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CAN in Automation (CiA)
international users and manufacturers group
Am Weichselgarten 26
D-91058 Erlangen
Phone +49-9131-69086-0
Fax +49-9131-69086-79
Email:headquarters@can-cia.de

Implementation of CAN-System in Truck-based Aircraft washing-system

K.D.Rupp FhG/IPA O.Wurst Putzmeister

Abstract

To wash aircraft's a truck-based washing system was developed. The computer system is divided into two parts, An industrial robot control (IRC) and a bord computer. This bord computer is responsible for the diagnostic and control of the system. A lot of signals must be analysed (about 250). To sample all these signals a CAN system is used. The advantage of this system is the distribution of connecting points and cabling. The safety of the whole system is higher than comparable systems with traditional wiring.

The presentation describes the advantages, constraints, requirements and drawbacks for the implementation of CAN-system in the aircraft washing-system.

Introduction

Aircraft cleaning was in former times manually work. We have developed a flexible truck-based system to automate the cleaning of aircraft's. The FH-26-SKYWASH system performs the important tasks in washing a fleet of aircraft with sizes ranging from a B737 to a B 747. The benefits of this system are:

Achieving better washing results with minimum manpower and shorter ground time.

Washing at any airport outside or inside the hangars with minimum infra-structural requirements.

