Technical Article

Simplify Radar Development for Your Next IoT Application

TEXAS INSTRUMENTS

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Sensing offers an opportunity for companies to increase functionality in existing products. In the Internet of Things space, for example, Omdia predicts that sensor shipments will increase by almost 20 billion units from 2020 to 2024, with radar sensing growing at a compound annual growth rate of approximately 30%.

Interest in and use of TI millimeter-wave (mmWave) radar is growing given its many advantages, including the ability to operate in challenging conditions; avoid privacy concerns; and provide high-resolution range, velocity and angle information.

In this article, we will provide some insights on optimizing costs associated with mmWave radar sensing solutions, share real-world examples of new product ideas and explore an actual board design to expedite development.

For systems already incorporating mmWave radar, cost reduction can enable new price points to fill a gap in the product portfolio or offer a new entry point for customers. A lower-cost solution can also help justify the addition of sensing capability to provide new functionality, convenience and marketable appeal. The building automation space is an example of these possibilities.

Drive Down Costs with mmWave Radar

A supplier of automatic doors for retail stores can establish a lower-cost entry point by offering a less-expensive automatic door, which could attract new customers and help justify additional adoption from existing customers. A lower-cost mmWave solution could help justify the extension of an automatic door's capabilities by sensing the directionality, in addition to the presence, of an individual to determine whether the door should or should not open or close. This additional capability can reduce heating and cooling costs for the building and overall mechanical wear of the automatic door.

When it comes to reducing costs, the decision is generally easy. As with many decisions, however, there are trade-offs to consider between meeting overall product requirements while reducing associated costs.

The three main areas contributing to the cost of a typical mmWave radar board are:

- Printed circuit board (PCB) design
- PCB substrate materials and manufacturing cost
- Electronic bill of materials (eBOM)

Let's walk through these areas and the concepts behind what reductions to consider when developing an mmWave radar board based on TI's IWR6843ABGABL sensor.

Simplify PCB Design

From a PCB design perspective, the goal is to avoid high-density interconnect designs and reduce complexity which results in lowering the board manufacturing costs. This can be achieved by replacing microvias with through vias and avoiding vias on the pads. Depending on the overall design of the board, you can potentially experience considerable savings, but you must weigh these savings against the potential increase in overall size. For example, our efforts in this regard show cost savings of approximately 40%, compared to a negligible-to-no increase in the board area.

Choosing PCB Materials

Many product managers and engineering teams would expect to use specialized Rogers laminate for radar boards to support at least the antenna layer. Based on experiments at TI, our empirical data shows that using

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a lower-cost, Isola FR408HR laminate for the antenna layer instead will achieve acceptable results at practical ranges. You must consider overall performance relative to the system requirements, but this range is reasonable in the context of typical mmWave radar systems. As shown in Figure 1, due to FR4 board the maximum round-trip gain is affected.

Item	FR408HR (FR4 board)	RO4835LP (Rogers board)	Comments
Max round-trip relative gain	149dB	157dB	~8dB lower
Azimuth field of view (FOV)	+/-60deg	+/-60deg	Same
Elevation FOV	+/-40deg	+/-15deg	Wider FOV in elevation for the IWR6843LEVM
Angle estimation error – azimuth	+/-8deg	+/-8deg	Same
Angle estimation error – elevation	+/-7deg	+/-7deg	Same

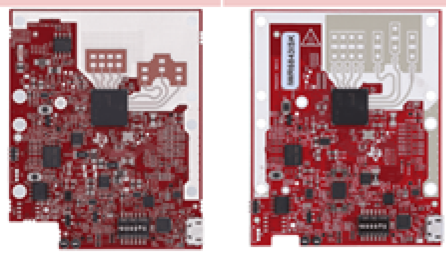

Figure 1. Comparison of FR4 and Rogers Boards

More Details on the Antenna Radiation Pattern and Material Can Be Found here.

This difference in gain results in slightly reduced range, as shown in Figure 2, but is arguably still within a reasonable performance expectation of typical mmWave systems.

For example, as shown in Figure 2, the left most column image represents detection of the target at 20 meters range with the Rogers board. For the same chirp configuration and using FR4 board, the approximate distance would be reduced to ~60% of the Rogers board due to ~8dB loss.

Under the same conditions, we can extend the range by increasing the number of chirps and the available SNR by coherently combining. This would be applicable for both Rogers and FR4. However, there are certain trade-offs that need to be looked at, i.e. by increasing the number of chirps power consumption goes up as shown in the middle and right most columns of Figure 2. We cannot keep increasing the number of chirps indefinitely to improve the SNR, as there are other trade-off besides power that need to be considered as well, such as limited on-chip memory, available processing power and refresh rates supported by the hardware.

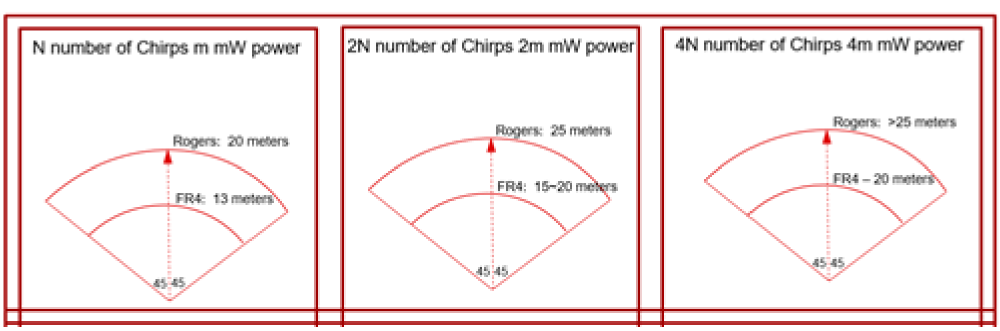

Figure 2. Rogers vs. FR4 Ranges

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In addition to the significant cost savings between Isola FR408HR vs. Rogers RO4835 laminates (approximately 30%), PCB fabrication companies are more familiar with FR4 and these materials are more readily available. The familiarity and FR408HR each further helps promote lower fabrication costs when using well-established and experienced partners and suppliers.

Reduce eBOM

The final cost area to consider of a radar board is the BOM. Since lower cost is the primary goal, developers should complete an analysis with that focus in mind. At TI, we have found that using discrete DC-to-DC converters is a more cost-effective way especially for non-safety applications to implement the power-supply subsystem for the IWR6843AQGABL radar sensor board. In the IWR6843LEVM design we have used the following DC-DC devices: TPS628502HQDRLRQ1, TPS6285020MQDRLRQ1, TPS6285018AQDRLRQ1 and TPS628503QDRLRQ1. These are fixed output voltage parts and lowest in cost. The adjustable voltage variants from the same family TPS628501, TPS628502, TPS628503 can also be considered for the power management, offering flexibility in design and more options for inventory management. With lower cost the primary goal, requirements for voltage monitoring and functional safety should also be considered when selecting DC-to-DC solution.

Overall, we achieved a combined savings of approximately 10% in both cost and area associated with the IWR6843AQGABL supporting subsystem.

Conclusion

Savings from a board's PCB design, PCB materials and eBOM can open up new product opportunities while expanding current product offerings. The applicable markets include building automation, factory automation and robotics; examples associated within these markets include lawnmowers, lower-cost wall-mounted AC units and lower-cost automated lighting systems. These savings are exemplified through the new IWR6843LEVM evaluation module.

IWR6843LEVM is fully supported by current mmWave SDK.

Additional Resources:

- Review industrial mmWave radar sensor
- For demos, labs, applications and source code review Industrial Toolbox for mmWave Sensors

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