GEORGIA INSTITUTE OF TECHNOLOGY — OFFICE OF CONTRACT ADMINISTRATION

# PROJECT ADMINISTRATION DATA SHEET

[x] ORIGINAL [ ] REVISION NO. ____

Project No. A-3486 GTRI/~~GIT~~ DATE 3/10/83

Project Director: N.C. Currie ~~School~~/Lab RAIL

Sponsor: McMaster University, Hamilton, Ontario, Canada

Type Agreement: Research Agreement A-3486, dated 2/25/83

Award Period: From 2/25/83 To 5/11/83 (Performance) --- (Reports)

Sponsor Amount: Total Estimated: $ 31,948 Funded: $ 31,948

Cost Sharing Amount: $ None Cost Sharing No: N/A

Title: X-Band Coherent Radar Support

## ADMINISTRATIVE DATA

OCA Contact William F. Brown Ext. 4820

1) Sponsor Technical Contact:

2) Sponsor Admin/Contractual Matters:

Dr. Alan C. Frosst, Asst. Vice-President
Research Services
McMaster University
1280 Main Street West
Hamilton, Ontario, L8S 4L8
(416) 525-9140

Defense Priority Rating: N/A

Military Security Classification: N/A
(or) Company/Industrial Proprietary: N/A

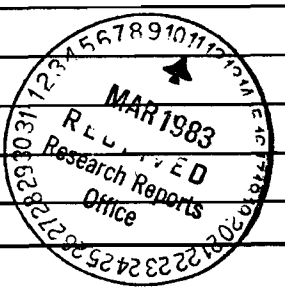
## RESTRICTIONS

See Attached --- Supplemental Information Sheet for Additional Requirements.

Travel: Foreign travel must have prior approval – Contact OCA in each case. Domestic travel requires sponsor approval where total will exceed greater of $500 or 125% of approved proposal budget category.

Equipment: Title vests with None proposed

## COMMENTS:

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GEORGIA INSTITUTE OF TECHNOLOGY OFFICE OF CONTRACT ADMINISTRATION

# SPONSORED PROJECT TERMINATION SHEET

Date 7/20/83

Project Title: X-Band Coherent Radar Support

Project No: A-3486

Project Director: N. C. Currie

Sponsor: McMaster University, Hamilton, Ontario, Canada

Effective Termination Date: 5/11/83

Clearance of Accounting Charges: 5/11/83

Grant/Contract Closeout Actions Remaining:

- [x] Final Invoice and Closing Documents
- [ ] Final Fiscal Report
- [ ] Final Report of Inventions
- [ ] Govt. Property Inventory & Related Certificate
- [ ] Classified Material Certificate
- [ ] Other _____

Assigned to: RAIL-IMD (School/Laboratory)

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FORM OCA 10:781

ENGINEERING EXPERIMENT STATION
Georgia Institute of Technology
A Unit of the University System of Georgia
Atlanta, Georgia 30332

21 April 1983

McMaster University
Office of Research Services
1280 Main Street West
Hamilton, Ontario L85 4L8

Attention: Mr. Brian Currie

Reference: Subcontract A-3486 on Prime Contract OSE 82-00241

Subject: Interim Letter Report on Project A-3486 Covering the Period 25 February 1983 to 31 March 1983

Gentlemen:

This interim letter report covers the technical efforts and status of work performed under the referenced contract. The period of performance is February 25 through March 31, 1983.

## Technical Efforts

The primary technical efforts on the contract during the performance period centered on assembling the coherent X-band radar. A revised block diagram was completed for the radar which is shown in Figure 1. This revised system includes the ability to calibrate the receiver amplitude by either injection of a microwave test signal or by illuminating a calibrated radar target and the ability to calibrate the phase by illumination of a steady radar target and varying the phase shifter in the transmitter line from $0^{o}$ to $360^{o}$.

Mr. Larry Briddle visited Georgia Tech on March 1, 1983 to "iron out" final details on the interfaces between Georgia Tech provided equipment and McMaster University or Canadian government provided equipment. A decision was made not to attempt to directly interface the McMaster digital recorder to the Georgia Tech NOVA computer because of the complexity of the interface and the short time to prepare for the field trip. However, it may be feasible to interface the two systems through an analog interface. Georgia Tech will provide the capability for digitizing analog data from three sources: 1) any of the on-site radars, 2) the Canadian government wide band video recorder, and 3) FM narrow band tape recorder.

As of March 31, 1983 all of the components for the coherent X-band radar have been obtained except the phase locked CW source which is due to be delivered in mid-April; however the manufacturer has advised that the delivery data has been slipped to mid-May. An X-band gun oscillator will be used as the source pending receipt of the phase locked source. Waveguide parts have been ordered and delivery is expected in mid-April. The final assembly of the coherent radar has begun, but has not been completed.

