS queue. Additionally, energy-expensive multi-user access and encryption operations can be delegated to the BS since the wired communication link is inherently secure.

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References:
Figure 27.6.1: Implemented eTextiles system with packet diagram shown.

Figure 27.6.2: eTextiles transceiver block diagram used for sensor nodes. The BS uses the same chip, but replaces the super capacitor with a battery.

Figure 27.6.3: Supply-rail-coupled (SRC) differential ternary transmitter.

Figure 27.6.4: RX front end (FE) consisting of four time-offset acquisition (AO) blocks.

Figure 27.6.5: RX back end (BE) used for synchronization.

Figure 27.6.6: Measured transient waveforms and table of measured results.
Figure 27.6.7: Die photograph of the eTextiles transceiver.