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Automatic Communication Control Configuration System through Lay Outing System Bus

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Abstract:
This paper introduces a new system of accelerating the pace of progress in intelligent robotics by the means of competition of high scientific standard and to maintain high standard of lay outing from the point of view of industry. The basic need of this project is higher production with minimal usage of time duration, so that lead time can be reduced to a larger extent. As no compromise in Quality of product can be expected with the output, so a better quality raw material is required in this work. We are highly concerned with the safety of the operation to be performed, this paper will also describe briefly about the safety of robot and the operator. The communication between the machine and the controller is taken place with the help of etherCAT. To reduce the man power, a system is created which will be automatically configured to the desired output. In this competitive world we think reducing the lead time will prove the human thinking capability above the world.

Keywords: Robotics, Automatics Control, System Bus

I. INTRODUCTION

In view of the increasing diversity of products and variants, it is necessary to enhance manufacturing productivity and flexibility in order to maintain or increase competitiveness. The term "robot" originates from the Slavic word "robota", in the sense of laborious work. Robotic technology is best suited to highly repetitive tasks, which they perform with consistently high accuracy, approaching 98 percent or better. Investing in people to meet growing demands requires explicit and implicit human resource costs, as well as expanded workspace, training, etc. And the pressure to find and add qualified staff is ongoing. Automation offers significant productivity expansion that alleviates capacity as a concern over the long-term. A flexible production system is an automatically operating production system that can be easily reprogrammed and adapted to manufacture different products. Robot centered modules of FPS, called robot modules or robot systems are intended for specified technological operations like welding, surface coating, packaging, etc. The robot module includes one or more robots (with manipulators and control devices), pallets for details or products, auxiliary positioning, transport devices, etc. Therefore, robot control means control of a complete robot module and a certain part of the production process. Software used for robot control has an object oriented structure.

Robotics market value is $8.7 billion and its software peripheral system costs $26 billion. Robots can basically be divided into two main categories: HUMNAOID ROBOTS and INDUSTRIAL ROBOTS. Industrial robots are beginning now to revolutionary industry. These robots do not look or behave like human being, but they do the work of humans. Robots are particularly useful in a wide variety of industrial application, such as material handling, painting, welding, inspection and assembly. KUKA Load is a software product with the following functions: Load can be categorized as follows:

1. **Rated/Pay load** – It can be defined as the maximum load that may be exerted on the robot flange under normal conditions without affecting any performance specification.
2. **Supplementary load** – It can be defined as the load that can be carried by the robot in addition to the rated load. It is mounted on the robotic arm, link arm and/or rotating column. Applications of small pay load robots are as follows as Welding and soldering, Arc welding, Packaging and order picking, Palletizing, Cutting machine tools

MANIPULATOR

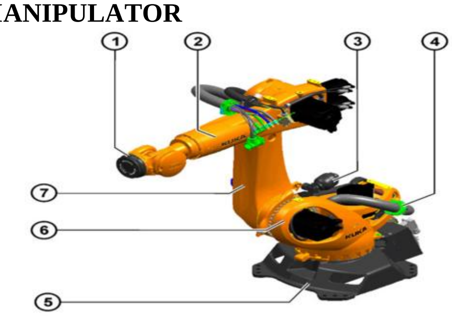

Figure.1. Overview of Manipulator components

1. In-line wrist
2. Arm
3 .Counterbalancing system
4 .Electrical installations
5. Base frame
6 .Rotating column
7 .Link arm

The counterbalancing system is installed between the rotating column and the link arm and serves to minimize the moments generated about axis 2 when the robot is in motion and at rest. A closed, hydro pneumatic system is used. The electrical installations include all the motor and control cables for the motors of axes 1 to 6. All connections are implemented as connectors in order to enable the motors to be exchanged quickly and reliably.

