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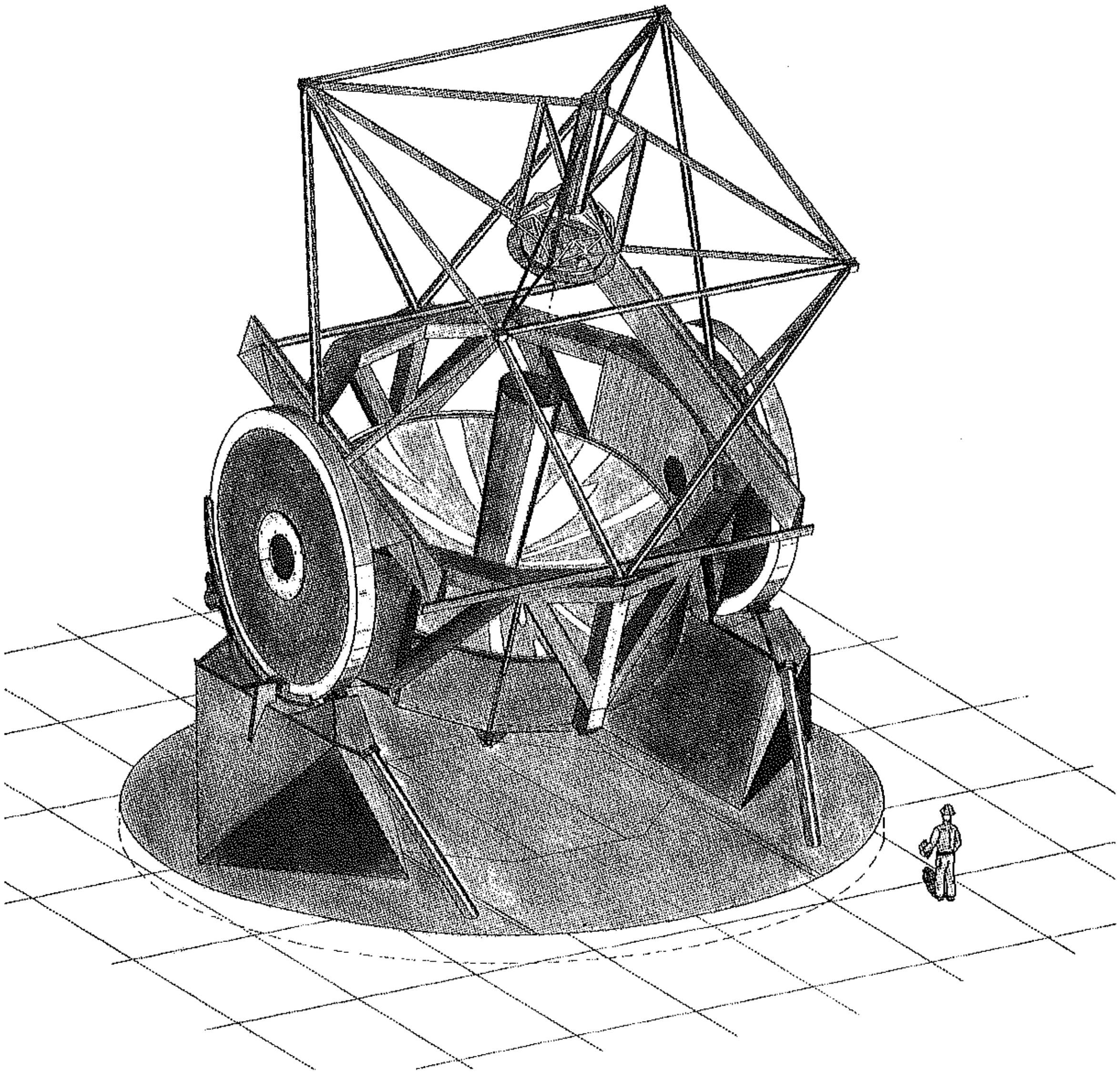

Evaluation of an Arcnet/8752 Based Communications System

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INTRODUCTION

Arcnet is a token-passing communications protocol that can be operated over a single twisted pair. It is a multiple-access, half-duplex system in that any node may transmit to any other node once it has the token. The system also allows any node to transmit to all other nodes at once, called broadcasting. Depending on the size of the network, the communication delays can be predicted to less than 20 milliseconds.

