EMERGING TECHNOLOGIES IN RF DESIGN AND IMPLICATIONS ON DESIGN FOR MANUFACTURABILITY AND TESTABILITY IN OUTSOURCED PRODUCTION

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ABSTRACT
RF-based products offer original equipment manufacturers (OEMs) greater system connectivity and flexibility. This paper will look at trends in RF design in utilities metering applications, and the pros and cons of subcontracting this work to experts in the field. It will also discuss the challenges associated with supporting the design for manufacturability and design for testability goals. Finally, it will look at key elements needed to efficiently team an electronics manufacturing services (EMS) partner, critical component supplier and OEM in the product development effort.

Factors driving increased integration of RF technology in utilities metering applications include:

- Lowered research and development (R&D) costs and greater availability of basic reference designs
- Increased interest from utilities are lowering cost structure through the use of more intelligent metering technology
- An active pool of automated meter reading (AMR) specialized companies and increased focus on this area by large meter manufacturers.

The end result is a growing market for companies with existing distribution channels. The challenge is that meter expertise and good distribution channels do not automatically translate to an ability to easily develop products incorporating RF technology. In some cases, EMS companies provide this missing link.

AVAILABLE TECHNOLOGY
AMR and meter OEM design departments have an interesting challenge. RF acceptance is high. The cell phone market is saturated and semiconductor companies are looking to broaden applications for RF on a chip to increase return on investment for that large development cost. This has resulted in overall decrease in both component costs and design cost. There is a high level of ability to design product by integrating off-the-shelf solutions. Semiconductor manufacturers are supplying evaluation modules that are tested and calibrated. As a result meter OEMs can integrate the technology to their device with minimal RF R&D.

The fact that semiconductor houses supply the printed circuit board (PCB) trace design which can be dropped into the existing design opens markets to companies with less RF expertise.

However, it is getting increasingly difficult to prototype finished products because the accuracy and precision when placing parts for UHF-Microwave RF products often dictates if they will work at all let alone what performance they can achieve.

BUSINESS ISSUES
Another market driver is increased interest from utilities in offsetting costs through more intelligent data collection and billing activities.

Meter reading carries a cost. Technology which enables data collection to move seamlessly from place of measurement to place of billing reduces cost. This seamless linkage facilities a range of options such as time of day billing, remote cutoff/turn on of meters, load shedding, leak detection, customer usage profiling and meter security. One technique for this communication technology is mesh networking, but the actual model used can have significant variance.

As these mesh networks grow in complexity, RF frequency ranges are going from UHF to microwave (e.g., 900Mhz up to 2.3-2.4GHz). In these continuously available transmission networks, such as GSM, wi-fi or other bespoke systems (450-900Mhz), meter data is broadcast directly back to a central office. A more localized approach involves fixed transponders and drive-by collectors to capture data locally and transfer to headquarters.

Eventually widespread wi-fi-enabled mesh networks will link to the internet transmitting in the 5+GHz range. While simplifying meter-to-central office linkage for utilities, this adds complexity to meter design as it drives miniaturization in PCB componentry (e.g., use of 0201 components).

RANGE OF PLAYERS
Companies developing product for this market range from traditional meter manufacturers to companies which simply specialize in developing AMR add-on devices for meters. Common elements among these companies are strong distribution channels and an understanding of market needs. However, many are not manufacturing experts, per se. Instead, they team with independent design firms and/or

EMS providers to access scalable technical expertise and manufacturing resources.

MASTERING TECHNOLOGY CHALLENGES

While R&D expense has significantly been reduced, RF product development efforts in this area typically require engineering resources focused on product enhancement, test plan strategy and test development. Third-party qualification in support of regulatory approvals may drive additional spins of the design. In short, bridging the gap from RF on a chip to an approved/fielded product requires specialized RF engineering expertise and ultimately a manufacturing partner capable of supporting a high mix/variable demand technology complex production and test process.

From a design standpoint, higher RF transmission ranges force a more precise PCB layout. With RF or any high speed digital technology, the length of the trace is a function of the wavelengths you are trying to send. Size is shrinking. Every trace is a component at these speeds rather than just a linkage. There is virtually no packaging anymore. The product must generate sufficient RF power to work in the correct band, yet have minimal interference with other equipment operating in the same spectrum. Pad design is extremely important.

For example, in one project a PCBA malfunctioned because the original component layout was not generating the correct power and was sending out harmonics that caused interference. Moving one capacitor half a millimeter to the left solved the problem.