**Plans for the Next Reporting Period**

During the next reporting period, the X-band radar will be completed and checked out. The radar and equipment will be shipped to Hamilton, and the field crew will depart for Hamilton.

**Financial Status**

Expenditures on the contract as of March 31, 1983 totaled $10,246 leaving $21,701 in the contract. Expenditures will increase dramatically during April and it is expected that expenditures will total $17,000 next month.

Respectfully submitted,

E. Martin
Project Director

Approved:

Nicholas C. Currie
Chief, Instrumentation and Measurements Division
Radar and Instrumentation Laboratory

Attachment - Figure 1

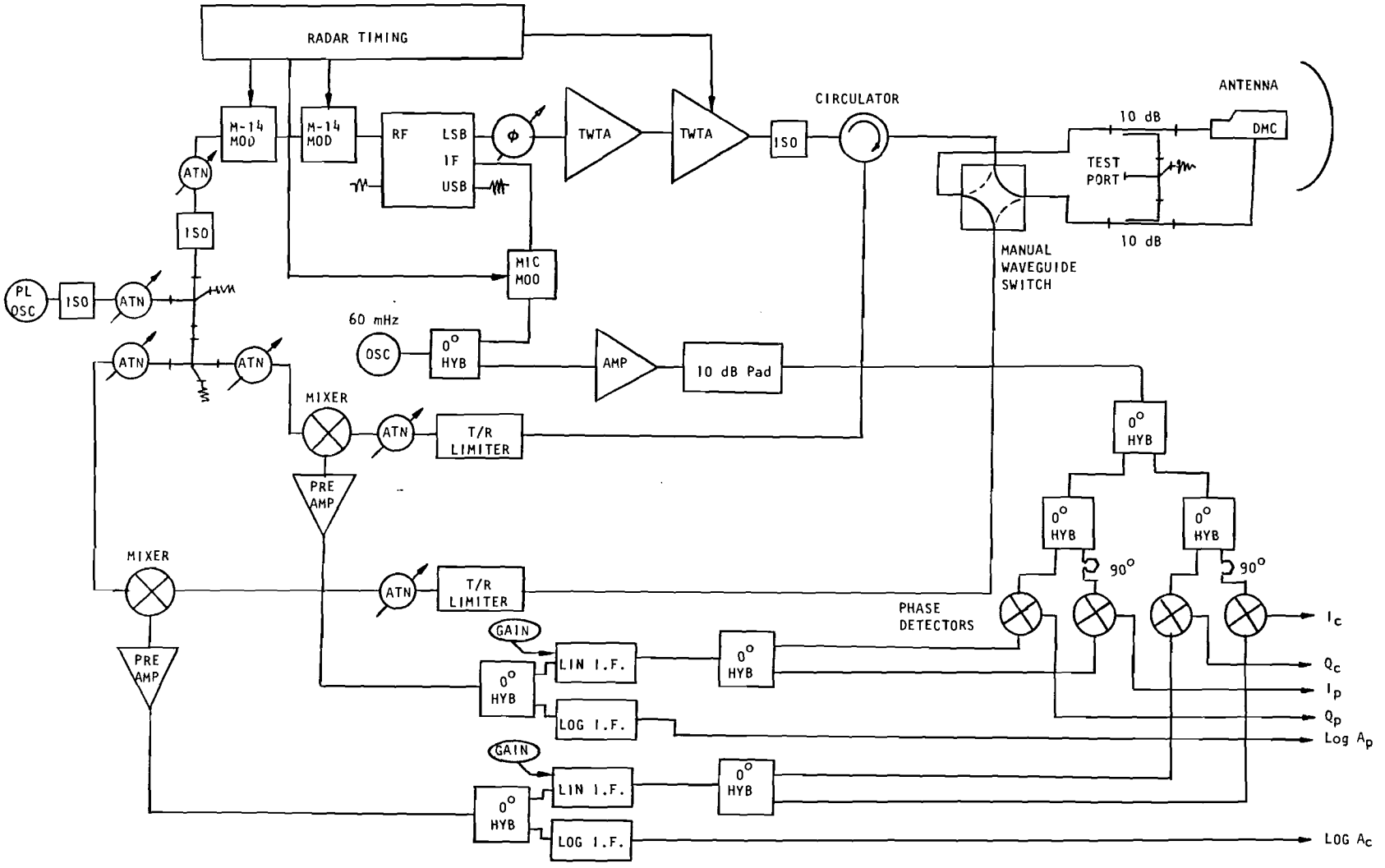


Figure 1. X-Band Coherent Radar

A-3485

ENGINEERING EXPERIMENT STATION
Georgia Institute of Technology
A Unit of the University System of Georgia
Atlanta, Georgia 30332

