MAKE vs. BUY? When Should I Reinvent the Wheel?

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The thorny choice between making and buying common circuit functions is faced by many system designers—and their companies—on a regular basis. This choice is also of great interest to companies (such as Analog Devices) that design, manufacture, and market input/output (I/O) functions. These companies have successfully served the industrial systems market by offering useful and reliable functions with guaranteed performance at modest prices.

Industrial I/O functions are complete signal conditioning solutions for companies whose primary business is design and assembly of large control systems. Typical functions are used for measuring temperature and pressure, interfacing with strain gauge signals, and controlling actuators. I/O products serving this market have to be reliable, endure harsh environments, meet agency approvals, and be cost-effective.

Should companies have to reinvent common I/O functions (the wheel)? Or should they purchase the solution from a vendor like ADI? Those who choose the option of buying I/O solutions from vendors like ADI can reduce time to market, save money, and free up valuable resources. However, it is natural to think that one's own engineers and shops can design and assemble a needed function—especially one that is not apparently very challenging—more cheaply and efficiently. Buying I/O functions from other companies is not pursued because in-house engineers and technicians have the necessary expertise (and are enthusiastic about doing the work themselves), because of unawareness of what's currently available, or because of unpleasant past experiences with vendors. It may perhaps come as a surprise to conduct an analysis and find that buying circuit solutions can actually be regarded as a source of added value to the system-level company.

From the *system designer's* perspective, the prospect of make vs. buy means the need to identify trade-offs. There are many considerations in coming to the right decision. Is making the function in-house really cheaper? Does making the function internally help get the end product to market faster? Can we find a good partner? Can we reach our performance goals? Is there risk in sharing trade secrets with potential partners? The answers to these questions are not easily found.

The *vendor's* perspective is one of business decisions. Opportunities are weighed, and commitments are made based on profit margins, potential for future business, and potential for technological benefits. Vendors must efficiently use their resources to remain viable and competitive. They must be able to offer attractive prices and lead times to be successful in the market.

One thing is certain: to be a successful enterprise, the deal has to benefit both parties (a win-win situation). If this is not the case (for example, sufficient information is not available for proper specifications, corners are cut to reduce cost, vendor capabilities are oversold), one or both parties will suffer pain somewhere in the future of the relationship.

GUIDING THE DECISION PROCESS

The following lists the key considerations in the make vs. buy decision process.

Cost
Time to Market
Internal Resource Allocation
Intellectual Property Protection
Partnerships
Weighing Future Benefits

Cost

Determining the cost in a make vs. buy situation is started by having a full understanding of the real internal cost for making the circuit. With this knowledge, the customer can then approach a vendor with a request for quote for the same function. Determination of internal costs should include material cost, labor costs, engineering and support costs, as well as overhead factors. An important area of cost often overlooked is *lost opportunity*, which occurs when scarce resources are used on projects that are not of primary importance.

The cost of buying the solution from a vendor like ADI can be found by simply requesting a comparable quotation of price for the function at the required performance level. The vendor may offer a standard product, or, as needed, semi-custom—or even custom—products.

Vendors can offer many advantages. In the case of Analog Devices, these advantages include the ability to obtain proprietary silicon solutions from product lines throughout the company at prices less than market cost—and access to inexpensive off shore manufacturing. By combining these two attractive features, the cost of industrial I/O functions made by ADI are among the lowest in the industry. By allowing such a vendor to do the entire design, and manufacturing, an OEM company can save material and labor costs, and free up their design resources. This allows the company's talent to concentrate more on their area of added value, such as system, software, and package design.

The acceptance of purchased I/O solutions is well established over years of experience. Analog Devices, for example, has demonstrated great success with the *3B, 5B, 6B, and 7B* series of products. These product lines are accepted industry standards, used by many OEMs for industrial I/O.

Time to Market (TTM)

Time to market is another area where purchasing a solution can offer significant benefits. I/O vendors are geared for quickly turning designs, reducing customer TTM. Quick time-to-market is a key to gaining market share. Buying I/O solutions can give a company a competitive edge by simplifying the market introduction process. Often the desired function is a standard product, with a lead-time of days or weeks.

Buying solutions allows for a company to focus on the many details of designing and introducing a new product without wasting internal resources and spending time on the design, implementation, and testing of the I/O functions.

Internal Resource Allocations

The profitable dedication of internal resources to the right tasks is a key challenge for a successful business. Companies insisting on their own I/O solutions often put themselves at a disadvantage compared to companies solving the same problem by buying similar functions from a vendor. The key point for OEMs to understand is the true nature of their company's value-added; in a system-level company, value is not added by designing and assembling industrial I/O devices that could be purchased.