Arcnet has two particular features that contribute to its robustness. The first feature is its ability to regenerate the token in the event of a network crash. If the token is lost due to node failure or electrical interference, the network is automatically restarted within 61 milliseconds. If the failure was due to a dead node, that node is deleted from the map of the system. The second feature is error detection and automatic retransmission in the event of an error. This is accomplished without intervention from any host hardware.

This report covers the operation of a particular Arcnet test system that has been implemented in the Santa Barbara Street electronics lab. The system was built using a COM20020 Arcnet controller chip (Standard Microsystems Corp.) paired with an 8752 microcontroller to form a complete node. The bandwidth of the Arcnet itself is 2.5 megabits per second, although as the test results will show, the throughput at any one node is limited primarily by the speed of the 8752. As implemented, the system could operate over a distance of four miles at full bandwidth. The system also allows a node to be added or removed from the network without disturbing the operation of the other nodes for more than a 61 millisecond (or less) reconfiguration time.

DESCRIPTION OF THE TEST SYSTEM

Figure 1 shows a block diagram for the implemented nodes Arcnet and Figure 2 shows the schematic for a single node as used in the test system. A node consists of four chips: an Arcnet controller, an 8752 microcontroller, an EPLD with glue logic, and a differential transceiver to interface to the twisted pair. Assembled, the board is about 1.75"x3.25". It operates from a single 5 volt supply, and draws 265 ma. If we use the cmos equivalents of the microcontroller and EPLD, the total draw could comfortably be brought below 100 ma. By further allowing the microcontroller to idle in a low-power state and by using a low-power transceiver, the quiescent current for the system would be reduced below 55 ma.

The circuit has 16 bits of general purpose I/O and supports an RS-232 type serial port in addition to the Arcnet. Furthermore, one interrupt line and two counter/timer lines are available. The RS-232 port and one output line were used in the tests to monitor the system behavior. The other I/O lines were not used.

TEST SYSTEM RESULTS

A minimum network was set up with two nodes and was tested with two data transmission protocols. The first protocol involved one node first requesting data and the other node then transmitting the data (request/reply); the second protocol involved a simple one-way data transfer from one node to the other. For each of these two data transfer scenarios, the system was tested with data packets of 10, 100, 300, and 500 bytes. This served to demonstrate a range of performance from sending small bits of information such as commands to peripheral systems to sending larger collections of data from a remote system to a host.

Table 1 lists the effective data rates for the transfers described above. The rates are calculated by considering only the data of interest (i.e., the 10, 100, 300, or 500 bytes) and the total time for the transfer, including the time to request and set up the data. This is significant since the COM20020 chip must first be loaded with the data before transmission can begin. The calculated rates also reflect the fact that the 8752 requires some time to process a request. Tables 2 and 3 show the breakdowns of the request, set up, and transmission times for the two types of exchanges.

Table 1
Effective Data Rates

No. of Bytes	Request/Reply	One-Way Transfer
10	16.3 kbps	180 kbps
100	150 kbps	1.01 Mbps
300	382 kbps	1.37 Mbps
500	557 kbps	1.55 Mbps

Table 2
Timing Breakdown, Request/Reply

	Number of Data Bytes			
	10	100	300	500
Setup Request (uC)	1430 us	1430 us	1430 us	1440 us
Transmit Request (A)	173 us	222 us	207 us	218 us
Process Request (uC)	2870 us	2870 us	2870 us	2870 us
Setup Reply Data (uC)	160 us	165 us	210 us	210 us
Transmit Reply Data (A)	273 us	658 us	1560 us	2440 us
Total Time	4910 us	5350 us	6280 us	7180 us

(uC) indicates times attributable to the 8752 microcontroller.
(A) indicates times attributable to the Arcnet.

