10 Key Tips for Building Better HMIs

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Human machine interfaces (HMIs) provide us with the means via which to interact with modern technology. They are available in a variety of forms, but regardless of the type that is employed, their purpose is to enable control functions to be carried while at the same time ensuring that the user experience is a satisfying one. As a result, HMIs need to be carefully designed for the purpose they have been assigned to carry out, so that efficient and timely operation is achieved. To increase the chances of success during the design and development of new HMI implementations, and to meet the functional expectations set by their users, some basic rules should be followed - as outlined in the following article.

1. Understand the application requirements

So, the first rule that needs to be abided by is gaining a detailed appreciation of the work the HMI will be needed for. By having a clearly defined comprehension of the functions and processes that will be undertaken, the effectiveness of the HMI will be far greater. Before starting with the HMI design, the processes which are going to be controlled and monitored must be carefully fathomed out. The frequency with which particular operations are executed needs to be estimated. Input and output variables must be identified - specifying which variables are under operator control and which variables will be shown on the HMI. Sometimes it could also be useful to provide insight on some relevant internal or intermediate variable, just for debugging or for procedural optimization.

2. Design for multiple users

Users with different training and skillsets will need to be able to interact with the HMI. Consequently, it is essential to gauge the degree of training that the HMI operatives will have and confirm that the HMI design adequately reflects this. In some cases, the HMI will be required to meet the needs and ability levels of a broad variety of users - but it is critical that the HMI should be straightforward to use without any significant problems, no matter if the operative is experienced or a relative novice. Eventually, different user levels can be defined. Once users become familiar with the HMI, they might establish shortcuts to speed up some repetitive or commonly utilized functions.

3. Keep graphics simple

Carrying on from the second point raised, it is essential to make the design as intuitive as possible, and avoid unnecessary complexity. One of the primary objectives of any HMI design is to reduce the cognitive load (i.e. the amount of mental processing power required for operating the equipment involved). If the user has to overthink things or perform too many actions then the likelihood of

them making mistakes will be greater. As we will see, this can not only lead to user frustration, but also have more serious outcomes - in some circumstances putting lives in danger.

4. Check for consistency

To eliminate (or at least limit) the chances of possible user errors, the HMI needs to maintain the same look and feel throughout. Consistency means that knowledge of one part of a HMI layout (such as a screen or a menu) can be transferred to another part of the same HMI, or potentially another similar HMI (e.g. from a different product in that series perhaps). Having the same visual attributes (fonts, icons and colors) and functional attributes (behavior of buttons, controls and menus) applied throughout the entire project will have benefits - from both a user and a design engineering perspective. Additionally, icons should be chosen to immediately convey the nature of contents or the actions that they refer to. No doubt should be left in the user's mind as to what their meaning is.

5. Optimization of data transfers

Control and monitoring systems are often needed to support rapid reactions. The graphical layout of the HMI should therefore be arranged with such concerns in mind - dispensing with the need to perform multiple queries when retrieving data, and enabling items of interest to be shown on the same screen.

6. The value of animation/video

As the saying goes 'a picture is worth a thousand words' - so choosing the right graphics and adding animation or video content, where applicable, will help to improve the quality of the HMI and the user experience derived. With technology continuing to progress, innovative and exciting new features are finding their way into industrial, retail, hospitality, automotive and public service applications. More and more HMIs are hence incorporating informative videos into their operation. The embedding of video into HMIs has two main advantages. Firstly, it allows real-time monitoring and inspection of a multitude of activities. Secondly, in a maintenance/repair context, it can assist workers when they are dealing with a problem - showing them how to replace a component part, replenish a consumable, etc.

7. Prevention of mistakes

In order to differentiate the HMI from those of the competition, a great deal of attention should be paid to delivering a strong user experience that is compelling and enjoyable. Effort must also be made though to mitigate potential sources of frustration, as well as safeguarding against the threat posed by errors occurring. In situations where an operative is controlling a factory automation system or the processing of hazardous chemicals, taking the wrong action due to a poorly constructed HMI could have life-threatening consequences. To prevent this from happening the HMI should be designed from the beginning in such a way that the chance of an error occurring is

minimized. However, if the user does inadvertently make a mistake during the HMI operation, well-crafted messages should be provided to the user. These may be used make certain that the action they are looking to execute is intentional, and if there is a problem that they are not skilled enough to solve themselves advice can be given on what they should do next.

8. Exploiting the available resources to the maximum

Most HMIs today need to be implemented on compact embedded systems, including a microcontroller unit (MCU) or possibly a system-on-chip (SoC) with a large flash memory needed to provide support, plus multiple peripheral interfaces (UART, SPI, I^{2}C, etc.). They can run a real-time operating system (RTOS) or even a full operating system (such as Linux). Embedded systems, however, don't have all the resources of a typical desktop computer. Accordingly, HMIs in this context need to be designed to get the most out of the available memory resources.

9. Balancing of budget and performance

Mechanical and bill-of-materials considerations should be given due consideration, as well. The choice of which hardware components to use and which technical solutions to adopt should be made in such a way as to satisfy both these sets of requirements. Those factors can affect, for instance, the size of the display needed, or whether to choose a resistive or a capacitive based touchscreen. Most importantly though, specifying advanced and highly optimized IC solutions will allow more streamlined HMI deployments - hence reducing the board real estate utilized, simplifying the procurement process and helping to keep power consumption in check, as well as curbing the overall expense associated with the system and the time taken to finish its development.

The multi-award winning embedded video engine (EVE) technology pioneered by Bridgetek has enabled a far more rationalized approach to HMI construction, getting rid of the need for a frame buffer, and allowing the use of lower end MCUs and smaller flash memories. The upshot is that cost, board space utilization and power budget advantages can all be realized. This is done by breaking the HMI down into a series of objects (circles, buttons, sounds, etc.) that each have a reference allocated to them. It significantly reduces the quantities of data that need to be transferred through the system, thereby lowering latency and meaning that HMI performance can be improved.

To make even better use of the system memory reserves and deliver greater functionality in even the most constrained of situations, the latest generation of EVE ICs are now able to employ adaptive scalable texture compression (ASTC) algorithms. Furthermore, the dedicated QSPI host port incorporated into each of these devices is exclusively for accessing external memory resources. This frees up the main system QSPI port for control purposes (so it no longer has to get involved in memory copy activities) - it thus reduces the system MCU's workload and can thereby concentrate on other tasks.

10. Fully utilize the support that is available

There are international standards and guidelines relating to HMI design. Based on feedback gained from numerous HMI implementations, across a wide range of different application scenarios, along with recognized well-established best practices, these can give valuable insight on how to go about developing and subsequently deploying a HMI system, and where resources should be apportioned in order to get the most effective results. It is recommended that the following sites are therefore consulted before embarking on an HMI project -
https://www.asmconsortium.net/deployment/guidelines/Pages/default.aspx
and https://www.iso.org/standard/53590.html

In addition, the relevant software development tools should be employed. Bridgetek has recently made further enhancements to its EVE toolchain, to help simplify the HMI construction process and shorten project completion times. This toolchain provides engineers with an intuitive drag-and-drop design environment through which they can start on their HMI projects, plus a diverse collection of useful project examples that can be referred to. Various pre-configured widgets may be made use of too (dials, sliders, clocks, etc.). More sophisticated features can also be accessed by engineers with greater levels of experience, so that they are able to build HMIs that possess superior functionality.