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Our roots go back to the International Liquid Crystal Company--the inventors of TN liquid crystal displays and the first LCD manufacturer in the world. We have over 30 patents (pins, fluids, and electronics) for improving the optical and environmental performance of LCDs.

LXD
LIQUID CRYSTAL DISPLAYS

Todd Bolanz, President

Serious transforms industrial and commercial products into interactive, industry-leading devices – unleashing IoT opportunities for Original Equipment Manufacturers (OEMs).

Leveraging the Serious Human Interface™ Platform of hardware and software technologies, OEMs deliver the complete human-machine experience – from HMI to Cloud. Partnering with Serious, OEMs achieve their digital economy evolution faster than imaginable, with substantially less effort.

Serious™
Human Connected Machines

Terry West, CEO

PAINLESSLY ADD A GRAPHIC HMI

E-cast

Powered by Embedded COMPUTING DESIGN

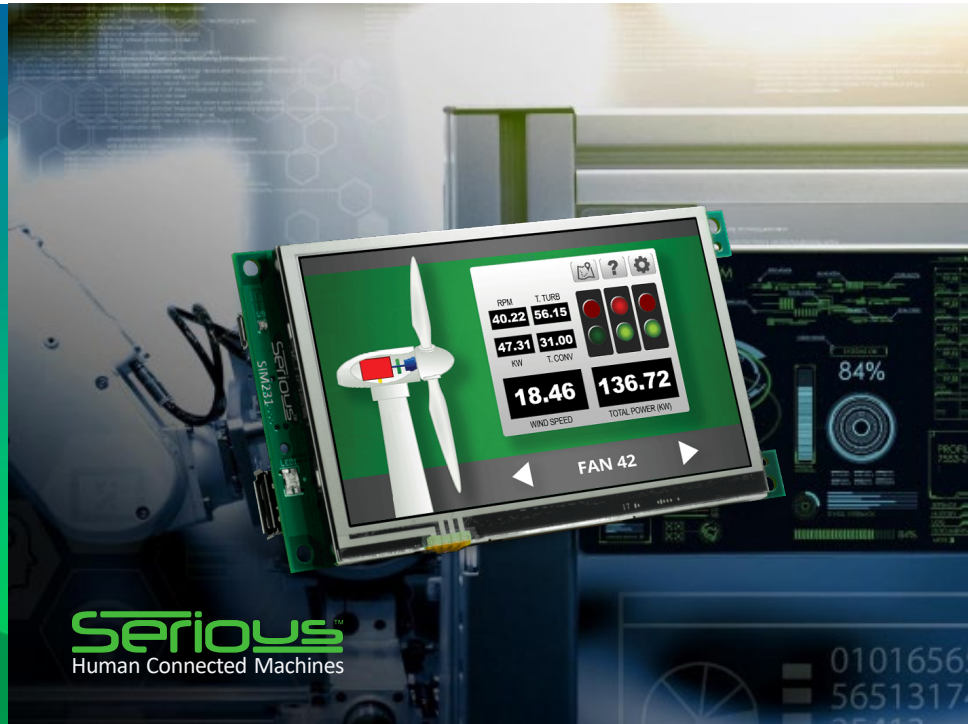
Overview

LCD Technology & Selection

- Selection key points
- LCD types & features
- Supply chain & quality

Platform Technology & Selection

- MCU & memory
