Implementation challenges for PCB tracking using RFID

Radio frequency identification (RFID) ICs are a popular alternative to barcodes for PCB tracking applications. This article outlines some of the challenges that may be encountered when implementing an RFID system

Since the 1980s, manufacturers have used barcodes to tag PCBs at the start of their way around the production cycle. Traceability is becoming more important as flexible manufacturing gains popularity; different versions or models of an electronic product can be produced based on the same PCB with different combinations of components mounted on it, depending on the demand for the various models. The product a PCB is intended for could even be changed half way around the cycle. Traceability is also very important in safety-related applications such as the aerospace sector, because if certain components malfunction and the parts have to be traced, data on the PCB's history is required in as much detail as possible, as quickly as possible. Tracking goods around the manufacturing process therefore needs to be done in an automated, machine readable way.

Barcodes are simple and inexpensive to implement although they have limited features. The barcode pattern is printed onto a paper label which is glued onto the PCB, taking up a relatively large amount of space on the board (not good for modern PCBs, where board space is critical since the boards are as densely populated as possible). The barcode is read by a scanner which needs to be able to "see" the paper label to read it, meaning it cannot be read from outside an enclosure. The PCB has to be in the right orientation with the barcode visible to the scanner. If the barcode gets torn, burnt, stained or greasy, it may render it unreadable.

Low information density

The data a barcode holds is simply a number which identifies the PCB. Data about that PCB can has to then be retrieved from a database. 2D barcodes have been introduced in recent years which are more reliably read by barcode scanners, even after being soiled or torn. They have a higher information density than their 1D cousins and can be read faster and more reliably. However the scanning technology for these barcodes requires high resolution camera equipment and the cost may outweigh the benefits.

RFID (radio frequency identification) devices have been proposed as a solution to tracking PCBs around the manufacturing process. An RFID chip, mounted on the board and combined with an antenna, provides a durable way of attaching a large amount of data about the PCB to each board. RFIDs can be read from a scanner at larger distances than barcodes, and do not require line of sight; the RFID chip can be read regardless of whether it is on the underside or opposite side of the PCB and can even be read from outside an enclosure. Increased readability is of paramount importance.

Another feature of RFIDs is that they can be programmed and reprogrammed to store additional information about each individual PCB, such as:

- Manufa cturer data
- Part number or order number
- Produ ction date
- Config uration status
- Software version

This information can be updated part way around the cycle if any of these parameters changes. There should be an ample amount of storage on an RFID chip for the traceability data required.

Challenges for RFIDs

Implementing RFID technology is not without challenges. A major roadblock in adoption to date has been that mounting an RFID chip requires specialised knowledge of RF design, for such key elements as design of the antenna and the associated filters and impedance matching circuit.

The antenna matching circuitry is necessary to achieve the required sensitivity, and can be complex to design, especially considering the limited PCB board space. The size of the RFID chip itself also contributes to the board space required, and it has to be placed and soldered precisely onto the antenna pattern on the board. A wide band pass UHF filter is required if the RFID is to respond to the different frequencies used worldwide, and this would be very difficult to achieve without the matching circuit.

Technology that overcomes some or all of these challenges has been developed by leading ceramic components manufacturer Murata.

MAGICSTRAP® ceramic module

Murata has used its LTCC (low temperature co-fired ceramic) technology to create an RFID device which combines the latest in ceramic materials with innovative design to produce a tiny module, called MAGICSTRAP® (see **figure 1**). The MAGICSTRAP® RFID module requires little RF expertise and no soldering or conductive glue to mount. Murata has developed and patented inductive-coupled terminals especially for the MAGICSTRAP® module, which do not require direct connection to the antenna – proximity is enough. It can simply be mounted onto the antenna using ordinary adhesive or even sticky tape. In terms of placement, sticking the chip on the antenna pattern to the nearest millimetre is sufficient – traditional package types for RFID modules require micron accuracy, so this is a huge step forward.

