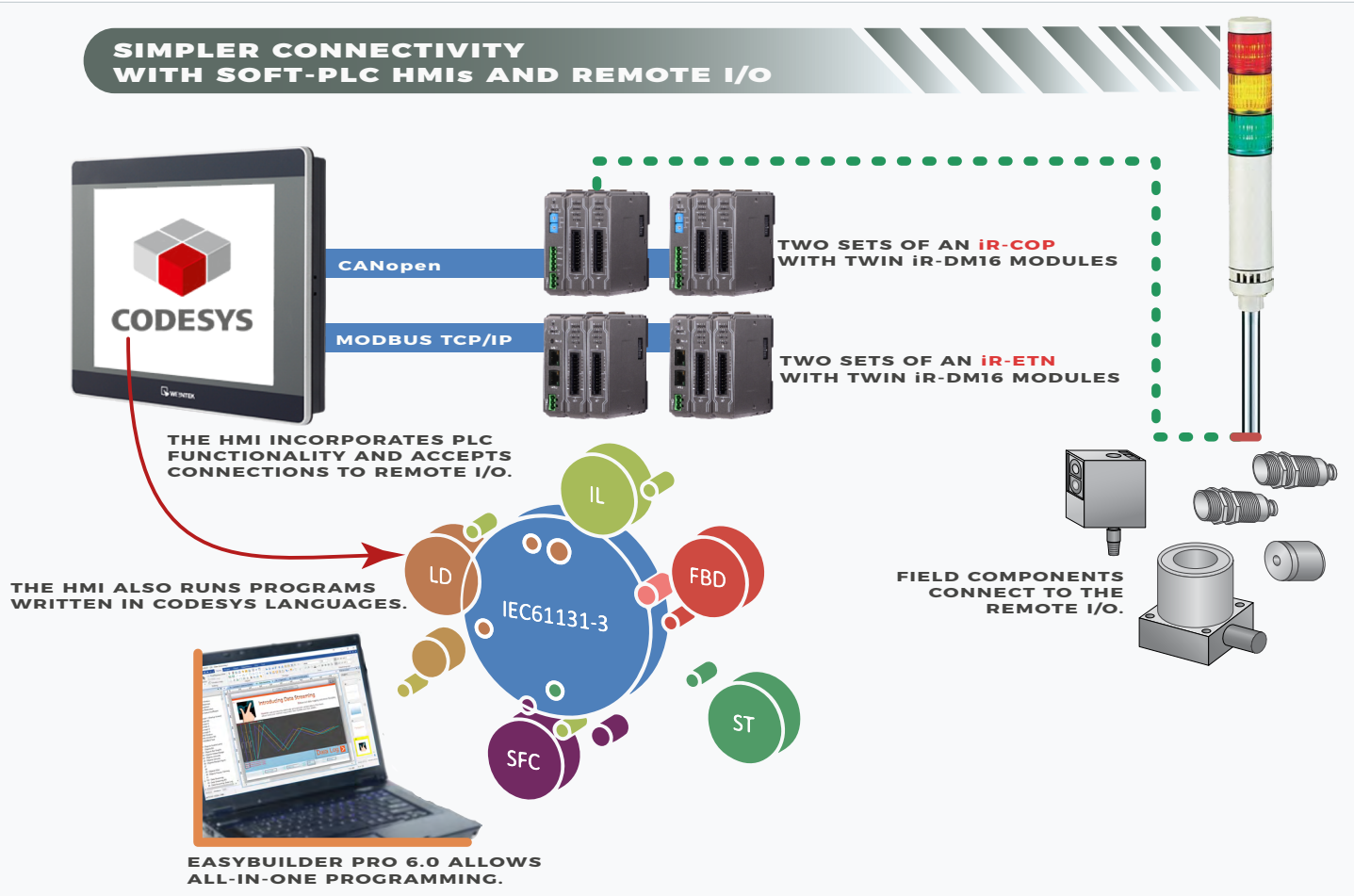# Better use of remote I/O with CODESYS-programmable controller HMIs

Machine automation (MA) and factory automation (FA) benefit from increasingly powerful components. Case in point: Some HMIs with PLC functionality (and CODESYS programmability) now support remote I/O connectivity.