- Software architectures
- All-in-one or distributed

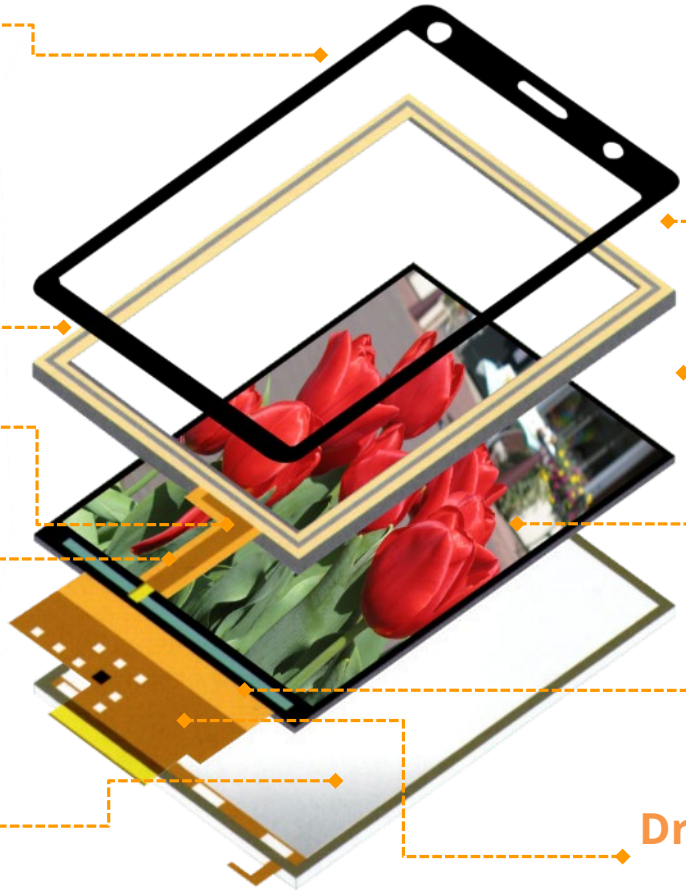


Selecting an LCD

- Specify the set of properties you need to meet your end-product application
  - Industrial
  - Medical
  - Automotive
  - Consumer
- Select the right LCD partner

- Consider HMI SOM partner (e.g. *Serious*) to abstract you from the supply chain complexity

Graphic LCD Basic Construction



Cover Lens
Chemically strengthened with optional coatings

Touch Sensor
Resistive/Capacitive

Touch Controller
Optional

Touch FPC
I2C; some larger panels USB

Backlight
High luminance/High saturation

Bonding
Perimeter or Optical Bonding

Optical Optimization
Sunlight readable, Privacy Filter

LCD
Various size, types

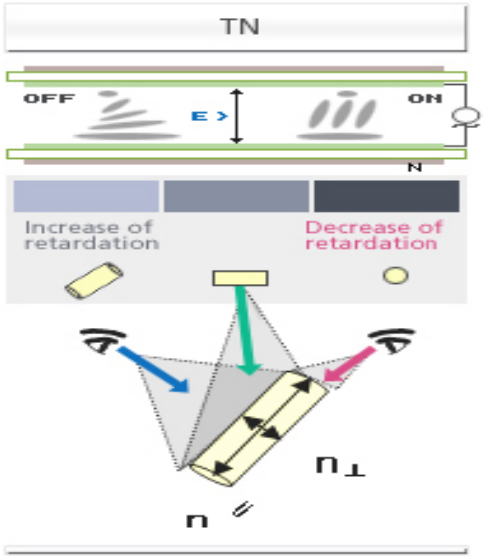
Mainboard Connectivity
FPC or LVDS Type

Drive IC , Timing control IC

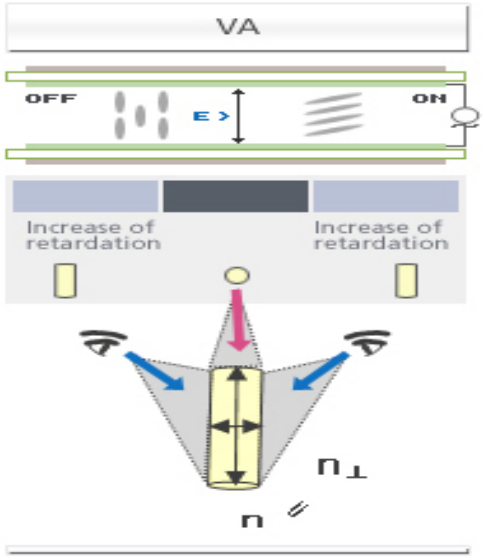
LCD SIZES & RESOLUTIONS

- Measured on the diagonal of the active pixel area
- Two basic aspect ratios: 4:3 & Wide
  - 4:3 aspect ratio is 640x480 resolution (VGA)
  - Wide aspect ratio is 800x480 resolution (WVGA)
- Use a “standard” size wherever possible
- Most standard sizes have a most-common resolution

