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"STANDARDIZATION LEADS TO MODULAR CONTROL DESIGN FOR MOVABLE BRIDGES"

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INTRODUCTION

In the mid-1980s the Florida Department of Transportation began an aggressive rehabilitation program for its oldest movable bridges. At about the same time the Programmable Logic Controller, having proven itself in industry, was beginning to appear in movable bridge systems around the country. Because the PLC was a relatively new device, most of the engineers who were involved in movable bridge design relied on the knowledge and experience of the control system vendors. Typically, the electrical plans were minimal and the contractor designed and built the controls. A dozen or so contracts were released with "performance" type specifications for the control systems in which the control system vendor designed and built the systems. The result was that no two systems were alike. This made training of operations and maintenance personnel difficult. Often, the original vendor had to be brought in to make adjustments or trouble shoot. There needed to be more control over the final design.

In 1991, the FDOT Structures Design Office and the consulting firm, Parsons Brinckerhoff, took the approach that the contract documents should be as complete as possible and thus standardize the control systems. The concept was taken further to make the control desks have the same general look and feel regardless of whether the operating machinery was AC, DC, or hydraulic.

This was accomplished by breaking the system into discrete modular parts which could be mixed and matched as required by the specific bridge requirements.

DESIGN DEVELOPMENT

Starting from scratch, a new design was developed using the same sequence flow diagram and general control desk layout that had been used on several previous bridges. Previous shop drawings were reviewed. Comments and complaints from the operations and maintenance districts were considered. The good was adopted or expanded upon and the bad remedied.

Emphasis was directed to the similarities between all movable bridges. Complete schematic and wiring diagrams, as well as PLC program ladder logic, were developed for traffic lights, traffic gates, span locks, brake operators, and general interlocks to provide for every conceivable variation of these operations. At the completion of the first design contract, a standard design package had been produced. Bridge specific schematic diagrams were then created from this standard.

By producing detailed contract drawings, using a standard design, there is now a uniformity between bridges to the extent that a given wire number is connected to the same device and has the same function on any bridge regardless of the type. The bridge controls all have the

same general look and feel, as well. To date, this standard design has been used in three Districts, on nine double leaf bascule bridges, three (3) four leaf bascule bridges, one double leaf rolling lift, one single leaf, one vertical lift and one swing bridge. (See plates 1 and 2.) An operator who has been trained on one of these bridges can go to any of the others and operate it intuitively with little or no additional training.

An important benefit of this standardization is that all of the contractors are now bidding on the same control system. The project is less susceptible to the contractor's misinterpretation of intent or cost cutting. Although the initial bids were higher than expected, costs should begin to come down as several of the contractors now have both the basic design and programming in hand.

The Structures Design Office had adopted this design for all "in house" work although a nonPLC based system is now being developed to be the "new standard".