Table 3
Timing Breakdown, One-Way Transfer

	Number of Data Bytes			
	10	100	300	500
Setup Data (uC)	160 us	160 us	210 us	205 us
Transmit Data (A)	283 us	633 us	1540 us	2370 us
Total Time	443 us	793 us	1750 us	2580 us

(uC) indicates times attributable to the 8752 microcontroller.
(A) indicates times attributable to the Arcnet.

The overall results indicate that the 8752 is the main bottleneck in most of the transfers. Only in the cases of the one-way data transfers with the larger packets did the delay due to the 8752 become less than half of the Arcnet transmission time. In the cases involving the data requests, the time taken by the 8752 was typically about two to ten times the active transmission time. The resulting effective data rates range over nearly a factor of 100 from 16.3 kilobits to 1.55 megabits per second, depending on the size of the transmitted data packet and whether or not the data was in reply to a request.

Even under the most charitable calculations, the network never reaches the advertised "data" rate of 2.5 megabits per second. There are several reasons for this, starting with the fact that each byte is really transmitted as 11 bits: eight data, two start, and one stop bit. The transmission of a byte of data therefore requires 4.4 microseconds. Moreover, based on the measured times it appears that there are about 50 bytes of overhead in each transmission. This is more than the 20 or so bytes suggested by the manufacturer's data sheet, and is of course most acutely felt with the shorter packets.

The results also show some timing differences between the two communications scenarios. In particular, when transmitting 500 bytes the measured times for the request/reply and one-way cases require 2440 and 2370 microseconds, respectively. In principle, it may seem that these two times (and several others) should be the same. In practice, the differences are probably due to the fact that a node must wait a variable time for the token before transmitting.

SUITABLE AREAS OF APPLICATION

As guidelines for system design, the timing results indicate that the type of exchange and size of the transmitted data need to be carefully considered. This is especially true when estimating the effective communication speed between two individual nodes. These results do not however imply a corresponding slowdown in the overall network performance; during "slow" transmissions, the network is to a large extent idle and is available for communications between other nodes. Even if point to point transmissions are effectively operating in the kilobit per second range, the network with all its nodes may effectively operate at megabits per second.

Broadly speaking then, the Arcnet is well suited for communications applications where moderate (tens to hundreds of kilobits per second) data rates are required. It is especially suited for decentralized communications where nodes on a network must talk to each other more or less at random. Such decentralized systems are further facilitated by the fact that nodes may be added or removed from the network without necessarily affecting the operation of the rest of the system (except for the reconfiguration time).

The overall advantages of the Arcnet as implemented with the COM20020 chip appear to be the following:

> --Transparent operation. All the details of data formatting, handshaking, error checking, and retransmission in the event of an error are handled by the COM20020.
>
> --Asynchronous operation. Any node may talk to any other as long as it has the token.

--Long range. The network transmission medium can be up to 4 miles long.

--Cheap and simple transmission medium. Arcnet can be run at full bandwidth on a twisted pair.

--Simple, compact construction and interface. As demonstrated in the test system, a complete node can be rather small, and the hardware and software interfacing is relatively simple.

--Easily expandable. Adding a node to a network amounts to simply splicing a connector into the existing transmission wires. Bridging to other networks including Ethernet can be done with commercially available buffer/translators.

--The system is "semi-deterministic" in that one can guarantee that a node will have the opportunity to transmit within a predetermined time even with the network fully loaded. This contrasts with other multiple access systems in which the transmission delays are impossible to predict and can become unmanageable on heavily loaded networks.

