Six Hidden Costs in a 99 Cent Wireless SoC

Considerations when choosing between a wireless module and a wireless SoC

Six Hidden Costs in a 99-Cent Wireless SoC

What you don't know about dropping a wireless SoC onto the board could delay your product

So, you want to save money by using a low-cost system-on-a-chip (SoC)? If you're trying to decide between using a wireless SoC or a wireless module, be sure you know the tradeoffs. In this whitepaper, we explore the often overlooked elements of deciding between a module or an SoC.

Table of Contents:

So You Want to Save Money With a Wireless SoC?

When trying to save money by using a wireless system-on-a-chip (SoC), two options present themselves:

First, using a wireless SoC on the product printed circuit board (PCB). This is typically smaller and cheaper than a wireless module, but designing with it may include hidden costs. Second, using a wireless module with an SoC inside. A majority of the design is already done, including a fully-characterized PCB with RF optimization and antenna layout, shielding, timing components (crystals), the SoC's supporting bill of materials (BOM), regulatory approvals, and standards certifications. But they are generally more expensive and larger than the SoC.

So, which one is the easier and more cost effective option? The answer changes depending on the product, the designer, time-to-market, and so on. Further, the best option changes with volume.

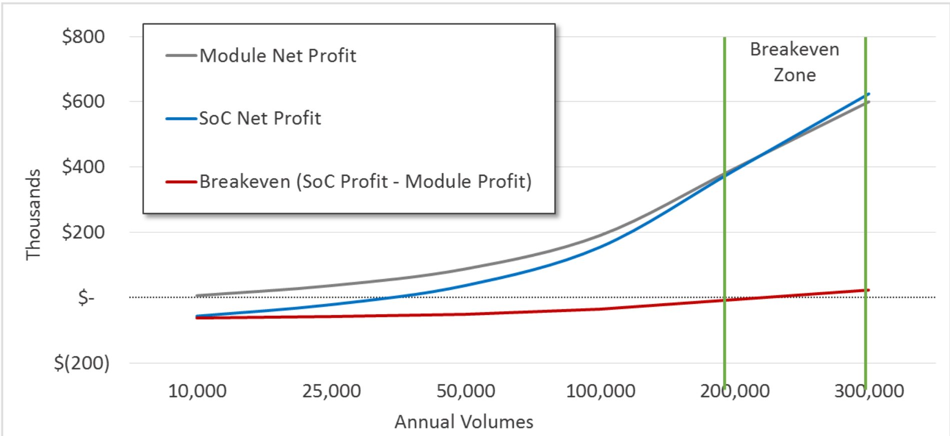
Breakeven Analysis

Modules cost more than their SoC equivalent, but many companies use them extensivley. Why? And what's the breakeven volume for selecting between one option and the other? Here's a high-level cost comparison of wireless modules versus a wireless SoC:

Cost Category (for a single product)	Wireless Module	Wireless SoC
Board design effort (antenna, layout, match, PCB, debug)	Low	High
Resource and lab equipment costs	Low	High
Regulatory certifications costs	Low	High
Standards certifications costs	Low	Med
Time to Market risks	Low	High
100K pricing (in our intro / example above)	$3.07 each	$0.99 each

