

# DeviceNet media redundancy: A technical approach

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**[Abstract]** The media problem is one of the major causes of DeviceNet node failure in factory floor application; and one survey in a typical industrial application shows that a great percentage of DeviceNet system failure is caused by media problem. This paper presents an approach of designing DeviceNet media redundancy; this approach will improve the reliability of DeviceNet system; meanwhile, it is a simple and low cost solution that does not change current DeviceNet hardware and firmware.

**Key Words:** DeviceNet, Redundancy, Media, Failure, CAN,

## 1. Background

DeviceNet systems are mostly used in factory floor where environment is pretty severe: the environment conditions may cause DeviceNet cable wear out, broken, twist; and they may also cause DeviceNet connector loose connection, or DeviceNet terminator loose connection or other unexpected situations. And the media failure directly contributes the DeviceNet system performance degradation: the temporary lost connection of network will cause communication connection time-out and the result is a lot of resent packets, which actually waste a lot of bandwidth. Permanent damage on cable will cause nodes off or system down. Figure 1 shows a typical DeviceNet application in factory floor [5] and any of the cable may subject damage.

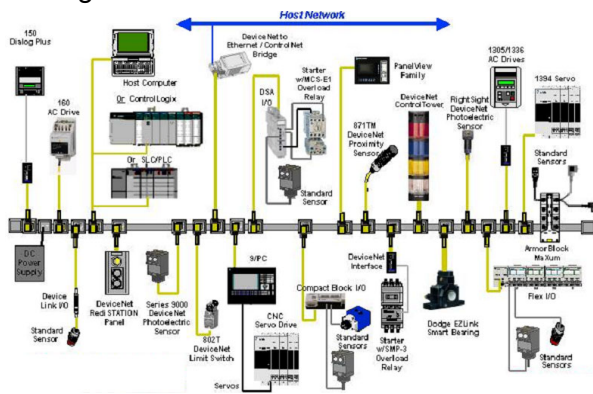


Figure 1 DeviceNet System in Factory Floor

According to one survey made by IMS (Intelligent Maintenance System, University of Michigan and University of Wisconsin at Milwaukee, USA) in a typical industrial application, 40% of DeviceNet system failure is caused by cable damage or wears or other cable problems. (See the blue part in Figure 2). And this result is not independent case since there are same reports in other industrial applications, though the percentage is different from case to case.

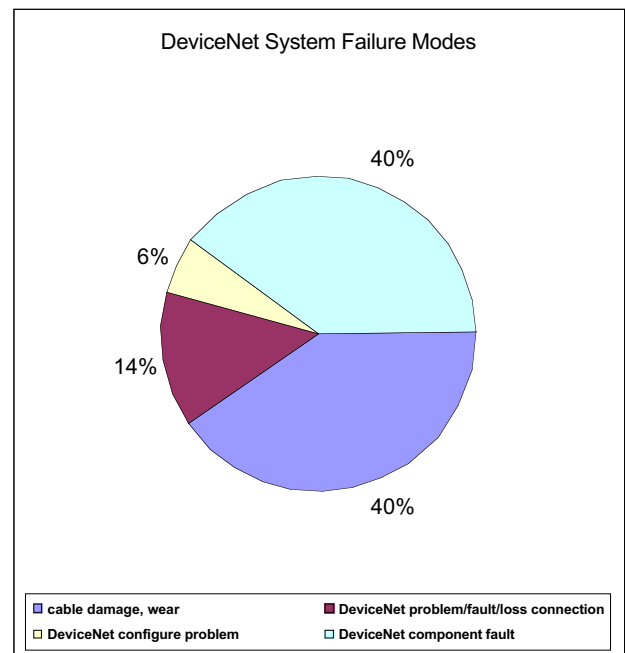


Figure 2 DeviceNet System Failure Modes

The media problem, in some cases may cause system unstable, the data frames are resent many times and network bandwidth is wasted and the performance is degraded; and finally the network will go Bus-Off, the system will be shutdown and productivity lost.

However, the statistic result of Figure 2 also tells us a fact that if the DeviceNet media problem can be solved, 40% of system failure would be avoided, or greatly reduced. So this topic is worth to put energy of studying the technical solution to solve this problem. The field bus reliability is one of the most important features of industrial network. And any improvement of this area is a great enhancement of its application, especially in the factory low floor.

Of course the most effective and direct way to solve this problem is to backup the DeviceNet system media, or add one more redundant cable to secure the system reliability.

This paper will first review the several solutions of CAB based redundancy system, compare their features and then presents a technical approach of DeviceNet media redundancy solution, which can solve the DeviceNet system failure caused by cable problem. The special requirements and considerations of DeviceNet media redundancy system are also presented. Finally a typical DeviceNet media redundancy system application scenario is given.