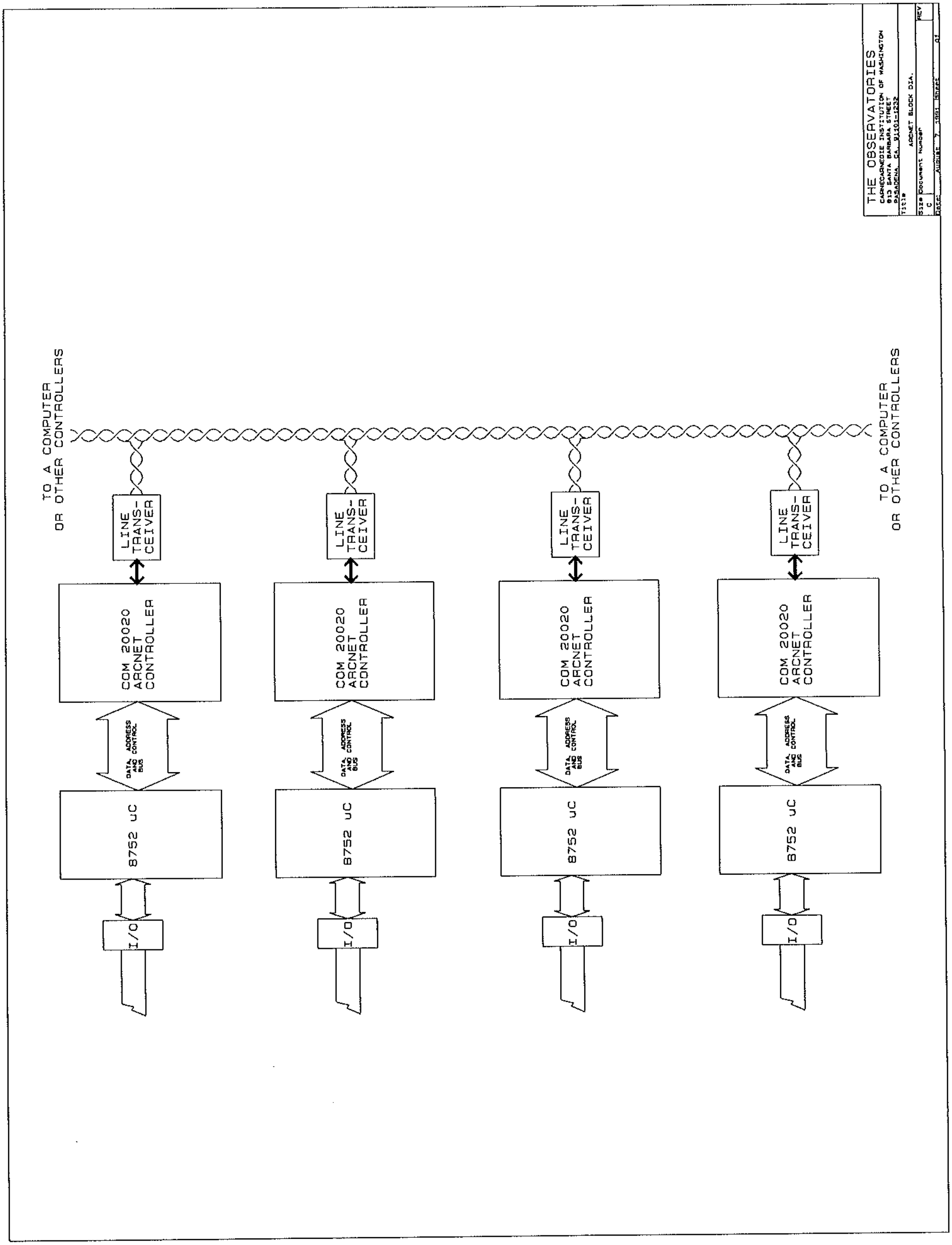
CONCLUSIONS

Arcnet as implemented for this investigation is a good technical solution for perhaps 90% of the control needs for a telescope. For applications where very high speed is not an issue (dome control, temperature monitoring, engineering data logging, etc.), Arcnet is certainly fast enough even when coupled with an 8752 microcontroller.

Arcnet's current lack of commercial support is perhaps its most significant disadvantage. Cards which fit into a variety of computer busses to talk on an Arcnet are commercially available, as are bridges to other networks; however integrated I/O modules (digital, analog, power, etc.) do not appear to be readily available.

Arcnet's moderate speed is perhaps also a drawback, but is probably not a serious one. We anticipate that, in any event, the telescope environment will have two networks: one being considerably faster--and very likely more involved--than the other. Arcnet could fill the need for the simpler network.

