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Laser Beam Scanning (LBS): The Ideal Solution for AR Wearable Applications

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SPIE. AR|VR|MR

LaSAR ALLIANCE

Definitions

VR

Virtual Reality – Occluded view and a fully immersive experience

AR

Augmented Reality – Simple digital content is overlaid onto physical world

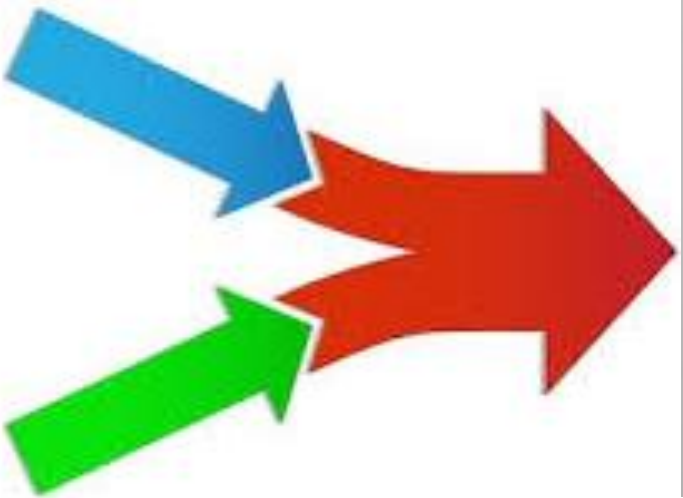
MR

Mixed Reality – Physical and Virtual worlds are fully merged with visually accurate depth, perspective, texture, shade etc.

The Main Challenge

Source: https://www.forbes.com/sites/solrogers/2019/09/11/what-we-know-about-hololens-2/#2885224d4662

Source: https://variety.com/2019/digital/news/magic-leap-mobile-ar-1203109944/



Source: https://www.slashgear.com/north-focals-smart-glasses-price-change-prescription-lenses-showroom-tour-14565763/

- To achieve the desired form factor key determinants, <u>to first order</u>, are:
  - Near-to-eye compact display technology
  - Highly efficient combiner optics technology
- Start with simple and broadly useful applications ➔ smart glasses
- Then, add additional functionality as technology & solutions mature

Key requirements for AR wearable devices

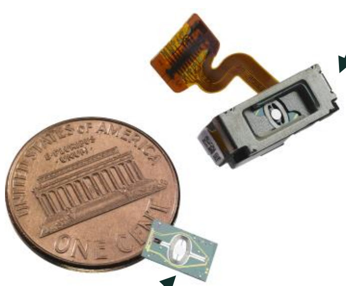
Goal: Head-up, Hands-free, All-day-wearable AR glasses which means glasses must be usable, comfortable with the requisite performance

Indoor and outdoor use	Peak brightness > 1000 cd/m2 (transparent lenses)
Form factor	Fashionable eyeglasses
Low Power (system)	< 1W
Light weight	< 70g
Low latency (motion to photon)	< 4ms
Range of FoV	30^o – 40^o (AR) to > 80^o (MR/XR)
Range of resolution	720P (AR) to > 1400P (MR/XR)
Eyebox size	> 10mm x 10mm

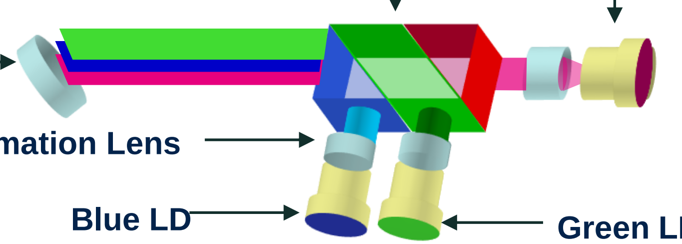
Laser Beam Scanning (LBS) – The Ideal Solution

Requirement		LBS solution
Ultra small microdisplay	→	MEMS Micromirror with LBS
Compact illumination source	→	Advanced laser diode packaging
High brightness (light engine)	→	$>10^6$ cd/m^2 (nits)
Low Power (system)	→	< 1W
Thin, lightweight lenses	→	DOE or HOE Waveguides

