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QUARTERLY REPORTS FOR RS-600 PROGRAMMABLE CONTROLLER - SOLAR HEATING AND COOLING

Prepared by

Rho Sigma
11922 Valeria Street
North Hollywood, California 91605

Under Contract NAS8-32256 with

National Aeronautics and Space Administration
George C. Marshall Space Flight Center, Alabama 35812

For the U. S. Department of Energy
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RHO SIGMA, INC.

Contract NAS8-32256

First Quarterly Report (DRL-10)

February 1, 1977
December 7, 1976

TO: James D. Hankins
FROM: Joseph L. Imholte
Rho Sigma, Inc.
SUBJECT: Monthly Status Report

CONTRACT: NAS8-32256 Month Ending 30 November 1976

1. TECHNICAL PERFORMANCE

During the month ending 30 November 1976, Rho Sigma completed the preliminary research for the design of the microprocessor control subsystem. An industry survey was conducted for the requirements to be met by a microprocessor controller. Meetings were held with other companies in the solar industry and discussed their needs and requirements for the future. This industry survey is discussed further in Section IV.

A study was also started on the microprocessor field to enable Rho Sigma to best determine the type of microprocessor to be used which will allow the greatest system flexibility and still be competitive with the remainder of the industries.

Rho Sigma has completed their preliminary table of specifications for the controller and has an initial block diagram matching the requirements as determined by the above study.

cc: McMurray
II. Schedule:

Enclosure A shows, via bar chart, the progress Rho Sigma has made toward the completion of the contract. The requirement study is complete and work on the microprocessor study is nearing completion. The preliminary work on the system specification and block diagram is also complete.

III. Cost:

This item has been deleted.

IV. Industry Survey:

During the course of this reporting period a number of industrial organizations were contacted to discuss requirements for advanced control systems. These organizations included:

IBM, Huntsville, Alabama  
Westinghouse, Baltimore, Maryland  
General Electric, King of Prussia, Pennsylvania  
A.O. Smith Company, Kankakee, Illinois  
TRW Systems, Los Angeles, California  
Solaron, Inc., Denver, Colorado

From these discussions several aspects of control systems requirements became apparent. One of the major problems with current controls results from the use of "two-stage" thermostats. This type of thermostat turns on the solar heat when a demand is present. If the room temperature continues to drop, indicating insufficient solar heat capacity available, the second stage cuts in generally about 2°F difference, turning on the back-up system. The problem arises when the thermostat is "set-back" at night time, and the house cools to a relatively low temperature (60-63°F). In the morning, the
thermostat is manually advanced to 70°F. Since the thermodynamic lag of
the house is long, the difference between the instantaneous thermostat
setting is 70°F - 63°F = 7°F. Hence, even if adequate solar energy is in
storage, the back-up heater is energized to raise the room temperature.

Another key point that became apparent is the increasing use of air systems.
All of the major companies visited were using air for one or more applications.
In many of the designs currently on the drawing board, the air systems need
proportional position control of dampers. This will require servo-feedback
loops under operation of the controller.

A summary of the characteristics which are currently believed to be representa-
tive of needs are given in the matrix below:

\[
\begin{array}{|c|c|c|c|}
\hline
\text{INPUTS} & \text{#} & \text{CHARACTERISTICS} & \text{OUTPUTS} & \text{#} & \text{CHARACTERISTICS} \\
\hline
\text{Analog} & 16 & \text{mv D.C.} & \text{Servo} & 4 & 0 \pm 24 \text{ VAC} \\
\text{Switch} & 12 & 0-24V AC/DC & \text{Switch Closures} & 8 & 0-10 \text{ AMPS/110VAC} \\
\text{Closures} & 1 & (\text{Internal}) & 110VA & 4 & 0-20 \text{ AMPS/24VAC} \\
\text{Time} & 1 & \text{Digital} & \text{Pulse} & 4 & 0-10kc \\
\text{Trains} & & \text{Time Display} & (\text{Plug-In}) & 1 & \text{Visual (Sonic)} \\
& & & \text{Proportional} & 4 & 110VAC @ 10 \text{ AMPS} \\
\hline
\end{array}
\]
Most of the companies interviewed had little or no idea of what the control needs would be for advanced solar systems that incorporated air conditioning (refrigeration) and energy conservation techniques in an integrated package. The characteristics shown on page three must be treated as tentative and will be refined over the course of this work.
January 10, 1977

TO:     James D. Hankins
FROM:   Joseph L. Imholte
SUBJECT: Monthly Status Report
CONTRACT: NAS8-32256
PERIOD:  Month Ending 31 December 1976

TECHNICAL PERFORMANCE

1. During the month ending 31 December 1976, Rho Sigma completed the system specification and the microprocessor study for the Model 600 microprocessor controller. Rho Sigma is presently negotiating with a subcontractor for the hardware necessary for the controller.