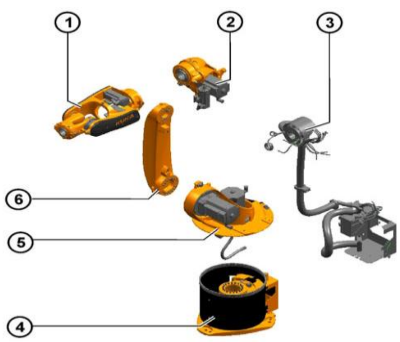

Figure.2. Assemblies of the Manipulator

1. Hollow-shaft wrist 4. Base frame
2. Arm 5. Rotating column
3. Electrical installations 6. Link arm

II. ROBOT CONTROLLER

With the KR C4, robotic technology leader KUKA is launching a control system onto the market that integrates robot, motion, sequence and process control. But that is not all. Even more important is the fact that the complete safety controller is seamlessly integrated into the KR C4 control system. In other words, the KR C4 performs all tasks at once. In the new control system, KUKA has systematically dispensed with limiting hardware and replaced it with intelligent software functions. The concept is thus characterized by its absolute openness and future compatibility. The KR C4 is literally shorter than its forerunner, the KR C2 controller. This makes it an attractive, space-efficient option. Items such as couplers for cell safety systems or Ethernet-based field bus systems are now directly incorporated just with software. KUKA Robotics proposes this will lead to greater controller longevity and fewer maintenance needs.

III. HUMAN MACHINE INTERFACE (HMI)

Figure.3. Teach Pendant (KUKA smartPAD)

The HMI is a crucial part of the machine. It is the only direct link between the operator and the machine as a whole. The smart pad has all the operator control and display functions required for operating and programming the robot. The communication flows from the KCP to the controller and robot via etherCAT. A way for an operator to monitor and control this equipment needs to be provided. This is where the HMI or as it more practically is called, the operator panel comes in to the picture. The HMI is a crucial part of the machine, since it is the only direct link between the operator and the machine as a whole. The HMI panel used in this project can communicate with the PLC either through serial communication (RS232, USB or RS422), via Ethernet (RJ45), through a CC-link (RS485) or wirelessly.

IV. INTERFACE FOR ENERGY SUPPLY SYSTEM

The robot can be equipped with an energy supply system between axis 1 and axis 3 and a second energy supply system between axis 3 and axis 6. The A1 interface required for this is located on the rear of the base frame, the A3 interface is located on the side of the arm and the interface for axis 6 is located on the robot tool. Depending on the application, the interfaces differ in design and scope. They can be equipped e.g. with connections for cables and hoses. Detailed information on the connector pin allocation, threaded unions, etc. is given in separate documentation.

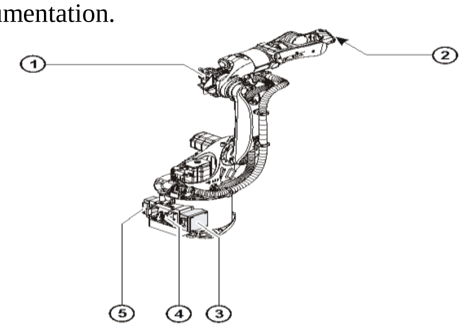

Figure.4. Connecting cables and interfaces

1 Interface A3, arm
2 Interface A6, tool
3 Junction box, control cable X312nd control cable X41 (for Safe Robot only)
4 Interface A1, energy supply system
5 Connection, motor cable X3

V. CO-ORDINATE SYSTEM

During the operator control programming and start-up of industrial robots, the co-ordinate systems are of major specification. The following co-ordinate systems are defined in robot controller.

1. World co-ordinate system.
2. Axis Specific co-ordinate system.
3. Tool co-ordinate system.
4. Base co-ordinate system.

Principal of jogging in word co-ordinate system

Translation along the orientation direction of co-ordinate system: X, Y, and Z. Rotational about the orientation directions of the co-ordinate system: angles A, B and C. In the case of the motion command the controller first calculate a path. The starting point of the path is the tool center point. The direction of the path is specified by the word co-ordinate system.

Axis Specific co-ordinate system

In Axis co-ordinate system the robot can be moved only one axis at a time. In this co-ordinate system we move the arms of the robot either in positive or in negative side. With the help of soft keys we control the movement. Generally we use this co-ordinate system for testing the movement of a particular axis.