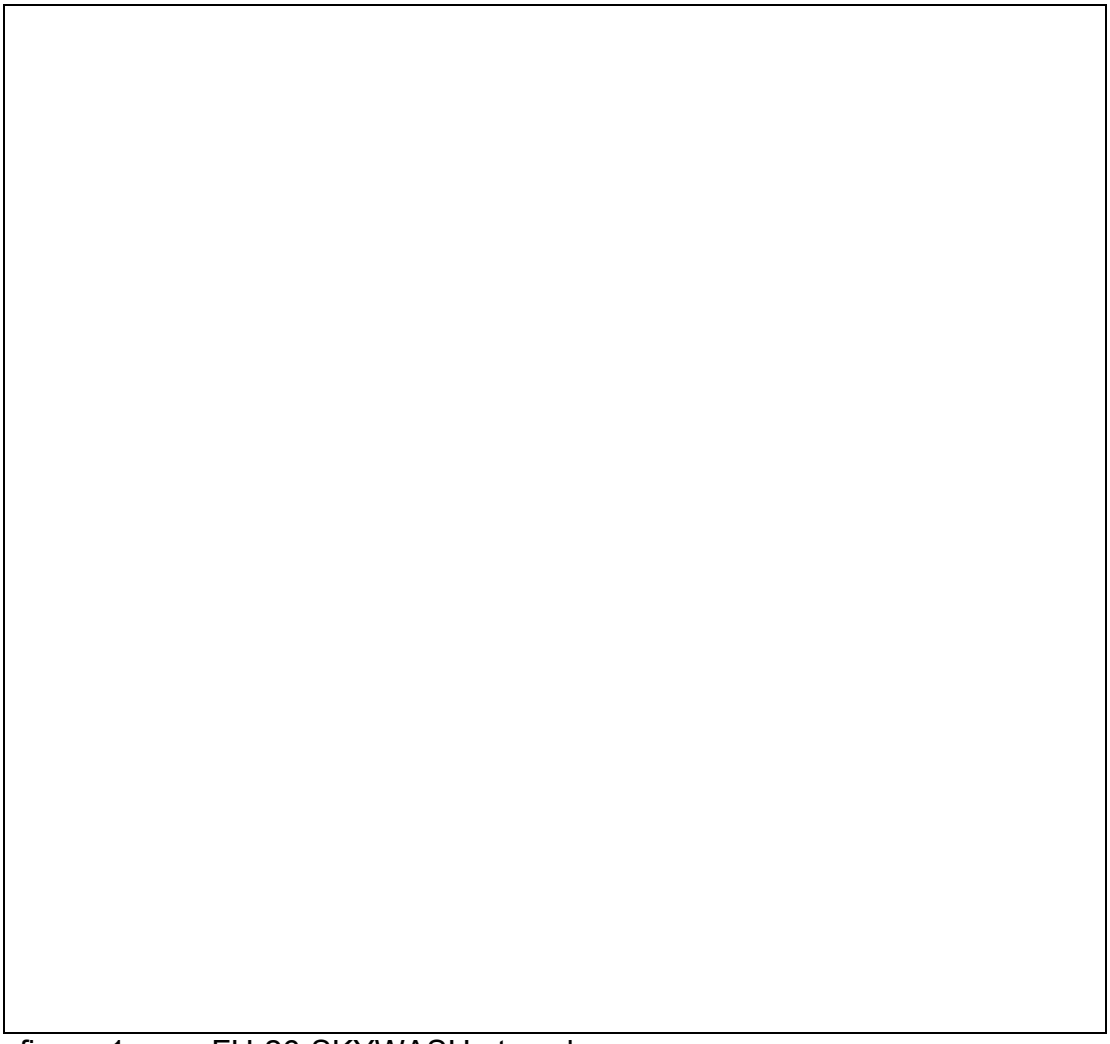

figure 1: FH-26-SKYWASH at work

In 1993 the FH-26-SKYWASH was tested successfully. For 6 months at "Deutsche Lufthansa" at Frankfurt Airport on several aircraft's, for Example B747-400 and B737-300, have been washed. The suitability of the SKYWASH

for optimisations has been proved. Based on the test results of the FH-26 a new configuration SW-33-SKYWASH will be developed.

APPLICATION

The control system is made up of two computer systems, a movement controller and a supervisor controller. This systems are integrated in the overall cleaning system. Figure 2 shows the Layout of SKYWASH application

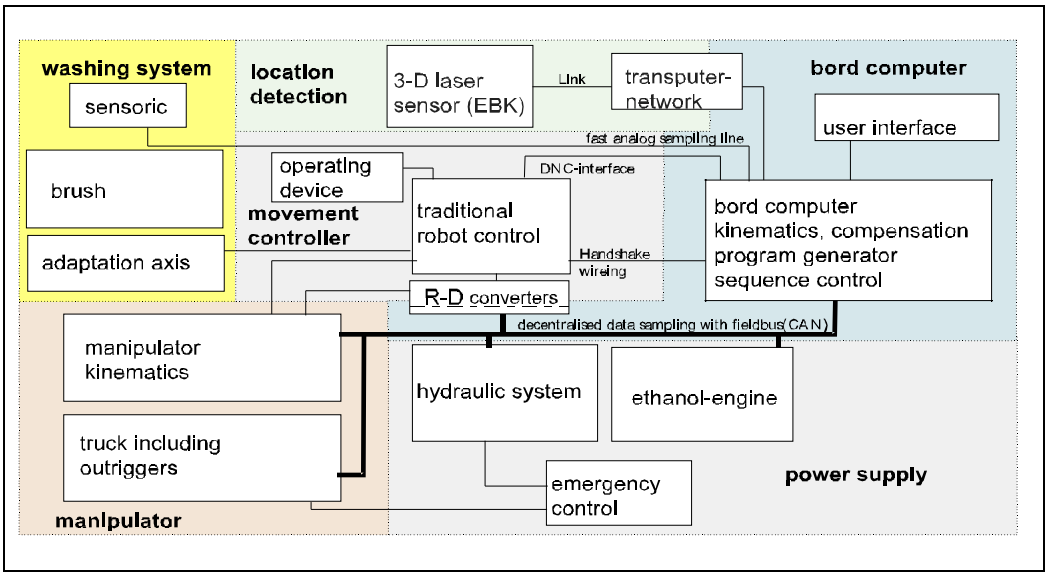

figure 2: Layout of the overall system

For this application the bord-computer was developed, including a CAN-system for supervision and data sampling. The board computer performs kinematics transformations to compensate the deflection of the manipulator and to transform the programs to the measured relative location of the manipulator to the aircraft. A data base handles all program data and produces a logfile with the exceptions during the cleaning process. Additionally this computer is used for maintains and setup of the machine. Figure 3 shows the layout of the bord-computer including the fieldbus system CAN.

