NASA-CR-194234

HIGH EFFICIENCY LOW COST MONOLITHIC MODULE FOR SARSAT DISTRESS BEACONS

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P. 26

CONTRACTING AGENCY: NASA LEWIS RESEARCH CENTER

CONTRACTOR: MICROWAVE MONOLITHICS INCORPORATED

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SBIR PHASE II: 1987 Phase II [redacted]
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N94-18852

Unclas

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MICROWAVE MONOLITHICS INCORPORATED

PROGRAM OBJECTIVES

* DEVELOP A HIGHLY EFFICIENT, LOW COST RF MODULE FOR SARSAT BEACONS
* ACHIEVE SIGNIFICANTLY LOWER: BATTERY CURRENT DRAIN,
AMOUNT OF HEAT GENERATED, &
SIZE OF BATTERY REQUIRED
* UTILIZE MMIC TECHNOLOGY TO IMPROVE: EFFICIENCY,
RELIABILITY,
PACKAGING, &
COST
* PROVIDE A TECHNOLOGY DATABASE FOR GaAs BASED UHF RF CIRCUIT ARCHITECTURES

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ABBREVIATED PHASE II STATEMENT OF WORK

TASK 1) COMPLETE MODULE DESIGN STARTED IN PHASE I

TASK 2) FABRICATE INITIAL MODULES

TASK 3) CHARACTERIZE INITIAL MODULES

TASK 4) ITERATE INITIAL DESIGN INTO FINAL DESIGN

TASK 5) FABRICATE FINAL MODULES

TASK 6) CHARACTERIZE FINAL MODULES

TASK 7) REVIEW FINAL DESIGN

TASK 8) ASSESS PRODUCTION DESIGN

TASK 9) PREPARE FINAL REPORT

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PHASE II PROGRAM ACCOMPLISHMENTS

* HIGH EFFICIENCY GaAs MMIC POWER AMPLIFIER DESIGNED, FABRICATED, & CHARACTERIZED

* PERFORMANCE ACHIEVED:

	OUTPUT POWER	> 5 WATTS
	ASSOCIATED GAIN	> 25 dB
	POWER-ADDED EFFICIENCY	~ 60 %

* MONOLITHIC GaAs PHASE MODULATOR DESIGNED, FABRICATED, & CHARACTERIZED

* AVERAGE MEASURED PHASE ERROR < 0.03 RADIANS

* ALL PROGRAM TASKS COMPLETED

* ALL PROGRAM GOALS MET AND/OR EXCEEDED

* TWO SETS OF GaAs MONOLITHIC POWER AMPLIFIERS AND PHASE MODULATORS DELIVERED TO NASA

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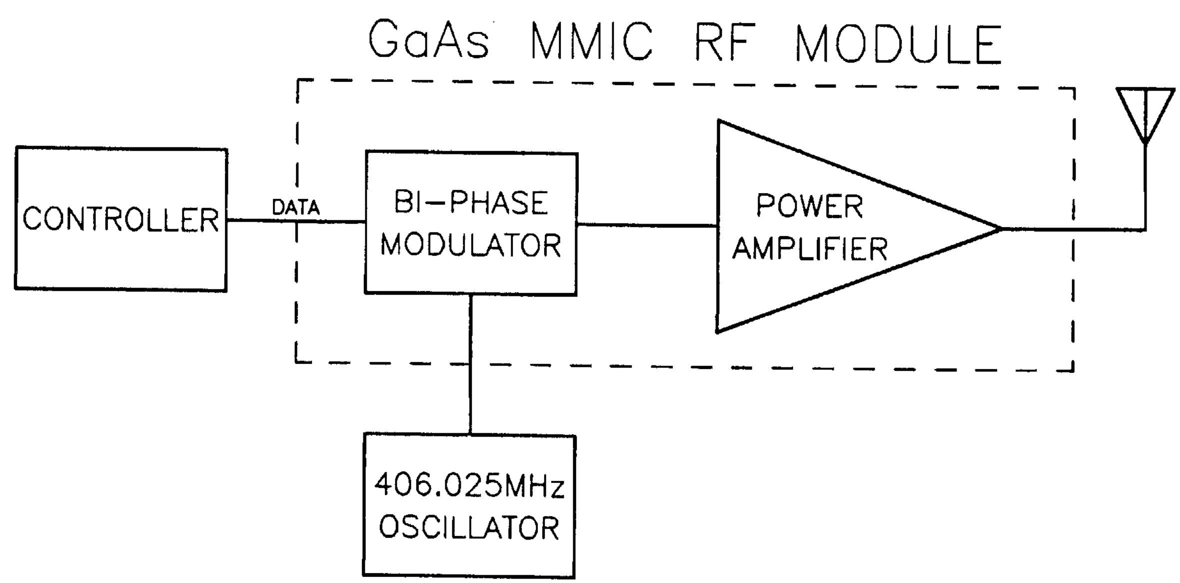

