EMBEDDED DISPLAY INTERFACES

BUILD OR BUY?

Factors to consider when integrating a full colour touch interface

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One consistent design trend in recent years has been the increased use of Full Colour Touch Interfaces. These colourful, easy-to-use products combine input/output technologies such as traditional screen technologies, buttons and rotary switches into a single unit. Everybody is familiar with smartphones and tablets, but touchscreen applications also include other consumer devices such as coffee machines and kitchen appliances as well as commercial and industrial machines including drink dispensers, medical diagnostic equipment, machine tools and more.

A touchscreen interface, with its graphical user interface (GUI) and touch control, adds an aesthetically pleasing look and intuitive interaction to a variety of commercial and industrial products. This explosive adoption is reflected in recent revenue forecasts expected to exceed US$100 billion by 2027.

As a result, designers and manufacturers are looking to include a Full Colour Touch Interface in their new devices or to upgrade existing products. Often, this task is easier said than done, particularly for smaller organisations that may lack the engineering resources needed. Even larger manufacturers with the necessary expertise may be hard-pressed to develop a display solution to accommodate shortening production and development cycles.

Considerations in the make vs buy decision

Choosing the right LCD solution for a product can be difficult. For the embedded designer, incorporating an LCD can be as demanding as the rest of the design. There are many things to consider when making the initial decisions.

The two most important considerations: design in a discrete LCM and develop all required libraries and software to drive the display (discrete design), or use an off-the-shelf intelligent display module (IDM) that is virtually ready to run out of the box (modular solution).

When deciding whether to buy an off-the-shelf module or design a discrete solution in-house, the designer must evaluate development cost, bill-of-materials (BOM) cost, design flexibility, scalability, development time and available design expertise.

Each solution has benefits and drawbacks. For example, when looking purely at BOM cost, a discrete design may seem like the more attractive option compared to the cost of a ready-made module. However, factoring in the development time and resources required by a discrete design versus a ready-to-run module solution, the short- and long-term cost benefits may be offset by the ease of use and speed of development of an off-the-shelf module.

Comparison of a modular solution vs a discrete design

Consider an example where an existing application or device is upgraded to replace the existing buttons and simple display by a touchscreen with a GUI. Figure 1 shows the original and upgraded versions of a drink dispenser. In the next section we will explore the various factors to consider when deciding between a discrete design or a purchased module.

Discrete design implementation

The discrete design begins with an evaluation of the existing hardware. Many simple applications are designed around a low-cost 8 bit microcontroller (MCU) that must now be upgraded to control a full-colour graphics display with a touch interface. Most MCUs can interface to an LCD through a driver integrated in either the MCU or the display or by adding a discrete driver. In either case, the MCU's available resources affect the size and resolution of the display. For example, an 8 bit MCU may be able to drive a two-line dot-matrix display but may not have the processing resources to drive a larger screen.

To create an engaging, graphically rich experience, the designer will need to add a significant amount of embedded software into the application, such as libraries and image files. Alone, the development effort of having the LCD as an output device is already significant, but it gets even more complex when touch functionality is added, and the LCD is used as an input device.

Considerable effort is required for hardware and software development when using this approach. Once the application development is complete and production begins, the manufacturer is then responsible for quality control of the display and all its components. Any issues can cause line-down problems and require redevelopment or tweaking of the display drivers and a dedicated team of engineers may be required to fulfill this task.

Although developing a custom discrete design gives control over the BOM costs, the trade-off is an increase in the development budget. It is also important to consider the development time. It may take six months or longer to complete a lower-level design before development of the GUI can begin.