Automated machines and installations rely on remote sensors, motion axes, switches and actuating devices, and production data to function. Collecting inputs and sending outputs to these peripheral data nodes are I/O modules. Remote I/O (sometimes abbreviated RIO or RI/O) usually takes the form of standalone hardware that collects the signals from field devices to feed back to a PLC (or rack into which a PLC is mounted), PAC, PC, or another controller. But as we'll explore, some new HMI hardware integrates controller functionality and connects directly with remote I/O modules to simplify integration.

The Weintek cMT controller HMI offers PLC functionality and CODESYS programmability. It connects to hundreds of other controllers from dozens of other manufacturers to simplify system installation. The controller HMI accepts analog, digital, and thermal signals from remote I/O to excel in oil and gas and wastewater applications. Plus users can create a cMT CODESYS project in CODESYS software, and then use it within Weintek EasyBuilder Pro (EBPro) 6.0 software for streamlined programming.

SIMPLER CONNECTIVITY WITH SOFT-PLC HMIs AND REMOTE I/O

CANopen

MODBUS TCP/IP

TWO SETS OF AN iR-COP WITH TWIN iR-DM16 MODULES

TWO SETS OF AN iR-ETN WITH TWIN iR-DM16 MODULES

THE HMI INCORPORATES PLC FUNCTIONALITY AND ACCEPTS CONNECTIONS TO REMOTE I/O.

THE HMI ALSO RUNS PROGRAMS WRITTEN IN CODESYS LANGUAGES.

IL
LD
FBD
IEC61131-3
ST
SFC

FIELD COMPONENTS CONNECT TO THE REMOTE I/O.

EASYBUILDER PRO 6.0 ALLOWS ALL-IN-ONE PROGRAMMING.

1

Basics of remote I/O — and the Weintek offering

Remote I/O modules are cost-effective pieces of hardware for system control and monitoring. Many work even in hazardous locations, and most have basic processing capabilities to run communications and transmit and receive data to and from a main controller. The controller in turn accepts this data and executes higher-level application software.

Because remote I/O brings connectivity closer to operations, it enables otherwise impossible installations while minimizing wiring and its associated labor. In fact, use of remote I/O is sometimes required by sprawling operations with extensive arrays of I/O nodes or plants with expansive physical layouts. Remote I/O systems support distributed machine design (where systems are built on multiple frames) by consolidating HMIs and software. Some remote I/O module assemblies also run much faster than local I/O … and software and quick-connecting hardware for remote I/O setups can make expansion simple should plant operations need to grow.

Remote I/O installations can reduce programming requirements because they complete simple tasks while letting main controls handle advanced (or high-speed) processing, measurement, and output commands. Such I/O functionality paired with controls programmed with CODESYS-standard languages serve factory, energy, process, mobile, embedded, and building automation.

In many cases, remote I/O installations include DIN-rail-mounted modules ganged with a bus coupler. This assembly then connects to the controller to share signals to and from mechanical contacts, valve positioners, flow and pressure transducers, temperature transmitters, 4-to-20 mA devices, thermocouples, visual and audible safety-signaling devices, and even drives to run electric motors, pumps, and fans.

Where remote I/O includes modules connect directly to controls via cables, throughput of data associated with configuration, diagnostics, and normal operations is fast and secure. In another departure from distributed I/O (which usually includes multiple processors controlling one operation's various sections and physically distributed bus-connected I/O cards) remote I/O usually relies on a single processor collecting all the I/O signals.Where fieldbus interfaces are pre-

Shown here is an Ethernet coupler that works with the Weintek controller HMI. It's a MODBUS TCP/IP slave with dual Ethernet support and Ethernet cascading — as well as direct support of drivers generated by Weintek EBPro software.

