Q-23109-URS

KTA-21 – unique robotic solution

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1. Robotic solution

The industrial robotic cell is devoted for the incubator canopy postproduction, here the canopies would pass through for modification. The location of the cell placements will be chosen in factory to be as optimal as possible regarding the ideal workflow steps.

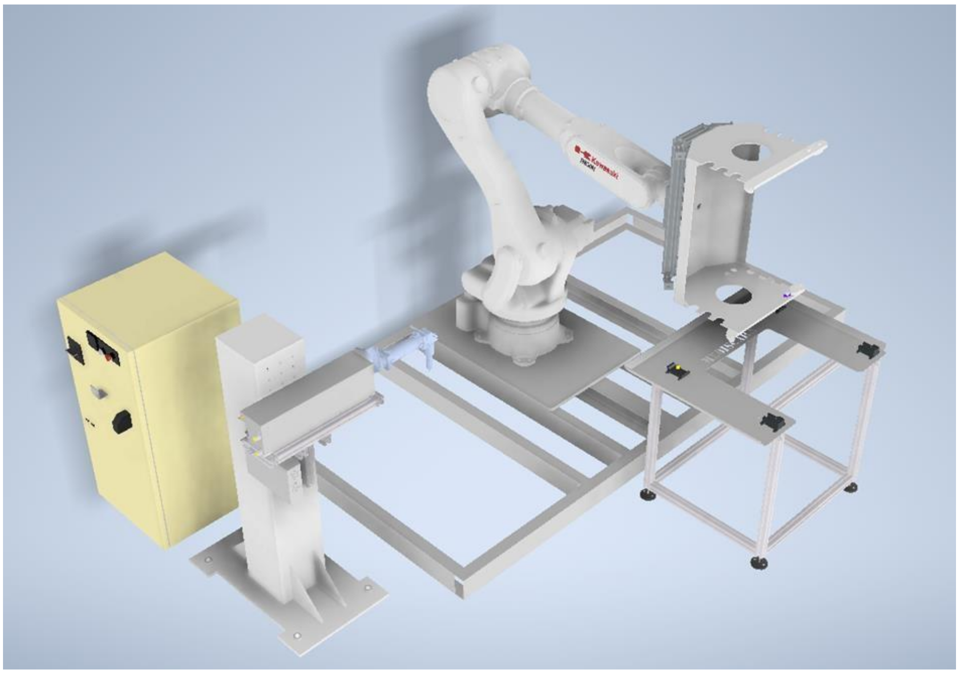
Software of the cell is running on a server PC and Teach Pendant is used to display HMI for controlling the cell. The server PC has high computational performance for running each subtask of the solutions parallelly. It runs the two developed software: Master Control Unit for the communication between the embedded systems and the Management Web Application. Alongside these software solutions, the server must calculate and send the path for the industrial robot. Due to the fact that the main server is located and already installed at Medicor facility in Hungary, as a result of collaboration of Medicor Elektronika and Lasram Engineering, this system will be able to create connection with the existing one, thus a local server in the new facility could greatly increase the provided data of the production process moreover the efficiency shall improve alongside that greatly.

Industrial cell for canopy laser cutting (Workshop)