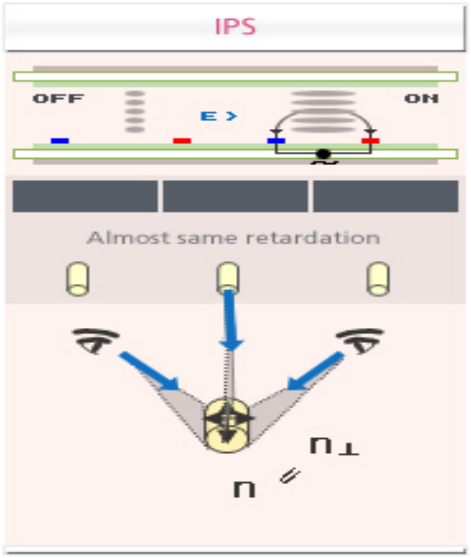
TFT DISPLAY TECHNOLOGIES



- Standard commodity technology
- Good viewing angle from 3 directions
- Lowest cost in 7” and below and non-leading-edge resolutions



- Niche process with unique benefits
- Good all-way viewing angle, excellent contrast ratio



- Standard technology
- Excellent all-way viewing angle
- Common in 7”+ sizes and leading edge resolutions

BACKLIGHT FEATURES

- Brightness (mcd/m^2 or “NITs”)
  - 250 most common; indoor suitable
  - 500 bright indoor; shaded outdoor
  - 800 bright outdoor readable
  - 1000 direct sunlight readable
- Lifetime: Heat and Humidity are LED enemies
  - 20,000 hour: normal
  - 30,000 hour: somewhat common
  - 50,000 hour: premium cost but widely available
- Power
  - Typically wired in series and/or parallel “strings” requiring constant current boost supplies with voltages typically 9 to 23V
  - Power supply can be integrated on-module

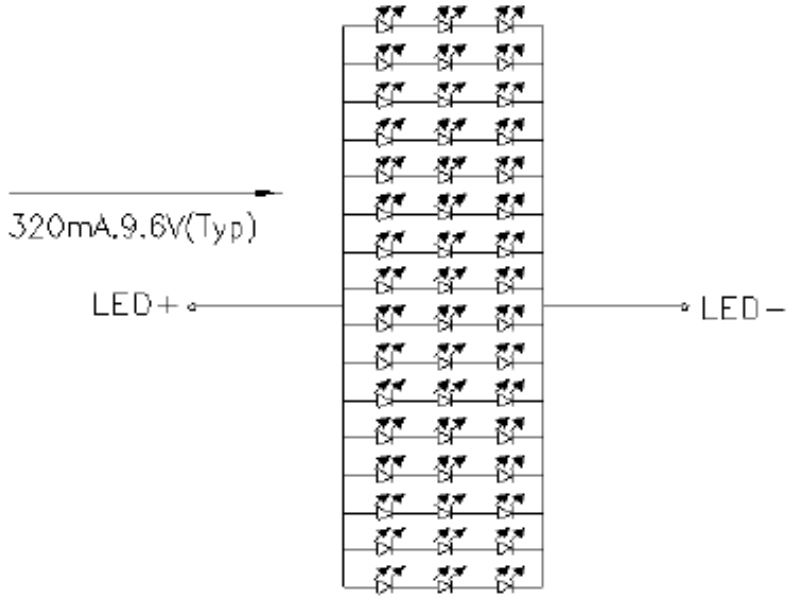
TYPICAL BACKLIGHT DATA SHEET

7. Backlight Characteristics

7.1 Parameter Guideline of LED Backlight

Symbol	Parameter	Min.	Typ.	Max.	Units	Condition
V_L	LED Light bar Driving (Row output)	8.7	9.6	10.2	V	Ta=25℃ Note A ,Note C
I_L	LED Current	--	320	--	mA	Ta=25℃
LT	LED Life Time	30,000	--	--	Hours	Ta=25℃ Note B ,Note C

Note A: I_{LED}=20 mA (Per LED)
Note B: The LED life time define as the estimated time to 50% degradation of initial luminous.
Note C: under room temperature(25℃, Humidity 30-60% RH) and IL=320mA.