Shown here is an iR-COP CANopen bus coupler with an iR-DM16 module. The bus coupler supports baud rates of 5 kbps to 1Mbps and allows quick node and baud-rate changes. The coupler also allows remote changes to communication settings — and direct EBPro driver support without the need to import code. Shown here (lower right) are plug-in modules that install without a screwdriver; only a flathead screwdriver is needed to remove cables. Up to 16 digital I/O are possible per module (including transistor and relay outputs); up to four analog I/O are possible with 16-bit resolution and configurable voltage ranges including temperature RTD and TC.

integrated into the hardware, they're fixed. In contrast, modular I/O modules let design engineers select from several options. No matter the format, open fieldbus interfaces impart more flexibility than proprietary interfaces (which may limit how many system and field components are compatible). Case in point: Weintek Ethernet MODBUS couplers can daisy-chain to connect diffuse Ethernet devices, and then the last Ethernet port in the series can be used as a diagnosis port.

Taking flexibility still further are software-based (soft) PLCs. As we'll explore, these controllers are spurring more remote I/O use and even displacing local rack-mounted PLCs and I/O in some cases.

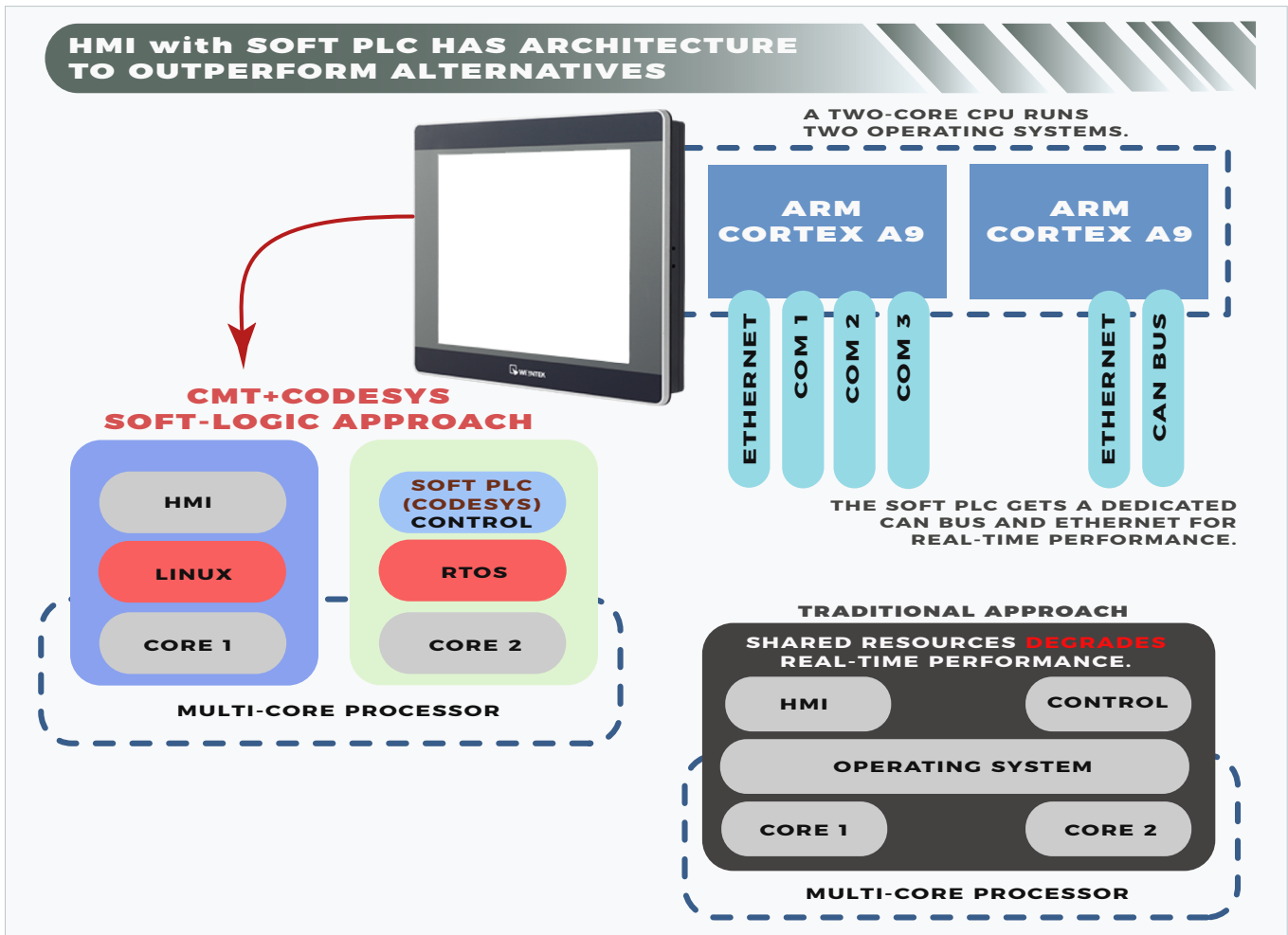# 2 Controller HMIs (cMTs with PLC functionality) and bus couplers with the I/O