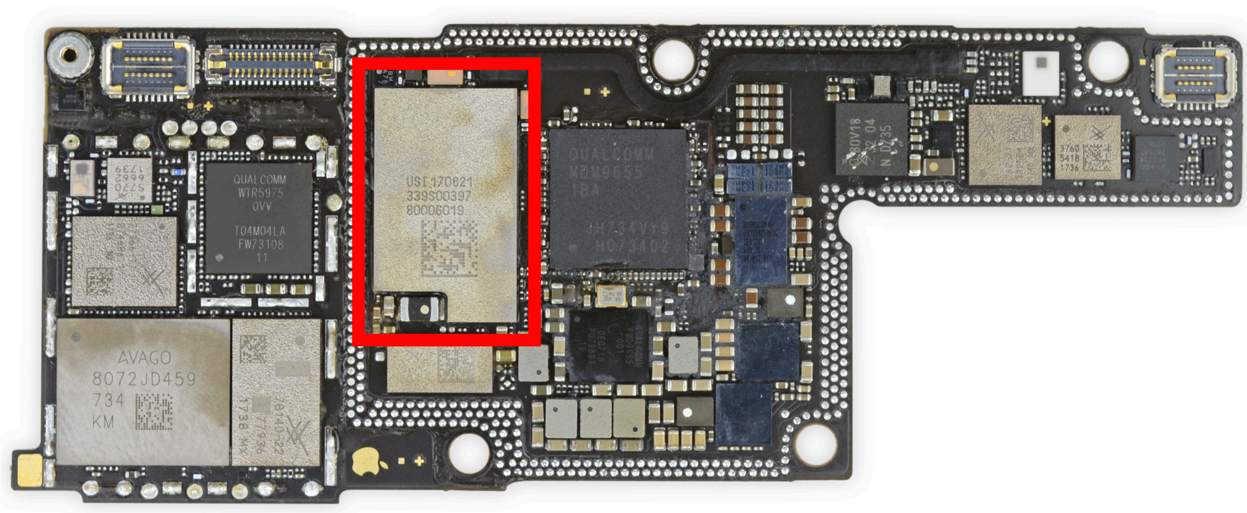
Breakeven Assumptions

1. Flat $3.07 wireless module pricing between 10k-300k annual volumes;
2. Flat $0.99 wireless SoC pricing between 10k-300k annual volumes;
3. Flat $0.50 SoC bill of materials (BOM) pricing;
    - Module price includes the BOM. SoC does not.
4. Gross Margin = $5.12 or 40% above module price. Assume both SoC and module use this for the sales price contribution to the end product;
5. SoC requires 3 months of extra development time due to more complexity in design, certification, and regulatory approvals.
6. Given the above, the annual breakeven volume falls between 200k and 300k.



Breakeven example for using a wireless module versus a wireless SoC

This breakeven figure may seem high, but even at these volumes, it still may not justify using an SoC. For example, the iPhone 6 is the bestselling iPhone model of all time, selling hundreds of millions of units, and it – along with the iPhone X – use a module. Below is a teardown of the iPhone X revealing the use of a WiFi / Bluetooth module.



So why is a breakeven on this so complicated? Because modules remove unknown risks that come with using a wireless SoC, and unknown risks are by definition hard to quantify in dollars or weeks.

Hidden Cost #1: RF Engineers and Design

An RF engineer is required for an SoC design. Or, at a minimum, access to RF engineering expertise from the SoC supplier. RF engineers can be expensive. The Glassdoor.com estimates an RF Engineer's salary is $80-152K/year, unloaded, which does not account for overhead (office space, benefits, etc.). In the US, this typically adds about 33% on top of the salary.

Hiring an RF Engineer = $80k-152k/year + 33% overhead = $100k-200k/year.

RF Application Notes – Not Always as Easy as 1, 2, 3

SoC suppliers provide application notes (AN) like Silicon Labs' AN930 to help provide guidance for RF layout. These include recommended antennas, traces, board material, and matching networks to maximize performance while minimizing cost and footprint.

However, since every design is different, the recommendations are always—*always*—hard to get exaclty right. In fact, industry experts will attest that it is very common for product designers to follow an application note's recommendations "exactly" and still have performance issues compared to the datasheet specifications and/or product expectations.

Module companies charge more for their products partly because they are already RF-optimized within a small footprint and low BOM. The whole "system" can be placed on the end product board in one simple step.

Of course, it is "never always" easy. But in the base case, putting a module on the board is measurably easier than putting down an SoC. See the table below for some issues that affect RF performance.