MODULAR CONTROLS

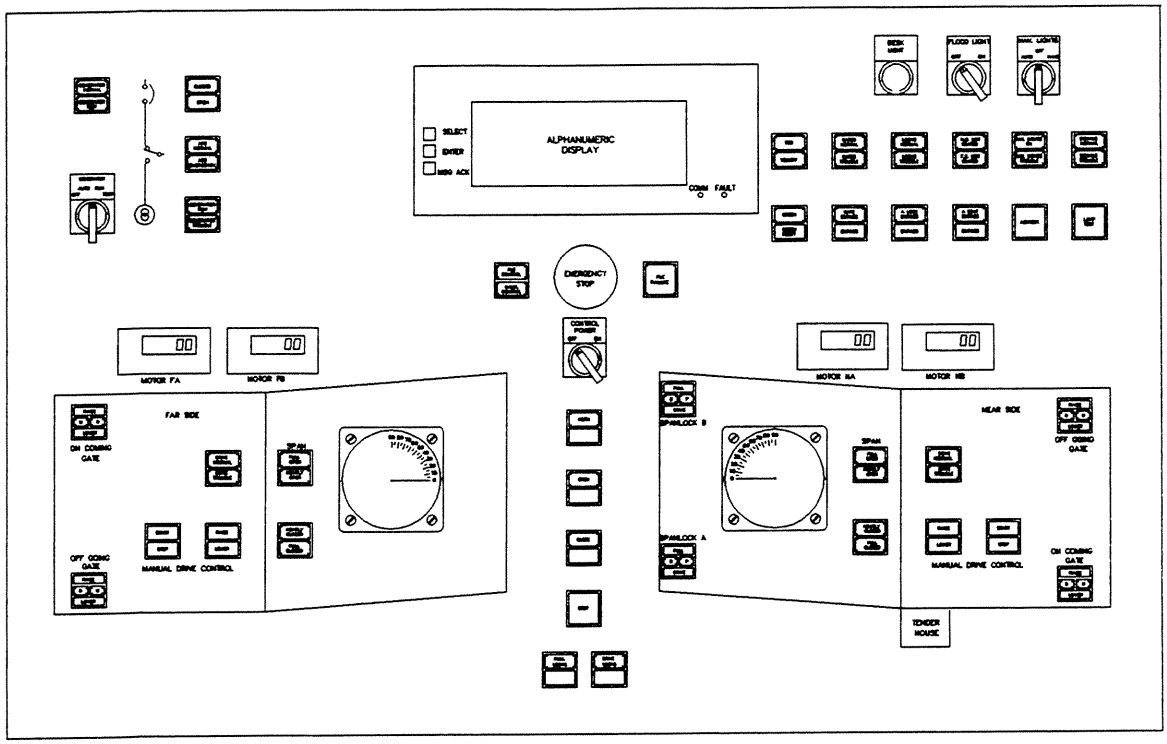
The control system was developed with the assumption that the contractor would procure components from different sources. To minimize interface problems between the various parts, a modular approach was taken.

Central to the control system is the Bridge Control System which is basically the control desk and main control cabinet. The Main Span Drive System, the traffic gates, span locks and any other peripheral equipment are discrete subsystem blocks which are controlled and monitored by the Bridge Control System.

The control philosophy is that for each device, whether it is a gate operator or the main drive system, the bridge control system provides the operate command signal to run and the field limit switches provide the stop command. In the case of the main span drives, this approach reduces the otherwise complex interfaces to simple contact closures. This a departure from the common practice of having the PLC control everything based on a resolver or some other type of position sensing device. All of the acceleration, speed control and deceleration are controlled by the drive system control itself.

