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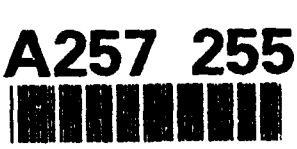

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INSTRUMENTATION FOR MILLIMETER-WAVE POLARIMETRIC MEASUREMENTS OF INHOMOGENEOUS MEDIA

Fawwaz T. Ulaby, Principal Investigator
Kamal Sarabandi, Research Scientist

ARO Contract DAAL 03-91-G-0202

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13. ABSTRACT *(Maximum 200 words)*
ARO Contract DAAL-03-91-G-0202 is an instrumentation grant for upgrading the University of Michigan's millimeter-wave radar systems, which operate at 35, 94, 140, and 215 GHz. The funds were used to (1) improve the data acquisition and control system, which operates all four channels, (2) convert the 35, 94 into single-antenna configurations, convert the 140 GHz into a coherent-on-receive polarimetric mode, and add a bistatic scattering capability to the 35, 94 and 140 GHz systems.

14. SUBJECT TERMS
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1. INTRODUCTION

Since 1985, The University of Michigan has been involved in an intensive program aimed at characterizing millimeter-wave scattering from terrain. The program, which has been supported by ARO, includes theoretical studies and experimental observations covering a wide range of terrain conditions, including bare soil surfaces, asphalt and concrete roadways, vegetation, and snow cover. In response to a request for funds to upgrade the mililmeter-wave scatterometer systems, ARO awarded the University of Michigan an instrumentation grant in July, 1991. This report describes the modifications made and the new capabilities of the four-channel radar system with operating frequencies at 35, 94, 140, and 215 GHz.

2. SYSTEM CAPABILITIES

The following table provides an overall summary of the capabilities of the MMW Scatterometer System. An entry denoted as "current" refers to the capability of the system prior to July, 1991, and when denoted as "new", it refers to the capability of the system as of July, 1992. Because of delays in delivery by some of the component manufacturers, the 140-GHz bistatic scattering mode is not yet in place, but should be completed by September, 1992.

	MMW SYSTEM CAPABILITY MODE			
	35 GHz	94 GHz	140 GHz	215 GHz
Two-Antenna Backscatter	Current	Current	Current	Current
Single-Antenna Backscatter	New	New		
Fully Coherent Polarimetric	New	New		
Coherent-On-Receive Polarimetric	Current	Current	New	
Bistatic Scattering	New	New	New	

More detailed descriptions of the realied capabilites are given next.

2.1 Control/Data Acquisition

A new HP 3488 Switch/Control System with Hp-Basic Language Processor was purchased and integrated with the radar system to provide control and feedback for many parts of the four-frequency radar system, including polarization control and antenna pointing.

The Hp-Basic Language Processor provides control for numerous HP-IB instruments in an IBM compatible computer. The Hp 8753 Network Analyzer provides the two channel back-end necessary to fully utilize the new dual polarization receivers at 35 GHz, 94 GHz, and 140 GHz. The Elevation/Azimuth positioner provides computer-controlled general purpose positioning ability for both radars and targets.

2.2 Radar System Modifications

The system block diagram of the newly modified 35, 94, and 140 GHz radar systems are given in Figures 1-3.

The 94 GHz radar and the 35 GHz radar have been modified so that they can operate in three modes: Single-Antenna Mode, Fully Coherent, and Bistatic Scattering Mode. The 140 GHz radar has been modified to operate in two new modes: Coherent-On-Receive Mode and Bistatic Scattering Mode. All three radars will retain the ability to operate in Two-Antenna-Backscatter Mode. The 35 GHz radar and the 94 GHz radar already have Two-Orthogonal -Polarization Receivers. The 35 GHz radar and the 94 GHz radar now have waveguide-polarization-switches installed in their transmitters in place of the old system of rotatable waveplates in the transmit antennas. This results in a more repeatable, pure, and homogeneous transmit polarization. (The 140 GHz radar already has this type of polarization switch.)

3. EQUIPMENT LIST

Table 1 provides a complete list of the equipment and components purchased for implementing the system modifications described in the preceding section.

4. PERSONNEL

Since this grant was specifically intended for the purchase of equipment, no personnel were supported by this grant.

