White Paper

BRT_WP_002

Replacing Instruments with Graphical Displays using BT88x Series

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1 Introduction

Following on from the widespread adoption of touchscreens on phones and mobile devices, there is an established trend of using colour touch-enabled graphic displays to replace control panels with indicators and mechanical switching on all kinds of products and machines. This adds a modern feel to the product as well as having many operational and functional benefits through the entire product life cycle compared to mechanical controls.

In recent years, the range of display panels available has diversified considerably with displays of different sizes and shapes becoming cost effective for low to medium volume designs too. These include small displays, which are ideal for replacing LCD modules such as 16 x 2 Character displays, and circular displays, which are ideal for replacing mechanical gauges and fixed-segment type LCD displays.

These displays allow designers to leverage the significant benefits of using colour graphic displays for updates of existing products and for new designs.

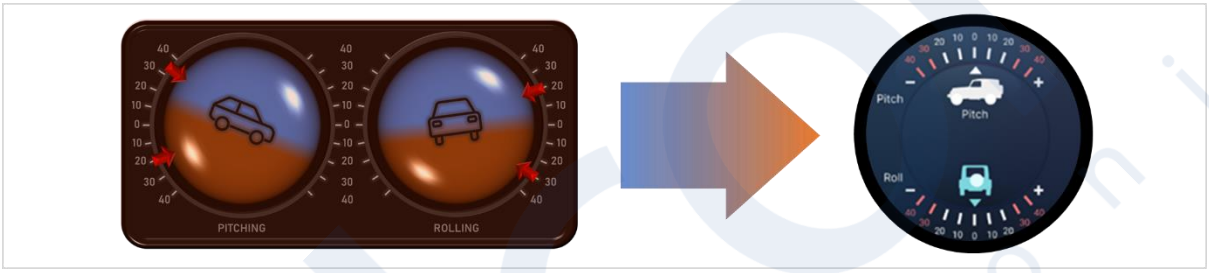


Figure 1 – Advantages of replacing a mechanical instrument with a graphical display

2 Benefits of using Graphical Displays

Using graphical displays in applications which had traditional gauges, LED indications, dot-matrix displays, fixed segment displays etc. opens up many possibilities and benefits including:

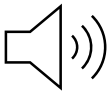
2.1 Enhancing Visual Appearance

- ✓ Give the product a modern look and feel and make it more user friendly.
- ✓ Update the user interface and add features in future easily with firmware updates.
- ✓ Incorporate your style and brand to the product, and even tailor them for products with different end applications or end-user brands.
- ✓ Provide uniform illumination with easily adjustable brightness.

2.2 Integrating Touch Capabilities to the instrument itself

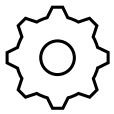
- ✓ Replace buttons and controls which would be located around the instrument, simplifying product assembly and reducing the space occupied on the panel.
- ✓ Create intuitive controls including different types of buttons, sliders, dials, and indicators.
- ✓ Use resistive or capacitive touch depending on the application.

2.3 Integrating Audio Capabilities



- ✓ Acknowledge user touch via clicks or tones for a more intuitive user experience.
- ✓ Generate alert sounds and alarms to get the user's attention.

2.4 Useability and Functionality



- ✓ Show many different parameters on a single instrument (on the main screen or by implementing multiple pages).
- ✓ Provide dynamic scales for gauges, improving readability and ease of use.
- ✓ Use different languages, font sizes and measurement units for international marketplaces and to improve accessibility.
- ✓ Optimize the behavior and response of gauges and readouts (for example by implementing a response curve or damping of a meter pointer in software).
- ✓ Reduce panel layout restrictions due to the shallow depth of LCD screen assemblies.
- ✓ Avoid issues with mechanical parts requiring maintenance and suffering from wear.