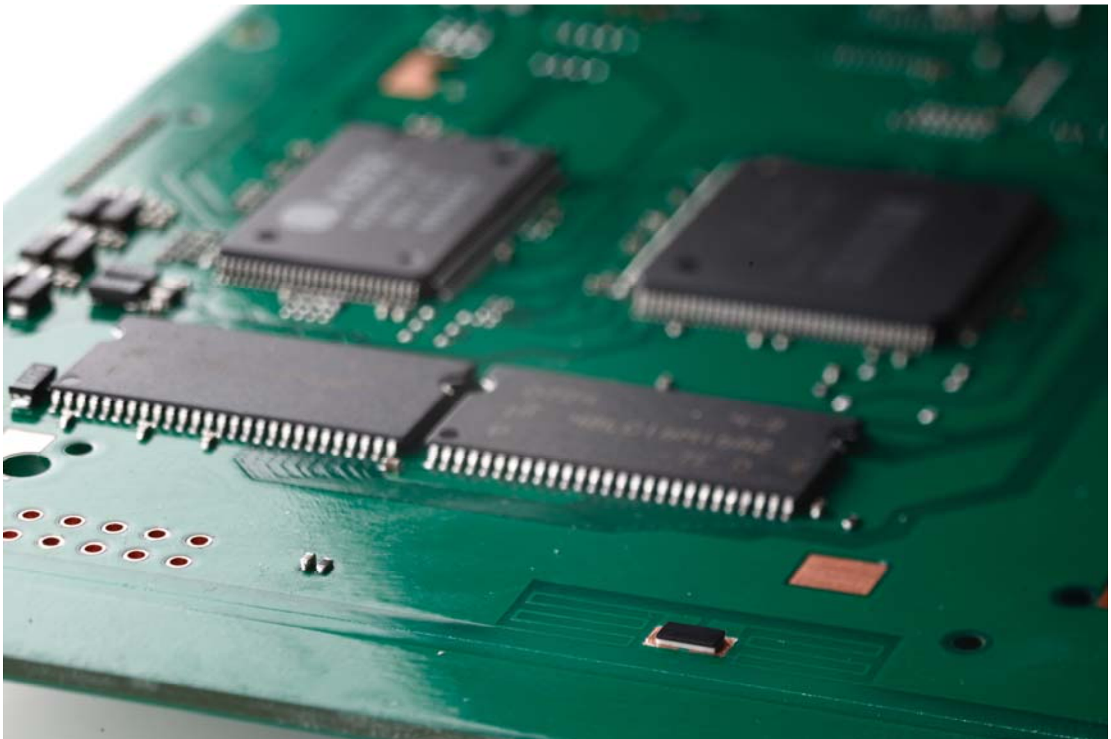

Figure 1: Murata's MAGICSTRAP® module mounted on its antenna pattern

The module comprises Murata's LTCC (low temperature co-fired ceramic) substrate, plus IC and packaging. All the necessary RF circuitry is embedded within the LTCC substrate of the module, with the IC then mounted on top (see **figure 2**). The LTCC substrate incorporates the wideband antenna filter circuit, the antenna impedance matching circuit and 10kV ESD protection. It is only 550um thick.

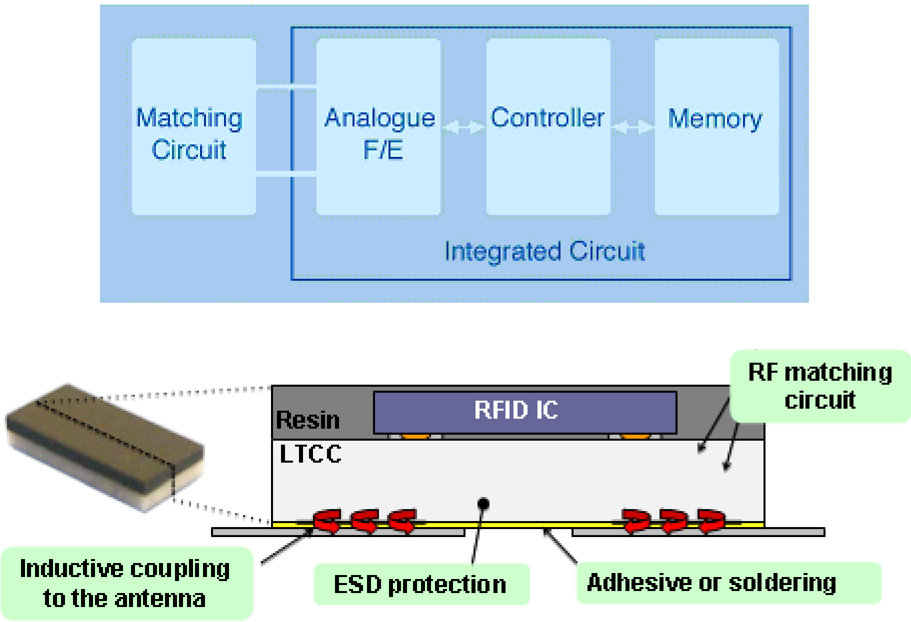

Figure 2: Construction and block diagram of a Murata MAGICSTRAP® module

The antenna itself utilises a metal pattern and the ground plane of the PCB as part of a dipole antenna (see **figure 3**). The ground plane of the PCB receives the RF wave from the air while the antenna pattern fixes the centre frequency and bandwidth of the RFID. It is important to note that a change in PCB supplier may result in even the slightest change to the properties of the PCB ground plane material, and affect the accuracy of the circuit.