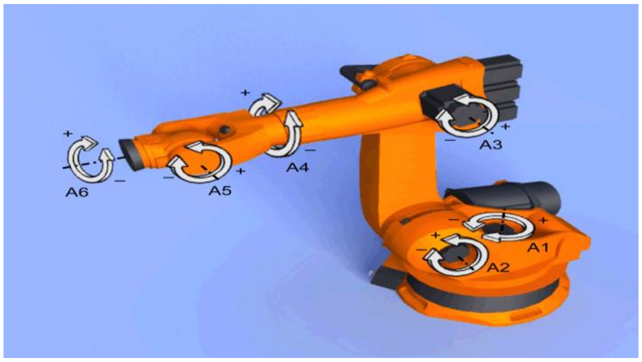

Figure.5. Axis Specific co-ordinate system

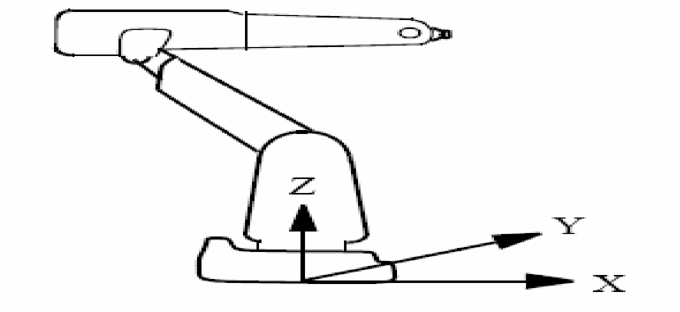

Figure.6. Base coordinate system of a manipulator

Cylindrical coordinate system

A cylindrical coordinate system is a three-dimensional coordinate system that specifies point positions by the distance from a chosen reference axis, the direction from the axis relative to a chosen reference direction, and the distance from a chosen reference plane perpendicular to the axis. The latter distance is given as a positive or negative number depending on which side of the reference plane faces the point.

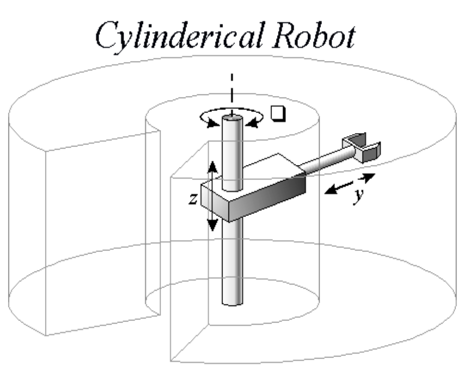

Figure.7. Cylindrical coordinate system

Spherical coordinate system

In mathematics, a spherical coordinate system is a coordinate system for three-dimensional space where the position of a point is specified by three numbers: the radial distance of that point from a fixed origin, its polar angle measured from a fixed zenith direction, and the azimuth angle of its orthogonal projection on a reference plane that passes through the origin and is orthogonal to the zenith, measured from a fixed reference direction on that plane.

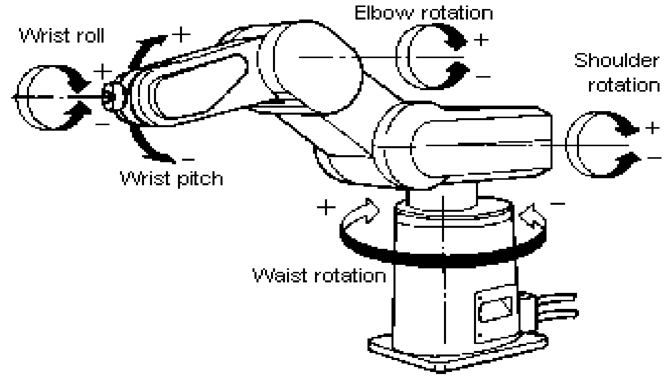

Figure.8. Spherical coordinate system

Work Envelop of KUKA Robot, KR 16

Workspaces are to be restricted to the necessary minimum size. A work space must be safeguarded using appropriate safeguards. The safeguards (e.g. safety gate) must be situated inside the safety zone. In the case of a stop, the manipulator and external axes (optional) are broken and come to a stop within the danger zone. The danger zone consists of the workspace and the stopping distances of the manipulator and external axes (optional). It must be safeguarded by means of physical safeguards to prevent danger to persons or the risk of material damage.