**2. Review of Possible Solutions**

The DeviceNet cable includes the 24VDC power and CAN\_H, CAN\_L signal wire, and an optional shield wire. The cable problem can be lost of power or lost of signal, or both. Figure 3 shows the DeviceNet cable.

DeviceNet technology is based on CAN, and there are several solutions have been presented before to improve the CAN system's reliability, most of them use

redundant method to achieve this feature [1,3].

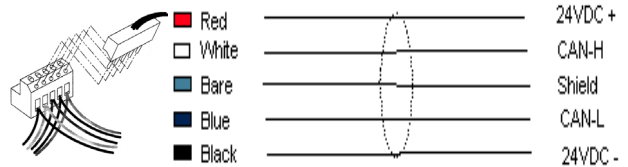


Figure 3 DeviceNet Cable

A typical solution of redundancy is to use two signal paths (each includes a CAN controller and a CAN transceiver). Figure 4 shows a media redundant solution in which two independent CAN signal paths are connected to same MPU. The MPU can have built-in simple logic to decide which CAN path is healthy that can be used. If both cable are healthy, then it will select the one packet arrive first. If one path is failure, the good one will take over it and the failure on can be switched off. This solution doe not consider the power transfer.

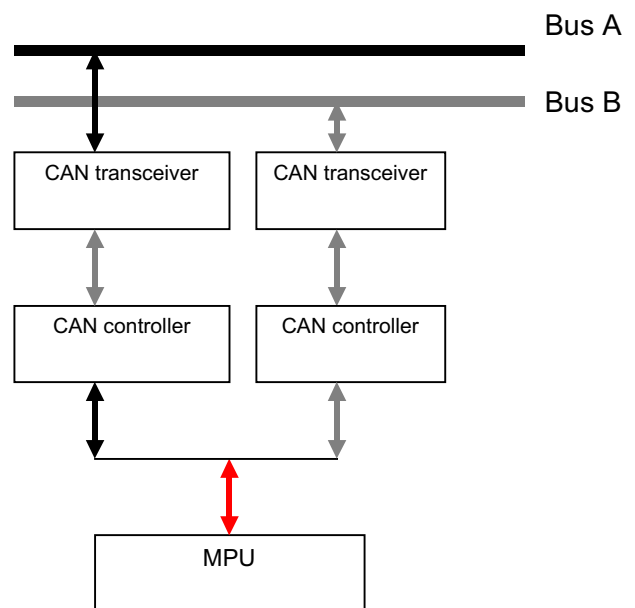


Figure 4 Redundancy Solution 1

This solution requires the MPU has internal logic to identify the active CAN controller and response to its interrupt. This logic is totally firmware work. We call this is a built-in redundant solution since it requires the node itself has two CAN bus interface. If the MPU has built-in dual CAN

controller, such as MB90F543, this solution can be very easily realized <sup>[4]</sup>, of course the cost is a little bit higher.

Another solution <sup>[1]</sup> is the two signal paths are arbitrated in transceiver level, see Figure 5, if two media cable are both OK, the first-arrive-signal path will be selected as the active path, the signal in this path will be sent to the controller and an interrupt will be sent to MPU. In case of one cable has problem; the other one will be selected as the active one, thus is, the CAN cable is switched. This solution has only one CAN controller and need hardware circuit to arbitrate the healthy CAN bus.

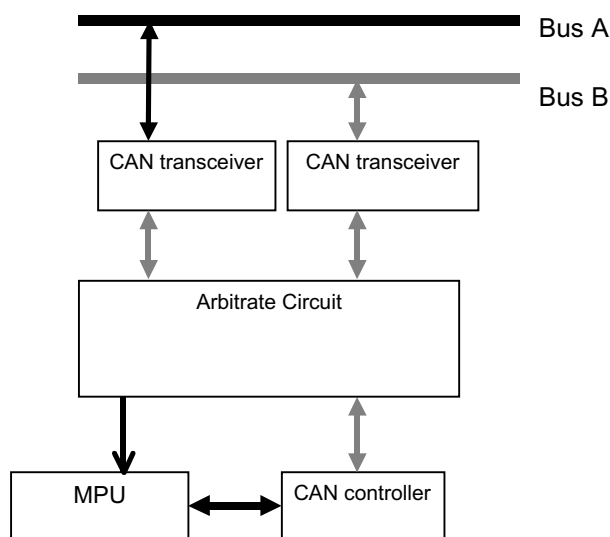


Figure 5 Redundancy Solution 2

Both of above two solutions are not suitable solution for DeviceNet application. DeviceNet has 24V power wire, which also needs to be switched. And for every standard DeviceNet node, we hope it can be used for both redundancy configuration and non-redundancy configuration without hardware and firmware change in the node or any other configuration, customers need a kind of plug-and-play method.