RF Performance Factor	Potential RF Impact
Antenna type, supplier, and placement	Antenna placement, type, material composition, manufacturer, and cost can change signal gain to the matching network resulting in mismatch and poor performance.
Antenna trace shape and length	Minor variations in length and shape can change the expected signal energy and therefore the recommended matching network.
Board manufacturer	Differing distances or insulation material between layers, PCB vias, , trace widths, screw holes, etc. can have effects.
Component suppliers	At RF frequencies, different suppliers' components can behave differently and result in different performance. This can result when designers use "the ones they have on the shelf" versus the recommended supplier, or save a few pennies with a cheaper alternative.
Component types	Different component technologies can affect received power and voltage (e.g., wire-wound resistor vs. thin-film).
Plastics and screw location	Screw placement can have coupling effects for both radiated and received energy.
Battery location	Battery location and technology can affect signal power. A charging battery can also be an unknown player.
Display location	Like batteries, displays can create interference on the antenna.

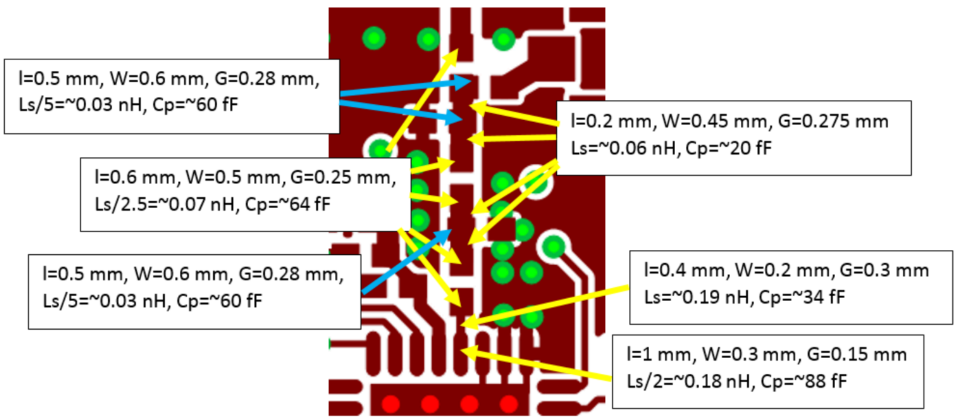
Hidden Cost #2: Lab Equipment and Facilities

RF engineering requires special equipment, software, and facilities to debug RF designs.

Lab Equipment	Cost to Own	Cost to Rent/Day
Calibrated traceable gain horn antenna	~$2,500	Included in a single day rental at test facilities. This is generally $1,000-$3,000/day.
Bi-conical antenna	~$2,000	
3D positioner	~$2,000	
Spectrum analyzer	~$6,000	
Wireless testing software with desired modulation	~$1,500	
RF isolated, anechoic room (5m x 5m)	~$20,000	
Wireless standard emulator, sniffer, and debug	~$20,000	

Hidden Cost #3: PCB Layout and Antenna Selection

How hard can it be? Many engineers believe it should be easy to follow an application note for layout. While that can be true in many cases, antenna application notes are often complex. AN930, the *Silicon Labs Blue Gecko Bluetooth Low Energy 2.4GHz antenna application layout guidelines*, provides some good examples of the nuances involved. It's designed to provide detailed RF parameters for the layout, to help customers get close to a "perfect" layout on their first try.



But the PCB will *always* need tweaks to optimize antenna performance. These take time—a few days to determine what needs to be tweaked and a week to turn the board at a local PCB manufacturer. Two weeks, done multiple times, adds up quickly when a typical development can take 16 to 20 weeks. As mentioned before, wireless modules can generally be successfully placed on a product board with very simple guidelines. It is still necessary to test a design's RF performance, but with a module, it will likely be much more predictable.

Hidden Cost #4: Regulatory Approvals and Wireless Standard Certifications

Products that operate in the unlicensed frequency bands require regulatory "type approvals." Many also require a wireless standard certification, such as Bluetooth, Wi-Fi, and Zigbee.