3 Applications

There are a huge range of applications which can benefit from gauges and instruments implemented using colour graphical displays, including:

- Electric Vehicles and Bikes (e.g., battery charge levels, temperatures, speed, tyre pressures, fluid levels, inclinometers)
- EV Charging stations (e.g., charge status, costings, user instructions)
- Home Thermostats (e.g., combi boiler pressure gauge, air conditioning control)
- Garden Equipment (e.g., fuel/charge level gauge, fullness of waste bag/basket)
- Industrial Machines (e.g., pressure gauge, temperatures, rotational speeds)
- Smart Home/Building (e.g., lighting control, clocks, HVAC control)
- Audio Equipment (e.g., status display, audio output graphic display)
- Secure Entry (e.g., on-screen keypads and status information)

4 Driving the Display

A key consideration in adopting colour graphical displays is the way in which the display content is generated. The product which will incorporate the display may have an existing microcontroller which handles tasks (such as controlling a heating or air conditioning system) or it may be completely mechanical (for example a speedometer which uses a mechanical connection to the speed sensor on the axle).

Ideally, the display itself should require as little processing as possible from the host MCU to avoid affecting its main application but at the same time must also provide an attractive and user-friendly interface. For existing mechanical designs, it is also desirable to keep the workload in generating the display content to a minimum to allow the use of small low-cost MCUs in the product.

Adding a graphics controller to the design alongside the MCU is very advantageous for a number of reasons. It allows the designer to remain with their preferred microcontroller brand. They can select the model of MCU without being constrained to devices with built-in graphics capability, and so can choose the best one for the application based on its other key specifications (such as peripherals, footprint, cost etc.). It also allows the graphics-related code to be independent of the MCU type, and the MCU software development tools. This in turn allows the code to be easily transferred should a different host MCU be desired. A change in host MCU may be required to support other updated product features, as part of cost reduction, or due to the original MCU or its software tools being discontinued or phased out.

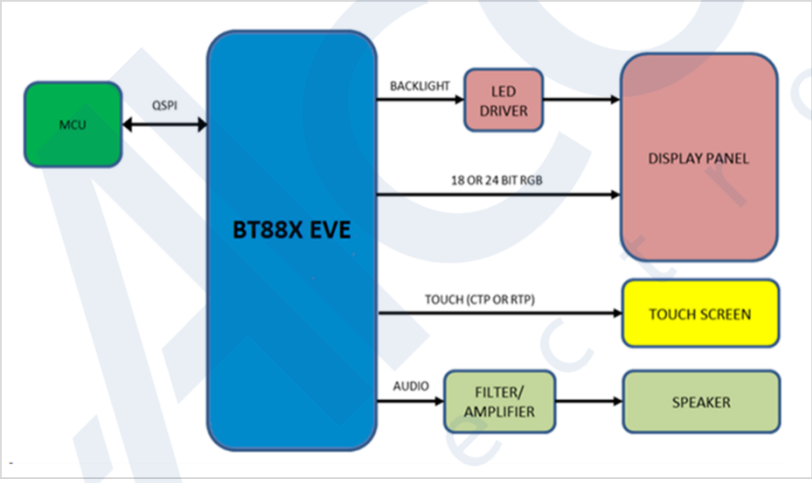


Figure 2 – BT88x Block Diagram

The new BT88x range of display controllers are an ideal partner for a small display panel and are well suited to instrumentation applications. These applications often use 5”, 4.3” or 3.5” panels, bar-type displays or circular displays.

Some of the features which make the BT88x well-suited for these applications include:

- **Simple but Powerful command set** – BT88x’s object-oriented approach to generating graphics allows comprehensive and attractive interfaces to be created easily whilst demanding a low workload from the host MCU.
- **Supporting wide range of displays** - BT88x’s RGB output with configurable display settings allows a wide range of panels to be used. The PWM output allows easy control of

the backlight brightness whilst the swizzle feature re-maps the RGB signals to ease PCB routing.

- **Portrait or Landscape** – BT88x's screen rotation setting allows the display to be mounted at 90 degrees to its native orientation to best suit the form factor of the product and for ease of mechanical mounting and connections.