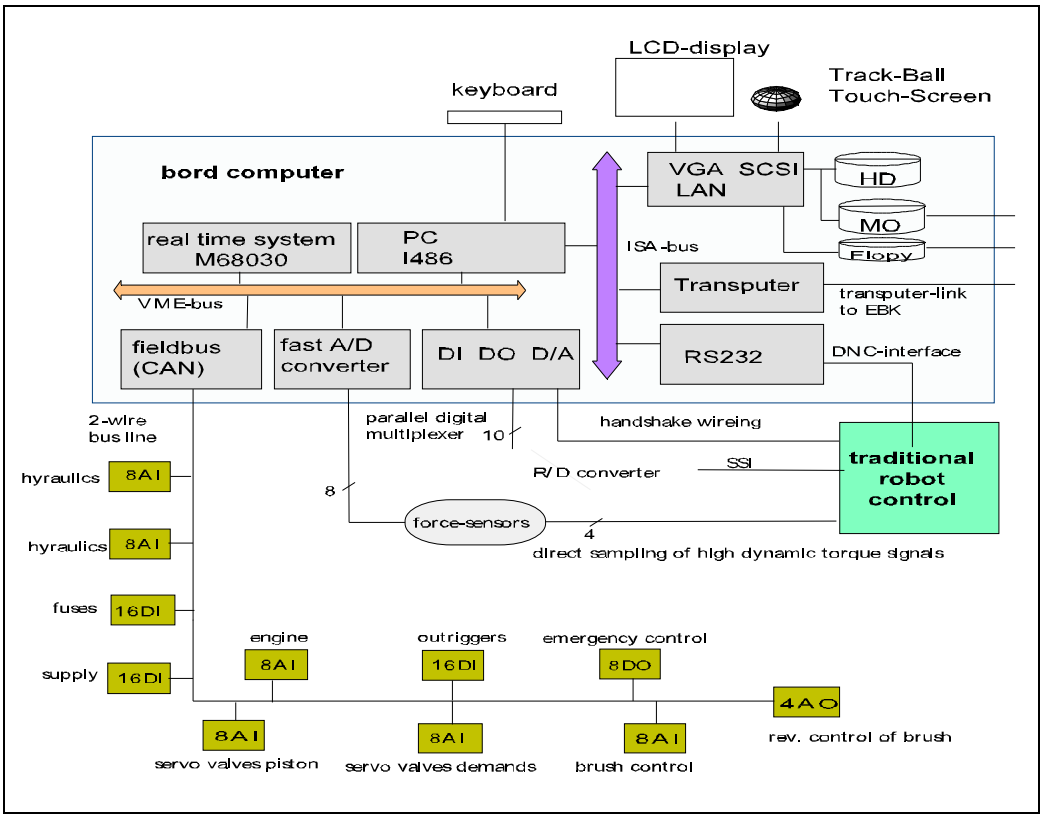

figure 3: Layout of the bord computer system

The supervisor- and diagnostic system has more than 120 digital signals and 80 analog input signals to handle. The following table gives an overview to the relevant signals:

channel	channel group	signals	line	
1..40	intern conditions	flags, state		process, programs, steps
40..80	compensation system	shifts	DNC	shift vectors transmitted via DNC
80..320	hydraulics	analog inputs	CAN	pressures, temperatures, flow, level
	demand values	analog inputs	CAN	demands of the controller
	angle signals	multiplexed digital input	DI	Resolver digital signals with customised multiplex module
	torque's	high frequency analog signals	fast AD-input	position and force at the brush
	limit switches	digital inputs	CAN	functions for the outriggers, PLC
	fuse	digital inputs	CAN	monitoring of power supply
	engine	counters, digital, analog	CAN	temperature, pressure, rev counter, gas position, ethanol level
320..1040	state of traditional robot controller	PLC, kinematics	DNC	

Requirements and Constraints

1.1 Criteria of Operation for a Fieldbus-System

An efficient solution for this summery of input data, satisfying the requirements, must be found for a complex system like SKYWASH. The only suitable way to sample and to process the number of analog and digital signals is to use a multi-processor system. There are several solutions possible:

a) centralised system layout

One of the system processors is exclusively used for data collection. It is built either as a processing unit working with the data sampling boards or with an intelligent data sampling unit.

b) non-centralised system layout

The analog-digital conversion is done near the sensors. The converted signals are transmitted digitised to the processing unit.

For the SKYWASH application, the fieldbus system was used for the following reasons:

The available mounting space in the region of the central processing unit is very small. A solution using central sampling boards is hard to realise because of the large number of signal-lines. A solution using multiplexed signal-lines requires a lot of hardware and software development.

One sensible solution for this problem is to use decentralised sampling modules which transmit data to the host computer in digital format. Analysing the market for available systems there were no doubts to select one of the most spread system.