Figure 1

35 GHZ RADAR

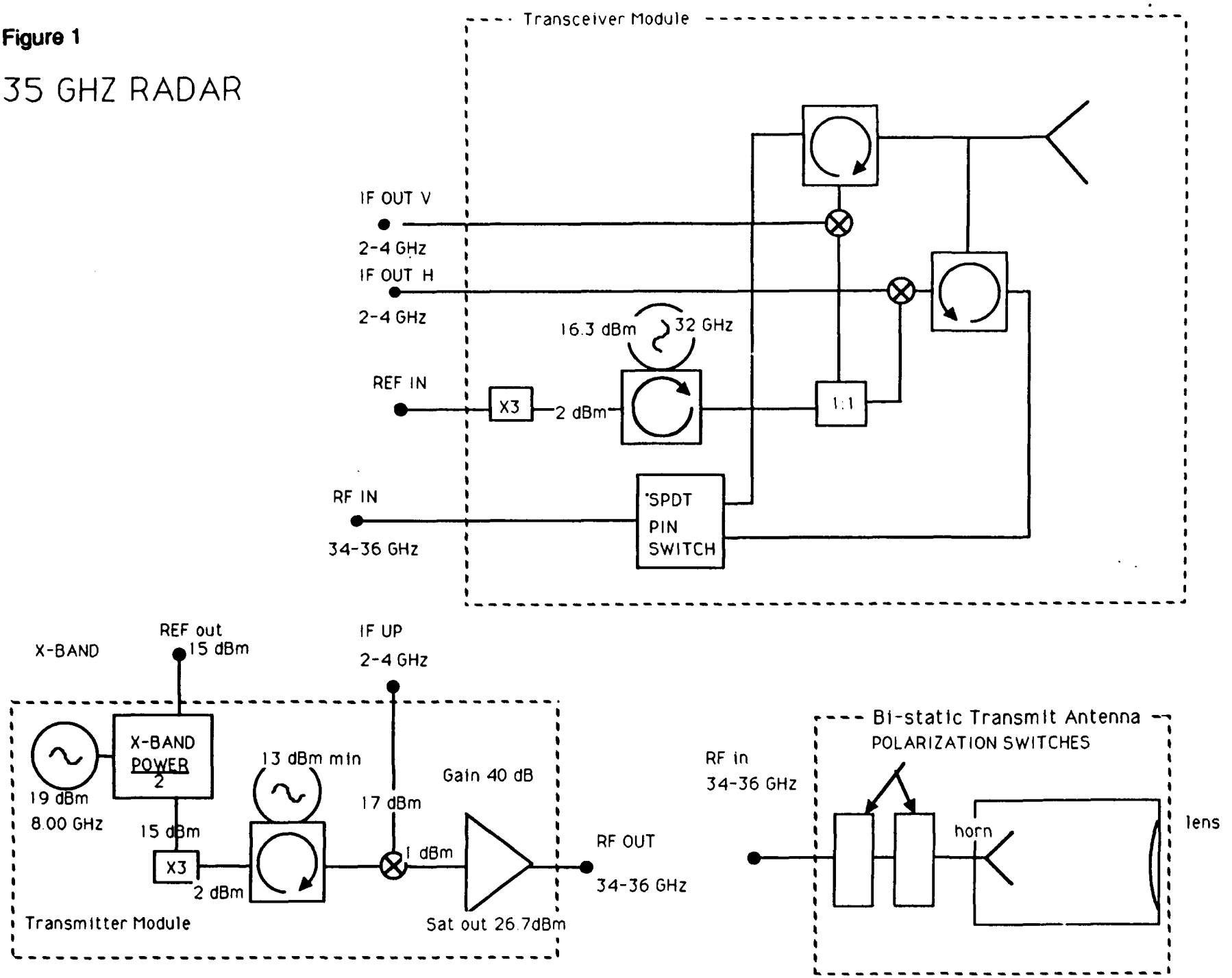

Figure 2

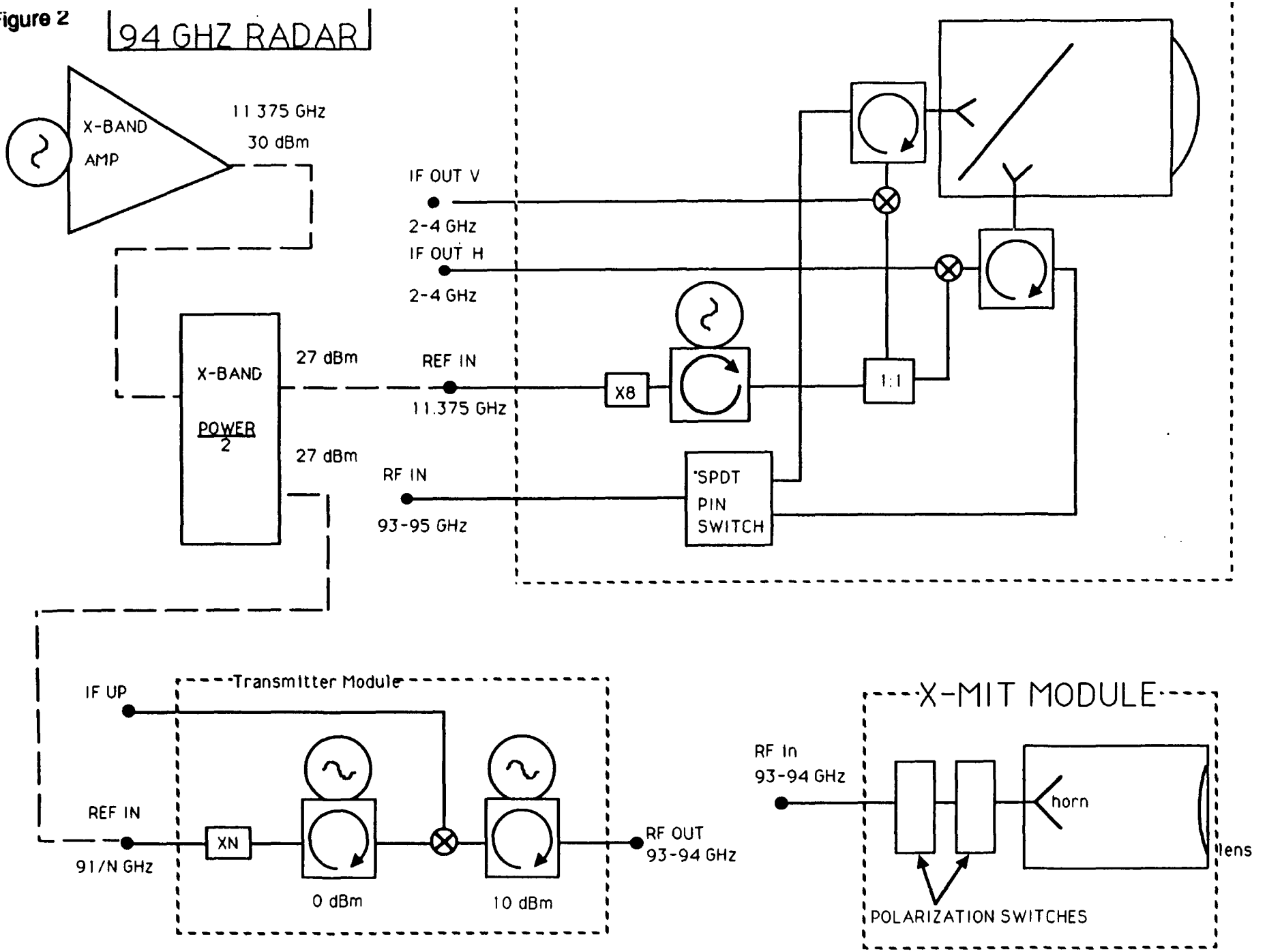
94 GHZ RADAR
X-BAND
AMP
11 375 GHz
30 dBm
IF OUT V
2-4 GHz
IF OUT H
2-4 GHz
X-BAND
POWER
2
27 dBm
REF IN
11.375 GHz
X8
1:1
27 dBm
RF IN
93-95 GHz
SPDT
PIN
SWITCH
Transmitter Module
IF UP
REF IN
91/N GHz
XN
0 dBm
10 dBm
RF OUT
93-94 GHz
X-MIT MODULE
RF In
93-94 GHz
horn
lens
POLARIZATION SWITCHES