Component selection is also important and is an area where value for price must be considered. The lowest cost components may not perform as anticipated or may have availability issues over the longer lifecycles normally associated with these products.

Integration of design and manufacturing resources becomes critical both in terms of technology and overall product cost competitiveness.

Test strategy should help ensure continued product conformance to appropriate regulatory agency compliance standards. Testing should provide an aid for the manufacturer to put in corrective measures to improve yield. The process should also include a feedback loop that ensures that as design issues are identified (i.e., component tolerance variances), information is sent to the design house to drive corrective action in the next design spin. This helps the design company optimize the product for manufacture. At the same time, while test should be effective enough to ensure products are compliant, they need to be cost effective in volume production.

In the manufacturing process, robust inspection processes can also be critical because, when products in this application fail, it may be a noticeable compliance failure that draws the attention of not only the end customer but also that of the agency regulating the end customer.

KEY POINTS IN SELECTING AN EMS PROVIDER

While the term product realization is widely used in the EMS industry as a generic description of design through delivery capability focus, in this case industry-specialized product realization is truly the service needed.

Key benefits the EMS provider should be prepared to deliver include:

- A robust product development process which includes both support of conceptual design issues and the more traditional design for manufacturability/design for testability (DFM/DFT) expertise
- Ability to support needed prototyping for product qualification and the subsequent ability to efficiently transition to volume manufacturing
- Engineering expertise related to RF test strategy and test development
- Component selection recommendations which consider quality, availability and cost
- Ability to place fine pitch components
- Ability to support software integration and other customization requirements in a variable demand environment
- Ability to provide required testing to ensure continued product regulatory compliance
- Ability to support post-manufacturing requirements such as fulfillment, repair depot and spares support.

EXAMPLE

How can an EMS provider add value to an RF product development and realization process? Often these contributions are made incrementally throughout the process and long-term result in shortened design cycles, reduction in design to production learning curve issues and improved quality. The following example outlines a project outsourced by an OEM wishing to add RF technology into its system solutions for the utility market.

Key challenges which needed to be addressed included:

- A requirement for a product operational life of 15+ years
- Hostile operating environments which could include high moisture contact and significant temperature variations
- Different product configurations for different markets
- High engineering change notice (ECN) activity particularly in relationship to software revisions
- Variable demand driven by utility ordering practices
- A regulated design which could require formal re-qualification if component substitutions were made.

The EMS provider managed mechanical enclosure design, design for testability and component selection. DFM considerations took into account the EMS provider's manufacturing equipment constraints and processes which were aligned with IPC design guidelines.

The EMS provider evaluated component life cycles and approved vendor list (AVL) choices. In terms of component life cycle analysis, semiconductors were the primary focus in potential obsolescence evaluation. Recommended AVL choices were based on price competitiveness, track record of supplier performance and availability. When component substitutions were recommended, the EMS provider sent samples and data sheets to the OEM's design house for evaluation. This particular EMS provider also had strengths in custom wound coil design and manufacture. The design house specified the requirements for an inductive coil, but the actual bobbin was selected and wound by the EMS provider.

An additional area of focused collaboration was design for testability (DFT). The EMS provider had expertise in both in-circuit test development and RF functional test and fixture development. As a result, they developed the test programming, functional test set and fixtures. They also made recommendations to the design firm for connector placement to support test node accessibility and optimum RF signal integrity during test.

Test development was an area of greatest technical complexity. Test node accessibility and RF signal integrity drove specialized focus in both the product design and test fixture development. Additionally, the test process needed to incorporate a software programming step.

Product life issues were addressed in the initial design process during component selection and qualification testing. A potting process was utilized to minimize/eliminate environmental exposure.

The EMS provider's systems for configuration control and traceability supported the high levels of ECO activity and challenges associated with multiple product configurations. The Company uses ISO 9001:2000 as its primary quality management system and has very specific procedures to enhance its ability to support customer needs for ensuring documented quality, configuration control and traceability.

CONCLUSION

Market drivers are creating significant opportunities in RF-based utilities metering applications. For OEMs, the trick to best capitalizing on these opportunities is combining existing marketing expertise with a strong team capable of rapidly developing, qualifying, manufacturing and shipping products.

REFERENCES

[1] L. Fleming, 'Integrating Strategic Alliances in Product Development and Manufacturing', Global SMT & Packaging, February 2007.