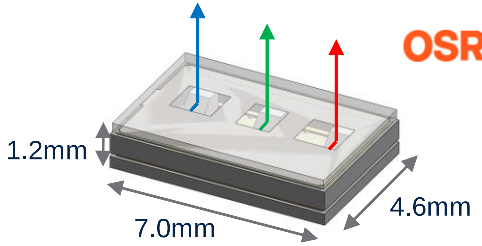
MEMS Package

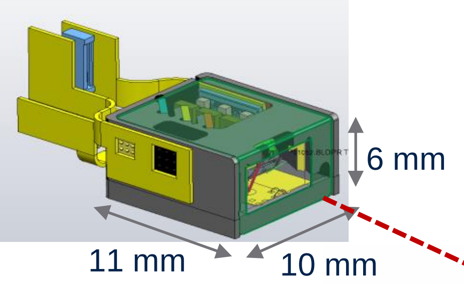


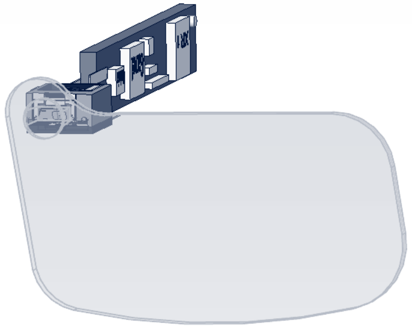
MEMS Die

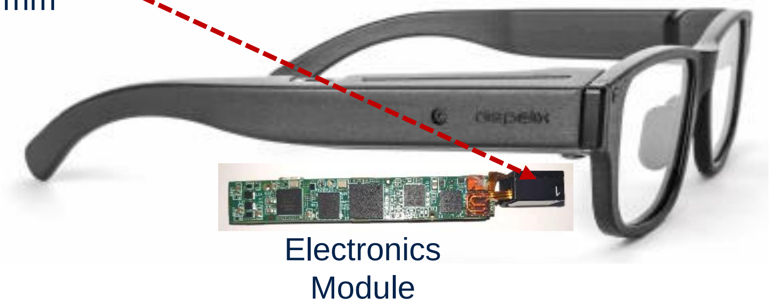


Operating Principle of LBS









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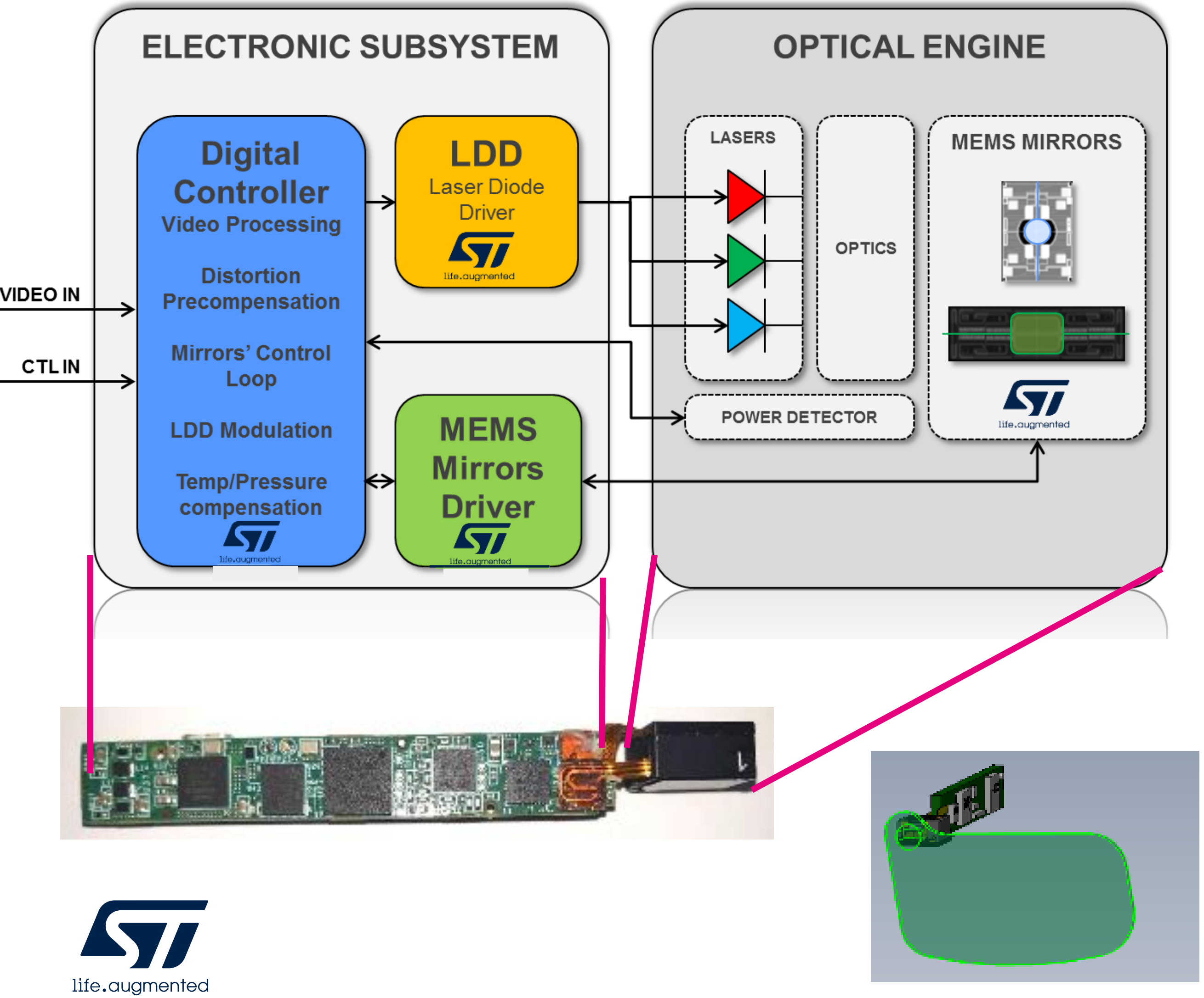
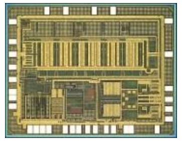
LBS Reference Design Architecture

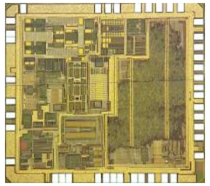


- **MEMS Mirrors**

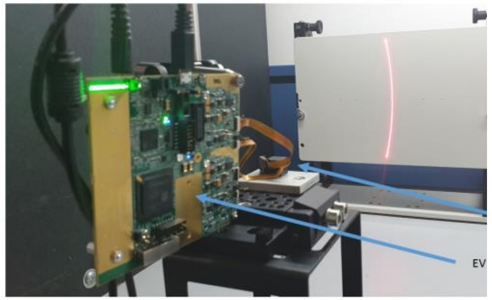
- **Mirrors Drivers**
  - Electrostatic, Magnetic, Piezo drivers
  - High efficiency / Energy recovery drivers



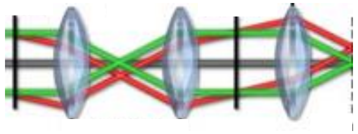
- **Laser Diodes Drivers**
  - <500ps rise/fall time for crisp pixels
  - Ultra low power – Optimized for AR
  - 3 / 4 channels (RGB / + IR)



- **Control Loops and Video**
  - HW / SW Mirror control loop
  - Laser control loop
  - Calibration
  - Video processing



- **Relay Optics**
  - ST patented design to maximize performances with waveguides