Figure 1



TO A COMPUTER OR OTHER CONTROLLERS
LINE TRANS-CEIVER
COM 20020 ARCNET CONTROLLER
DATA, ADDRESS AND CONTROL BUS
8752 uC
I/O
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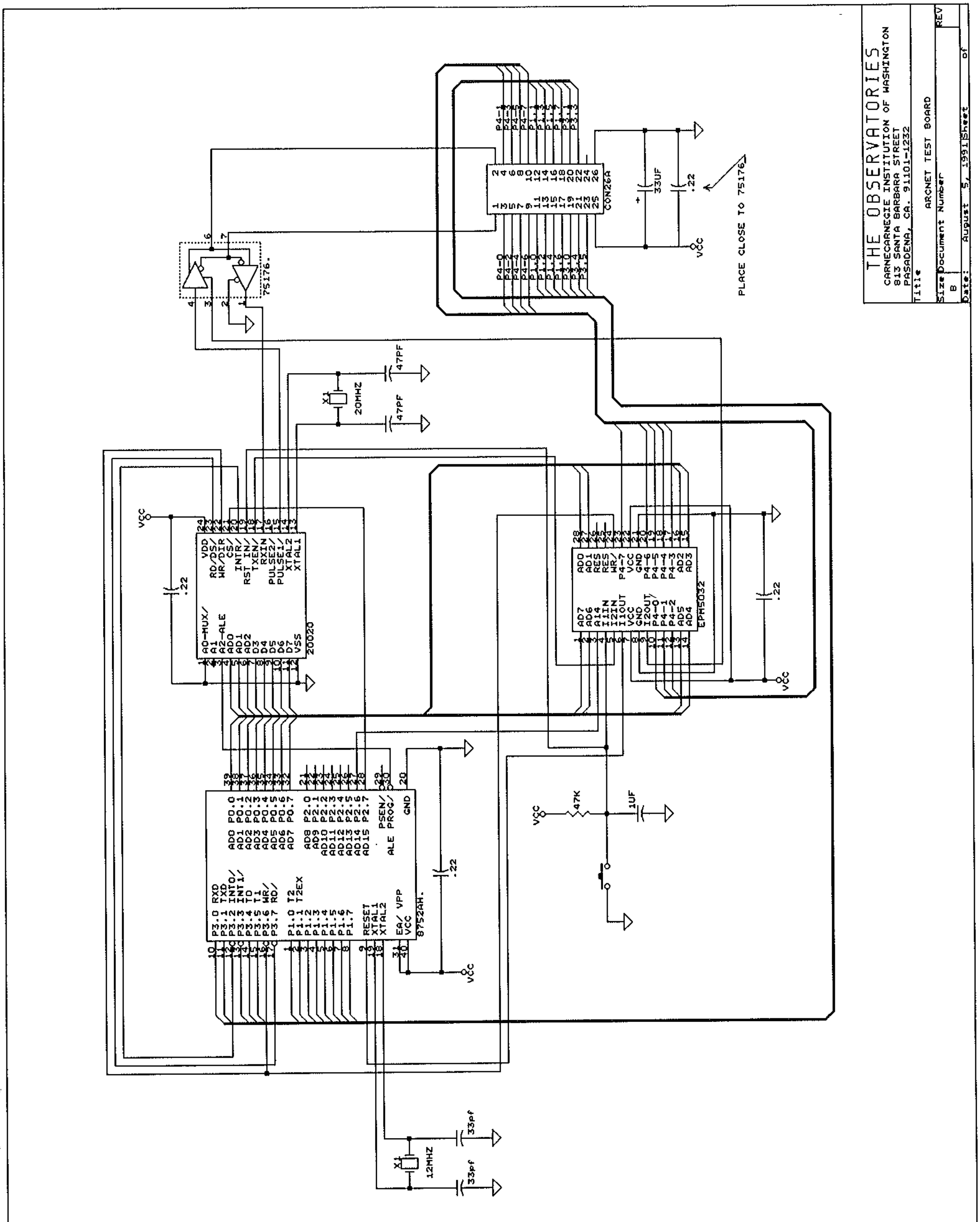
THE OBSERVATORIES
ARCNET BLOCK DIA.

Figure 2


THE OBSERVATORIES
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