FUNCTIONAL BLOCK DIAGRAM OF SARSAT DISTRESS BEACON USING GaAs MMIC RF MODULE CHIP SET

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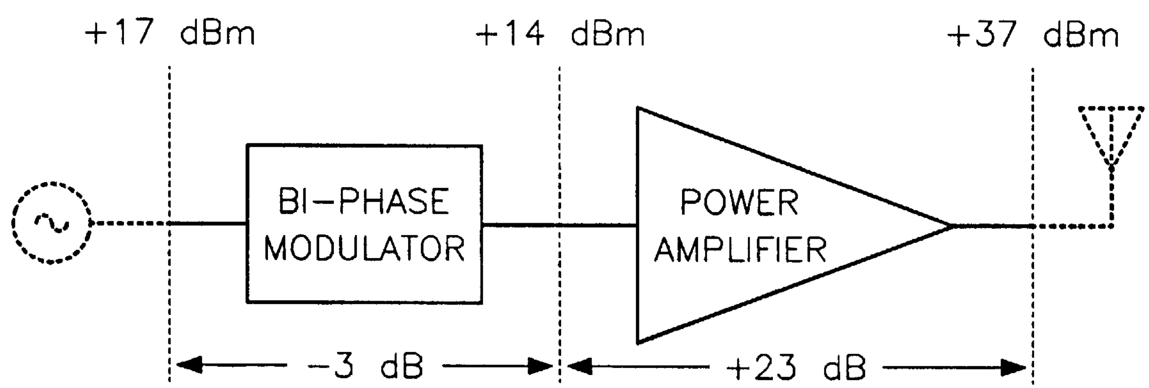

BLOCK DIAGRAM OF THE SARSAT BEACON RF MODULE

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PERFORMANCE GOALS FOR THE MONOLITHIC GaAs SARSAT BEACON PHASE MODULATOR

Operating Frequency	406.025 MHz
Input Impedance	50 ohms
Output Impedance	50 ohms
Phase States	0.0 degrees
	+1.1 radians (± 0.1 radians)
	-1.1 radians (± 0.1 radians)
Insertion Loss	< 3 dB for all phase states
DC Supply Voltage	9 to 15 Volts
DC Supply Current	< 10 mA

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PERFORMANCE GOALS FOR THE MONOLITHIC GaAs SARSAT BEACON POWER AMPLIFIER

Operating Frequency	406.025 MHz
Input Impedance	50 ohms
Output Impedance	50 ohms
Output Power	5 Watts
Power Gain	10 dB
Power-Added Efficiency	> 50%
DC Supply Voltage	9 to 15 Volts
Idle DC Supply Current	< 5 mA

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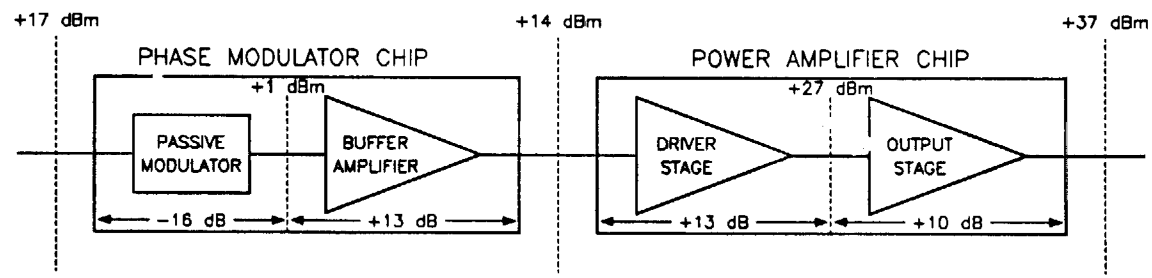