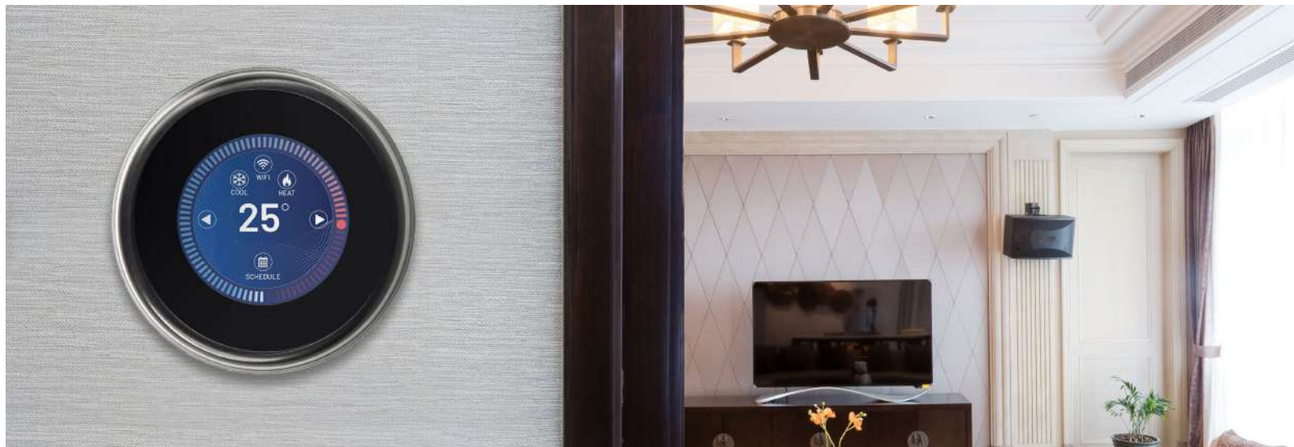
The added BOM complexity can also influence the long-term availability of the selected components. If one of the key components is discontinued, redevelopment of the GUI may be necessary and can cause extended and costly line-down delays. This in turn can extend the delivery lead time of the end-user application, causing customer dissatisfaction.

Figure 1: Buttons replaced by a full colour GUI with touch on a drink dispenser. Source: 4D SYSTEMS

Modular design implementation

The alternative approach uses an off-the-shelf IDM such as the gen4 series from 4D SYSTEMS. Typically, modules of this type feature an industry-standard interface such as I2C, SPI or UART for communications to the host MCU. Some modules also include an embedded MCU that handles all the graphics elements and may also include I/O and other peripherals to potentially allow the module to run the entire target application.

Many modules are supported by a library of functions allowing relatively easy control from the host MCU. Some come with an integrated development environment (IDE) that integrates the design and construction of the GUI as part of the overall embedded design process. Some IDEs feature drag-and-drop 'WYSIWYG' style



development workflows, enabling extremely fast prototyping and application development without the need to write any code.

A benefit of using the module approach is that the drivers, primitives and GUI functions have already been developed and tested. The host MCU can offload all the display tasks to the module so that the host can dedicate its resources to the main application and engineers can focus on the actual GUI design without having to worry about low-level development.

Integrating an IDM into an application is far simpler and straightforward when compared to a discrete design. The display module removes all the lower-level design requirements and the developer can focus on developing the actual GUI and the core application. This allows prototypes to be ready in a few days and the final application in a couple of weeks, radically reducing time to market.

Additionally, the module supplier assumes responsibility for maintaining quality control and ensuring a continued supply of components, drastically reducing the risk of an unplanned, costly redesign. In display modules that integrate a dedicated graphics processor, this risk is eliminated altogether as the developed GUI will 'travel' with the processor and will not be affected by the display technology.