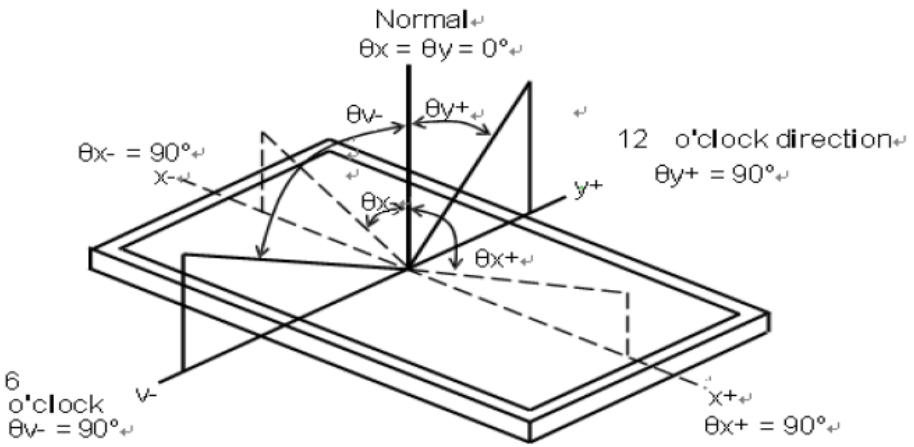


VIEWING ANGLE

- Measured in degrees from straight-on viewing
- Normal TN TFTs have one bad “gray scale inversion” angle
  - Expressed as clock-hour (e.g. *6 o’clock inversion*)
  - This limitation is fine for most usage models
  - Caution: sometimes the 6/12 o’clock refers to the good angle, sometimes the bad!
- Optical Viewing Angle (OVA) films
  - Low cost solution for improving gray scale inversion angle (Poor man’s IPS)
  - Overcomes grayscale problems at a small premium & brightness compromise
  - Great for turning a landscape TFT into a portrait TFT
- IPS & true MVA have excellent all-round viewing angles

TYPICAL VIEWING ANGLE DATA SHEET

B. Definition of Viewing Angle



TN

Item		Symbol	Specification			Unit
			Min.	Typ.	Max.	
Viewing Angle (See 6.4)	Horizontal	θX+	55	70	-	Deg.
		θX-	55	70	-	
	Vertical	φY+	35	50	-	
		φY-	55	70	-	

IPS

Item		Symbol	Specification			Unit
			Min.	Typ.	Max.	
Viewing Angle (See 6.4)	Horizontal	θX+	80	89	-	Deg.
		θX-	80	89	-	
	Vertical	φY+	80	89	-	
		φY-	80	89	-	

TN W/OVA FILM

Item		Symbol	Specification			Unit
			Min.	Typ.	Max.	
Viewing Angle (See 6.4)	Horizontal	θX+	60	75	-	Deg.
		θX-	60	75	-	
	Vertical	φY+	60	75	-	
		φY-	60	75	-	

LXD LIQUID CRYSTAL DISPLAYS

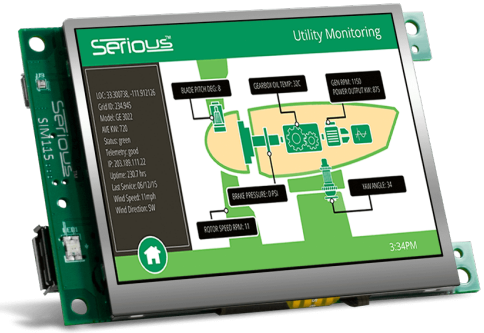
TOUCH TECHNOLOGIES

- Resistive touch still the most cost effective
  - Works well in many environments including thick gloves & water
  - Generally single-touch
  - Raw analog signals brought to tail stock; mainboard is responsible for reading
  - Normally “4 wire” resistive; cost premium “5-wire” adds damage resiliency
  - Requires calibration

- Capacitive touch – elegant, modern, but adds cost
  - Requires sensors and capacitive touch controller built into the touch sensor
  - Single/multi-touch, slide, glide, etc…. just like your phone/tablet
  - Water/glove tolerance improving with new touch controllers & sensors

- Other niche touch technologies available at significant cost premiums and supply chain narrowing

TOUCH TECHNOLOGY EXAMPLES



Non-Touch

No cover glass

Capacitive

Cover glass with
integrated sensors/controller
and i2c FPC

Resistive

Cover glass with
surface bonded resistive Mylar layers
and 4-wire FPC

MANY OTHER LCD OPTIONS

- Perimeter vs. Optical bonding
- Many optical/mechanical films and coatings
  - Polarizers, viewing angle enhancement, anti-reflection, anti-glare, anti-fingerprint, anti-shatter, anti-shard, ….
- Custom FPCs
- Custom cover glass
- Choice of Cap touch controller: price/features/longevity vary widely
- Display Interface options
- EMI/RFI shielding
- Enclosures