The data required for the preliminary design review was delivered along with additional data to better describe Rho Sigma’s approach to the contract.

SCHEDULE

II. Enclosure A shows, via a bar chart, the progress Rho Sigma has made toward the completion of the contract. No schedule problems are foreseen at this time.

COST

III. This item has been deleted.
February 4, 1977

TO: James D. Hankins
FROM: Joseph L. Imholte
SUBJECT: Monthly Status Report

CONTRACT: NAS8-32256
PERIOD: Month Ending 31 January 1977

1. TECHNICAL PERFORMANCE

During the month ending 31 January 1977, Rho Sigma has completed negotiations with a subcontractor to design and build the necessary circuit boards to be used in the Model 600 microprocessor controller.

The preliminary design review was also completed at Rho Sigma's facility in Van Nuys, California.

Fairchild Instrumentation in San Jose, California has been given a purchase order to design the F8 based microprocessor. The contract with Fairchild will enable Rho Sigma to expand an existing system into a solar controller. This approach will allow for the final production units to be produced at a competitive price. A copy of the Fairchild proposal and Rho Sigma's purchase order is enclosed.

The preliminary design review was attended by:

Robert J. Schlesinger - Rho Sigma
Ed S. Feltzman - Rho Sigma
James D. Hankins - NASA
Ken Rinaldo - Fairchild
Dominic Norcia - Fairchild

II. SCHEDULE

The enclosed Bar Chart has been modified to encompass Fairchild's delivery date along with Rho Sigma's task.
### Voltmeters

<table>
<thead>
<tr>
<th>Full Scale Range</th>
<th>Resolution</th>
<th>Impedance (Megaohms)</th>
<th>Bias Current TYP MAX</th>
<th>Overvoltage Protection VDC VRMS</th>
</tr>
</thead>
<tbody>
<tr>
<td>±1.9999V</td>
<td>±100 V</td>
<td>&gt;1000</td>
<td>2.5mA 7.5mA</td>
<td>200 240</td>
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<tr>
<td>±19.999V</td>
<td>±10.045V</td>
<td>100</td>
<td>250pA 750pA</td>
<td>500 350</td>
</tr>
<tr>
<td>±199.99V</td>
<td>±10.03V</td>
<td>100</td>
<td>250pA 750pA</td>
<td>500 350</td>
</tr>
</tbody>
</table>

### ANALOG INPUT

- **Configuration**: Instrumentation type floating differential or single ended input.
- **Ratiometric Operation**: With external reference, or comparison voltage
- **Common Mode Voltage**
  - AC Powered Models: 600 V between input and earth ground
  - DC Powered Models: 1 Volt P-P between input and ground
- **Common Mode Rejection** (With 1k Source Imbalance)
  - AC Powered Models: 50 to 60Hz, slight rolloff above 60Hz
  - DC Powered Models: 50 to 60Hz, slight rolloff above 60Hz
- **Normal Mode Rejection**: 30dB @ 50Hz; 32dB @ 60Hz; -6dB/octave thereafter.
- **Overvoltage Protection**: Max. input without damage - see table above.

### PERFORMANCE

- **Accuracy (120 days)**: ±0.02% of reading ±1 digit
- **Linearity**: ±0.005%
- **Max Temperature Coefficient**
  - (0°C to +55°C)
    - of full scale: 30 ppm/°C
    - of zero: ±0.005% F.S./°C
- **Setting Time**: 900msec to 0.1% error from a (+) or (−) F.S. step input
  - Higher filtering for increased NMR or reduced setting time is available; contact factory.