- **Capacitive or Resistive touch options** – BT880/2 (resistive) and BT881/3 (capacitive) also have an innovative touch tagging feature which makes it easy to determine which item is being touched as well as tracking linear and rotary slide motions, simplifying the software significantly.

- **Audio output with sound generation** – BT88x have a diverse range of built-in sounds and tones which can be triggered via a simple register write, as well as being able to play back audio tracks.

- **Use with any MCU** – BT8xx use a standard SPI, Dual-SPI or Quad-SPI connection to the host MCU allowing a wide range of embedded controllers to act as host. Most BT88x applications can use standard SPI (MOSI, MISO, SCK, CS) which is available on almost any MCU.

- **Built-In Widgets** – BT8xx has a series of built-in widgets such as gauges, text, gradient, buttons, sliders etc. which make it easy to add controls and displays to the design. Support for various image formats also allows easy addition of logos and themes.

- **Built-In Fonts** – BT8xx also has a series of built-in fonts of different sizes. The ability to use custom fonts generated using the EVE Asset Builder allows the style and branding of the product to be easily customized as well as the text sizes etc. to aid useability.

- **Small Footprint for easy integration –** BT8xx has a compact VQFN 48 (BT880/1) or VQFN 56 (BT882/3) package and has a low external component count allowing integration into compact devices. It also eases retrofit into the PCB area of existing products.

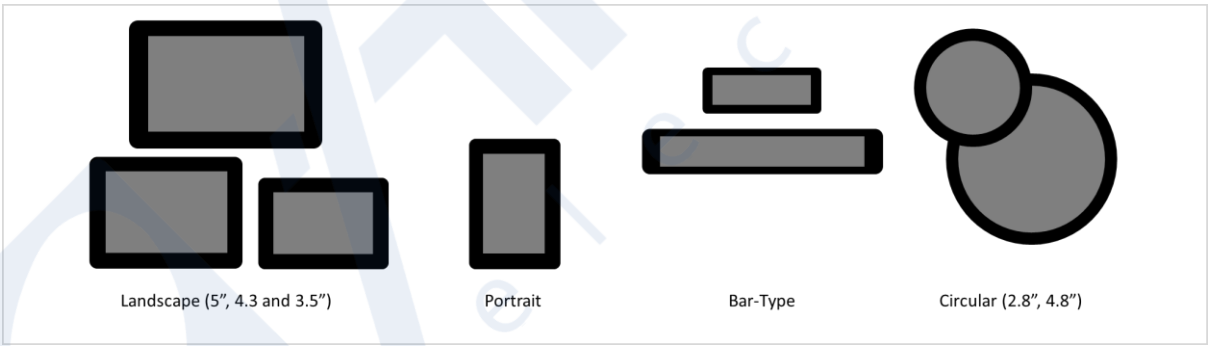


Figure 3 – Different display sizes and form factors

5 Development Considerations

In addition to the capabilities of the graphic controller and display, another vital consideration is the development of the graphical content. This has a significant impact on the feasibility of adding the graphics controller, as well as the timescales for the overall design stage itself. Several factors can also make designers anxious to consider using colour graphical display technologies for their gauges. One such factor is the learning curve. When replacing mechanical indicators, the instrument itself may be entirely mechanical or have some analogue electronics to drive it and so creating graphical interfaces may be unfamiliar to the designer. Even when adding a display-based gauge to an existing electronic product, the designers may have little or no experience in working with graphical design. Even on systems which have a display, such as a fixed segment-based display, the programming techniques for a full-colour graphical display will also differ.

Another factor is the user expectation. Users are now very familiar with graphical interfaces on products. This can be very beneficial when adding a graphical interface to the product, as it helps ensure the end customers will become quickly accustomed to using the product. However, simply adding a graphical display is no longer enough to be deemed a unique selling point and to make a product up to date. The display is now a big part of the user experience and has a big influence on their impression of the product, both in terms of appearance and useability. Therefore, having the right tools to help create a Human Interface which meets, and exceeds, the user's expectations is vital.