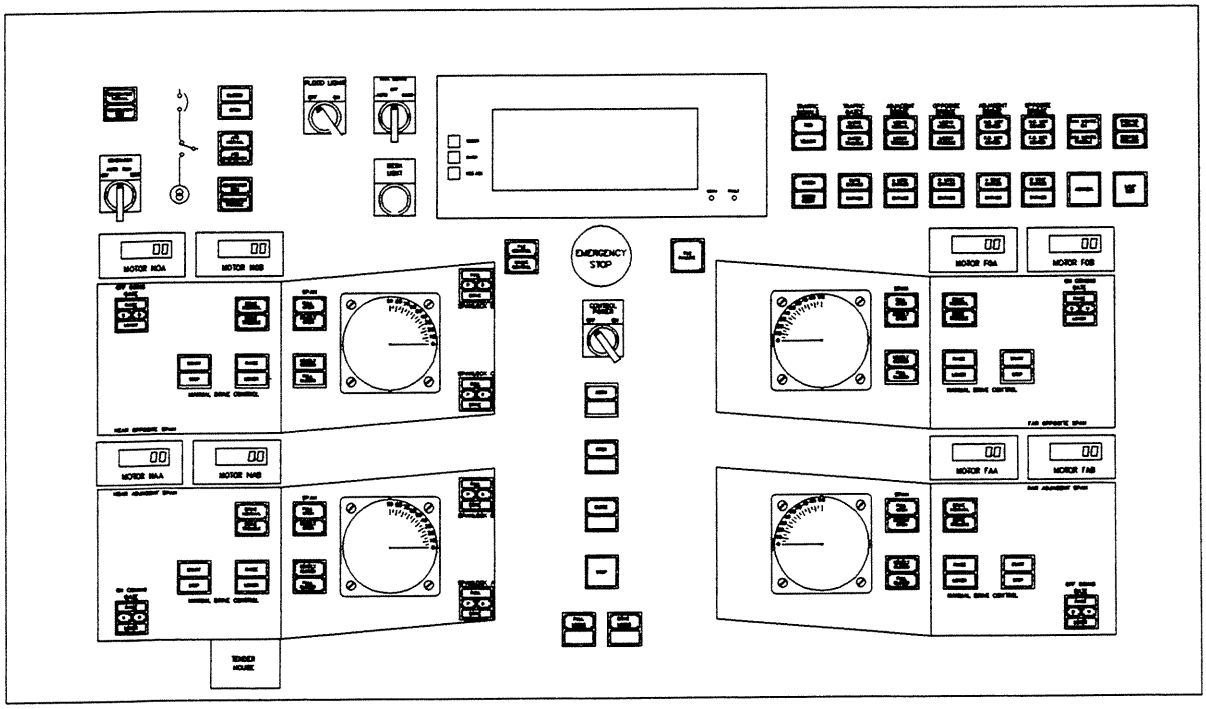
This simplification allows for the same Bridge Control System to be interfaced with any type of span drive whether it is electro-mechanical or hydraulic. If the contractor chooses to go to different sources for the Bridge control system and the span drive systems each system can be checked out and operated without the other. Disputes arising from interface problems are eliminated.

Being able to operate the drives without the complete control system is especially useful when rehabilitating a bridge. It makes it possible to operate a bridge leaf as soon as the span



DOUBLE LEAF BASCULE BRIDGE

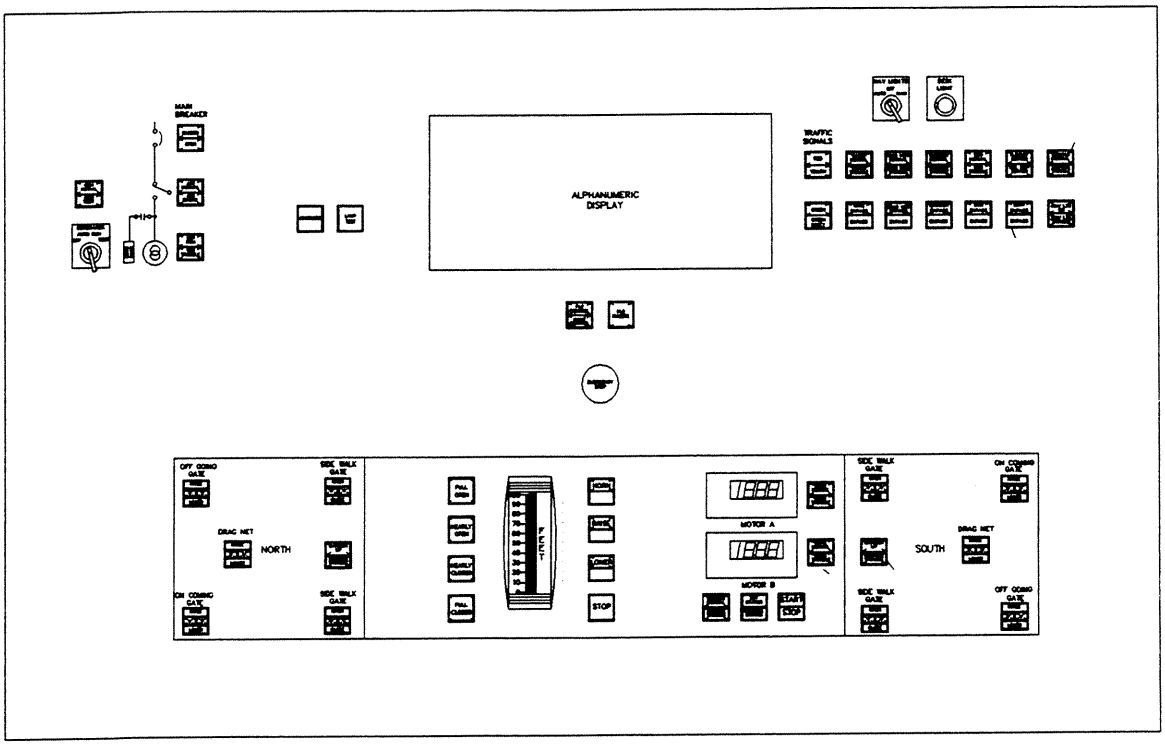
(DISTRICTS 1, 2, 4, AND 7)