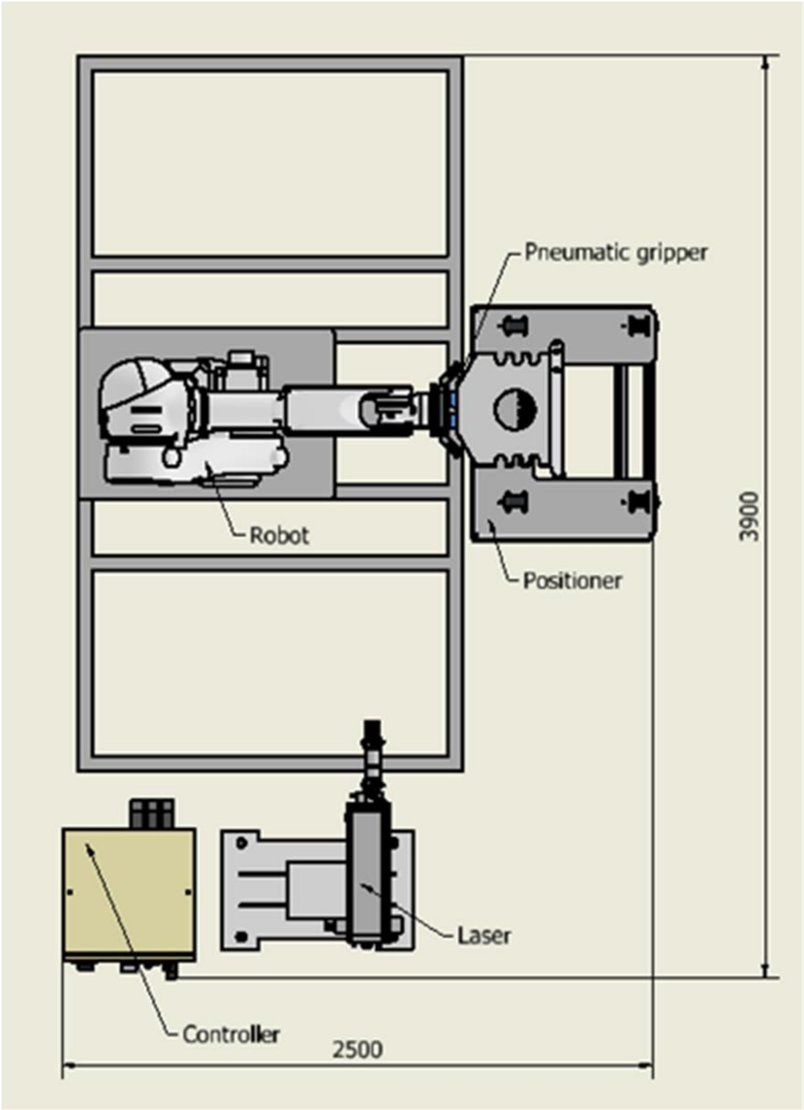
Incubator canopies are being produced off-site for Medicor, meaning that the manufacturer is highly dependent on its suppliers. If a customer required any modification on the incubator canopies, it would take several weeks or even months for the supplier to produce the modified canopies. By designing a custom laser cutting solution, a plexiglass incubator canopy can be modified on-site, resulting in huge time reduction of modified canopy production. Furthermore, being a greener solution, as there is no transportation needed for the modification of canopies.

The used 6-axis Kawasaki industrial robot is not a collaborative type, so it could be dangerous for a human operator during its path following movement, therefore isolation is necessary, where the user can only start the process if the necessary safety level is ensured. Since a high-power laser is being used for cutting plexiglass, a non-transparent wall has to be used, to provide eye protection. As the cutting procedure may result in the release of toxic gases, a suction system must also be implemented for removing any harmful gases from the air.

With the necessary security measures in place also on the software side, the first tests could be conducted in the factory. The laser cutter is PWM-operated from a microcontroller connected directly to the robot of the cell which is also responsible for displaying HMI and communication with the main server. All KPI values are monitored during operation, displayed on the cell's HMI, and sent to the local IoT agent, which forwards them to the server.



1. Figure Concept design and rendered picture of the cell's setup



2. Figure Schematic arrangement of components and approximate footprint

Basically, all canopies arrive to Medicor with the basic elements cut out, but there are optional features, which need to be modified for the customer's needs. For example, the X-Ray tray door is one of these, which could be cut on-site onto the canopy. Since there were orders for this extra, Medicor tried out the system in production by cutting this feature and modifying the existing parts.

The system works flawlessly, as an operator can load the canopy with ease, chooses the job for the robot and starts the robot using the dedicated HMI. (5. Figure) The 6-axis robot picks up the canopy from the dedicated jig using a pneumatic gripper and moves the canopy's chosen surface under the laser cutter and then moving the canopy along the cutting path. All transformation calculations are done previously with a tool designed for transforming the canopy surfaces for easier movement. The current state of the process can be tracked remotely, online and all KPIs are being calculated while the robot is working. The process could be observed through a window, but the HMI display also indicates if the cutting process has finished, and the modified canopy can be removed from the cell.