Acknowledging the importance of the design flow itself, Bridgetek support their EVE series of graphical controllers such as the BT88x with comprehensive code examples, design tools, as well as evaluation boards. These allow the designer to easily develop their application and to overcome these challenges.

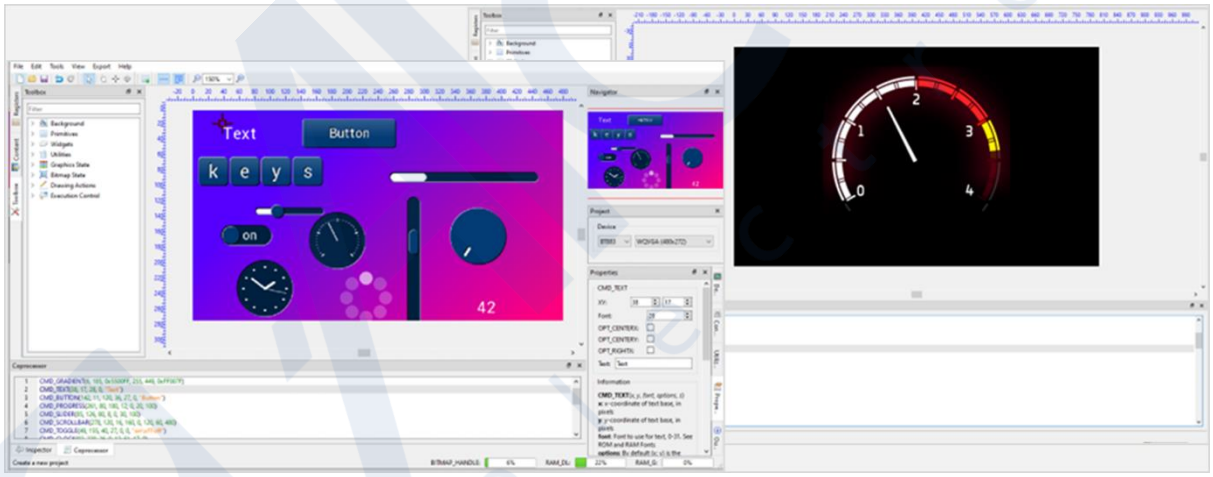


Figure 4 – EVE Screen Editor

On the software side, Bridgetek have a range of tools and code examples which are available to download free of charge and without license-based usage restrictions. Developers often have a preferred approach to designing their user interface, which may be oriented toward graphical drag-and-drop design tools, or toward a purely code-based approach. A range of software tools and examples are provided for the EVE family allowing developers to use their preferred method.

The visual tools include the **EVE Screen Editor (ESE)** which allows users to lay out their screen via drag-and-drop to optimize the layout and content. The ESE tool then provides the associated list of commands to be exported or copied into the user's code. An EVE module can also be connected to

the PC to preview the screen content on a real display. The proposed content can therefore be reviewed and optimized by the different departments involved before final implementation.