1.2 Constraints to a Fieldbus-System

- ❒ sufficient electrical protection from surrounding environment.
- ❒ Sampling modules and the transmission paths have to fulfil the requirements in mobile outdoor applications
- ❒ The minimum sampling rate for analog signals is 20 Hz, about 20 signals should be sampled with every 100 Hz.
- ❒ The first installation will have a bus-length of about 20 m. Further applications will have a bus-length reach of more than 50 m.
- ❒ Having a prototype in this application, changing the system structure and timing must be done without a lot of efforts.
- ❒ Minimum number of cable-crossings with protection against environmental conditions (if possible a no ring-system)
- ❒ High flexible wires with small curve radius, easy to mount and optimal for maintenance
- ❒ Requirement of computing time of the processing unit should be a minimum
- ❒ Confidence in transmission of data

1.2.1 Additional Advantages Using a Fieldbus-System:

- ❒ Electric destroyer of sampling modules causes no long term problems for the processing unit and can be detected.
- ❒ Errors on the transmission line can be detected. An adaptation of analog signals is necessary using conventional cabling with more then 20m length, could be dropped.
- ❒ Computing-power of the sampling modules can be used for pre-processing the signals. Therefor the needed calculation time for the processing unit can be reduced. High frequency signals (up to 1 kHz and more) can be pre-processed on decentralised CAN-modules and transmitted to the host in it

cycle time.

Example: filtering of analog signals

limit check and plausibility check for analog signals

reducing of data transfer rate using event triggering especially for digital inputs

reducing of data transfer rate using adequate information coding

1.3 The decisive factors for CAN

One of the most important criteria for selecting a system, fitting to the application is the possibility of expanding the basic system. For future extensions the number of connected modules, achieving the maximum data transmission rate has to be taken into account. Using decentralised sampling modules the CAN-protocol with a netto transmission rate of 8 byte fits very good to our application. With that 4 analog signals with 16 bit resolution or 16-digital channels with 4 bit using edge detection and an input- or an output fault line. An important feature of sensor interfaces to CAN is the availability of additional analog interface for emergency control or to interface the typical robot controller. For further applications this interface will be realised with a multi-master system using CAN. Performing this is only possible with a few field bus systems. CAN can easily be used in a multi line system. More than one CAN-bus could be Networked using controllers with more then one can interface. For applications like SKYWASH a interface for maintains is necessary. In case of malfunction of one module the system has to work on. It must be possible to bring SKYWASH manipulator down. Even is the host drops down an emergency control must be possible. Maintenance and implementation is easier using copper wires instead of light wires. The CAN system could be extended easily without a lot of new cabling an software adaptation. In spite of the compact protocol, CAN has a communication interface to setup and maintain modules by software for varying purposed in a standalone machine without using a lot of infrastructure. Existing references for the CAN system in the automobile area make the decision easier.

Limits of the CAN-System

With sequential transmission, the time-scheduling of the system is an important fact. To achieve the system state of an eleven axis manipulator the synchronisation time must be taken into account.

Analysing the minimum transmission time of demand signals, it was realised that the processing of data including the conditioning of demand signals could be performed on a central processing unit only for a system with low natural frequencies.

Controlling hydraulic dives has to be done decentralised using centralised monitoring and demand value generation (e.g. inverse kinematics, path controlling and observers for multi link manipulators). Whit the available SLIO-modules with sufficient computing power this requirement is not constraint.

1.4 Problems and difficulties of the realisation

The essential advantages of the field bus system could not be used in the existing system because it was mainly used as a diagnostic and monitoring system for a typical robot controller. There was no other possibility as to cable all monitored sampling modules of the robot controller in conventional manner using an adequate electric protection. Linking of signals to CAN was not done at the corresponding sensors but at the site of the robot controller.

The introduction of fieldbus-system CAN became difficult by the lack of technical acceptance of some partners. Especially there were doubts about the implementation of security functions and emergency control features.

1.5 Possible extensions

Disadvantages of using a CAN system is the missing CAN interface of sensors. A large number of analog sensors is applied with complex output circuits to convert analog to digital signals. The use of conventional CA-chips with build in analog inputs (12 bit resolution) will eliminate this circuits without additional costs. For the initially plant mobile application (e.g. automobile and construction) The industrial protection laws (IP 67,...) should be fulfilled. This

concerns both the electrical liability of the interference's of many sampling modules, and the sensitive to environmental influences. An important step should be performed in the area of connectors. Most of practical connectors for outdoor applications must be customised for use.

1.6 Options

Using CAN, to interface actors like servo valves much ***intelligence*** can be integrated to make maintenance and monitoring easier. In future on Networking of functional units more efforts will be spend. In this case an interface of a sensor-actor-system, process-data sampling and service is possible. Integrated solutions can reduce the costs of service in the future. By using suitable diagnostic systems the overall system safety can be improved.

Conclusion

For skywash application it turned out that the decision using CAN has been a good solution solving the problems in mobile applications. A large Number of signals can be sampled in different time scheduling. CAN is a suitable system for maintenance and use as a sensor actor interface. A further project is started with CAN transmission with a length more than 50m.

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