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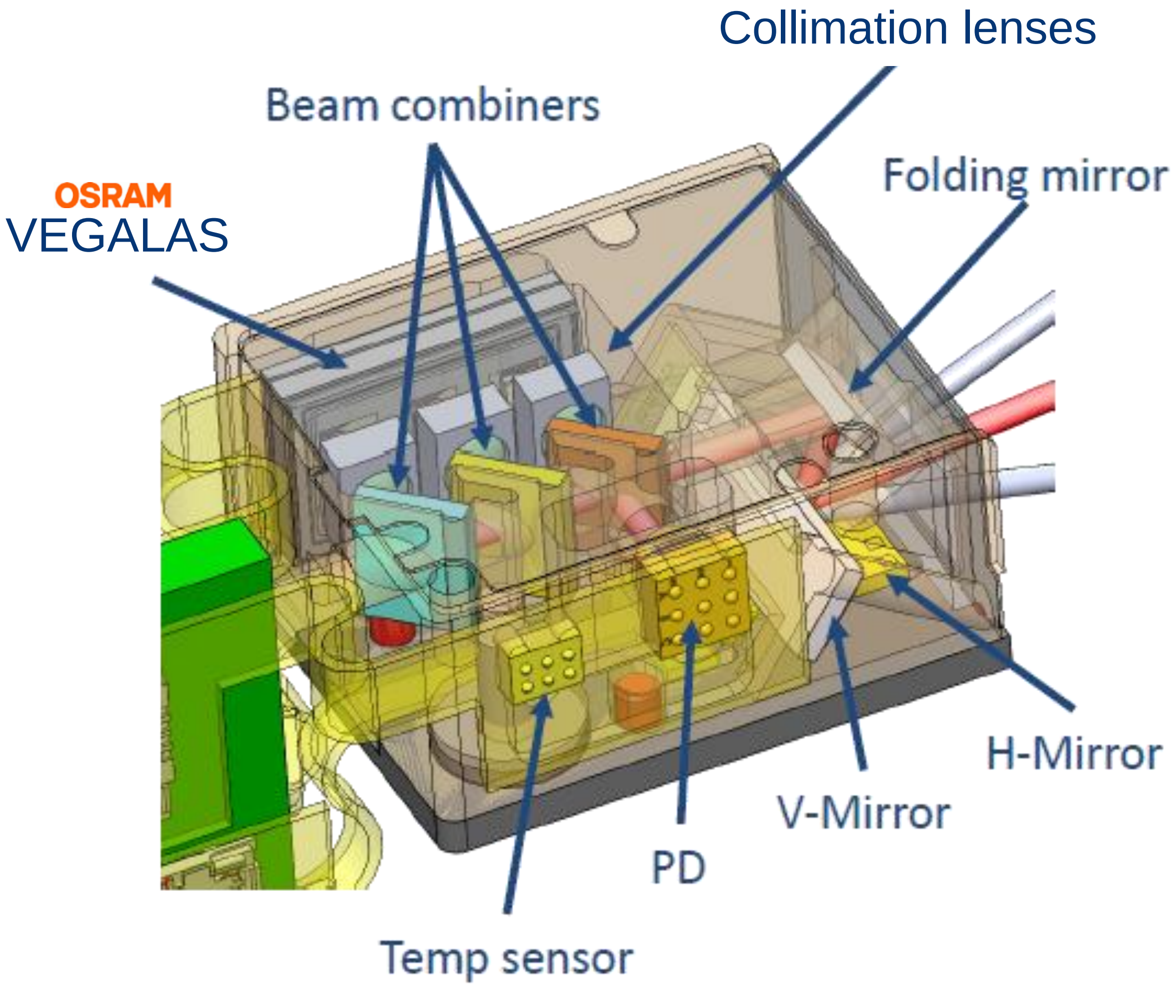
Anatomy of the ST LBS Optical Module



https://www.spie.org/PWO/conferencedetails/moems-miniaturized-systems?SSO=1#session-1

Session 6: Novel Optical Components II

Compact and innovative laser beam steering optical engine for smart glasses applications
Paper 11697-24
Author(s): Dadi Sharon, Elan Roth, Alex Domnits, Shlomi Erlich, STMicroelectronics Ltd. (Israel)