BLOCK DIAGRAM OF THE SARSAT BEACON RF MODULE COMPONENTS

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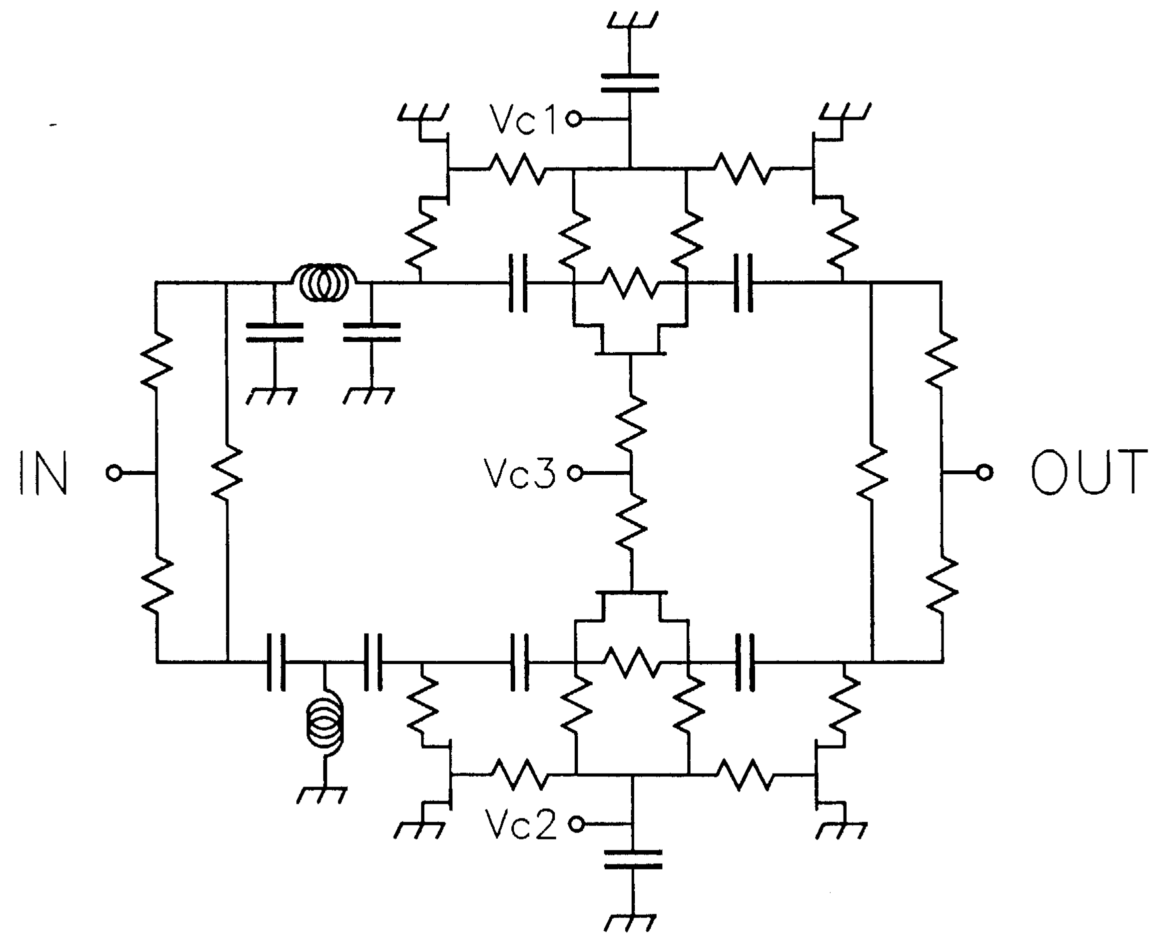