2. Intellectual Properties

Regarding the IPR aspects, following IPs have been identified.

Number	IP description	Internal Development (Lasram)
IP-1	MMWA – MediSCARA Manager Web Application	Yes
IP-2	MMCU – MediSCARA Master Control Unit	Yes
IP-3	MRTC – MediSCARA Robotic Transformation Calculator	Yes (in cooperation with Medicor)
IP-4	MGKC – MediSCARA G-Code Kawasaki Converter	Yes

MMWA.

A Flutter-based web application. It uses the KeyRock IdM for authentication and the OCB for its database. Manager Web Application allows to dedicated person with sufficient credentials to access of monitoring the current production. The ongoing production tracking is available for both developed robotic cells. A dedicated web interface contains this monitoring solution with Keyrock identification implemented. User roles are as follows:

- Manager, who has right to monitor the process via KPI-s, see the production history, make changes in the upcoming production sequence, connect to the developed Grafana Dashboard, see predictive maintenance for each robotic cell, and to send direct messages to the factory floor, in fact onto each cell's HMI, if necessary.
- Admin, who has similar rights as Manager, additionally get access to robotic movement parameters. This role is restricted for producer company, Lasram.

MMCU

This component serves as a proxy layer sending and receiving messages to and from a FIWARE IoT Agent (JSON Payload). The Master Control Unit (MCU) can be used to achieve communication to embedded devices (such as Industrial robot (TCP/IP), HMI, Laser controller etc.) which do not support the HTTP transport protocol or the NGSI-v2 data model. The IoT Agent is designed to relay north and southbound messages to and from IoT Devices. It achieves this by relying on the HTTP protocol. This means that a very large part of devices is excluded from the communication. To solve this problem, the MCU can process and relay southbound messages from the IoT Agent and use other communication protocols to connect devices to the Agent.

MRTC

Co-Developed with Medicor. Python based; simplified inverse kinematic calculator tailored for Medicor's incubator canopies. Calculates the precise joint coordinates for the implemented industrial robot for each to-be-manufactured sides of the canopy thus reduces the operation and teaching time for the end user. Simple GUI has been developed to make it more user-friendly.

MGKC

A simple command-line application written in Python. It converts a G-Code file to a .pg file (A motion file containing Kawasaki-specific motion instructions).

Can be used to transform any CAD / CAM software generated universally specified path to run on any Kawasaki robot therefore same travelling path can be achieved. Lasram implemented several upgrades since the first version, such as:

- Automatic minimal distance elimination
- Signal handling for external device control. Making it more usable for: Laser cutting, CNC machining and Handling.
- Movement correction

3. Intellectual Property Rights

IPR management is summarized using the table below.

In the following table Lasram Engineering Kft. and Medicor Elektronika Zrt. henceforth referred to as Lasram and Medicor respectively.

IP #	IP	Owner(s)	End user	Protection measure
1	MMWA	Lasram	Medicor	Apache2.0
2	MMCU	Lasram	Medicor	Apache2.0
3	MRTC	Medicor & Lasram	Medicor	MIT
4	MGKC	Lasram	Medicor	MIT

Each developed software is under Permissive Licenses.

Each universalized component is under Apache2.0 license.

The non-universalized components will be further developed and used various applications therefore the applied license is MIT to have less dependency and possibly less inconsistency as for future software compatibility like with GPLv2 projects.

4. Cybersecurity Progression

Components

The Orion Context Broker (OCB) is the central part of the project. It handles the context data of the entities in the project. It uses MongoDB as a backend database.

The IoT Agent is used to relay commands and information between the OCB and the IoT Devices (MCUs) on the shop floor.

The KeyRock IdM is used to authenticate and authorize access to these services. It uses a MySQL database as its backend.

The PEP Proxies are used to enforce the authentication and authorization to the OCB and the IoT Agent by only letting though requests that which have a valid authentication token acquired from the IdM.