29 June 1983

McMaster University
Office of Research Services
1280 Main STreet West
Hamilton, Ontario L8S 4L8

Attention: Mr. Brian Currie

Reference: Research Agreement for "X-Band Coherent Radar Support" GTRI Project No. A-3486

Subject: Final Report on Project A-3486 Covering the Period 25 February 1983 to 11 May 1983

Gentlemen:

The Georgia Institute of Technology, under contract with McMaster University, designed and assembled an X-band coherent instrumentation radar to be used for collecting amplitude and phase reflectivity data from sea ice. The system was shipped on 22 April 1983 to a field site at Baffin Island, Canada. Additional radars and the services of research personnel for operating the radars and data collection system were supplied under a separate contract with the Canadian Department of Fisheries and Oceans. This final report covers the work completed under the referenced research agreement with McMaster University.

## Radar Design

The purpose of the measurements under the prime contract with the Canadian Department of Fisheries and Oceans was to provide radar data which would possibly lead to the development of algorithms to discriminate between different types of ice. While the amplitude of the radar return signal provides useful information, the amplitude alone is usually not adequate for target discrimination. For this reason the full polarization scattering matrix was desired. The components which make up the polarization matrix can be measured with a dual polarized coherent radar. A radar for this purpose must be capable of transmitting orthogonal polarizations and detecting both the phase and amplitude of the parallel and cross polarized components of the received signal. A description of the coherent radar which was assembled at Georgia Tech for collecting the required data is given below.

## Transmitter

The transmitter used in the radar is a master oscillator power amplifier (MOPA) design using two traveling wave tube amplifiers (TWTA) to boost a low level signal to a final transmitted peak power of 1000 watts. The master oscillator is a Gunn diode microwave source and is used as the r.f. drive for a sideband generator and as the local oscillator for the receiver. The sideband generator produces output signals equal to the sum and difference of the r.f. and i.f. frequencies. The sum and difference frequencies (upper and lower sidebands) are available on separate output connectors. The lower sideband (difference frequency) was selected as the signal to be amplified by the amplifier chain. A precision calibrated phase shifter connected between the sideband generator and the first TWTA provides a known phase relationship for calibrating the I and Q channels in the receiver. The first TWTA provides a small signal gain of approximately 40 dB and will deliver 1 watt of power at its output. The second amplifier is a pulse modulated TWTA and provides an additional gain of 30 dB.

The output from the high power TWTA is connected to the antenna through a common transmit-receive waveguide section. This common waveguide section includes the following components: 1) a circulator to provide isolation between the receiver and transmitter, 2) a manual waveguide switch to change the polarization of the transmitted signal and 3) two 10 dB directional couplers for monitoring the transmitted power and for injecting a known signal level for receiver calibration. A 3 foot paraboloidal dish, fed with a dual polarized linear feed was used as the radar antenna.

## Receiver

The radar has dual channel superheterodyne receivers for detection of the reflected radar signals. Precision variable attenuators are included in the r.f. signal paths to generate a step calibration of each receiver channel. The received r.f. signals are converted to a 60 MHz i.f. frequency in balanced mixers and amplified through low noise preamplifiers. The master oscillator serves as the local oscillator input to the mixers. The i.f. outputs from the preamplifiers are equally divided and fed to linear and logarithmic amplifiers. The outputs from the linear i.f. amplifiers are used to develop the I and Q signal channels and the outputs from the logarithmic amplifiers provide a 60 dB dynamic range video amplitude signal. The I and Q outputs represent the coherent radar scattering matrix terms. The signals at the output of the I and Q channels are: $E_H$ Sin $\phi$, $E_H$ Cos $\phi$, $E_V$ Sin $\phi$ and $E_V$ Cos $\phi$. A list of the radar system parameters is shown in Table 1. Figure 1 is a block diagram of the system that was shipped to the Baffin Island field site.

## System Performance

The radar system was tested at the Georgia Tech Cobb County Research Facility prior to shipment. The measured peak transmitted power was 1025 watts and the tangential sensitivity was measured and found to be -81 dBm. Tangential sensitivity is subjective measure but usually gives reasonable results. Based on this measurement, the radar's minimum detectable signal (MDS) was -89 dBm. The system performance was calculated from the radar range equation and resulted in a predicted maximum range for

TABLE 1
X-BAND COHERENT RADAR PARAMETERS

| | |
|---|---|
| **Antenna:** | |
| Type | 3 ft Paraboloid |
| Feed | Linear |
| Polarization | Horizontal and Vertical |
| Gain | 37 dB |
| **Transmitter:** | |
| Type | TWT-MOPA |
| Power | 1 kW |
| Pulse Length | 200 ns |
| Frequency | 9.4 GHz |
| PRF | 0-5 kHz |
| **Receiver:** | |
| Type | Superheterodyne |
| System Bandwidth | 20 MHz |
| IF Frequency | 60 MHz |
| Reference Oscillator | Crystal Controlled |
| Noise Figure | 10 dB |
| MDS | -89 dBm |
| Amplitude Detection | Log and Linear |
| Coherent Outputs (I,Q) | A sin $\phi$, A cos $\phi$ |