Weintek's cMT controller HMIs run high-performance operating systems. They use remote I/O modules and Weintek's MODBUS TCP/IP and CANopen couplers for networking. The cMT HMIs have dual processors — one strictly for HMI functions and the other for soft PLC functions. The HMI logic includes Weintek's industry-recognized cMT HMI, which allows remote monitoring and an array of other features. The control logic complies with IEC 61131-3 for open-source programming and works as a performance real-time system — with fault tolerance and dedicated system memory, processing power, and other resources.

Control logic runs on a real-time operation system to guarantee real-time performance. HMI logic and control logic can be treated like separated devices, as they have their own memories, storage space, and process control. Heavy processing demand from either doesn't affect the other. That means the control logic maintains its high-efficiency real-time operation system while the HMI logic can help process batch processing, data collection, and display.

In fact, the Weintek design runs an asymmetric multi-processing (AMP) architecture. Compared with symmetric multiprocessing (SMP) found on the majority of today's computers (which run a single OS such as Windows across all cores of the CPU) AMP lets Weintek use different combinations of OSs on one CPU chip. That is what allows one general-purpose HMI logic running on one core and one real-time control logic on another core. Again, the systems can be treated as separate devices, so each has its own Ethernet port — and to connect to both, the user will need two RJ45 cables.

Another piece of the automation-network puzzle is the bus communication system. Many installations require an internal

In traditional components with soft PLCs, symmetric multiprocessing (SMP) means system resources are shared — which degrades real-time performance. The Weintek cMT+CODESYS HMI with soft logic outperforms even some traditional standalone PLCs on the market.

HMI with SOFT PLC HAS ARCHITECTURE TO OUTPERFORM ALTERNATIVES

A TWO-CORE CPU RUNS TWO OPERATING SYSTEMS.

ARM CORTEX A9

ARM CORTEX A9

ETHERNET · COM 1 · COM 2 · COM 3 · ETHERNET · CAN BUS

CMT+CODESYS SOFT-LOGIC APPROACH

HMI	SOFT PLC (CODESYS) CONTROL
LINUX	RTOS
CORE 1	CORE 2

MULTI-CORE PROCESSOR

THE SOFT PLC GETS A DEDICATED CAN BUS AND ETHERNET FOR REAL-TIME PERFORMANCE.

TRADITIONAL APPROACH

SHARED RESOURCES DEGRADES REAL-TIME PERFORMANCE.

HMI	CONTROL
OPERATING SYSTEM	
CORE 1	CORE 2

MULTI-CORE PROCESSOR

bus — sometimes called an iBus, memory bus or (in installations with standalone hardware) local bus — to connect internal system components. Shown below are the specifications of four versions of the Weintek iR-series iBus.

MODULES	MODEL	INPUTS	OUTPUTS	CYCLE TIME	COMPETITOR CYCLE TIME
4	iR-DM16 x 4	32	32	0.6 msec	3.2 msec
32	iR-DQ16 x 32	0	512	0.9 msec	25.6 msec
32	iRDl16 x 32	512	0	3.3 msec	25.6 msec
32	iR-Dl16 x 16 iR-DQ16 x 16	256	256	2.1 msec	12.8 msec

The bus modules get higher speeds than competitor offerings because the latter uses slow one-by-one SPI — and series connections to the coupler. In contrast, parallel I/O connections in the iR-series iBus to the coupler is efficient without incurring higher costs. These offerings have strong noise resistance as well.