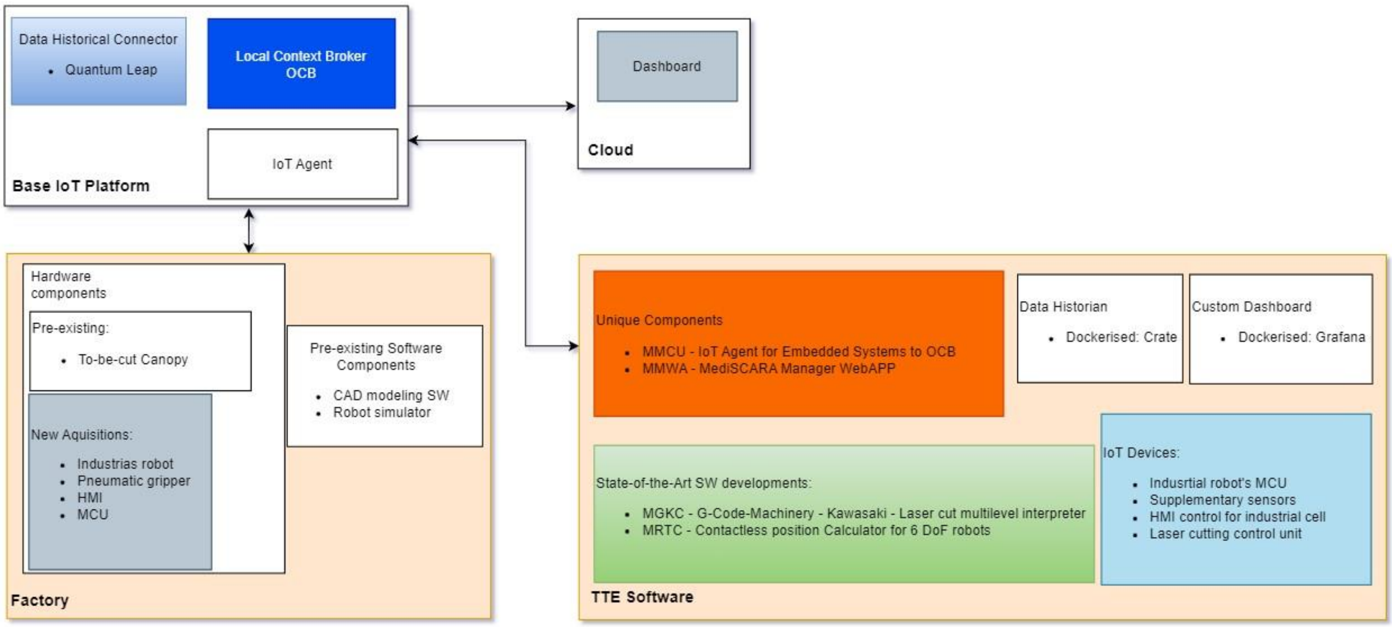
A standalone web application has been developed as part of the ROSE-AP components. This Manager Web Application also uses the KeyRock IdM for user authentication and authorization.

All these components as of now use the HTTP protocol and most of the message payloads are JSON objects.