SCHEMATIC DIAGRAM OF GaAs MONOLITHIC BI-PHASE MODULATOR

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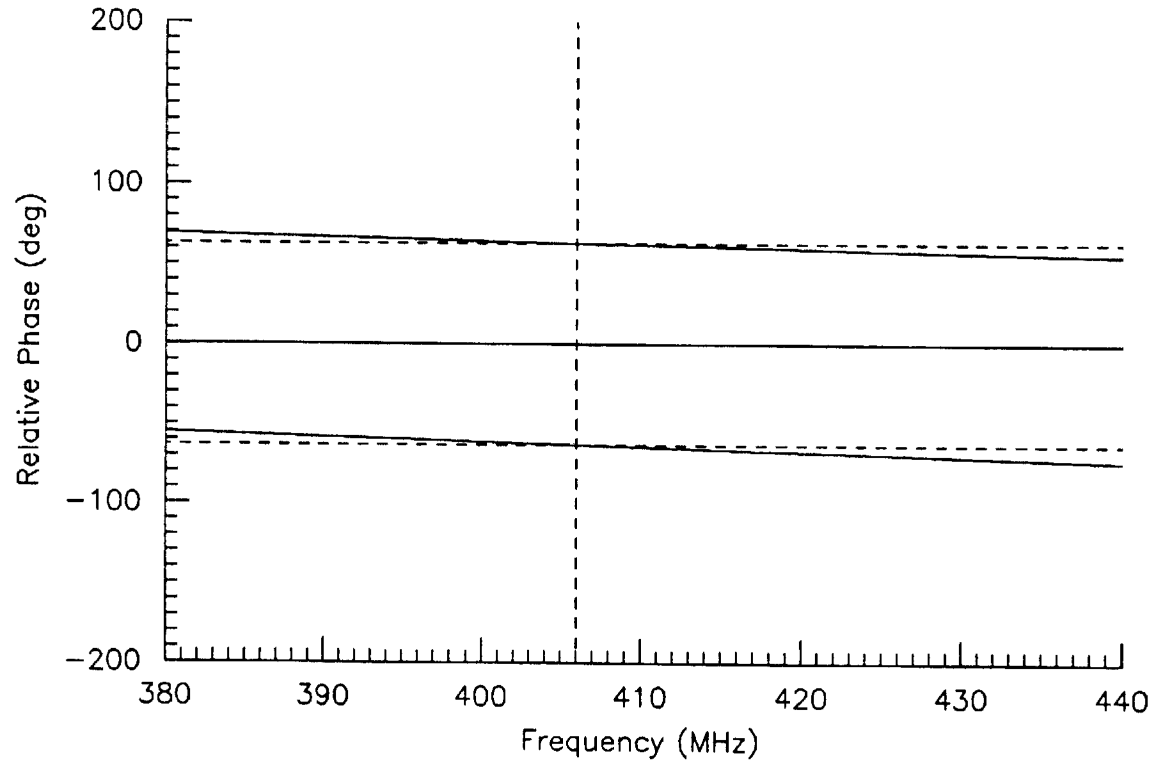