3

Control with a soft PLC (on the HMI)

Soft PLCs are software programs that run real-time tasks on computers — multi-tasking functions normally associated with traditional PLCs. Chief among these are I/O and discrete and PID control with networking, data handling, and computational capabilities.

Consider the Weintek cMT+CODESYS controller HMI with soft-PLC functionality. This option delivers dependable and deterministic program execution. In terms of speed, its execution of LoaD (LD) instructions —to load information from memory — and MOVe (MOV) instructions — to move information from operand to register — is comparable to that of traditional industrial PLCs:

CMT + CODESYS	
LD	10 nsec
MOV	16 nsec
MITSUBISHI FX5 MID-LEVEL MARKET OFFERING	
LD	40 nsec maximum
MOV	100 nsec
MITSUBISHI Q100UDEHCPU 1000K STEPS, 4K I/O	
LD	9.5 nsec
KEYANCE KV5000	
LD	10 nsec

Omission of the separate PLC makes for a more compact design. There's also internal communication between the controller HMI's dedicated display logic and dedicated control logic, which makes for faster display of data — and the ability to monitor controls directly from the display.

Of course, soft PLCs require implementation on suitable hardware with sufficient processing and memory capacity, as well as Ethernet, I/O, COM, and other modes of connectivity. They also require programming. In the last section of this white paper, we'll share how to create and download a CODESYS project to a Weintek HMI+PLC program; monitor a project running on the soft PLC; and visualize PLC information with EBPro.

4 CODESYS and its application in HMI+PLC components
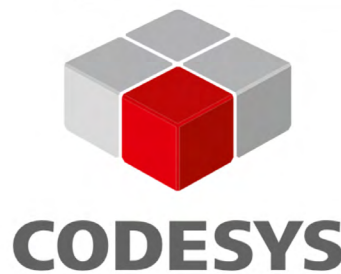
IEC 61131-3 defines the semantics, syntax, and displays of common languages for controller programming. CODESYS is a programming environment that supports development of code in all five 61131-3 languages … and Weintek cMT HMIs with CODESYS allow efficient setup and operation of the controller portion of the hardware.

Recall that CODESYS (Controller Development System) is a leading IEC 61131-3 programming tool. CODESYS is widely used because it supports 61131-3's five programming languages — those based on ladder diagrams, function-block diagrams, sequential function charts, instruction lists, and structured text. Because CODESYS output is machine code native to common processors, it also makes for control that's faster and more reliable than that based on interpreted code.