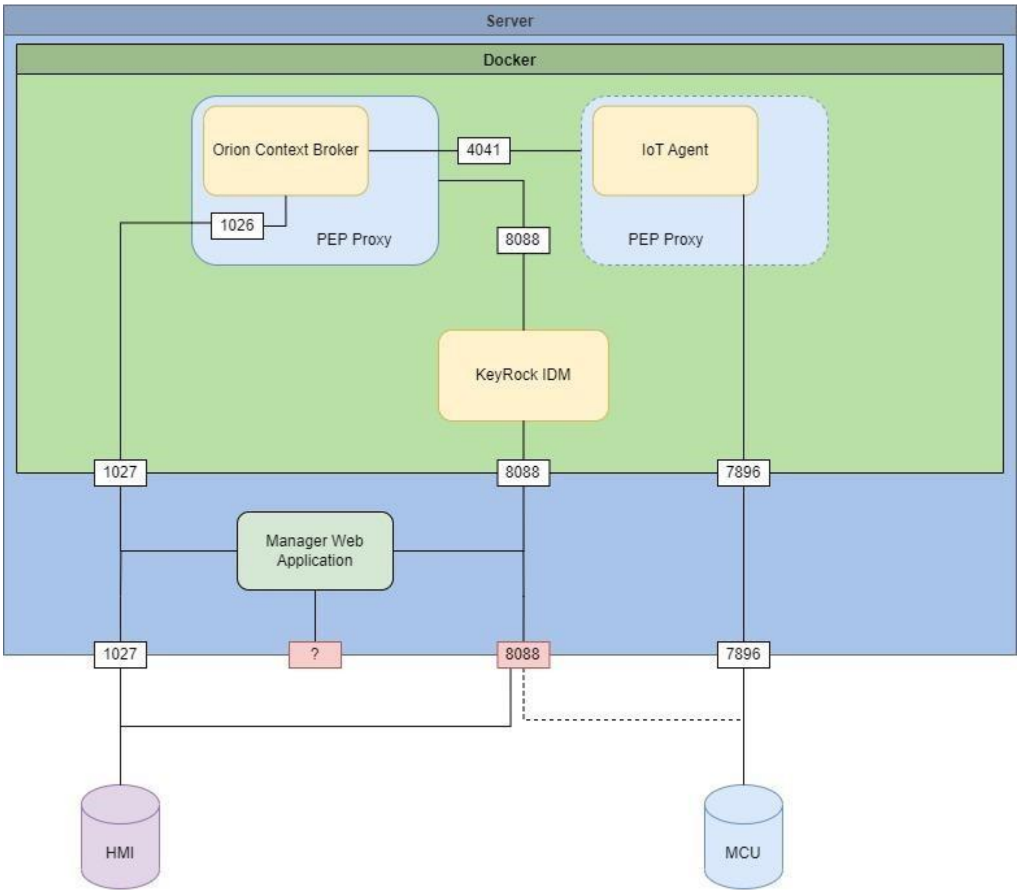
Implemented Cybersecurity measures.

The PEP Proxies are not necessary for the operation of the project however, they are necessary to block potentially unwanted or malicious requests. Furthermore, only the necessary ports are opened on the server. These can be seen on 4. Figure. as rectangles on the edge of the components. The ports marked with a white background color are open only to the local network and the ones marked with red are opened for the internet.

As one can see, the ports opened lead to the sensitive components only though secure layers (PEP Proxy, KeyRock IdM).



3. Figure Project's structure



4. Figure IoT Platform and the components within

Software Configuration

To set up and configure the software stack, Docker Compose was used.

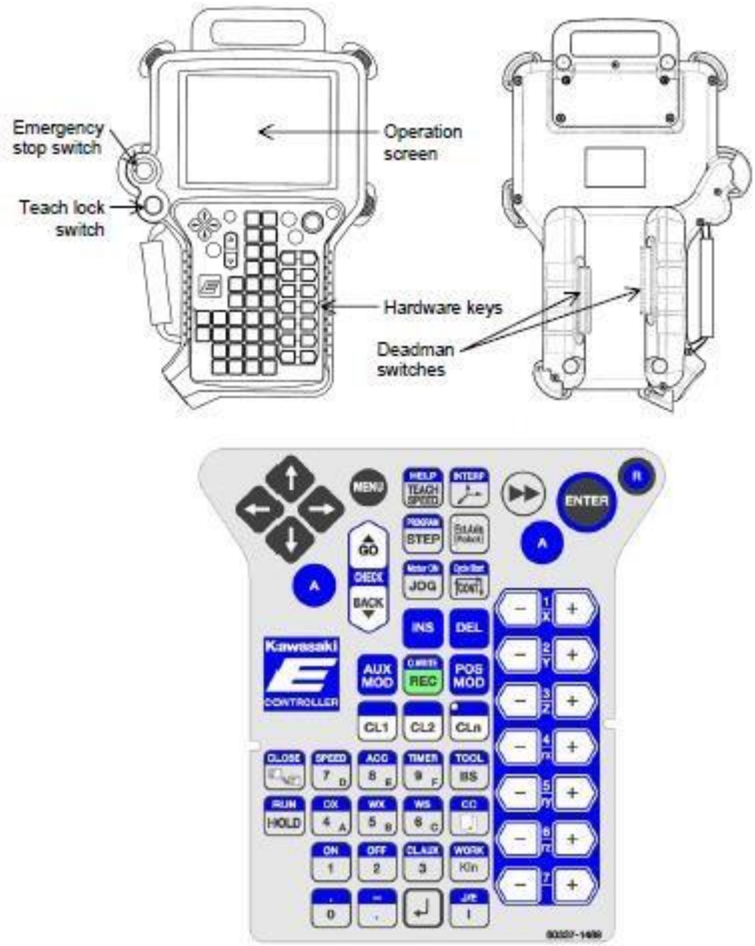
From the software MMWA, MGKC, MRTC are standalone programs, while the others need to be run in the specified configuration to function properly.