SUPPLIER SELECTION QUALITY, EOL AND CHANGE MANAGEMENT

- Key elements when selecting a LCD supplier
  - Technical Support/ Responsiveness
  - Worldwide delivery
  - NA Warehouse for JIT/Kanban programs
  - EOL management program
- Factory Quality Systems
  - ISO 9000
  - TS16949 (Automotive)
  - ISO13485 (Medical)
- Factory Visit for quality audit

Serious™
Human Connected Machines

High Performance HMI Solutions
with IoT Connectivity

Major HMI Platform Architectural Drivers

- LCD resolution & usage models (video, animation, frame rates, etc.)
- Scalability & Longevity
- Software
- Connectivity & IoT
- Distributed or Unified?
- Time and Cost to Market & to Sustain

LCD Resolution/Usage Drives MCU/RAM

Resolution	Frame RAM[1]	RAM LCD MHz (no video)[2]	RAM LCD MHz (with video)[3]	Typical DRAM Required	Typical MCU
320x240 (<=3.5″)	600kB	11	13	SDRAM x16 8MB+	100MHz 32-bit MCU
480x272 (4.3″)	1020kB	18	22	SDRAM x16 16MB+	100-400MHz 32-bit MCU
800x480 (5″, 7″)	3000kB	54	65	SDRAM x16 32MB+	240-1000MHz MCU/MPU
1024x600 (7″)	4800kB	86	103	DDR2/3 x16 32MB+	400-1000MHz MPU
1280x800 (10.1″)	8000kB	143	172	DDR2/3 x32 64MB+	600MHz+ MPU

[1]Two 32-bit frame buffers
[2]Servicing LCD @ 60Hz plus full screen redraw @10fps on 16-bit RAM, w/o refresh overhead
[3]Servicing LCD @ 60Hz plus full screen redraw @24fps on 16-bit RAM, w/o refresh overhead

- 24-bit color (RGB888) the norm for attractive gradients; 4 bytes/pixel
- Double buffering is normal – render in the background, then flip
- MCU/RAM HW architecture needs to support high end or scale
- GUI SW architecture is unique – visual object oriented/event driven

HMI Scalability + Longevity

How do you ...

- Scale UX and HMI for a range of cost/size products?
- Reuse all your software investment and knowledge
- Leverage and track evolving software/connectivity
- Sustain your software infrastructure
- Sustain your hardware infrastructure across EOLs (especially LCDs!)
- Track latest HMI innovations and cost points

THE SW+HW CHALLENGE

is the biggest

ARCHITECTURAL DECISION

your company has

EVER FACED

WINDOWS + INTEL

- Custom Apps & Drivers
- Custom + OS Frameworks
- OS, Stacks, Drivers
- Intel SBC

CUSTOM EMBEDDED

- Custom GUI
- Custom Frameworks
- Custom OS/Stacks/Drivers
- Custom HW

LINUX + SBC

- Custom Apps & Drivers
- Custom + OS Frameworks
- OS, Stacks, Drivers
- Custom or SBC