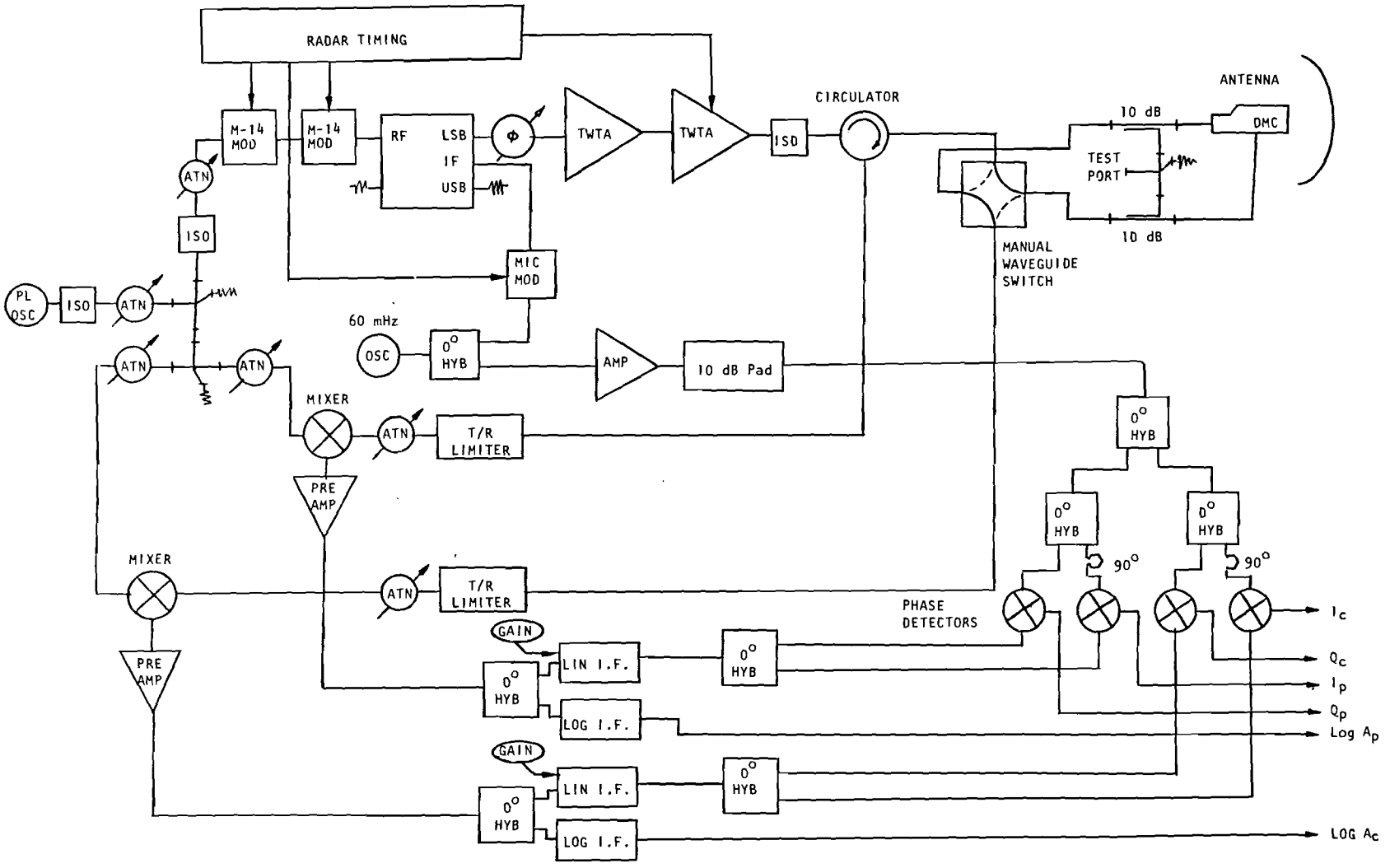


Figure 1. X-band coherent radar.

a 1 square meter target and a 10 dB signal-to-noise ratio of 5.6 km. The corresponding theoretical range predictions for the radar based on the noise figure of 8 dB and a temperature of $290^{0}$ K is 7.1 km.

This report is submitted as the final documentation of Georgia Tech Project A-3486.

Respectively submitted,

E. E. Martin
Project Director

Approved:

Nicholas C. Currie, Chief
Instrumentation and Measurements Division
Radar and Instrumentation Laboratory