Mechanical axis range limitation (optional)

Some manipulators can be fitted with mechanical axis range limitation in axes A1 to A3. The adjustable axis range limitation systems restrict the working range to the required minimum. This increases personal safety and protection of the system.

VI. TYPES OF MOTION

1. Motion type PTP:

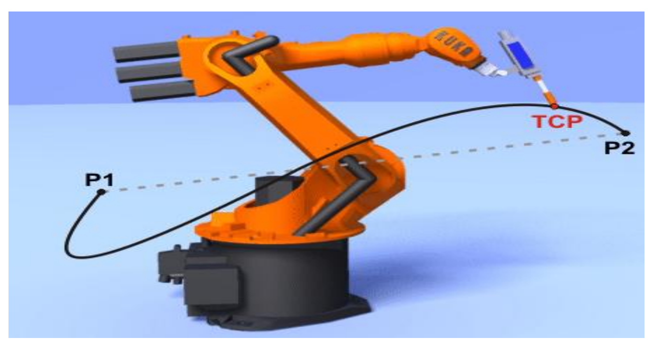

Figure.9. PTP Motion

The robot guides the TCP along the fastest path to the end point. The fastest path is generally not the shortest path and is thus not a straight line. As the motions of the robot axes are rotational, curved paths can be executed faster than straight paths. The exact path of the motion cannot be predicted

2. Motion type LIN:

The robot guides the TCP at a defined velocity along a straight path to the end point.

Figure.10. LIN motion

3. Motion type CIRC:

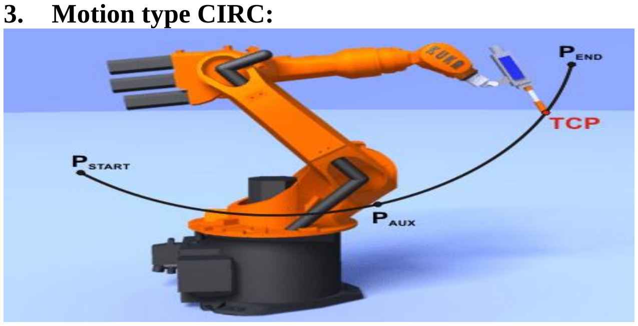

Figure.11. CIRC Motion

The robot guides the TCP at a defined velocity along a circular path to the end point. The circular path is defined by a start point, auxiliary point and end point.

VII. LAYOUTING AND INTREGRATION

Robotic cellular manufacturing systems (RCMSs) are a new type of manufacturing system in which one or more flexible robots carry out a large number of assembly operations that would be performed by human workers in conventional cellular manufacturing systems. When compared with conventional human cellular manufacturing systems, RCMS are seen to offer similar advantages, such as reduction of material flow distances and local inventory. However, although reduced operation costs due to automation of the manufacturing systems can be achieved by introducing RCMS, the design of assembly operations and robot teaching can become quite awkward and time consuming when launching new manufacturing systems.

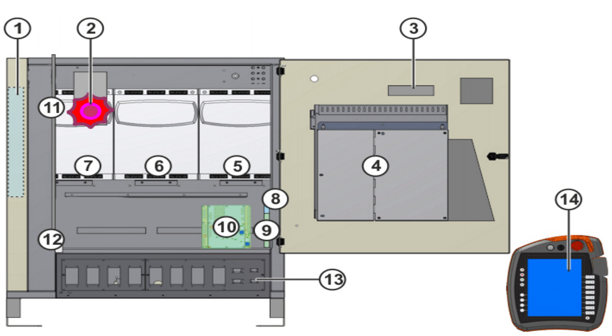

Figure.12. Control System

VIII. CO-ORDINATE SYSTEM

The robot controller consists of the following components:

1. Mains filter
2. Main switch
3. CSP
4. Control PC
5. Drive power supply (drive controller for axes 7 and 8, optional)
6. Drive controller for axes 4 to 6
7. Drive controller for axes 1 to 3
8. Brake filter
9. CCU
10. SIB/Extended SIB
11. Transient limiter
12. Batteries
13. Connection panel
14. KUKA smartPAD

KUKA Power Pack: Description

The KUKA Power Pack (KPP) is the drive power supply and generates a rectified intermediate circuit voltage from an AC power supply. This intermediate circuit voltage is used to supply the internal drive controllers and external drives. There are 4 different device variants, all having the same size. There are LEDs on the KPP which indicate the operating state.

- KPP without axis amplifier (KPP 600-20)
- KPP with amplifier for one axis (KPP 600-20-1x40)
- Peak output current 1x40 A
- KPP with amplifier for two axes (KPP 600-20-2x40)
- Peak output current 2x40 A
- KPP with amplifier for one axis (KPP 600-20-1x64)
- Peak output current 64 A

The KPP has the following functions

- KPP central AC power supply connection in interconnected operation
- Power output with 400 V supply voltage: 14 kW
- Rated current: 25 A DC
- Connection and disconnection of the supply voltage
- Powering of several axis amplifiers from the DC link
- Integrated brake chopper through connection of an external ballast resistor
- Overload monitoring by the ballast resistor
- Stopping of synchronous servomotors by means of short-circuit braking

KCB devices

KCB devices: The KCB includes the following devices:

- KPP
- KSP, middle
- KSP, left
- RDC
- CIB
- EMD

Control PC

- Power range: 11 kW to 14 kW per axis amplifier
- Direct infeed of the DC intermediate circuit voltage
- Field-oriented control for servomotors: Torque control

Cabinet Control Unit

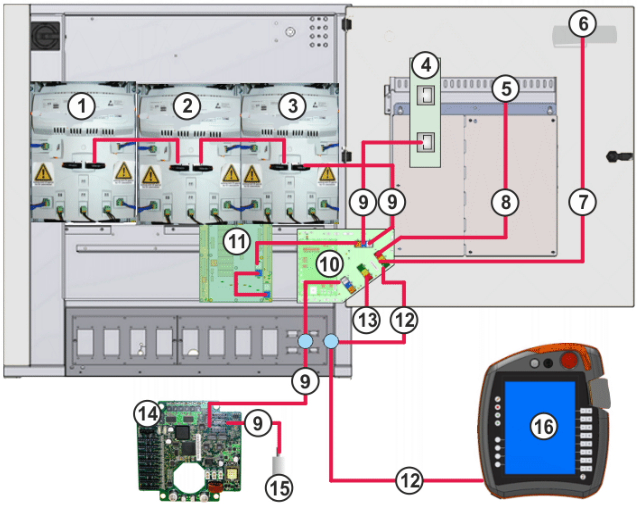

Figure.13. Bus devices
1 KSP, left
2 KSP, middle
3 KPP
4 LAN Dual NIC card
5 Ethernet motherboard
6 CSP
7 KSI/KLI
8 KUKA System Bus (KSB)
9 KUKA Controller Bus (KCB)
10 CCU
11 Standard/Extended SIB (optional)
12 KOI
13 KUKA Extension Bus (KEB)
14RDC
15 Electronic Mastering Devices (EMD)
16 KUKA smart PAD

IX. INTERFACE

The connection panel of the robot controller consists of connections for the following Cables:

- Power cable / infeed
- Motor cables to the manipulator
- Data cables to the manipulator
- KUKA smartPAD cable
- PE cables
- Peripheral cables

The configuration of the connection panel varies according to the customer specific Version and the options required. The following safety interfaces can be configured in the robot controller:

- Discrete safety interface X11
- Ethernet safety interface X66
- PROFI safe KLI or
- CIP Safety KLI

Communication & Control Device: The connection panel of the robot controller consists of connections for the following Cables:

- Power cable / in feed
- Motor cables to the manipulator
- Data cables to the manipulator
- KUKA smartPAD cable
- PE cables
- Peripheral cables

The configuration of the connection panel varies according to the customer-Specific version and the options required.