### DISPLAY

- **Type**: 7-segment planar solid state (LED): 0.5 in (1.27 cm) high numerals, readable at 30 ft.
- **Polarity Indication**: Automatic (+) or (−) symbol
- **Overload Indication**: "1" digit flashes when count exceeds 19999
- **External Hold**: Last conversion is held and displayed when EXT HOLD is maintained at logic "0". Reverts to internal trigger control when EXT HOLD input is open.
- **Decimal Point**: 3 position selectable (PC card models can be externally programmed)

### ENVIRONMENT/POWER REQUIREMENTS

- **Temperature Range**
  - Operating: 0°C to +55°C
  - Non-operating: -40°C to +85°C
- **Relative Humidity**: 0 to 85% (non-condensing)
- **Input Voltage**: See Table 1-1
- **Power**: 3.0watts (typ)
CONVERSION CHARACTERISTICS

Conversion Time
Target (Read) Rate
50 msec
Approx. 1/second (factory set)

DIGITAL OUTPUTS

NCD parallel (optional)
NCD bit serial (standard)
18 lines, 4 TTL loads (positive true)
1 count/2.2 sec, count window signal provided, 1 TTL load each
Print
Logic "0", 1 TTL load
Polarity
Logic "0" indicates +, 4 TTL loads
Overrange
Logic "1", 4 TTL loads
NCD Rating Connector
P/N FS 9740C-49, Amphenol 225-21521-101-117 or equiv.

PHYSICAL CHARACTERISTICS

Termination
15-pin dual row connector or 8-pin terminal strip
Input Rating Connector
P/N FS 9740C-49, Amphenol 225-21521-101-117 or equiv.
DIM (Standard)
Size (panel cutout)
1.772 in. (45 mm) x 3.622 in. (92 mm)
Max. depth behind bezel
3.8" (96.5 mm)
Terminal block
3.7" (94 mm)
Weight
14.5 oz. (411 grams) max
Case Construction
Molded A.E.S. meets UL 94-V-0
Calibration
Front access.

RELIABILITY PROTECTION

Warranty
18 months
Burn-in/Temp. Cycling
100 hrs. at 55°C w/pwr. and temp. on/off cycles.

MODEL NUMBERING

54 □ □ □ □

Case/Digits Type
54=4-1/2 0=Volt
(1/2" LED) Meter
Range Input Voltage Options
2=100/115Vac +10%
5=2V/mA 47-63Hz
7=20V/mA +10%
9=200V/ma 5=SVDC
5=SVDC 2.25V
0=PC card
Terminals
1=BCD
2=BCD
(600V opto isolated)
Strip
POOR QUALITY

[Signature] 1-20-77

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△ PERFORMED BY SUBCONTRACTOR

Model 600 Microprocessor
March 4, 1977

TO: James D. Hankins
FROM: J.L. Imholte
SUBJECT: Monthly Status Report
CONTRACT: NAS8-32256
PERIOD: Month Ending 28 February 1977

I. TECHNICAL PERFORMANCE

During the month ending 28 February, 1977, Rho Sigma conducted the design review with its sub-contractor, Fairchild Instrumentation. Rho Sigma also completed the preliminary software package and began the flow charts necessary for programming the F-8 microprocessor.

The design review was held with Fairchild Instrumentation at their Chatsworth, CA plant. Fairchild committed themselves to the specifications of the preliminary review with no exceptions. Fairchild has started charging hours to the packaging of the card cage and individual printed circuit board.

The design review with Fairchild was attended by:
- Robert J Schlesinger - Rho Sigma, Inc.
- Joseph L Imholte - Rho Sigma, Inc.
- Ken Rinaldo - Fairchild Instrumentation

Rho Sigma, Inc. has written a preliminary program specification which was reviewed with Fairchild Instrumentation at the above meeting. The necessary program block diagram and a total program flow diagram are being worked on by Rho Sigma at this time.

II. SCHEDULE

The enclosed bar chart shows the status of key events. As of this time the actual progress to making the predicted. The prototype design date was rescheduled from the middle of May to the middle of March.

III. COST

This section has been deleted.
II  SCHEDULE

The enclosed bar chart shows the status of key events. The prototype design date is now scheduled for 28 April, 1977.