In fact, CODESYS is a proven and easy-to-use IEC 61131-3 platform; the open standard works for programmable logic controller (PLC) setup. The programming environment generates well-proven code for factory, energy, process, mobile, embedded, and building automation. Features include data monitoring, scanning, tracing, and debugging. There is a variety of add-on modules and libraries. Plus there's subversion and version control … and MATLAB integration is also an option.
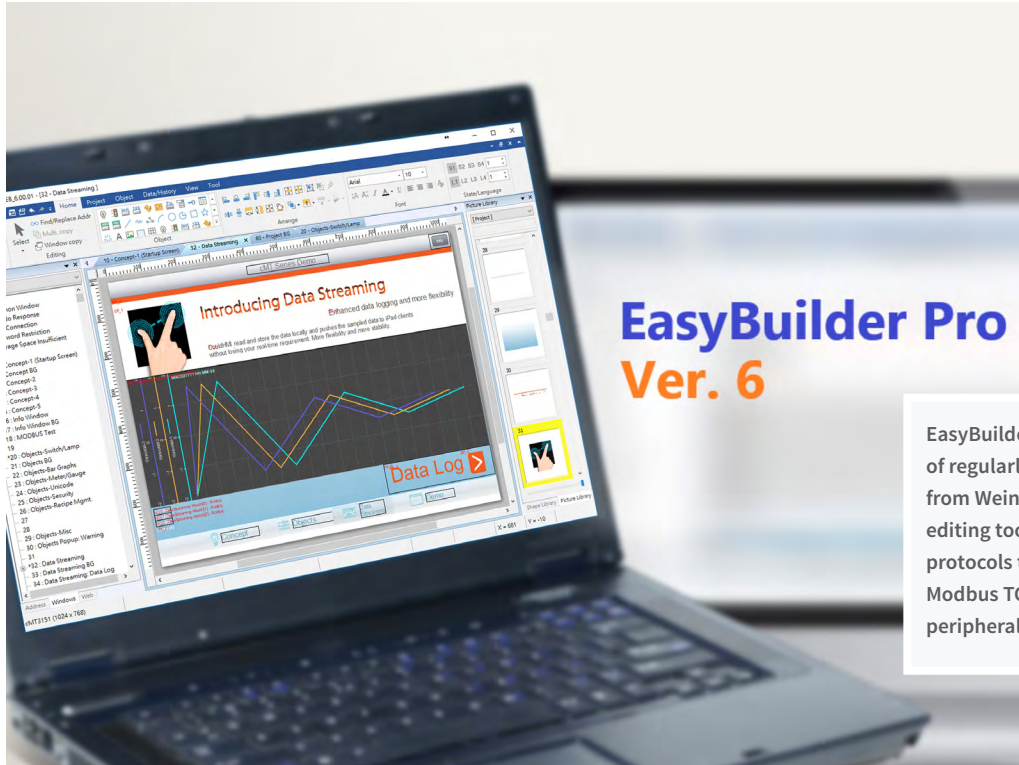
EasyBuilder Pro 6.0 is the latest version of regularly updated design software from Weintek. The visual project editing tool supports communication protocols that include Ethernet/IP and Modbus TCP for easy connection of peripheral (field) devices.

Because IEC 61131-3 and CODESYS let system programmers mix programming languages for projects, there's optimization of code — so a programmer might use ladder-diagram logic for basic interdependent machine functions alongside structured text to run interpolated tasks that are more complicated (to give one example).

5

Programming language of EasyBuilder Pro (EBPro)

Consider the Weintek cMT HMI with built-in CODESYS. It lets users visualize projects using EasyBuilder Pro (EBPro) — the manufacturer's own programming tool. The cMT communicates with hundreds of PLCs from dozens of manufacturers.

The cMT communicates with hundreds of PLCs and devices from dozens of manufacturers, enabling seamless data exchange between different systems. The cMT also connects directly with handy components like barcode readers or Ethernet printers, removing the hassles when integrating different components. cMT runs various IIoT protocols including MQTT and OPC UA. Remote monitoring with cMT Viewer and VNC is fast and easy, even on a Wi-Fi connection.

How does EasyBuilder Pro accept code imported from CODESYS?

Users need to export the symbol configuration from a CODESYS project as XML file. Then, users import the XML file into EBPro to give EBPro the symbols (tags) for assigning to different screen components such as buttons and lamps. Again, cMT HMI logic interfaces with the control logic via internal communications for networking that's far faster and simpler than that through RJ-45 wires in traditional setups. cMT HMI logic is also capable of monitoring CODESYS program status.

Click on the hotlinked thumbnails to watch videos showing the creation of a simple CODESYS project in just a couple minutes; how to import tags into Weintek EasyBuilder Pro (EBPro) 6.0 software; and a demonstration of the PLC control.

Although they are treated as separate devices, users can even monitor control logic from the HMI. What's more, it's is a default option … so users don't have to design a project to do this.

WEINTEK develops, designs, and manufactures practical HMI solutions in the new IIoT era. WEINTEK LAB's mission is to provide quality, customizable HMI-solutions that fulfill industrial automation requirements while maintaining customer satisfaction by providing on-demand customer service. Since the North American branch opening of Weintek USA in 2016, Weintek's innovative technology has been available for direct purchase in the USA and Canada.

Click on the hotlinked thumbnails to watch videos showing a demonstration of the trace function within CODESYS; how to add a module in CODESYS (which in turn imports into EBPro for control); and a demonstration of direct control through a cMT without a PLC. It shows how it's possible to directly control a remote I/O with all Weintek product series having CANopen connectivity — including eMT, MT8092XE, and cMT products.