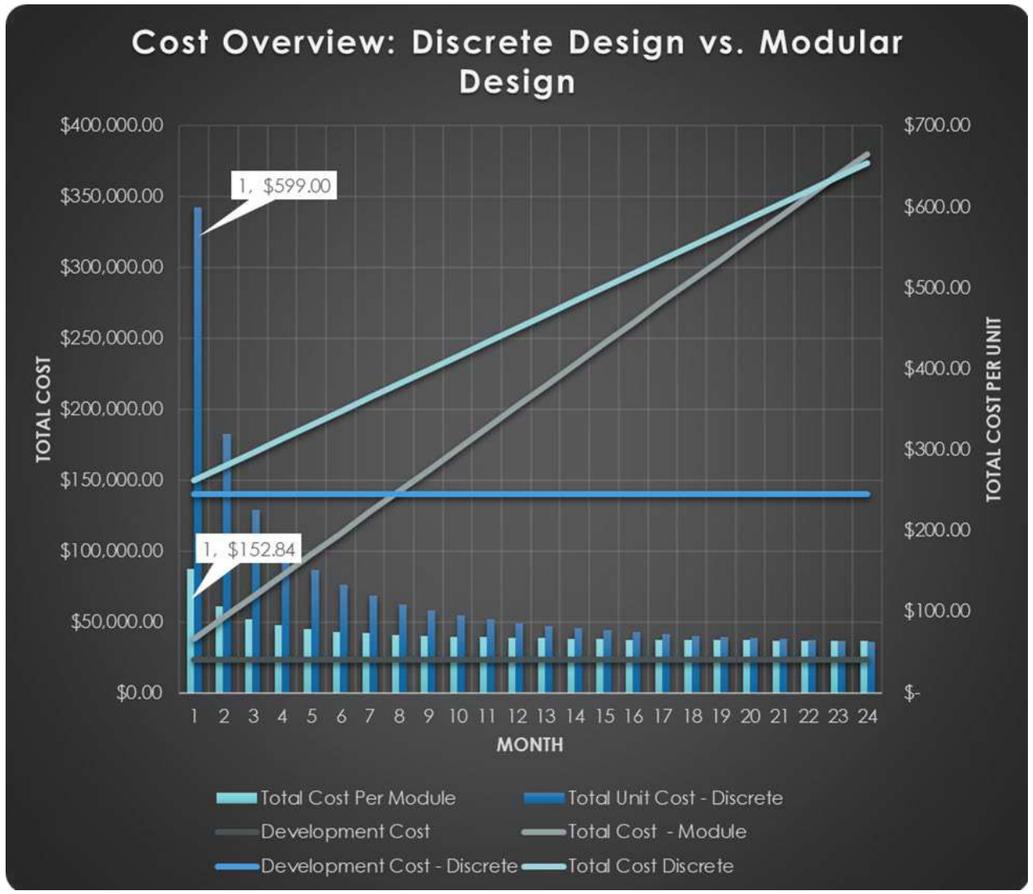


Figure 2: Cost comparison between discrete and modular display designs. Source: 4D SYSTEMS

Example cost analysis: Discrete vs. modular design

In this simplified calculation we compare the costs of the two approaches for a typical application: adding a 4.3 in LCD with capacitive touch to an existing design.

The design specifications are as follows:

- Annual requirement: 3,000 pieces of end user application
- Project lifetime: Two years
- Total volume required: 6,000 pieces
- Delivery volume: 250 pieces per month
- Assume the annual cost of a development engineer is $140,000 for illustrative purposes.

The table below compares the costs of the discrete and modular designs.

In this case, the modular design is slightly cheaper. Figure 2 plots cost versus time for each approach. The development cost for the modular design is significantly lower than the development cost of the discrete design. **The total cost per unit for the first batch of 250 pieces is also significantly lower with the modular approach: $152.84 versus $599.00.**

As the development cost of the discrete design is amortised over time, the total cost per unit drops rapidly. In the example application, the two total cost lines meet at the top right-hand side of the chart after 23 months, or total volume of 5,750 delivered units.

In this example, the modular solution is more cost-effective than the discrete design for volumes below 6,000 units. If all variables except the volume remained the same, and the volume requirement was 10,000 units, the discrete design would be more cost-effective. However, the per-unit price of the module is also likely to decrease at higher volumes, reducing the cost advantage of a discrete design.

Naturally, there are many other factors to consider when evaluating the most cost effective approach. Such as total BOM cost, sourcing costs, minimum order quantities, production costs, other labour costs and shipment costs etc. This over-simplified example illustrates that it is worth examining the costs further than just initial BOM costs when evaluating the total cost of a design approach. Oftentimes selecting a ready-made solution can result in significant cost savings although at initial glance it may not seem so.

Introduction to 4D gen4 HMI

4D SYSTEMS offers a variety of IDMs with a choice of sizes and touch options. The gen4 Series HMI modules have been designed to work with almost any form of host MCU or processor, including low-pin-count devices. This is possible as all the interaction between the display module and the host takes place over a simple serial link supported by most MCUs.