Intellectual Property Protection

The area of industrial control is specialized. Technological expertise, trade secrets, developed by years of participation in the industrial market, so-called *intellectual property*, is closely guarded. Sometimes the fear of losing this information prevents companies from discussing technological options openly with a vendor who is capable of providing solutions at reasonable cost.

The mechanism for assuring protection is a Non-Disclosure Agreement (NDA), which is agreed to by both parties. Reputable vendors adhere to good business ethics. Sharing of proprietary information is important when partnering with another company. The NDA spells out exactly the information that is deemed proprietary. This legally protects the companies involved from the loss of intellectual properties and rights.

With a signed NDA, both companies can reach a level of comfort and trust with each other. From here, solid business relations and partnerships are launched. This environment facilitates free flow of technical ideas and information and ultimately leads to the best and most cost-effective solutions for technical problems.

Partnerships

ADI realizes that having partners in business (i.e., establishing an ongoing relationship between an OEM and a vendor) can prove very beneficial if the arrangement is set up properly. The topics discussed earlier suggest what it takes to locate, communicate, and deal with a good partner. It's worth repeating that, for a relationship be successful, the deal has to be good for both companies (a win-win situation for both).

Of course, it is important to understand that competitors (of both the OEM and the vendor) are thinking of the same options. Nevertheless, within the industrial control market, the use of partnerships is very common.

Weighing Future Benefits

Quality products in the Analog Devices Input-Output Subsystems (IOS) product line have a both a proven record of offering cost effective high performance industrial I/O functions/solutions and the prospect of yet more user advantages going into the future. Many companies have realized benefits through developing a channel with ADI. By buying these products from ADI they can obtain a significant competitive advantage

REAL-WORLD EXAMPLE

We will use a tangible example to illustrate the benefits of buying, instead of making, a circuit function. The assumptions used in this example reflect realistic costs for material, services, and labor in today's market. This example is taken from experiences within ADI's IOS (*Input Output Subsystems*) product line.

The circuit function in question is an isolated, gain-of-1, signal-conditioner module, 1-5 V input to 1-5 V output for the front end of a large process control system. This function is commonly used in the process control industry for isolating terminated (250 ohms) 4-20 mA current-loop signals. The volume projection for establishing the cost of this function is 1000 units/year.

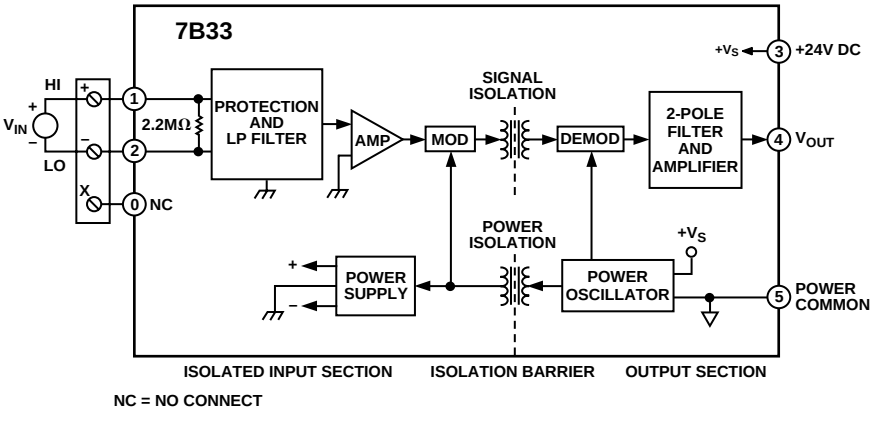
A block diagram of this simple function and a list of key specifications are shown below.

BUY Solution

A recommended option is to purchase the 7B33-01-1 from Analog Devices. The following outlines the consequences of this purchase:

Cost per Unit (100s)	<$60
Time to Market	4 Week Lead Time
Internal Resource Allocations	Minimal, Principally Component Verification
Intellectual Property Protection	No Risk
Partnerships	ADI, Industry Leader
Future Benefits	Industry Standard Product Format. Other Functions Available

By purchasing the solution, the buyer will spend $60,000 annually. The product is available in 4 weeks, with lead times reducible to delivery from stock (or just-in-time scheduling), if forecasting is provided. The buyer benefits from ADI's years of experience in applying isolation technologies, cost-effective robust packaging,



KEY SPECIFICATIONS

Accuracy (Calibration Error)	0.10% max
Linearity Error	0.02% max
Common-Mode Rejection	>100 dB
CMV, Continuous	1500 V rms
Input Impedance	>1 megohm
Input Bias Current	100 pA
Bandwidth	100 Hz
Power	+24 V @ <20 mA
Operating Temperature Range	–40°C to +85°C
Input Protection	120 V ac
Agency Certifications	CE, CSA

and standardized families of interchangeable products. Also all ADI products go through extensive reliability, and environmental testing to ensure product quality.