Components MMWA and MGKC are only reachable from within the server. This way malicious access is minimized.

All the above listed software components are tailored specifically for Medicor's needs and to fulfill the requirements brought by the current regulations and to ultimately enhance production process.

5. Kawasaki Teach Pendant

Lightweight Teach Pendant version for better user experience with 10-meter harness for necessary isolation from Econtroller.



5. Figure Dedicated HMI - Teach Pendant for control the robotic cell

6. Synrad Firestar ti80

Air cooled, OEM controlled device with radiofrequency excitation laser source with 10600nm output wavelength.

Table 4-11 Ti80 general specifications.

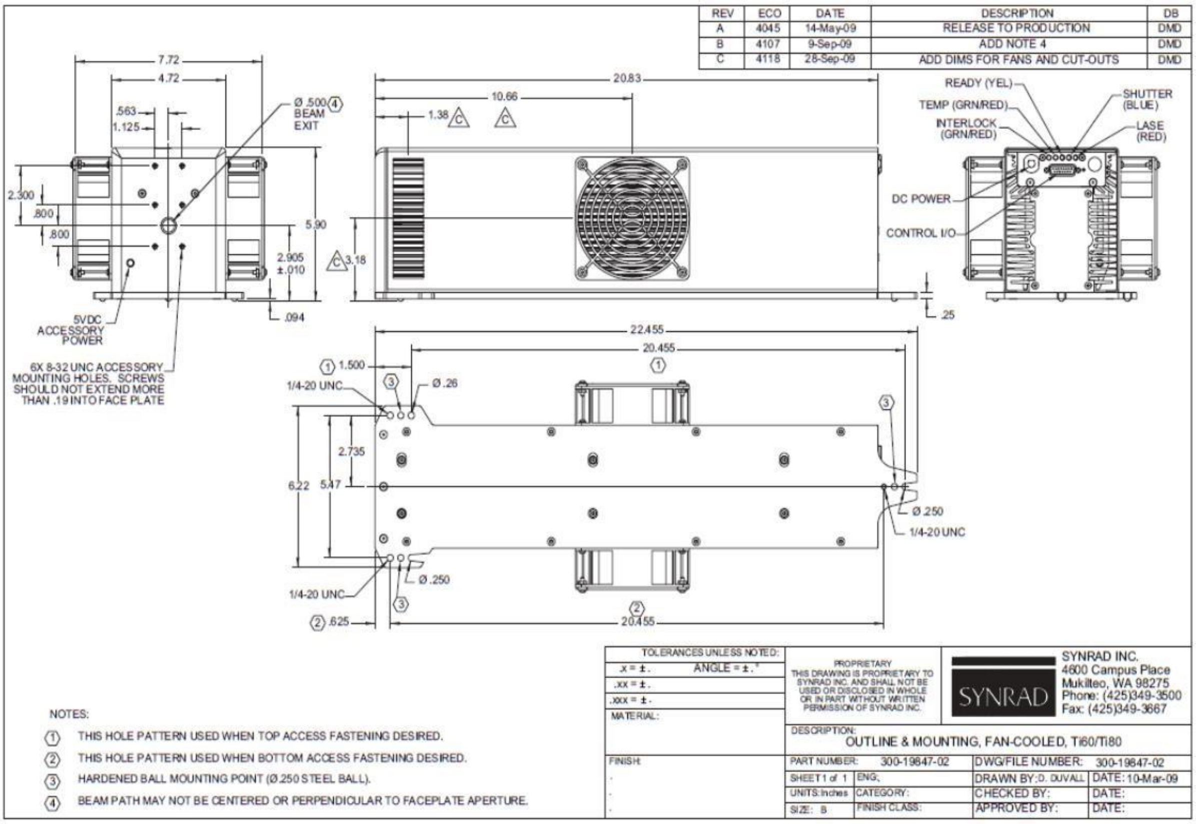
Parameter			
Output Specifications	10.6 µm	10.2 µm	9.3 µm
Wavelength, µm	10.55–10.68†	10.20–10.30	9.23–9.31
Power Output[1, 2]	80 W	80 W	80 W
Power Stability[3]	± 7%	± 7%	± 7%
Mode Quality, M^2	≤ 1.2	< 1.3	< 1.3
Beam Waist Diameter, at $1/e^2$, mm[4]	2.0 ±0.3	2.0 ±0.3	2.0 ±0.3
Beam Divergence, full angle, mrad	< 7.0	< 7.0	< 7.0
Ellipticity	< 1.2	< 1.2	< 1.2
Polarization	Linear, vert	Linear, vert	Linear, vert
Extinction Ratio	> 100:1	> 100:1	> 100:1
Rise Time	< 75 µs	< 75 µs	< 75 µs
Input Specifications			
Power Supply			
Voltage	48 V ±1.0 VDC		
Maximum Current[5, 6]	22 A		
Command Input Signal			
Voltage	+3.5 to +6.7 VDC		
Current	10 mA @ +6.7 VDC		
Frequency[7]	DC–160 kHz		
Duty Cycle	0%–100%		
Logic Low State (Vmin–Vmax)	0.0 to +0.8 VDC		
Logic High State (Vmin–Vmax)	+3.5 to +6.7 VDC		
Cooling Specifications	(Air-cooled)	(Water-cooled)	
Maximum Heat Load	1200 Watts	1200 Watts	
Minimum Flow Rate, Air	190 CFM per fan (×2)	N/A	
Static Air Pressure	0.70 in H_2O	N/A	
Recommended Flow Rate, Water	N/A	1.0–2.0 GPM	
Maximum Coolant Pressure	N/A	60 PSI	
Pressure Drop	N/A	11 PSI @ 1.5 GPM	
Coolant Temperature[8]	≤ 40 °C, ambient	18–22 °C	
Coolant Temperature Stability		± 1.0 °C	