Figure 3

140 GHz Radar Block Diagram

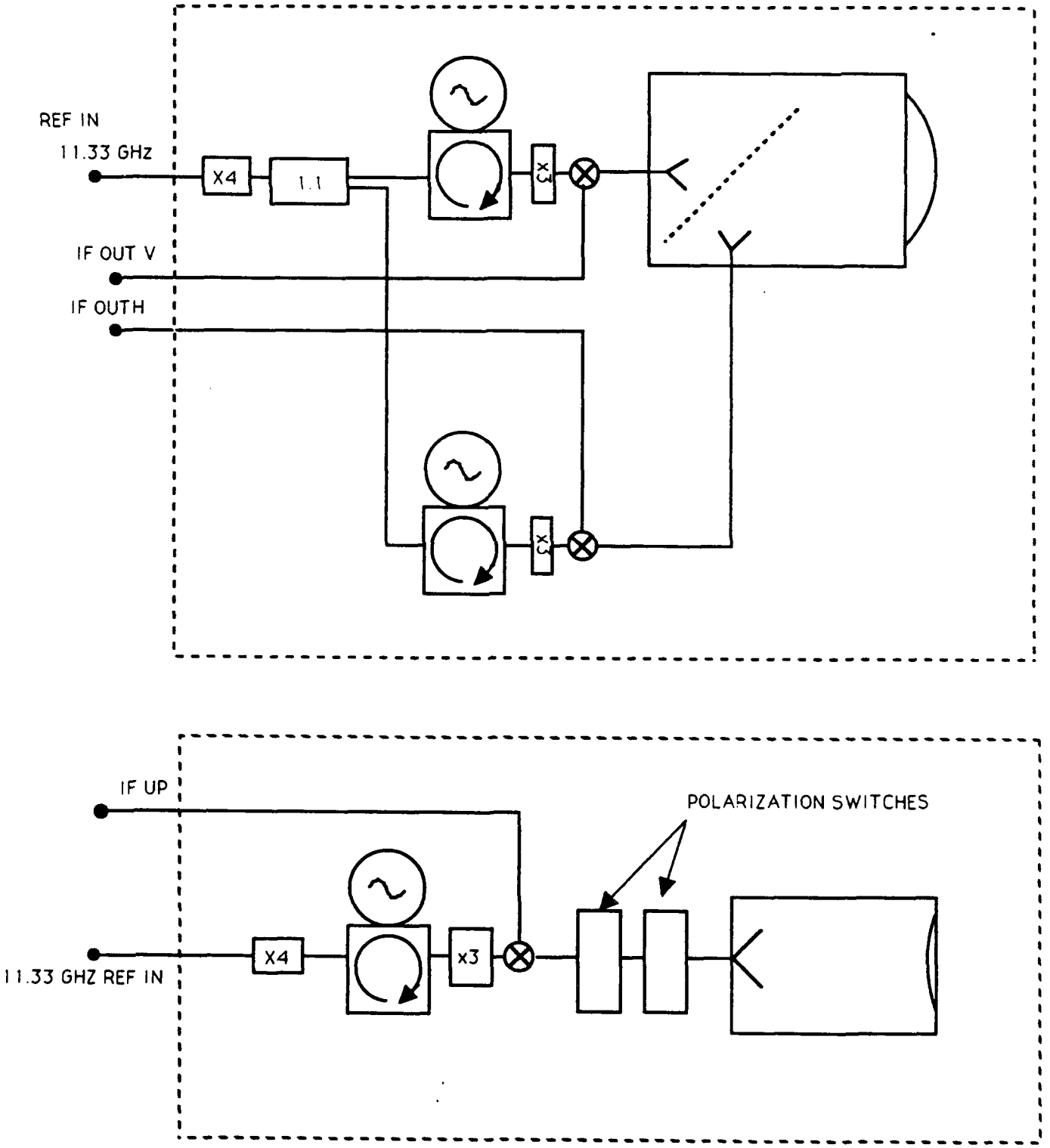

Table 1. Equipment List

NAME OF ITEM PURCHASED	VENDOR	COST
network analyzer	Hewlett Packard	28,620.00
switch/control unit	Hewlett-Packard	3,376.50
measuremt coprocessor	Hewlett Packard	1,050.90
superlift	Natl Ladder & Scaffold	1,169.00
power divider	Compucon	171.71
tripler	Pacific Millimeter	802.49
aluminum sheet	Univ Stores	150.50
speed reducer,motors	Detroit Ball Bearing	1,480.18
oscillator	Hughes	1,686.50
circulators, isolator	MRI	1,200.00
adapter connector	CompuAdd	336.70
digital i/o card,connectors	Hewlett Packard	774.00
actuators,capacitors	Motion	712.70
coaxial connectors	Compucon	293.60
diodes,isolator,circulators	MRI	3,700.00
quadrupler,multiplier	Spacek	2,806.00
analog laser	Industrial Control	2,441.40
amplifier	Miteq	1,352.67
oscillator	Millitech	702.67
aluminum sheet	Univ Stores	49.00
coaxial switches	JFW Industries	1,722.55
fluke multimeter	Wedemeyer Elect	155.19
jacks,attenuators	Compucon	143.59
waveguide section	Custom Microwave	334.00
controller,cards,driver	Servo System	2,150.16
power supplies	Acopian	1,142.94
switch control unit,modules	Hewlett Packard	2,695.50
mode junction	Atlantic Microwave	1,501.50
plugs,adapters,attenuators	Compucon	667.19
5 heaters	Hybrid Microcircuit	595.25
quadrupler,multiplier	Spacek	5,706.00
oscillator	M/A Com	2,002.50
oscillators	Miteq	2,102.67
diodes,isolator,circulators	MRI	2,000.00
cable,extender	Natl Instru	2,520.26
freq tripler	Alpha	7,495.00
digital i/o card,connectors	Hewlett Packard	80.00
plugs,adapters,attenuators	Compucon	126.41
polarizers	Hughes Aircraft	11,890.00
flanges,guides,bends	Aerowave	4,051.00
jacks,attenuators	Compucon	578.21
CTP-100T, BNC ends	DCO	452.55
speed reducer,motors	Detroit Ball Bearing	46.68
TOTAL COST		**103,035.67**