Hardware features

The 4.3 in Diablo16 gen4 IDM features a 4.3 in colour TFT LCD with 480 x 272 resolution and RGB 65K true to life colours. The module is capable of touch detection with resistive touch or capacitive touch options, microSD memory

Parameter	Discrete design	Modular design
# of development engineers	2	1
Development time (months)	6	1
Development cost (USD)	$140,000	$11,666
Estimate unit cost (USD)	$39.00	$59.50
Total cost (6,000 units)	$374,000	$368,666

Figure 3: A gen4 series display module with capacitive touch. Source: 4D SYSTEMS

storage, GPIO and communications, along with multiple millisecond resolution timers and audio generation. It is powered by the 4D LABS Diablo16 graphics processor, which offers an array of functionality and options for a designer, system integrator or user. 4D LABS is part of the 4D SYSTEMS family.

Hardware bundles with Raspberry Pi or Arduino interfaces are available and are recommended for first-time users.

Overview of IDE and GUI

All user application code is developed within the 4D Workshop4 IDE, a comprehensive software IDE for Microsoft Windows that provides an integrated software development platform for all of the 4D family of processors and modules. The IDE combines the editor, compiler, linker and downloader to develop complete 4DGL application code.

Workshop4 includes four development environments to choose from based on application requirements or degree of software expertise. Users can write their own 4DGL code from scratch; use a visual programming IDE that allows drag-and-drop placement of objects; or completely lay out a desired display using pre-written code modules.

The Workshop4 IDE uses a simple design flow to create the gen4 GUI. Once the designer has created a new project, they can choose the 4D environment appropriate to the level of detailed coding desired. The display module being used can be selected from a drop-down list. The Workshop4 User Guide discusses these steps in detail.

Figure 4: The Workshop4 Smart Widgets editor allows for codeless GUI development. Source: 4D SYSTEMS

Examples of successful applications

Customers in numerous fields have benefited from adding IDMs to their applications.

Drink dispensing machine Stiegl, a leading Austrian brewery, selected a 4.3 in IDM with capacitive touch and integrated bezel to upgrade their "Drink Module" modular drink dispensing system. The company developed the GUI software using the Workshop4 IDE. The result was a short development cycle and swift time to market. Over 400 systems have now been installed in Austria, Germany and elsewhere.

Building automation

The Sinclair Hotel in Fort Worth, Texas, offers smart interfaces throughout its luxurious rooms, allowing guests to select HVAC, lighting, window shades and even the shower to personal preference. Front-and-center is the 4Discovery smart display from 4D SYSTEMS, which was customised to work with project partners like Intel, Cisco, NuLEDs and Igor Tech. Best of all, the displays bolstered the hotel's energy efficiency.

Figure 5: The Stiegl Drink Module with the 4D SYSTEMS 4.3". Source: Stiegl

Figure 6. The Sinclair Hotel media control interface in the bathroom. Source: 4D SYSTEMS

