White Paper on Decision of Make vs. Buy of ISM RF Module

Written by Bruce Ulrich
October 2006

Abstract

As companies implement wireless features into their portfolio, they may require new expertise to their staff. While some may need to become proficient RF designers, many desire only to add wireless capability as a product feature. This latter group may consider embedding a pre-certified module into their design. An analysis of the costs for an RF module development is evaluated for consideration. These costs are compared to the costs of a module available for purchase. A breakeven point is determined to enable a decision threshold for make vs. buy. This breakeven point is tempered by other decision criteria that may influence the breakeven point.

Intro

Designing a system with a wireless link is a natural evolution to many products, and essential to others. Unfortunately, implementing an RF design can be complicated by physics, technology, and government regulations. This paper is written for the customer looking to implement a wireless design in their product, and evaluate the decision of purchasing a module or doing a design based on a proven reference design, based upon anticipated annual production. The purpose of this paper is to highlight the types of expertise, expense, and steps required to implement a wireless design, and compare the costs, development time, and time to market of an internally developed board and commercially available board.

While an internally developed board would likely more closely match the end product needs, the benefits of an off the shelf embedded board merit strong consideration. Embedded modules are available with small footprints and with enough versatility to match most requirements. In addition, these typically come pre-certified for immediate embedment into an end product. We will assume that the desired RF functionality can be identified in the market to meet the product needs.

To carry out the analysis and comparison, we are assuming a ZigBee Full Function Device module is being developed. Since costs change over time, the cost estimates are based on 2006 prices. Since RF and firmware capabilities vary between companies, we are assuming a relatively experienced team. To account for a less experienced team, the reader may assume a multiplier of 1.5 to 2 over the below estimated costs.

Project Description

The subject project is a ZigBee module based on IEEE 802.15.4. transceiver (CC2430), and adds in the required software and certifications. We will assume this is only the embedded module, and not a controller or gateway. This same analysis can be applied to these components as well, but it would increase the estimated NRE and BOM costs .

Assumptions:

- Hardware and Software Engineering is billed at $5k/wk This is a fully loaded cost which includes manpower, management, support personnel, facilities, benefits, and profit.
- Layout Engineer/Technician is billed at $3k/wk.
- Required specialty test equipment is rented at $750/Month
- Certification for FCC costs $10k. Additional country certifications could be added assuming $5k each.
- ZigBee certification costs around $3k
- ZigBee membership cost is excluded (manufacturer must be at least a ZigBee adopter to use the logo)

Engineering Design

Basing a new design on a proven reference design increases the likelihood that certain aspects of the design will work as expected. Leveraging the CC2430EM Reference Design would enable the design to progress quickly. The hardware engineering time is assumed to be related to the implementation of the reference design, and interfacing to the remainder of the board. The Firmware design time relates to the software management of the IC, performance optimization, operational code for frequency agility and spectrum management, transmit/receiver operation, power management, and other firmware aspects of the implementation.

The development kit includes hardware, software license, training, and support (it is assumed that the software compiler is already owned). We have estimated 4 man-weeks for testing on the first board, and 2 man-weeks for the second board spin. These numbers will increase for less experienced RF engineers.

	Units	**Unit Cost**	**Total Cost**	
H/W Eng (wks)	1.5	5000	$ 7,500	
Firmware (wks)	4	5000	$ 20,000	
Dev Kit (License)			$ 10,000	
Layout (wks)	0.5	3000	$ 1,500	
PC Board + assy	1	1250	$ 1,250	
Testing/verification/mods (wks)	4	5000	$ 20,000	
Relayout (wks)	0.25	3000	$ 750	
Respin PC Board + assy	1	1250	$ 1,250	
Equip Rental (Month)	2	1000	$ 2,000	
Testing/Verification (wks)	2	5000	$ 10,000	
Subtotal				$ 74,250

Many companies look at the above total with sticker shock since the cost is higher than they may have anticipated. Note that the manpower costs can be billed differently internally, since the overhead costs may not be included. However, this estimate is reasonable based upon hiring an external design contractor or consultant, and more closely represents the actual costs including opportunity costs.

After the module is working as expected, the product must be certified for RF and ZigBee, and made ready for manufacturing. This includes developing a production tester, signing a contract manufacturer, and setting up the approved vendors list for the RF components . These are all elements that will be handled naturally as part of the systems development; however, when RF is included in the end product, all of these become more complicated as the RF performance can vary upon manufacturing, testing, or the AVL. Combining these for this application yields the final cost estimate:

Test Board/System	**Units**	**Unit Cost**	**Total Cost**	
H/W Eng (wks)	2	4000	$ 8,000	
Firmware (wks)	4	4000	$ 16,000	
Layout	1	3000	$ 3,000	
PC Board	1	500	$ 500	
Testing/Verification (wks)	8	4000	$ 32,000	
Certification/Testing			$ 10,000	
ZigBee Certification/Testing			$ 3,000	
Subtotal				$ 72,500
Total				**$ 146,750**

Note that it is assumed that the RF and ZigBee certifications are passed the first time, and only one region is being certified. If the end product needs certification in multiple end regions, or compliance re-testing is needed, the testing costs will increase. Testing/verification is assumed to include optimization time. Often times, this testing can consume many more man-weeks to optimize the power, reduce packet loss, increase range, and testing in a wide variety of environmental conditions.