FOUR LEAF BASCULE BRIDGE

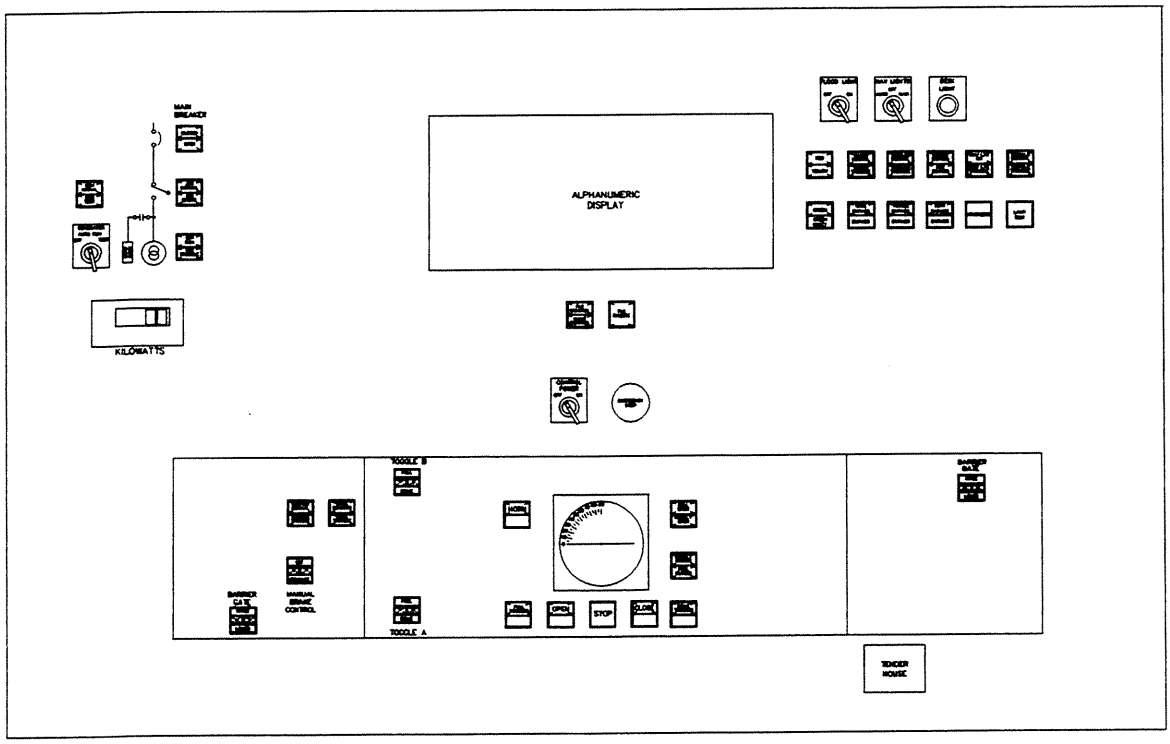
(DISTRICTS 1, 2, AND 7)

PLATE 1



VERTICAL LIFT BRIDGE

(MAIN ST. JACKSONVILLE)



SWING BRIDGE

(BLACKBURN PT. SARASOTA COUNTY)

PLATE 2

drive system is connected even if the rest of the bridge control system is not fully installed. In the case of SR105 over Sisters Creek, the bridge was able to stay operable, without extended closure periods, during the entire construction period. While the far side machinery was being replaced, the near side continued to operate on the existing control system. After completion of the far side machinery, it was possible to operate the far side on a temporary power supply while the new system motor controls and machinery installed on the near side. Although the new control system was not completed for several weeks, the both leaves were operable using temporary pushbutton controls.

