

Design of an M6800 Based

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INTRODUCTION

The M-6800 has been successfully used as a real time process controller for automatic weigh batching systems. The weigh batchers are marketed by MCM Systems to ready mix cement producers and are also rapidly gaining acceptance in other applications which require precision batching of dry material and fluids for operator selected mix designs.

The MCM Systems unit, illustrated in Figure 1, is an integrated process control system consisting of a manual control panel and a process control computer with appropriate interfaces to material batching control and measurement systems. In this application the manual control panel provides full manual back up control for all material batching processes. However, the normal mode of operation is full automation under control of the processor.

This article describes the design and optimization of an M-6800 based controller for the system. Following a brief

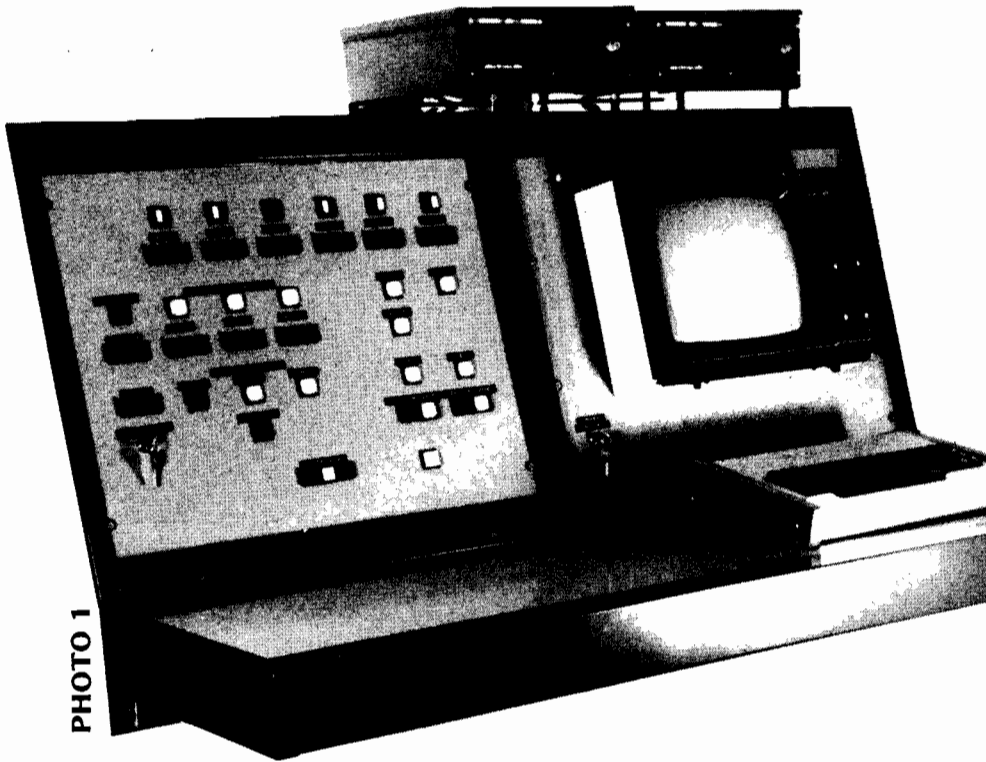


PHOTO 1

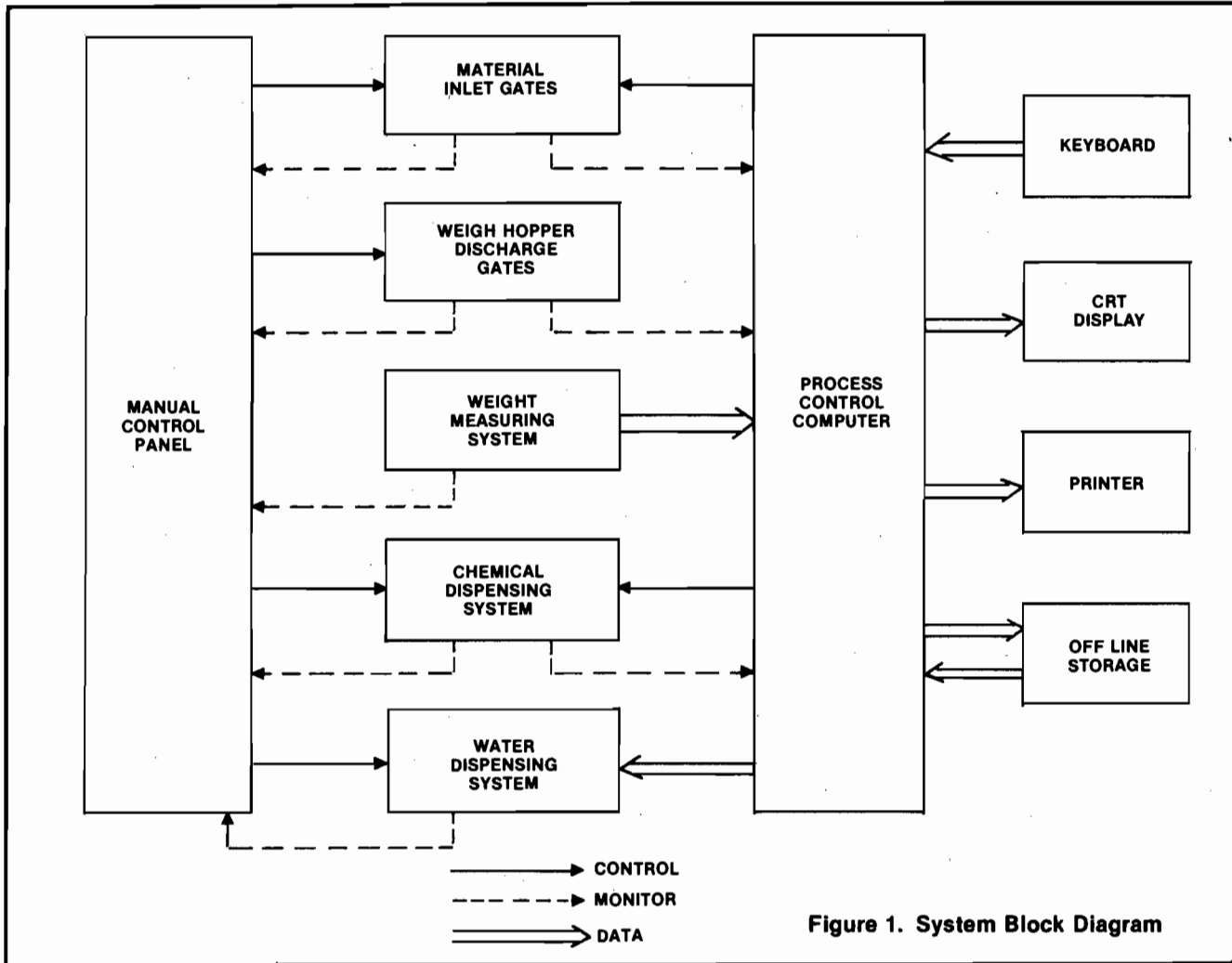


Figure 1. System Block Diagram

Automatic Weigh Batching System

Review of the batching process the hardware and software design processes are reviewed.

MATERIAL BATCHING REQUIREMENTS

Precision batching of materials within a cement plant require a sequence of mechanical gate openings and closings of the inlet of aggregate and cement materials into central weigh hoppers in accordance with a prescribed mix design. Also, when required for the mix, air entraining fluids (admixtures) are batched into holding vials for subsequent discharge into the cement. The controller which automates these processes has been designed to meet cement industry batching standards. This necessitates that within a given batching cycle, material batch weights must be held within specified tolerances. If an out of tolerance condition occurs within a batching cycle the controller must stop the cycle, check out machine controls and await the manual intervention to restart the batch, following correction of the error condition.

CONTROL PROCESSOR REQUIREMENTS

The controller for the batching system is the master executive for the weigh batching process. It controls all mix design data input, schedules the batching and handles batch recycling. It also detects batching errors and external plant failures. At the beginning of a process, the system accepts operator inputs of material batch weights. These may either be numeric keyins in response to processor generated prompts or standard mix design material parameters which are recalled from permanent storage. Following the data input mode it computes all batching tolerances, displays all material parameters and prompts the operator to start the cycle.

In response to the operator initiated start code, the system executes the batch cycle. This consists of a sequential opening and closing of various material inlet gates. In each case the close command is generated on the basis of accumulated weight during the material inlet process.

At the completion of the batch cycle the system prints a ticket which shows target batch weights and actual batch weights and header data such as a date time code and customer name and address. It then prompts the operator to either recycle the current batch or initiate a new batch.

COMPUTER DESIGN

The design process for the controller was performed within the following tasks:

1. Processor architecture and external interface design.
2. Software design.
3. System integration and testing.

Our design activities in each of these areas are described in the following paragraphs.