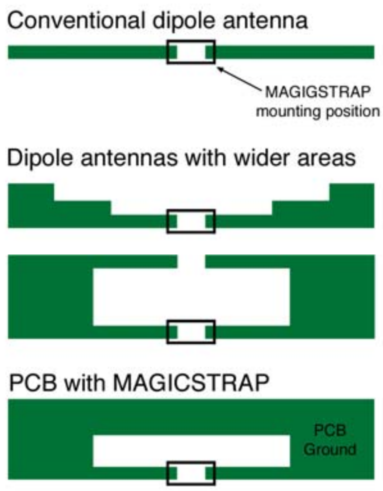

Figure 3: MAGICSTRAP® recognizes the ground plane of the PCB as part of the dipole antenna

The embedded wideband antenna filter circuit, plus a single wideband antenna (for which Murata provides a reference design), allow MAGICSTRAP® to be readable over the band 860-960 MHz at a range of up to 5m. This means the same module and antenna pattern can be used worldwide (in Europe, the US and Japan), saving cost and inventory for manufacturers. It is possible to use different size/shape antenna patterns which trade off surface area versus read distance (see **figure 4**). Since the RFID recognizes the ground plane of the PCB as part of the dipole antenna, it's also dependent on the size of the PCB. The largest antenna shown here is 32 by 13mm and gives a read range of 5m, but bigger antennas are possible on larger PCBs for applications such as white goods.

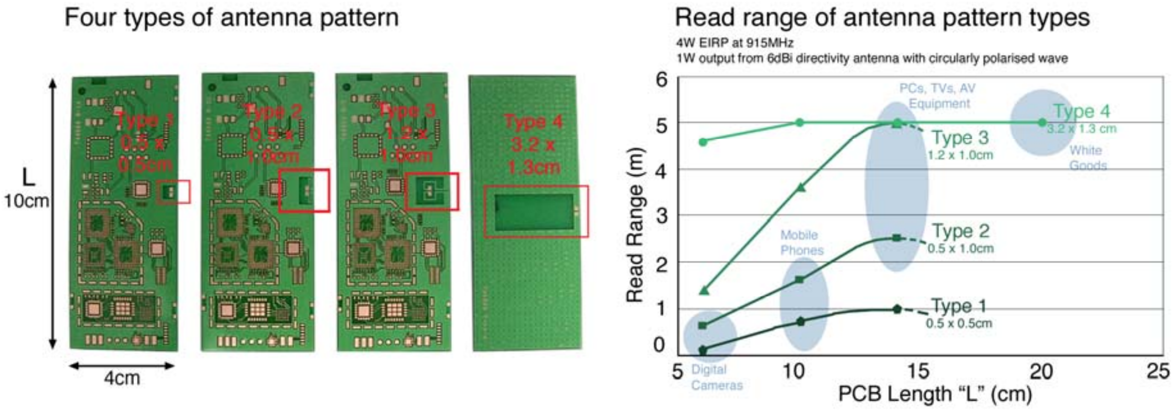

Figure 4: Read range is dependent on the size of the antenna pattern and the size of the PCB

Several options for memory capacity are available by selecting a different RFIC without changing the antenna design. MAGICSTRAP® modules with memory between 512bit and 2kbit are available.

In summary, RFID technology allows tracking data to be attached to a PCB in an easy and machine readable way. Some of the challenges associated with use of RFIDs include design of an associated RF circuit, mounting the RFIC or module accurately and making sure the band pass filter is wide enough to accept frequencies used for RFID chips worldwide. Murata's MAGICSTRAP® is a tiny RFID module that incorporates all the necessary RF circuitry, embedding it within the multilayer ceramic substrate to remove the need for RF expertise. It can be mounted with only millimeter accuracy using ordinary adhesive or sticky tape, with the ease of handling of an SMD component. Murata's strengths in multi-layer ceramic devices are the enabling technology for this product, which will ultimately drive widespread adoption of RFID technology.

Murata www.murata.com