The total cost of getting a product ready to produce is therefore estimated around $145k. The natural tendency would be to take the module price, subtract the raw BOM cost, and calculate the breakeven point. For instance, assume the BOM cost (including PCB, assembly, and test) for the RF portion is $6 and the module purchase price were $19, the breakeven point would be estimated around 12k units ($145/$13) for 1 ku/yr. However, the breakeven estimate ignores the cost of capital, delayed market entrance, final product yield impact (due to RF), and tech support for the RF module vs. product level. Some of these are difficult to quantify, so we again will make some assumptions for the purpose of simplicity:

Assume:

- cost of capital is 12% annually
- 1 year for development, test, certification, and release to production
- New end product reaches 50% of the anticipated volume after year 1, and 100% of anticipated volume after year 2
- Ignore the costs of delayed market entrance, final product yield impact, and increased tech support

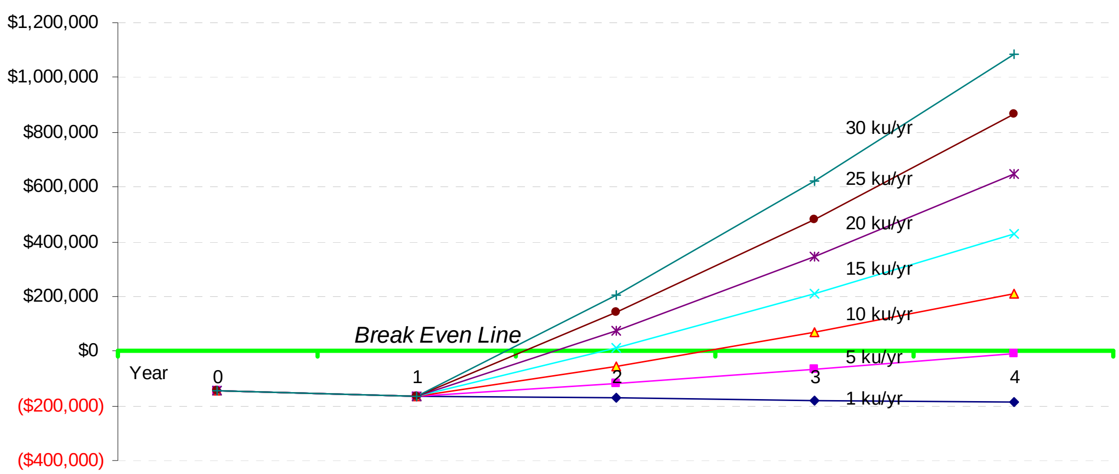
Of the ignored elements, the delayed market entrance is typically appreciable, and warrants independent consideration despite being difficult to quantify in this estimate.

Revising the breakeven analysis, yields the following estimate:

Breakeven Analysis					
Year	0	1	2	3	4
1ku/yr	($146,750)	($164,360)	($171,083.20)	($178,613.18)	($187,046.77)
5ku/yr			($119,083.20)	($68,373.18)	($11,577.97)
10ku/yr			($54,083.20)	$69,426.82	$207,758.03
15ku/yr			$10,916.80	$207,226.82	$427,094.03
20ku/yr			$75,916.80	$345,026.82	$646,430.03
25ku/yr			$140,916.80	$482,826.82	$865,766.03
30ku/yr			$205,916.80	$620,626.82	$1,085,102.03

Essentially the breakeven date depends upon the build rate. The breakeven occurs the first year if the product sells approximately 15ku in the first production year, or in the second year after the unit has sold approximately 18ku across the first two years.

Graphing this data shows the project a loss for the first two years (Year 0 and 1). The loss widens in Year 1 due to the time value of the investment. Projections based on higher run rates (such as above 10 ku/yr) become positive in Year 2.



Price reductions, based on volume, were considered in this analysis. Prices will drop for both a purchased module or the discrete BOM at approximately the same rate. Note that the manufacturing cost includes programming of the micro onboard the RF module during final production test.

Transitioning a Buy to a Make

Many companies can enter their end markets early by purchasing a completed module, and then have a custom module built at a later time. This way, they are able to participate in their end market immediately, and develop a custom solution as time permits. In this case, the software to work with the module can be leveraged with the in house design. This situation is wise to consider at the start of the project, and included in the initial discussions with the module provider. Many module providers can offer low cost of IP transfer to embed into the end product. Essentially this transition is to the benefit of the customer since his next gen product will have a lower cost of development and still maintain similar optimal performance. This is to the benefit of the module manufacturer since their business is typically based on module, design services, and IP sales. Engaging in this discussion prior to selecting a module or manufacturer may ensure a smooth transition when it does occur.

Conclusion

Most projects start with enthusiastic projections of market potential. While these may be accurate long term, they sometimes optimistically estimate the time for new markets to develop, and may underestimate the impact of delayed market entrance. This paper attempted to bring to light the costs of development of a new industrial RF based product, and highlight the cost benefits of buying a pre-certified embeddable module based on volume expectations, and internal expertise.