Processor Architecture and External Interfaces

Early in the system design process we chose to implement the controller with an off-the-shelf M-6800 system. The M-6800 was chosen for its versatile I/O structure. The decision to use this system followed a make versus buy analysis which showed overall engineering costs to be minimized through the use of a suitable off-the-shelf mainframe. Following a detailed investigation of candidate M-6800 systems, we chose the GIMIX mainframe for the following reasons:

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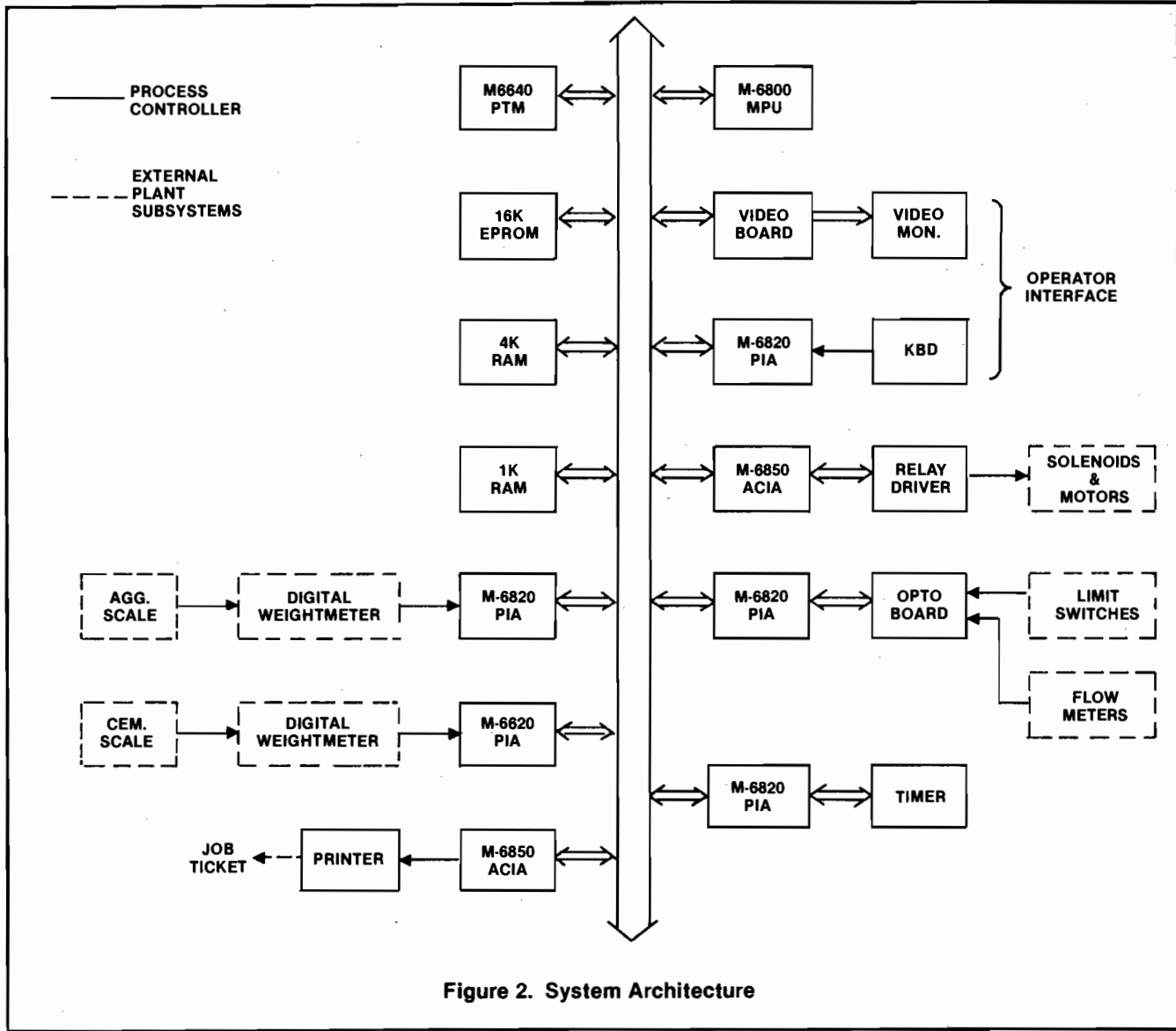


Figure 2. System Architecture

1. The GIMIX system is built to the highest quality commercial standards. This minimizes life cycle costs for the controller.
2. The GIMIX power supply offers the best overall AC line regulation for operation within the hostile industrial control environment.
3. The GIMIX relay driver board and opto board are ideally suited as the primary control system interface elements for this application.