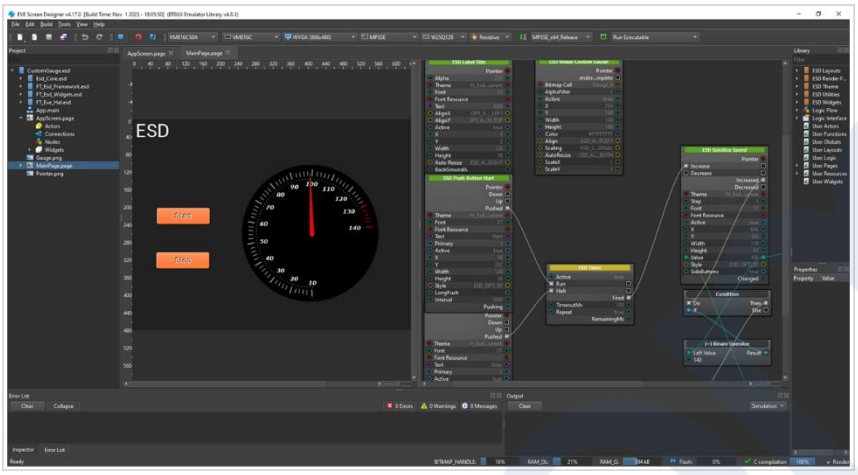


Figure 5 – EVE Screen Designer

The **EVE Screen Designer (ESD)** tool further extends this by providing a visual drag-and-drop user interface to create the on-screen content. The ESD tool also generates the code to navigate between pages and to control the widgets on the display using a logic based graphical editor. The code is exported in the C language for porting to the target MCU.

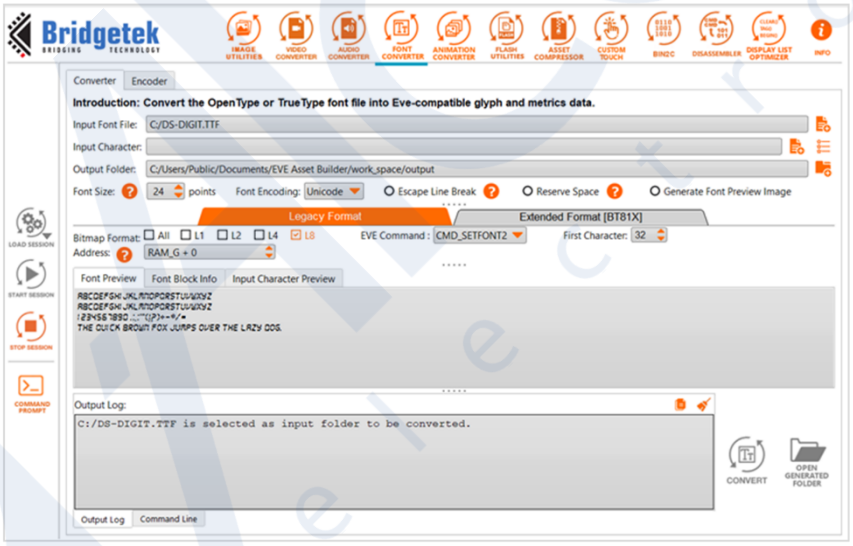


Figure 6 – EVE Asset Builder

The **EVE Asset Builder (EAB)** software is used to convert assets such as fonts, images and audio files for use in the application. The use of custom fonts allows a great deal of flexibility in terms of branding and support for different languages and scientific/currency units. BT88x supports several image formats but the EAB also allows other formats to be converted into supported ones for use in the user interface. This allows the use of logos and backgrounds for example so that the product can have a strong style and brand association. Other assets include audio files which can be converted allowing them to be played via the BT88x using its audio output features.

Many developers also prefer to implement their interface directly in code. As a standard SPI/Quad-SPI peripheral, the EVE family including the BT88x can be programmed in any language as the commands all translate to a series of commands and register operations over SPI. To help developers get up and running quickly, Bridgetek provide extensive software examples free of charge. These are provided along with code libraries for a wide range of MCU platforms which implement the EVE command set on top of a standard SPI interface allowing developers to use the EVE commands directly in their program. Porting guides are also provided to ease the process of porting to MCUs which are not directly included in the code already.

6 Hardware and Prototyping

Whilst the final design will likely use a Printed Circuit Board (PCB) designed to fit the enclosure of the product, the designer can utilize the BT88x development modules in order to develop and prototype their design. The modules can also be used in final products, especially the versions with plastic bezels for ease of mounting of the display. The documentation and schematics also provide a good reference when designing the final product hardware.

The IDM2040-43A is an intelligent display module which includes a BT883 graphics controller driving a 4.3" 480x272 capacitive touch screen and an on-board RP2040 microcontroller. The module has connectors to access the GPIO, UART, I^2C and SPI from the RP2040 as well as optional serial connections for RS232 and RS485. The VM880C is a credit-card sized module featuring the BT880. This module allows the addition of a resistive touch panel (for example 4.3" or 5" 480x272 display). The module has SPI connections to the host MCU via a pin header. This can also be used with a USB-SPI interface such as the C232HM series of cables from FTDI / Connective Peripherals in order to begin development using a PC running Visual Studio or EVE Screen Editor acting as the host MCU.