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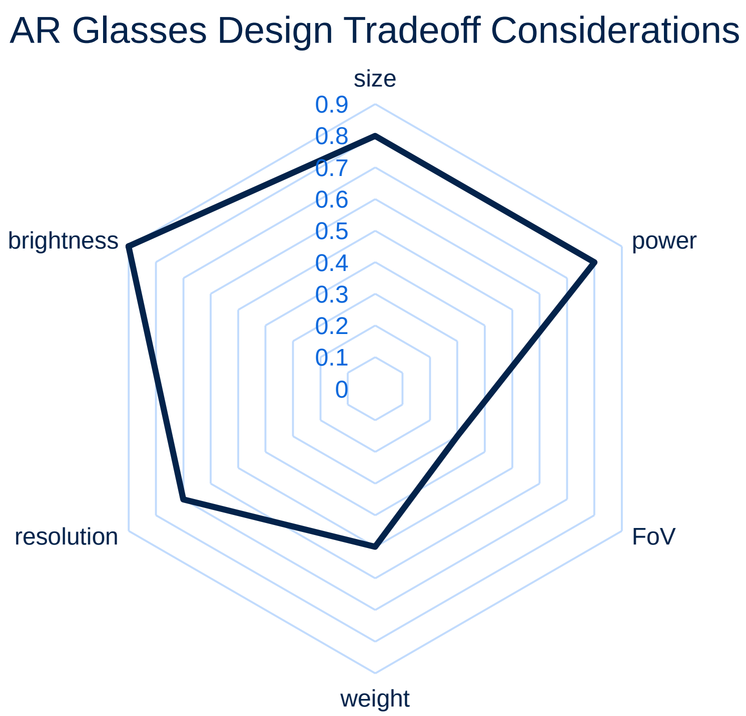
Putting it All Together – A Proof-of-Concept

Demo Specification		
FOV (diagonal)*	30°	24°(H)x18°(V)
Brightness	1300	cd/m^2
Image Aspect Ratio	4:3	
Eyebox	10 x 10	mm
Eye Relief	16	mm
Color	RGB	
Resolution	33	pixels/deg
Fresh Rate	60	Hz
Full System Weight	58	g

* Note: The FoV of the MEMS Mirror scanner is 56^{o} diagonal

Images as Seen Through the Glasses

Trade-offs (system consideration)



Example only

- Design of AR wearables must be holistic in nature
- Optimize for the application
  - Simple text, symbology and graphical overlay
    - FoV ~ 30º-40º, >10mm eyebox, >1000 nits, <70g, monocular, eyeglass style
  - Fully immersive experience with holographic rendering
    - FoV >80º, >10mm eyebox, >500 nits, >1440P, <200g, binocular, HMD style
- LBS addresses a number of constraints and challenges

It Takes a Village: LaSAR Alliance Ecosystem

More Partners to be Announced
&
Open to More Members

Join the Alliance!

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Thank you

Contact info: bharath.rajagopalan@st.com

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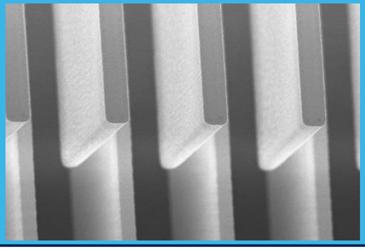
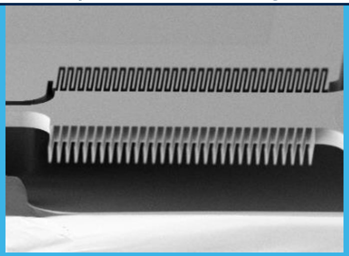
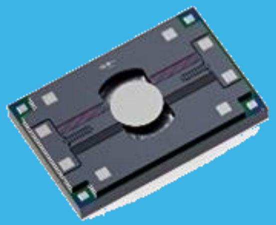
A wide range of mirror technologies in mass production

ST is the leader in LBS solutions with more than 12 million mirrors shipped to date