Of particular note is the ability of 7B-Series products to withstand 1500 V rms continuous common mode voltages. This requires special process techniques in fabricating the transformer and the board (PCB)—techniques that have been refined over years of experience with isolation-type products. Finally the product comes with CSA and CE certification.

The user will have to make a small investment of internal resources for the normal acceptance process of verifying that the component (7B33) meets specifications; and of course design verification of overall performance in the system is usual. An additional source of confidence is the knowledge that an industry-standard product from an industry leader is being used in the system, and that other I/O functions are also available in this same product family. Naturally, increased discounts are available if the user's product is successful and quantities increase.

MAKE SOLUTION

The following analysis of the "real" cost to make this function includes an itemization of typical costs for the entire design process, in-house manufacturing, design verification, documentation, material costs, and agency approvals.

In-house engineering and engineering services are estimated using a rate of $75/hr or $3000/week, CE and CSA approvals costs are estimated at $3,000 (although this cost may be subsumed in the costs of agency approval for the overall system). The material cost for this function is about $25/unit, labor and overhead costs to build the product are $25/unit.

The cost of the design is estimated as:

Design Engineer	4 Weeks	$12,000
PCB Layout	3 Weeks	$ 9,000
Packaging Design	4 Weeks	$12,000
Documentation	4 Week	$12,000
Design Verification	8 Weeks	$24,000
Resource Costs	23 Weeks @ $3000/Week	$69,000
Agency Approval		$ 3,000
Total *Development* Costs*		$72,000

*($72 per unit for the first 1000 units)

It should be noted that this example assumes a reasonable degree of competence in I/O function design. Achieving an adequate level of performance, price, and reliability may turn out to be difficult for the unaware. Transformer design is a critical area to insure meeting the isolation-voltage specification. For the sake of this demonstration, these key areas are assumed to have been addressed and under control. Further, if this were a signal conditioner that had more design ramifications, such as a linearized thermocouple input module (7B47), the assumed risk becomes even greater.

Once this design is released, it can be manufactured for approximately $50/unit. This is a $10/unit "saving" from the purchased solution, or $10,000 annually. Just to pay back the $72,000 investment at this rate, the design will have to be in use for about 10 years ($73,000 is the approximate present value of $10,000 per year for 10 years at 6%), Considering that this is only break-even, and that the invested capital has not generated any return, this is a poor use of scarce resources by any standard.

A much more desirable and usual expected payback period is 2 years. If only $20,000 has been paid back on the development costs in 2 years, the $50,000 that was sunk ($50,000/2,000 = $25 per unit) should be added to the manufacturing cost, resulting in a real cost per unit of $75, or 20% more than the cost of purchasing the devices. Thus, by making the function, the company incurs a large and unnecessary risk, and in fact has lost money because of this unfortunate business decision.

The development schedule for this type of product is approximately 20 weeks. This assumes that every step in the development goes perfectly. Schedules are always an area of risk. It is likely that the design and release of this simple I/O function will be on the critical path for the overall process control system release.

By making instead of buying, this company has put its system release at risk.

The use of internal resources is wasteful and adds an unnecessary opportunity cost. Key resources are wasted on projects that do not add value to a system-level company's products. The evidence of this is the negative return on invested capital. If these resources were applied to *system* design, or some other value-added task that improves efficiency, the company could realize (for example) faster time to market for its end product.

The money put toward designing this simple I/O function is an expense, not an investment.

By choosing to make this product, the systems company has gained some organizational learning, but in a technological and business area that is not on the mainstream of success in their field. In addition an opportunity has been missed to develop more knowledge in their own systems business by spending resources more relevantly.

Making this function is a losing proposition.

Because the company did not look for or choose to "partner", they are at risk from their competition. The company will realize no benefit in the future because of this missed opportunity to partner with a leading company in a joint venture.

Here is the bottom line of the "Make" solution results:

Cost	$75
Time to Market	20 weeks, on critical path
Internal Resource Allocations	Significant and high risk
Intellectual Property Protection	N/A
Partnerships	None
Future Benefits	Little, if any

SUMMARY

The above example is a realistic assessment of a typical choice situation in today's market place. It shows that there is a trap in deciding to "Make" circuit solutions instead of buying the solution from a substantial, experienced, and well-qualified vendor with a proven product line. In all the key factors that contribute to making the decision, "Make" is shown to be riskier and more costly. The lesson to be learned is that designers and decision makers in enterprises must at all times be aware of what their real business is and carefully think through the consequences of make-or-buy decisions that "re-invent the wheel." Decisions that fail to take advantage of existing products, and the customization capabilities of their manufacturers, may well weaken the company in the long term. The discipline of a bias towards "Buy" for high-performance circuit solutions can be a valuable asset.