Another solution is to use wireless DeviceNet system in some special area where the cable system is not suitable to use since (constant moving parts are applied or cable can be easily worn-out).

The wireless system is beyond this paper's scope.

### 3. Targeting the Requirement

Based on the above analysis here we define the industrial application requirements for DeviceNet media redundancy solution:

- a. The redundancy system shall be independent and transparent to the DeviceNet node, so there is no hardware, firmware and configuration change
- b. Both 24VDC DeviceNet power wire and signal wire in DeviceNet cable can be redundant
- c. Easy and instant installation, no system re-configuration is needed
- d. Low cost solution

To meet these requirements, we present following approach on DeviceNet redundancy system.

### 4. Technical Approach

Based on those application requirements we defined above, we design the redundant system. The media redundant facility, a redundancy box includes two DeviceNet cable connection, each cable has DeviceNet power and CAN wires, and there is a arbitrate circuit box to select one of DeviceNet cable as the active one. There is only one DeviceNet connection to the target DeviceNet node and this node does not know which cable it is currently used.

Both DeviceNet cables are connected to each node's redundant box that is mainly consisted of bus arbitrate circuit, see Figure 6. The key is the designing of the redundant circuit; its main function is identity the active bus and switch from the failure bus to the active bus.

During power up, the redundant box select the first active bus and use its power. When a DeviceNet node transmit the message, it transmits over both buses; while receiving, the arbitrate circuit select

the one that first receives the message. Once one bus is failure, the arbitrate circuit lock up its channel and the non-failure bus will continue working.

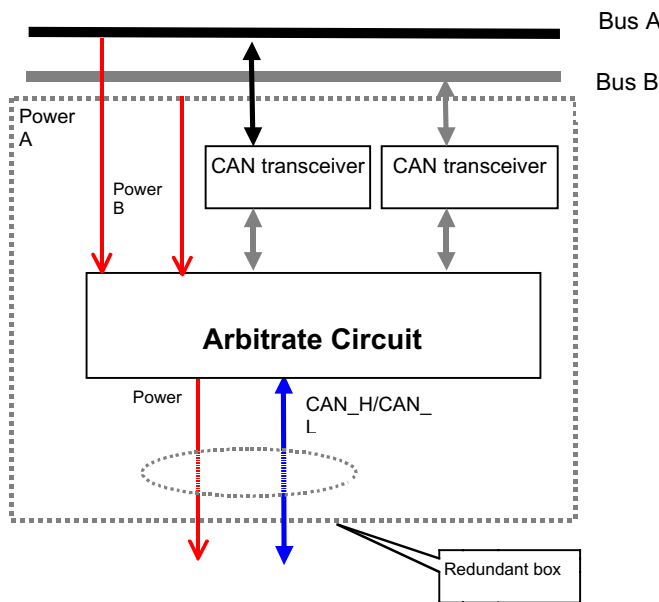


Figure 6 Redundancy Box Composition

The CAN signal arbitration circuit is presented in Figure 7, it works in this way:

The arbitrate circuit has two parts: one selects the working power, the other select the working CAN bus. In the CAN bus arbitrate circuit, there are re-trigable single-state trigger and a compare circuit [1], and there is power arbitrate and switch circuit. When message comes in, the signal is compared in the circuit and the late coming CAN channel is lock up by it. Once a bus is fail, its CAN signal will stay in one level (H or L) and the trigger will never be triggered, so its output will stay at low level, this channel is locked up. One important thing is: the pulse width that the single-state IC (for example, 74LS 122) generated shall no less than 12 consecutive bits in the frame.

The healthy cable selected not necessary has both healthy signal and power: the first up power is first selected as active power source and the other power is locked out; if the active power is lost then the other one cab be switched in automatically. During the media transfer, there is possibility that some DeviceNet packets lost, but the connection will be

resumed soon. This is acceptable for most industrial application.