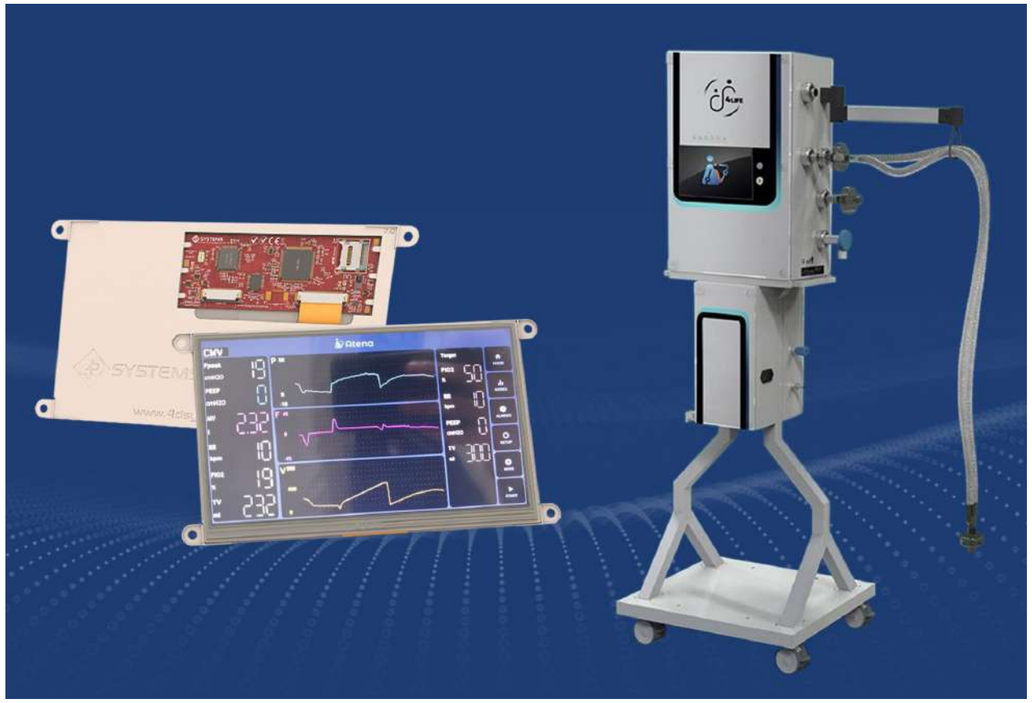


Figure 7: A CEiiA ventilator and its 7 inch display. Source: 4D SYSTEMS

Medical ventilator

As part of the worldwide fight against COVID-19, Portuguese company CEiiA set out to design a new invasive medical ventilator called the Atena without prior experience in developing such devices.

The development team was working under a tight deadline and the design had to be low-cost and easy to assemble. Based on past experience with 4D SYSTEMS, the CEiiA team selected the 7.0 in gen4-uLCD-70DT as the display and the gen4-BEZEL-70B. It took them just 45 days to design and produce their first complete ventilator.

To date, CEiiA has produced around 1,000 units of the first version of the ventilator for use locally and are currently gearing up to export units to countries that need them the most. As the manufacturing team gained experience, they managed to reduce the production time of a ventilator from 40 minutes down to 15 minutes.

Conclusion

An integrated touchscreen interface is a popular upgrade to a wide range of consumer, commercial and industrial products. When considering such an upgrade, designers must balance many factors, including development time and cost, unit cost, available expertise and many others.

4D SYSTEMS has forged its place as a global leader in the design and development of intelligent graphic solutions. To access the most innovative hardware, software, and meticulously customised and cost-effective solutions, visit the 4D SYSTEMS website.

About 4D SYSTEMS

We are committed to effectively empowering the engineers, designers, and makers of the world with state-of-the-art intelligent display solutions.

Whether they're developing embedded systems for the market or tinkering with intelligent hardware on the weekend - the world partners with us to access the most innovative hardware, software, and meticulously customized and cost-effective solutions.

We don't just sell display solutions, we create and design solutions for our customers. Since 1990, 4D Systems has forged its place as a global leader for intelligent displays and graphics processors. Our growing range of embedded displays leverage oLED and LCD technology, while our range of dedicated graphics processors provide the horsepower to bring superior yet affordable graphics systems to any application. These powerful, rich graphics displays are also complemented by resistive or capacitive touch in many instances, for a comprehensive user interface solution.

Perpetual research and development drives evolutions in our hardware solutions. Our proprietary WS4 software has been uniquely developed to provide engineers with a powerful utility for rapid prototype, development, and deployment of solutions into whatever scenario you have planned.

While our heritage is in providing power for commercially-destined embedded systems, an area we remain committed to, the maker movement has also created new interest and requirements for rich displays. Our suite of Arduino and Raspberry Pi compatible display hardware provides market-leading capabilities, without prohibitive cost or development challenges even for novice users. Native display capabilities for Arduino compatible hardware in particular are quite limited. Our integrated solutions take care of the processing, so a rich user experience is possible with standard Arduino hardware.

It goes without saying that quality matters every step of the way. Our hardware and software engineering teams are well seasoned, and work with ISO9001 certified production factories using our own quality assurance procedures for impeccable outcomes. Hardware is available directly or via one of many distribution partners across the globe. Our hardware is directly supported by our engineering team for impeccable problem solving, so you're not alone.

We're constantly evolving and adapting to the needs of our customers, to rapidly improve and forge new technologies.

Contact 4D SYSTEMS

Get in touch to discuss your latest projects, display experience, our products or to request any information. We'd love to chat.

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