Note The following safety interfaces can be configured in the robot controller:

- Discrete safety interface X11
- Ethernet safety interface X66
- PROFIsafe KLI or
- CIP Safety KLI

The discrete safety interface X11 and the Ethernet safety interface X66 cannot be connected and used together. Only one of the safety interfaces can be used at a time. The configuration of the connection panel varies according to customer requirements and options. In this documentation, the robot controller is described with the maximum configuration.

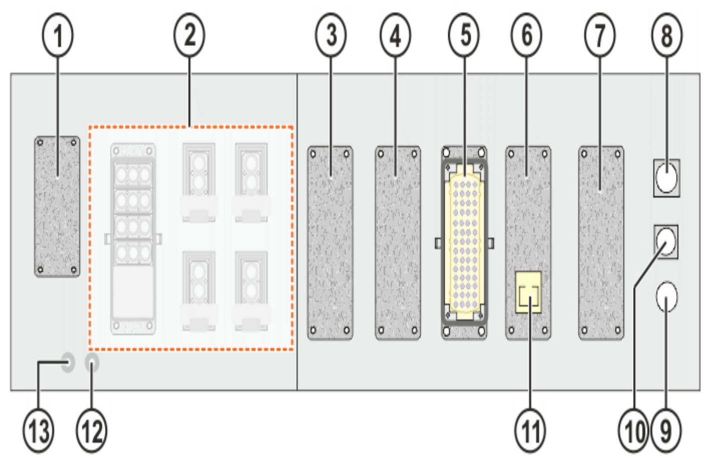

Figure.14. Connection panel overview
1 Blanking plate
2 Motor connector interfaces
3 Optional
4 Optional
5 Interface X11
6 Optional
7 Optional
8 X19 smartPAD connection
9 X42 optional
10 X21 RDC connection
11 X66 Ethernet safety interface
12 PE1 Ground conductor to manipulator
13 PE2 Ground conductor to main infeed

X. CONTROL PC INTERFACE MOTHERBOARD

The following motherboard variants can be installed in the control PC

- D2608-K
- D3076-K
- D3236-K

Motherboard D2608-K interfaces

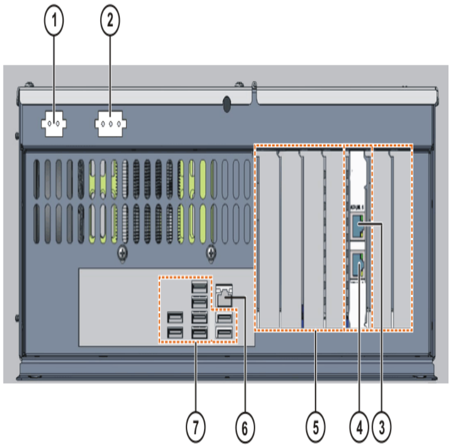

Figure.15. Motherboard D2608-K interfaces

1 Connector X961, power supply DC 24 V
2 Connector X962, PC fan
3 LAN Dual NIC – KUKA Controller Bus
4 LAN Dual NIC – KUKA Line Interface
5 Field bus cards, slots 1 to 7
6 LAN Onboard – KUKA System Bus
7 8 USB 2.0 ports

XI. PROFINET

PROFINET is the industrial standard which is based on Ethernet. It enables to exchange IO data in the real time. PROFINET consists of elements, such as a controller, devices and supervisors. The robot can behave as a PROFINET controller or device. PROFIBUS is a field bus developed by Siemens and it is the dominating communication protocol. In Germany and in middle Europe. CC-link is another field bus which is developed in Japan by Mitsubishi and DeviceNet is big in North America mainly because it is developed by the American, Company Rockwell Automation. There is also a number of newer communication protocols that use industrialized Ethernet (Computer networking technologies for local area networks.) to increase the flexibility and Communication possibilities compared to the older ones mentioned above. Some examples of communication standards that use Ethernet are; EtherCAT, PROFINET and EtherNet/IP.