ELECTROSTATIC

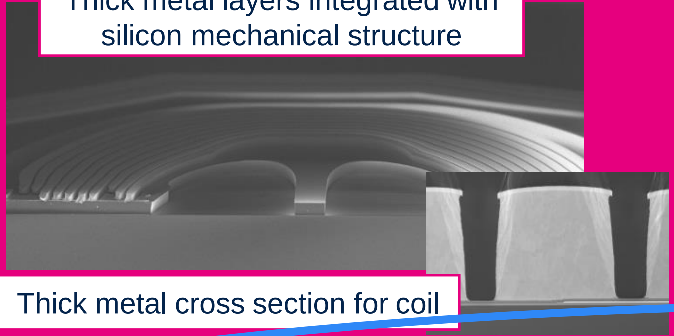

Staggered comb fingers

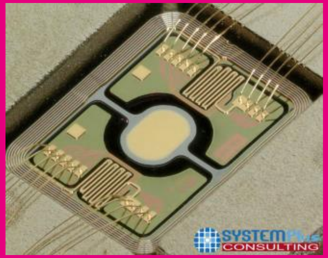
In-plane comb fingers




- High aspect ratio DRIE silicon etch for comb drive actuators (silicon thickness ≥40um), allowing both quasi-static and resonant operation
- Use of wafer-to-wafer bonding techniques to realize 3D integrated structures

ELECTROMAGNETIC

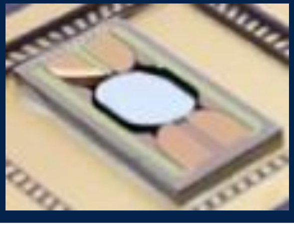
Thick metal layers integrated with silicon mechanical structure

Thick metal cross section for coil

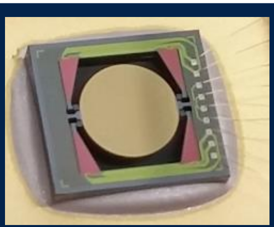


- Thick metal ECD growth (>20um) to allow low resistance coil actuator
- Integrated piezoresistive position sensors
- Thin (160um) finished holed wafers in production

PIEZO ELECTRIC

Thin Film PZT Mirror





- Thin Film PZT (≤2um), in Mass Production
- Integrated piezoresistive position sensor
- Use of wafer-to-wafer bonding for 3D integrated structures

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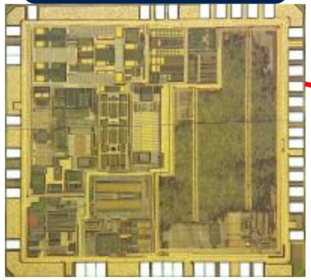
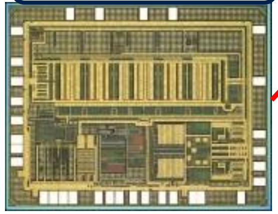
High Efficiency TF PZT Drivers

MAIA



Bellatrix

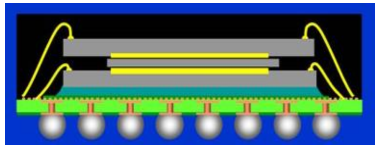


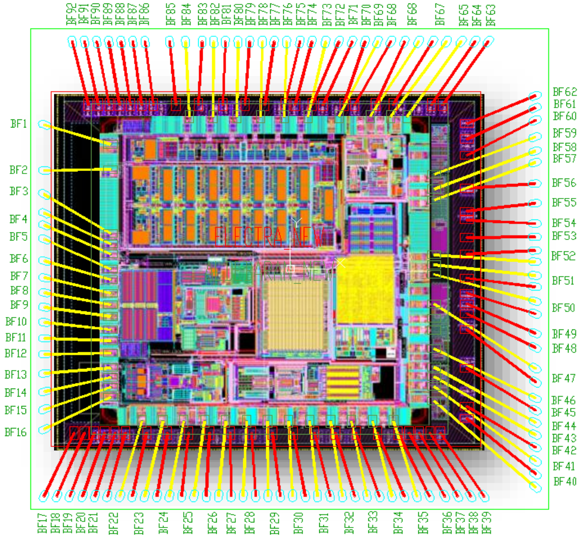
ASIC PCB

Now

$P = CV^2 f \rightarrow \frac{1}{6} CV^2 f$

ARGO





Soon

$$\frac{1}{10} CV^2 f$$

Smaller footprint

Less external components

Fully Integrated Raster Scan (HW ctrl loop)


MATCH
Time to complete: 1 h 40 min