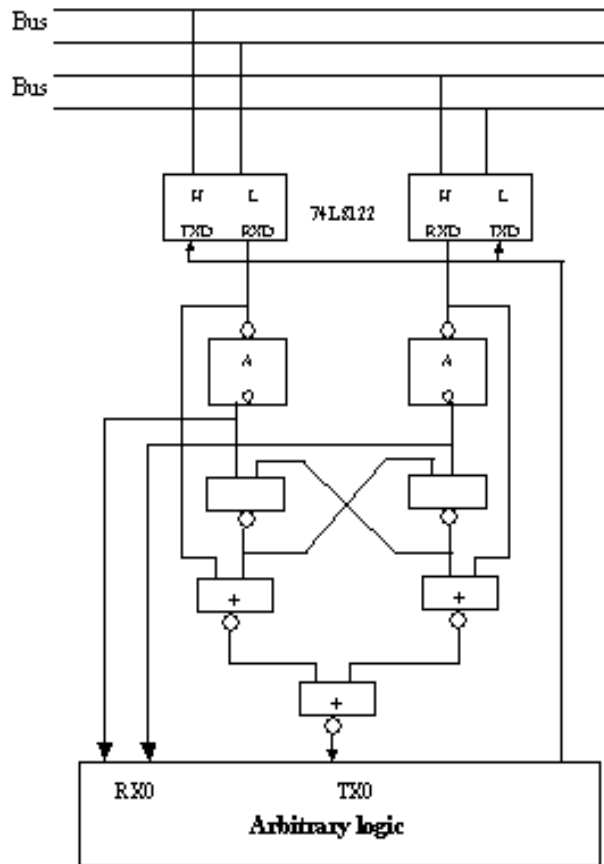


Figure 7 CAN signal Arbitration Circuit

The keys of designing this arbitration circuit box are:

- a) Only one CAN signal cable can be selected as active DeviceNet signal path, the other one is locked out whatever it is good or bad
- b) The first up power wire is selected as DeviceNet power, the power wire is only switched to the other one when the current one is failed
- c) In the arbitration circuit box there are only three connection interfaces: two DeviceNet connection connected to the two field cables, and one DeviceNet connection connected to the DeviceNet node, no other wiring necessary
- d) No standalone power supply is necessary for this box

- e) Optional selected cable indication is a positive add-on

One disadvantage of this kind of solution is that due to the introduction of arbitration circuit, the communication delay is added. However, since DeviceNet is not fast network and this small delay is acceptable and the reliability is somewhat more important.

Figure 8 shows an application scenario of media redundancy DeviceNet system: in one side the two DeviceNet cables are directly connected to the redundant box with the standard DeviceNet open connector; the other side of this redundant box use same connector connected to DeviceNet node. So to each node, the redundant media is transparent to it, and the DeviceNet does not know which cable it is currently used. Please also note all DeviceNet nodes in the network shall use redundant box, if any of them does not use it the system may not work properly.

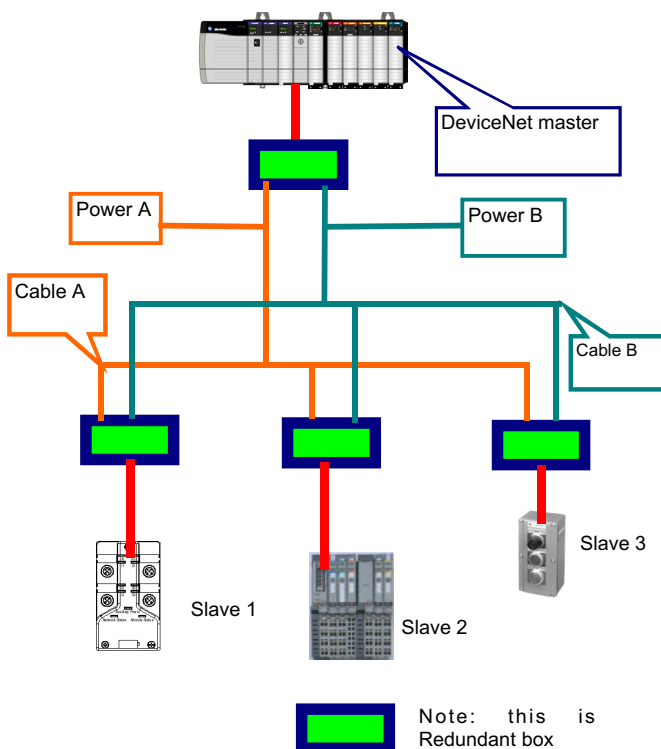


Figure 8 DeviceNet Media Redundancy System

## 5. Conclusions

Media problem is one of the major causes of DeviceNet system failure, especially in the factory floor area where there is many moving parts. Solving the DeviceNet cable by providing redundancy mechanism can greatly improve the DeviceNet system reliability in these areas.

The DeviceNet redundant system is different from the most of CAN redundant application since in DeviceNet the 24VDC power is in the same cable of CAN wire in most cases. So the 24VDC power is also need to be backup besides the CAN signal wire. This is the special requirement for building the media redundant system of DeviceNet application; another requirement is that the instant installation and easy connection with the standard DeviceNet nodes.

To solve the DeviceNet media failure problem, a technical approach of DeviceNet media redundancy is presented in this paper. This technical solution can improve DeviceNet system reliability without hardware and firmware re-designing in the DeviceNet node. Compare with other solutions in CAN redundancy application, this solution meet the special requirements of DeviceNet application and it also has advantages of easy installation and low-cost. The prototype of this solution is under developing and the detail result and performance will be given in the future.

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