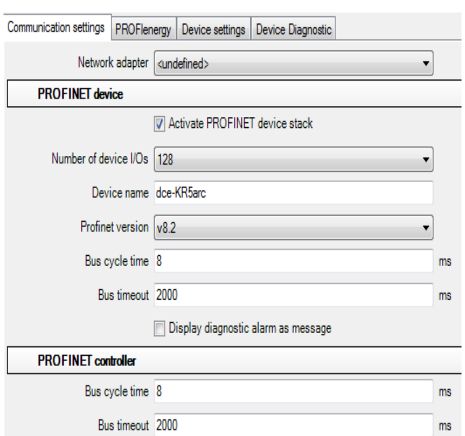

Figure.16. PROFINET

Communication to the field level: software stacks or gateways? With the pre-existing Ethernet equipment in the PC, the field bus connections to Ethernet-based field buses such as PROFINET or EtherNet/IP could be entirely realized in software instead of using more expensive, specialized hardware. Thus, connections to conventional field buses such as PROFIBUS or DeviceNet are not integrated by installing plug-in cards in the controller, but rather via EtherCAT communication gateways in the I/O system.

4.2.2 Ethernet and EtherCAT for internal communication and communication with sensors, actuators and I/O

All internal communication and the communication to the lower-level I/O level take place via standard Ethernet or EtherCAT. Therefore, only two different, yet standard communication protocols are used in the universal bus physics (cables, plugs and Ethernet controller chips) in the KR C4 robot controller. Standard Ethernet is used internally for addressing the KUKA hand-held controller, for connecting and synchronizing several robot controllers within a KUKA Robo Team group or for connecting an engineering laptop, for example.

XII. ETHERNET / ETHERCAT FRAME STRUCTURE

A variety of components and many of them need to communicate with other parts of the system. This is normally solved with the use of a PLC which is an industrial computer that specializes in control of automation and electromechanical devices. A PLC is a microprocessor that depending on the price and performance class can handle different numbers of input and output signals to and from other devices and components in the robot cell.

EtherCAT Datagram Header Address

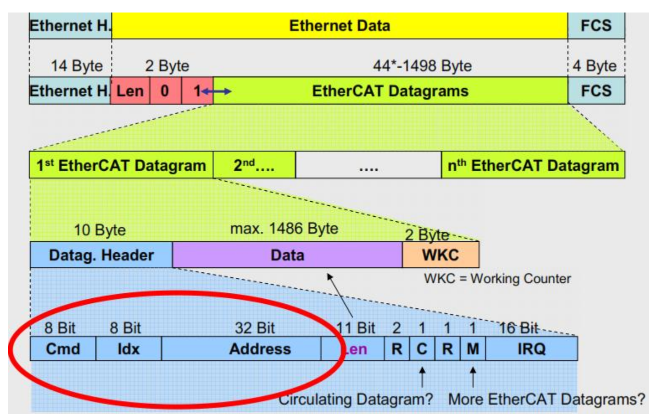

Figure.17. Datagram Header Address

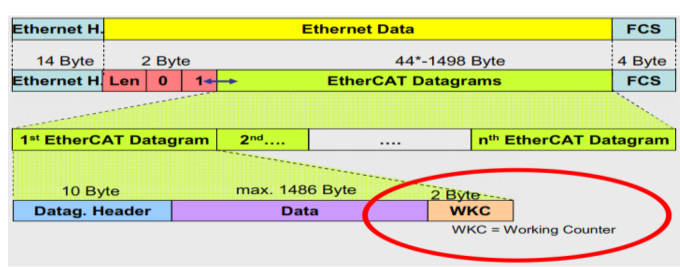

Figure.18. Datagram Header Address

• EtherCAT Datagram ends with a 16 Bit Working Counter, Working Counter counts the number of interactions of devices addressed by an EtherCAT Datagram, EtherCAT Slave Controller increments the Working Counter in hardware – if the controller is addressed and the addressed memory is accessible (Sync Manager), Each Datagram should have an expected Working counter value – calculated by the configuration tool, The Master checks the valid processing of EtherCAT Data grams by comparing the Working Counter with the expected value. Special case: RW addressing methods will increment WKC by 2 for write access and by 1 for read access