By standardizing the interface between the Bridge control system and the other subsystems it is possible to mix and match module blocks. See Plate 3. It is conceivable that a control system originally designed for a bridge with variable frequency drives (VFD) could be redirected to a hydraulically operated bridge with very few modifications. In fact, the hydraulic system vendor who had provided complete control system on two of the first bridges bid on the controls for a VFD driven system.

BRIDGE CONTROL SYSTEM

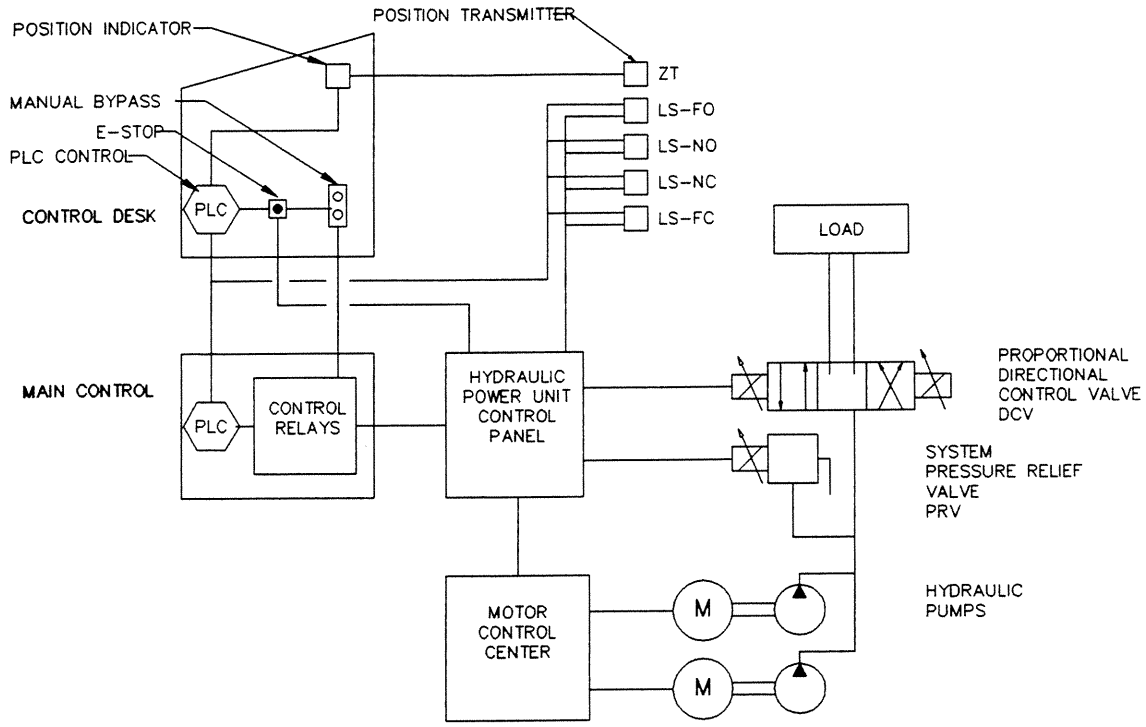
The current Bridge Control System is PLC based with a relay based backup. Normal operation of the bridge, under PLC control, is semiautomatic. That is, the operator must initiate each step of the operating sequence. The PLC provides the interlock logic which prevents improper operation as well as minor sequencing tasks associated with the span lock and span drive operations.

The relay back up system completely bypasses the PLC. This mode of operation would be used for maintenance functions as well as for emergencies should the PLC fail. It, too, is fully interlocked to prevent improper or unsafe operation. However, there is no sequencing and all operations are strictly manual.