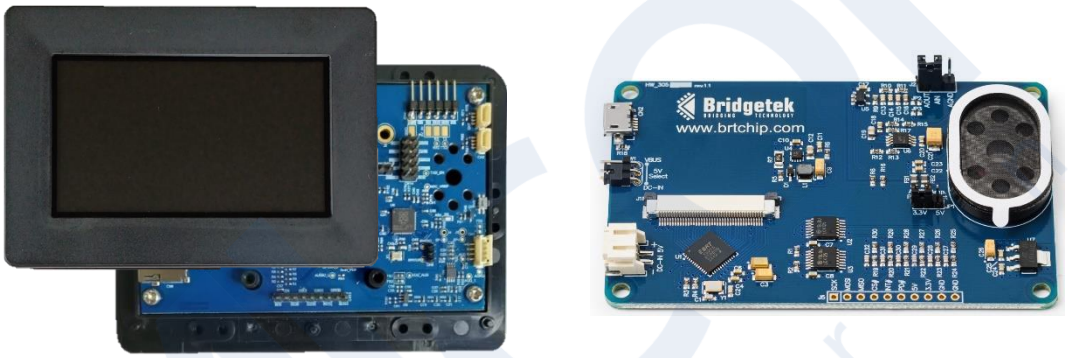


Figure 7 – IDM2040-43A and VM880C Modules

7 Inclinometer Demo

The Inclinometer demo from Bridgetek gives one good example of how a mechanical indicator can be replaced by a small circular display. In this case, the new Bridgetek BT881 display controller is used along with a Raspberry Pi RP2040 MCU (as found on the Pico module) to generate the graphics on the 2.1" capacitive touch screen. The code can be written in popular languages such as Circuit Python or C using the wide range of library examples and application examples provided by Bridgetek.

Figure 8 – BT881 Inclinometer Demo

Features include:

- Combine the data from multiple separate gauges onto one screen.
- Display warnings etc. on the screen itself, for example when the vehicle exceeds the limits for the inclination.
- Implement controls such as brightness sliders and time setting on the instrument itself instead of external dials.

8 Conclusion

With touch-enabled colour graphics displays becoming readily available in a range of shapes and sizes, it is worthwhile for designers of products (both new designs and updates of existing designs) to consider the benefits of using a touch-enabled graphical user interface in their product. Along with the availability of the displays themselves, the graphics controllers such as the BT88x series from Bridgetek and their supporting development tools and software have evolved significantly, making it easier than ever for designers to create professional and user-friendly interfaces to make their products stand out in the marketplace and give their customers the best possible user experience.

9 Contact Information

Refer to https://brtchip.com/contact-us/ for contact information

Distributor and Sales Representatives

Please visit the Sales Network page of the Bridgetek Web site for the contact details of our distributor(s) and sales representative(s) in your country.

Appendix A – References

Document References

NA

Acronyms and Description

Terms	Description
EV	Electric Vehicle
EAB	EVE Asset Builder
ESD	EVE Screen Designer
ESE	EVE Screen Editor
EVE	Embedded Video Engine
FTDI	Future Technology Devices International
GPIO	General Purpose Input / Output
HVAC	Heating, Ventilation and Air Conditioning
I2C	Inter-Integrated Circuit
LCD	Liquid Crystal Display
LED	Light Emitting Diode
MCU	Micro Controller Unit
PCB	Printed Circuit Board
RGB	Red Green Blue
SPI	Serial Peripheral Interface
UART	Universal Asynchronous Receiver / Transmitter

Appendix B – List of Tables & Figures

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Appendix C – Revision History

Document Title:	BRT_WP_002 Replacing Instruments with Graphical Displays using BT88x Series
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1.0	Initial Release	26-12-2023