The computer hardware configuration for the controller and its external interface is illustrated in Figure 2. The AC power switching to actuate plant functions is performed by the relay driver board. This unit receives computer initiated switching commands via the ACIA port and controls the switching of General Electric RR-8 relays. The various elements of the power relay array interface with solenoids for opening and closing of mechanical material inlet gates and with motors for controlling fluid pumps.

The opto board interfaces with external limit switches associated with mechanical gate openings and closures. This enables the AC switching subsystem to be closed loop in that failure to detect a gate opening or closure following a switching command, constitutes an external plant error condition. Upon detection of the error the system executes an error processing mode.

The scale subsystem components are Electroscale Inc. DR-525 digital weighmeters. Each of these interface with the processor via a PIA digital I/O port. During a weigh-in process, BCD representations of aggregate and cement weights are read into the system from these units.

Flow meters are used to measure the accumulated volume of fluid during admixture and water input process. These units measure volume delivered in terms of successive switch closures. The output of each flow meter is read into the processor through one port on the GIMIX opto board. This enables a special software routine to count the number of successive detected switch closures during an admixture input process. Hence, when the detected fluid volume reaches its target value, a shut off command is sent to the pump motor via the relay driver board.

Certain functions within the process require elapsed time measurement. The GIMIX programmable timer which resides on their eight-port PIA board was selected for this function. This enables software control of the timer and precise measurement of elapsed time.

The system also requires an accurate measurement and recording of the time of day at the completion of each batch cycle. This is performed very nicely by the M-6840 PTM which is on the GIMIX CPU board. The master control program resides on two 8K EPROM boards. This eliminates the necessity for floppy disk drives or tape drives which are susceptible to failure within this dusty industrial environment.

The system also uses 4K of volatile RAM for temporary storage of data values and scratch pad memory. In addition, it includes 1K of non-volatile RAM for permanent storage of mix design data.

Software Development

All software development was performed on a GIMIX system equipped with dual Smoke Signal Broadcasting mini floppy disk drives. The SSB external storage subsystem was selected for the inherent reliability of the floppy disk controller board. System software tools included GMXBUG, SSB DOS68.31, the SSB editor/assembler and the Microwave Systems Inc. ABASIC compiler.

All software components which handle interfaces with external subsystems were written in M-6800 assembly language. These include the relay driver and opto handlers, the digital weighmeter handler and the elapsed time controller. The main control program which handles operator I/O and controls the batching sequence was written in ABASIC. We selected the Microwave Systems ABASIC compiler for this application since it produces efficient machine code, which is readily adaptable to the EPROM environment. The use of this compiler was a major factor in the success of this project.

The system uses segments of GMXBUG for initialization and operator I/O. We performed minor modifications to GMXBUG in order to post special screen formats during system initialization.

We paid particular attention to the design of the display and operator interface segment of the software since the weigh batching system must be operated by personnel who are not familiar with computer operations. To achieve our design goal of having a simplified operator interface we chose a tree structured menu system which enables the operator to select a particular processing mode from a displayed menu of processing options. Also during the data input mode, the system displays all mix design parameters following operator key in of the data. This presents the operator with a summary of the data which he has entered into the system and enables him to make corrections before the system enters the autobatch mode.

System Integration and Testing

The weigh batching unit prototype hardware which is illustrated in Photo 1 has been installed in the Midstate Ready Mix Inc. plant in Oneida, New York. It has been successfully integrated with plant electro mechanical controls and has undergone extensive testing for the past several months. The test results show that the system is capable of holding cement batching tolerances within one percent of target weights over a target range from 600 to 10,000 pounds and aggregate tolerances within two percent of target weights over a target range from 1,000 to 30,000 pounds.

The unit also serves as a useful information system for the cement plant operator in the daily operations.

CONCLUSIONS

The success of this project demonstrates how a relatively expensive off-the-shelf microcomputer system can be structured to perform a set of real time process control functions in a difficult industrial control environment. Development of this controller was performed within the constraints of a low engineering budget. The key ingredients of this successful project were:

1. Application of good systems engineering and computer engineering techniques in the translation of detailed requirements into an efficient structure for the controller.
2. The selection of reliable computer hardware which can operate within this hostile industrial control environment.
3. The selection and judicious use of sound software development tools. □

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