* Specifications subject to change without notice.
† Typical. Actual wavelength range may vary from 10.2–10.8 µm.
1 This power level is guaranteed for 12 months regardless of operating hours.
2 48 VDC input voltage to obtain guaranteed output power.
3 From cold start (guaranteed) at 95% duty cycle.
4 Measured at laser output.

Environmental Specifications	
Operating Ambient Temperature Range[9]	15 °C–40 °C
Humidity	0–95%, non-condensing
Physical Specifications	
ti80, water-cooled (KW, SW models)	
Length	22.98 in (58.4 cm)
Width	5.62 in (14.3 cm)
Height	5.90 in (15.0 cm)
Weight	26.2 lbs (11.9 kg)
ti80, fan-cooled (KF, SF models)	
Length	22.46 in (57.1 cm)
Width	7.72 in (19.6 cm)
Height	5.90 in (15.0 cm)
Weight	28.9 lbs (13.1 kg)
ti80, air-cooled (SA models)	
Length	22.46 in (57.1 cm)
Width	6.22 in (15.8 cm)
Height	5.83 in (14.8 cm)
Weight	25.5 lbs (11.6 kg)

* Specifications subject to change without notice.
5 User-supplied cooling fans on SA models may increase current load by an additional 1.0 A.
6 ti-Series lasers have no appreciable in-rush current.
7 Tested at 5 kHz.
8 Water-cooled lasers can be operated at coolant temperatures up to 30 °C (86 °F) in order to reduce problems associated with condensation; however, this may result in decreased laser performance and/or reduced laser lifetime.
9 Published specifications guaranteed at a cooling temperature of 22 °C. For ti-Series lasers, some performance degradation may occur when operated in ambient air or cooling water temperatures above 22 °C. With air-cooled lasers, output laser power typically decreases 0.5–1% per degree Celsius increase in ambient temperature.