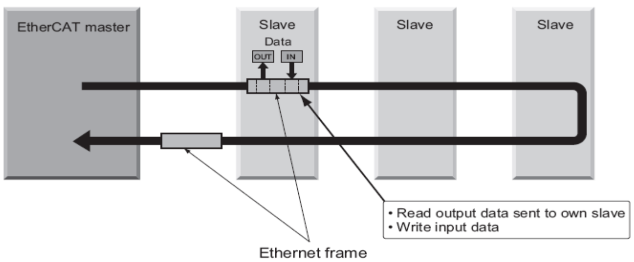

Figure.19. Ether CAT Mechanism

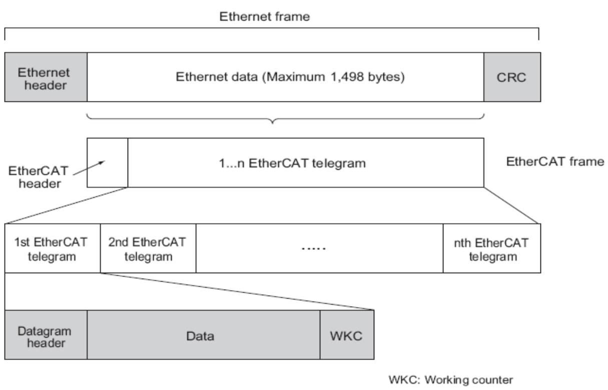

Figure.20. EtherCAT Frame

Ethernet over EtherCAT

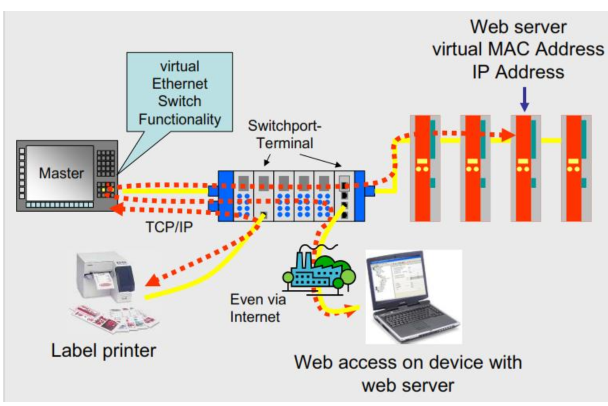

Figure.21. Ethernet over EtherCAT

Purpose of Ethernet over EtherCAT: Tunnels transparently Ethernet Frames over EtherCAT. Tunnelling reduces the cycle times without restrictions and To optimized available bandwidth. Used for devices with TCP/IP stacks (e.g. Web Server) and for infrastructure devices like Switch Terminals. Allows to access corresponding devices in the normal IP network in combination with a' Virtual Ethernet Switch' (Layer 2) on the master side.

XIII. CONCLUSION

Robotics establishes a wide range of technologies for the future of the growth of the industry. Our project also has the ability to resolve the error occurring in between the operation in an industry. This is resolved with the help of pre defined library of errors and their remedies which can occur in an operation. We think by reducing the lead time of an operation, the society can be offer products of better quality with lower prices and this project will have a bright future because the living of standard can also be improved. This paper can be concluded as the reduced lead time for the operation performed in an industry. The set uptime has been eliminated by reducing the time cycle of the operation. Industrial robots have been applied in full-scale construction – as a replacement for manual labor. Our intent in research enables a wide range of robots performing the task very instantly. The best part of our project is that it operates on Real Time Operating System (RTOS), which have the excellence in controlling and observing factor of the operation to be performed. All the operations are performed on the basis of safety as the first priority of either the robot or the operator operating the task

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