LEVERAGED EMBEDDED

- Custom GUI (abstracted)
- COTS Frameworks
- COTS OS/Stacks/Drivers
- COTS HW

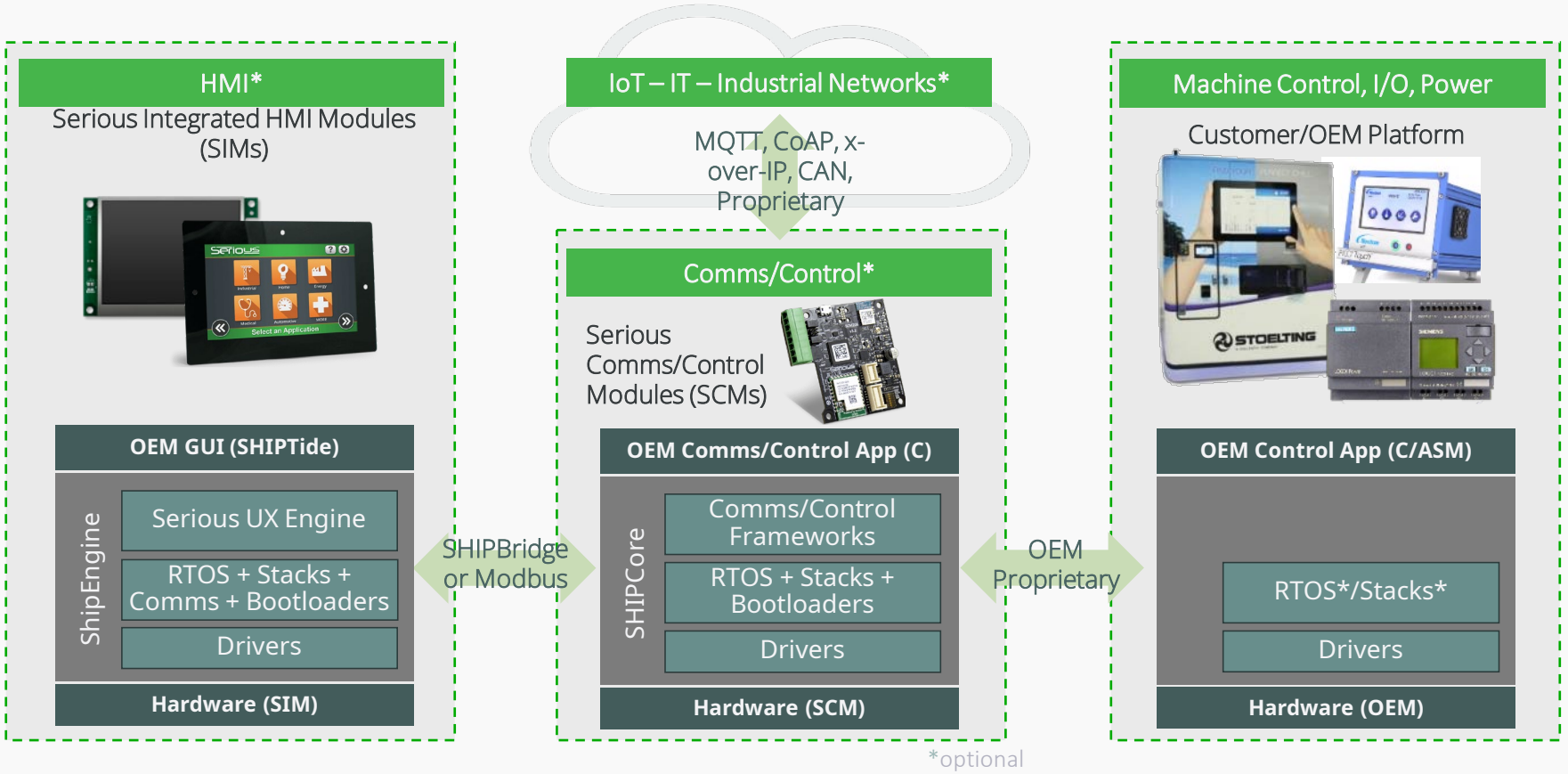
Connectivity & IoT

Internet of Things (IoT): Digitize or Die

Nicolas Windpassinger, Global Vice President, Schneider Electric

- Many Proprietary + IT + IoT + Industrial Protocols and Ports
- Inter-device connectivity usually straightforward (RS485, GPIO,..)
- New HW/SW comms technologies are rapidly evolving
  - WiFi, BT, 4G NB/CAT-M1 even Ethernet
  - IPv4/v6 + TLS 1.2 & future crypto
  - IoT protocols MQTT, XMPP, CoAP, others, especially OTA content/updates
- HMI drives MCU, RAM & UX SW Architecture
- Comms/Control drives MCU, RAM, peripherals, but differently

Distributed System Architecture



HMI (+Comms/Control) Summary

- Fast-evolving HMI (and IoT/Comms) technologies are embedded system architecture “disruptors”
- Dramatic increase in hardware, software, and supply chain complexity
- Huge effort to create HW/SW infrastructure that is scalable, sustainable, secure.. and tracking the industry
- Requires new engineering/management thought processes about the total cost of products

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