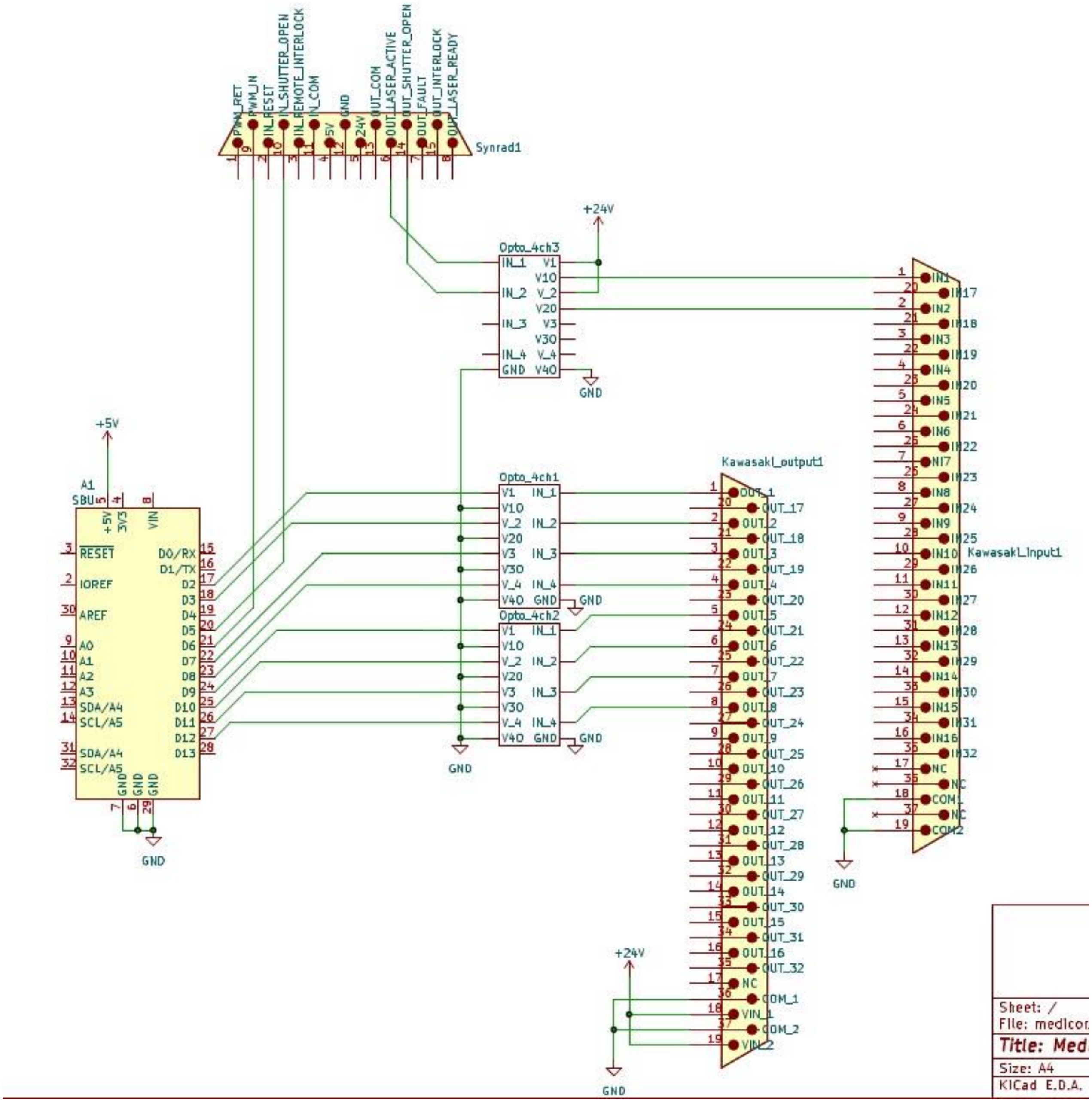
6. Figure Synrad laser source specifications 80SA-NIL 80W



7. Figure Synrad ti80 laser source mechanical drawing

7. Electrical drawing of IoT connection

Connection among robot digital signals – microcontroller – optocouplers for isolation and Synrad laser source.



8. Figure Schematic electrical connection