Some wireless modules come pre-certified for type approval and wireless standards. Adding them to a product brings these approvals and certifications along, although the product designer must apply for membership in the standards bodies and conduct some product-level regulatory testing. Wireless SoCs do not carry product type approvals or pre-certifications.

Certifying Body	Estimated Cost	Module Pre-Certification Applies (Yes/No)	Wireless SoC Certification Applies (Yes/No)
FCC	~$7,900	Yes	No
ISEDC (Canada)	~$7,900	Yes	No
ETSI/CE (Europe)	~$7,900	Yes; some limited end product testing/re-testing required	No

South Korea	~$4,500	Yes	No
Japan	~$8,500	Yes	No
Bluetooth	~$8,000	Yes; additional membership fee required	No: additional membership fee required
Zigbee	~$4,000	Yes; additional membership fee required	No: additional membership fee required

Regulatory testing costs and type approvals vary by country. Some countries will accept others' approvals. For example, the United States FCC Part 15 approvals and paperwork are accepted by Canada without the need for further testing, but require separate application, approval, and certification mark.

Every wireless standard requires certification and paid membership in the standards body. Each certification body is independent and will not accept others' certifications. There are consulting companies for the approval and certification processes. They understand exactly what's required, how to test, how to correctly complete reports, and when an approval or certification is required. Appendix 3 provides a list of certifying bodies, guidelines, estimated costs, and consulting companies.

Hidden Cost #5: Reduced Product Revenue from TTM Delays

One of the biggest hidden "costs" in using a wireless SoC versus a module is the risk of missing the market window due to incremental time to design it in, test it, debug it, type-approve it, and certify it.

Every day the product is not on the market is a day of lost revenue. This can range from a few weeks to a few months. As we saw above with the iPhone 6, removing risk of time to market is a key reason why some very large volume companies still use modules even though they cost more.

Hidden Cost #6: Supply Management and Assurance

For companies with low-volume production runs, modules can mitigate supply risk. A module supplier bargains for SoC supply in their modules on behalf of its entire customer base. Therefore, they consolidate demand and insulate small companies from potential line-down situations if there is a shortage of SoCs. Sourcing a single module is also simpler than sourcing all the components to put an SoC on the board.

Moving from Wireless Modules to Wireless SoCs

When a company using modules decides to move to wireless SoCs, the question becomes how to reuse the software they have developed with the module. Module companies generally provide a proprietary software application programming interface (API) for their modules. This provides their customers with an easy-to-use API that allows them to transition between different modules for different SoC versions and/or wireless standards. It also helps the module company retain the module customer as a result of their software investment; the customer won't want to port their code from the proven, hardened, and mature wireless module to a new, unproven, and unfamiliar wireless SoC.

Single Source for Wireless Modules and Wireless SoCs

Some suppliers sell both modules and SoCs. As such they may support a more seamless software migration between modules and SoCs, using the same development tools for both. This provides the advantage of de-risking the initial product development and achieving faster time to market, but still allowing for a future cost reduction without changing software. Silicon Labs is one example of such a company. The company has a heritage of pioneering RF innovations, and a long history of working with module companies. Silicon Labs acquired two strategic module providers: BlueGiga, a company specialized in designing, certifying, supporting, and manufacturing Bluetooth and Wi-Fi modules, and Telegesis, a leading provider of Zigbee and Thread modules. Silicon Labs has become a one-stop-shop for both wireless SoCs and wireless modules, delivering common software, stacks, support, and development tools.

When a company using modules decides to move to wireless SoCs, the question becomes how to reuse the software they have developed with the module

Conclusion

The decision whether or not to use a wireless module or a wireless SoC has a high degree of associated complexity that depends on volume, time to market urgency, risk tolerance, and available resources. By choosing a single supplier who can deliver both modules and SoCs while protecting software investment, the migration from module to SoC is simplified if and when the breakeven analysis warrants the move.