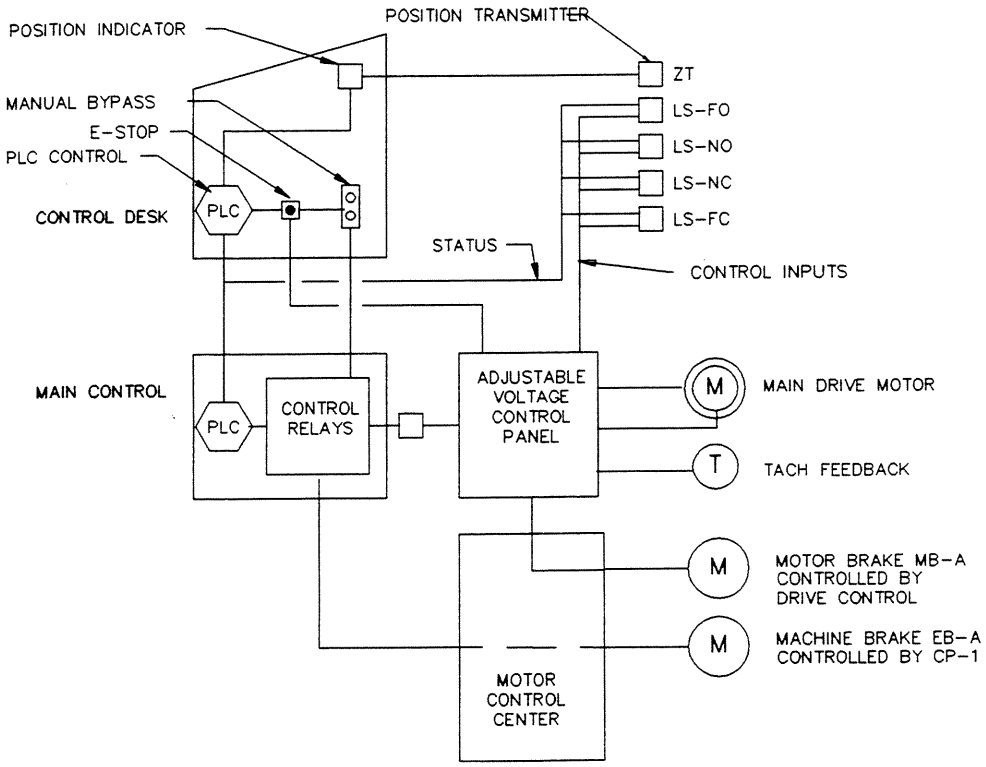
In practice, it is possible to switch from PLC to relay mode, or vice versa, at any time during a bridge operation without having to do any more than turn a selector switch.

CONTROL DESK

The control desk is arranged to relate the various control push buttons, geographically, to the traffic gates, locks, and spans. A graphic representation of the bridge is engraved on the control desk surface and push buttons and indicator lights are located accordingly. When using this basic layout, it is important to consider the orientation of the control desk with respect the roadway and waterway. A desk which has been configured for a house facing traffic does not work well on the other side. In most locations, it would be best if the desk faced the roadway rather than the water. However, in most rehabilitations, the desks have generally been oriented the same way as the originals.



BLOCK DIAGRAM
HYDRAULIC DRIVE CONTROL



BLOCK DIAGRAM
ELECTRONIC DRIVE CONTROL

PLATE 3

The indicator lights on the desk provide prompting as well as status. At the completion of each step of the operation, the operator is given a choice of continuing or reversing the sequence. The active devices are indicated by flashing lights.

An alphanumeric display is provided for display and storage of alarm messages. In early designs the messages have displayed virtually all status changes as well as alarms. In the new scheme, only trouble alarm messages are displayed.

CONCLUSION

To date, there have been four different suppliers of this control system; three hydraulic systems, one VFD and one DC. All of the systems look and operate similarly. As there were virtually no field changes on any of these jobs, the constancy of the circuits from one bridge to another has been assured.