With an annual run rate of 10ku/yr, the payback period for an in-house design is Year 2, assuming strong in-house RF experience. If there is little RF experience in-house, this breakeven run rate could climb to 4 years or more. Additionally, even with an experienced design team, the in-house designed end product will enter the market 1-2 years after it could with an embedded RF module. In addition, as testing requires a wide variety of conditions, the testing time and costs could be overwhelming to many companies attempting to integrate RF.

The specialized knowledge required to create an RF module is expensive to develop and can become a maintenance and support headache for many companies. If the volumes for a module are expected to exceed 15-25ku/yr, then the decision for an in-house design moves from a breakeven to a profitable ROI. Module companies that understand their targeted end market can typically offset this minimum requirement with many end customers, each of which may consume up to 5ku/yr across multiple products. As a result, it is beneficial for end customers to search many module manufacturers based on their end product needs, and devote their R&D efforts to their core IP, and let the specialists create the optimal RF solutions.

IMPORTANT NOTICE

Texas Instruments Incorporated and its subsidiaries (TI) reserve the right to make corrections, modifications, enhancements, improvements, and other changes to its products and services at any time and to discontinue any product or service without notice. Customers should obtain the latest relevant information before placing orders and should verify that such information is current and complete. All products are sold subject to TI's terms and conditions of sale supplied at the time of order acknowledgment.

TI warrants performance of its hardware products to the specifications applicable at the time of sale in accordance with TI's standard warranty. Testing and other quality control techniques are used to the extent TI deems necessary to support this warranty. Except where mandated by government requirements, testing of all parameters of each product is not necessarily performed.

TI assumes no liability for applications assistance or customer product design. Customers are responsible for their products and applications using TI components. To minimize the risks associated with customer products and applications, customers should provide adequate design and operating safeguards.

TI does not warrant or represent that any license, either express or implied, is granted under any TI patent right, copyright, mask work right, or other TI intellectual property right relating to any combination, machine, or process in which TI products or services are used. Information published by TI regarding third-party products or services does not constitute a license from TI to use such products or services or a warranty or endorsement thereof. Use of such information may require a license from a third party under the patents or other intellectual property of the third party, or a license from TI under the patents or other intellectual property of TI.

Reproduction of TI information in TI data books or data sheets is permissible only if reproduction is without alteration and is accompanied by all associated warranties, conditions, limitations, and notices. Reproduction of this information with alteration is an unfair and deceptive business practice. TI is not responsible or liable for such altered documentation. Information of third parties may be subject to additional restrictions.

Resale of TI products or services with statements different from or beyond the parameters stated by TI for that product or service voids all express and any implied warranties for the associated TI product or service and is an unfair and deceptive business practice. TI is not responsible or liable for any such statements.

TI products are not authorized for use in safety-critical applications (such as life support) where a failure of the TI product would reasonably be expected to cause severe personal injury or death, unless officers of the parties have executed an agreement specifically governing such use. Buyers represent that they have all necessary expertise in the safety and regulatory ramifications of their applications, and acknowledge and agree that they are solely responsible for all legal, regulatory and safety-related requirements concerning their products and any use of TI products in such safety-critical applications, notwithstanding any applications-related information or support that may be provided by TI. Further, Buyers must fully indemnify TI and its representatives against any damages arising out of the use of TI products in such safety-critical applications.

TI products are neither designed nor intended for use in military/aerospace applications or environments unless the TI products are specifically designated by TI as military-grade or "enhanced plastic." Only products designated by TI as military-grade meet military specifications. Buyers acknowledge and agree that any such use of TI products which TI has not designated as military-grade is solely at the Buyer's risk, and that they are solely responsible for compliance with all legal and regulatory requirements in connection with such use.

TI products are neither designed nor intended for use in automotive applications or environments unless the specific TI products are designated by TI as compliant with ISO/TS 16949 requirements. Buyers acknowledge and agree that, if they use any non-designated products in automotive applications, TI will not be responsible for any failure to meet such requirements.

Following are URLs where you can obtain information on other Texas Instruments products and application solutions:

Products		**Applications**	
Amplifiers	amplifier.ti.com	Audio	www.ti.com/audio
Data Converters	dataconverter.ti.com	Automotive	www.ti.com/automotive
DSP	dsp.ti.com	Broadband	www.ti.com/broadband
Clocks and Timers	www.ti.com/clocks	Digital Control	www.ti.com/digitalcontrol
Interface	interface.ti.com	Medical	www.ti.com/medical
Logic	logic.ti.com	Military	www.ti.com/military
Power Mgmt	power.ti.com	Optical Networking	www.ti.com/opticalnetwork
Microcontrollers	microcontroller.ti.com	Security	www.ti.com/security
RFID	www.ti-rfid.com	Telephony	www.ti.com/telephony
RF/IF and ZigBee® Solutions	www.ti.com/lprf	Video & Imaging	www.ti.com/video
		Wireless	www.ti.com/wireless

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265