III  COST

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<table>
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△ PERFORMED BY SUBCONTRACTOR
April 7, 1977

TO: James D. Hankins
FROM: J. L. Imholte
SUBJECT: Monthly Status Report
CONTRACT: NAS8-32256
PERIOD: Month Ending 31 March, 1977

I TECHNICAL PERFORMANCE

During the month of March, 1977, Rho Sigma met with NASA and IBM and conducted a "preliminary" prototype design review. Rho Sigma's subcontractor, Fairchild, has built the breadboard and begun the P.C. board card design. Rho Sigma has completed the preliminary programming flow charts.

The review held in Huntsville, Alabama was attended by:

James D. Hankins            MSFC
James R. Currie            MSFC
Paul Hamby            MSFC
T. N. Vann            MSFC
Thevis Barton            IBM
W. W. Scott            IBM
B. J. Doran            MSFC
R. J. Lewedag            MSFC
J. L. Imholte            Rho Sigma
R. J. Schlesinger            Rho Sigma

Although the necessary data was not available for the prototype design review; the system was reviewed and questions answered. The official prototype review will be held at Rho Sigma's plant in Van Nuys, California on 28 April 1977.

Fairchild Systems has been contacted and they are on schedule and will provide the necessary documentation for the prototype review.

The preliminary flow charts for the RS 600 program are finished and will be reviewed with Fairchild.
RHO SIGMA, INC.

Contract NAS8-32256

Third Quarterly Report (DRL-10)

August 1, 1977
May 9, 1977

TO: James D. Hankins
FROM: J.L. Imholte
SUBJECT: Monthly Status Report
CONTRACT: NAS8-32256
PERIOD: Month Ending 30 April, 1977

I. TECHNICAL PERFORMANCE

During the month of April, 1977, Rho Sigma held the Prototype Design Review at its Van Nuys Plant, delivered the finalized programming specifications and flow charts and reviewed the system with Fairchild.

The Prototype Design Review was conducted at Rho Sigma's Van Nuys, CA, plant. The review was attended by:

James D. Hankins MSFC
E. S. Pletzman Rho Sigma
Joseph L Imholte Rho Sigma
David W. Corbin Fairchild

The review covered the data package sent to NASA and all of the RID's resulting. Both Fairchild and Rho Sigma were aware of the RID's and appropriate action is being taken.

A new date was set for the first article review. It will now be held at Rho Sigma on 13 July, 1977.

Rho Sigma held a system design review with its subcontractor, Fairchild. The finalized program specifications and flow charts, minus the exact system equations were accepted by Fairchild. Details on the display and packaging were also discussed with the design to be fixed at a later date.
2. **SCHEDULE**

The enclosed Bar Chart shows the status of key events. The **First Article Review** is now rescheduled for 13 July, 1977.

3. **COST**

This item has been deleted.
<table>
<thead>
<tr>
<th>Support Task</th>
<th>Oct</th>
<th>Nov</th>
<th>Dec</th>
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**Progress Schedule**

Model: 600 Mk
TO: James D. Hankins  
FROM: J.L. Imholte  
SUBJECT: Monthly Status Report  
CONTRACT: NAS8-32256  
PERIOD: Month Ending 31 May 1977

I. TECHNICAL PERFORMANCE

During the month of May, 1977, Rho Sigma received the RID's from the prototype design review and completed the necessary documents to satisfy the RID's.

Fairchild, the subcontractor has completed 80% of the hardware and 80% of the program for the Microprocessor necessary to operate the RS 600.

II. SCHEDULE

The enclosed bar chart shows the status of key events.

II. CONCLUSION

This item has been deleted.
July 13, 1977

TO: James D. Hankins
FROM: J.L. Imholte
SUBJECT: Monthly Status Report
CONTRACT: NAS8-32256
PERIOD: Month Ending 30 June, 1977

I. TECHNICAL PERFORMANCE

Rho Sigma reviewed the RS 600 with Fairchild during this reporting period. The first unit is undergoing program check out. The hardware is operational and the software is approximately 90% operational. Rho Sigma is scheduled to take acceptance of the first unit on 18 July, 1977 and should be ready for the first article review on 4 August, 1977.

No major problems were encountered during the review and the system operations via the keyboard was exercised and noted so that work can continue on the operations manual.

II. SCHEDULE

The enclosed bar chart shows the schedule and status of key events.

III. COST

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**Progress Schedule**