PREDICTED PHASE STATES VERSUS FREQUENCY OF GaAs MONOLITHIC BI-PHASE MODULATOR

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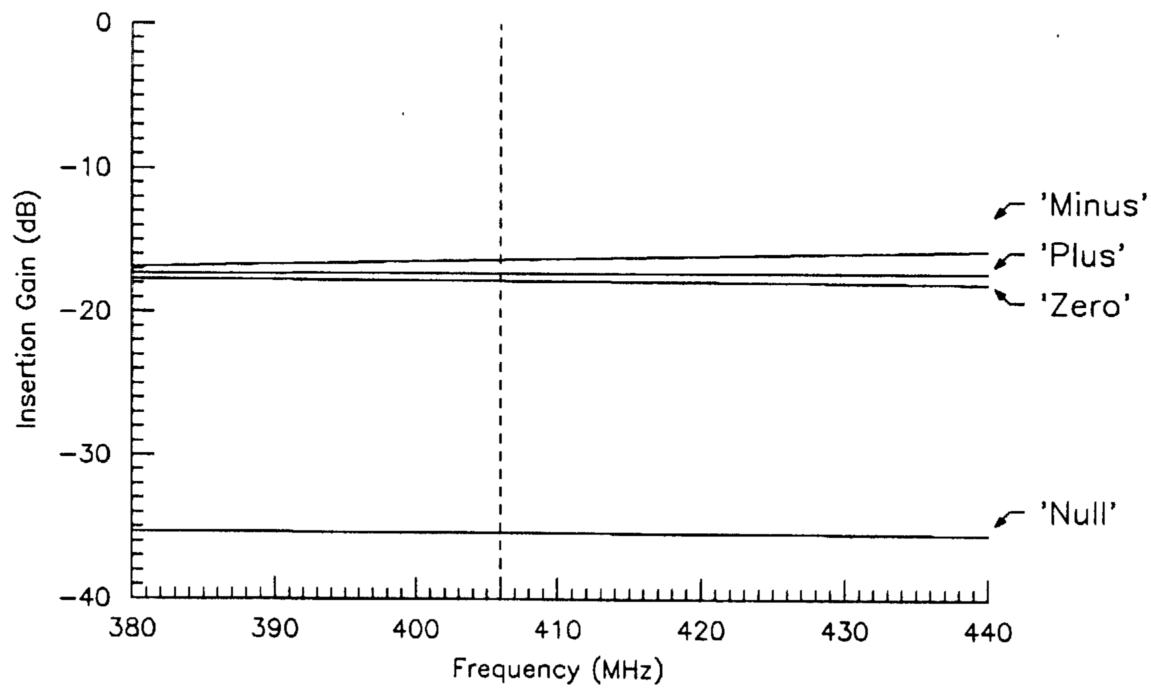

PREDICTED INSERTION LOSS VERSUS FREQUENCY OF GaAs MONOLITHIC BI-PHASE MODULATOR

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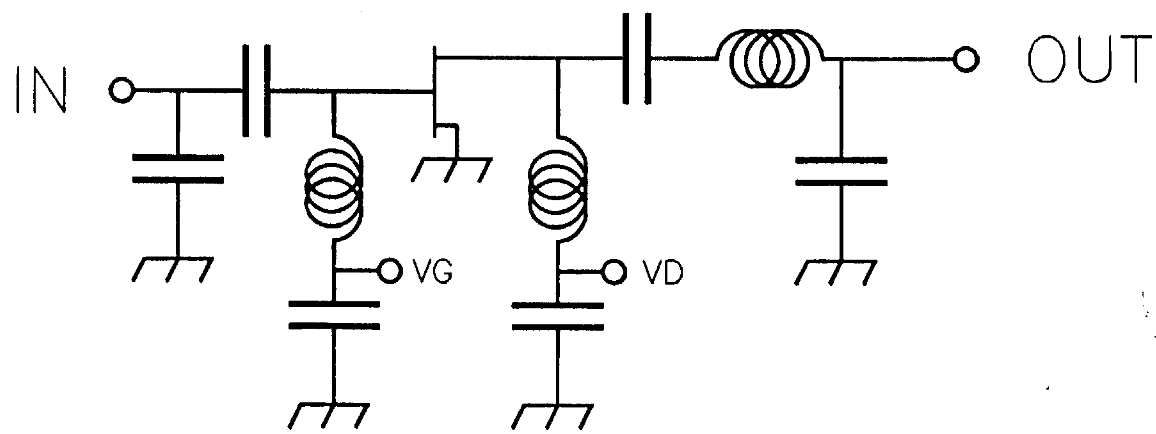

SCHEMATIC DIAGRAM OF GaAs MONOLITHIC BUFFER AMPLIFIER

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PREDICTED PERFORMANCE OF GaAs MONOLITHIC BUFFER AMPLIFIER @ 406.025 MHz

SMALL SIGNAL GAIN	= 12.5 dB
OUTPUT @ 1 dB COMP.	= 19.3 dBm (85 mW)
STAND-BY DRAIN CURRENT	= 5 mA

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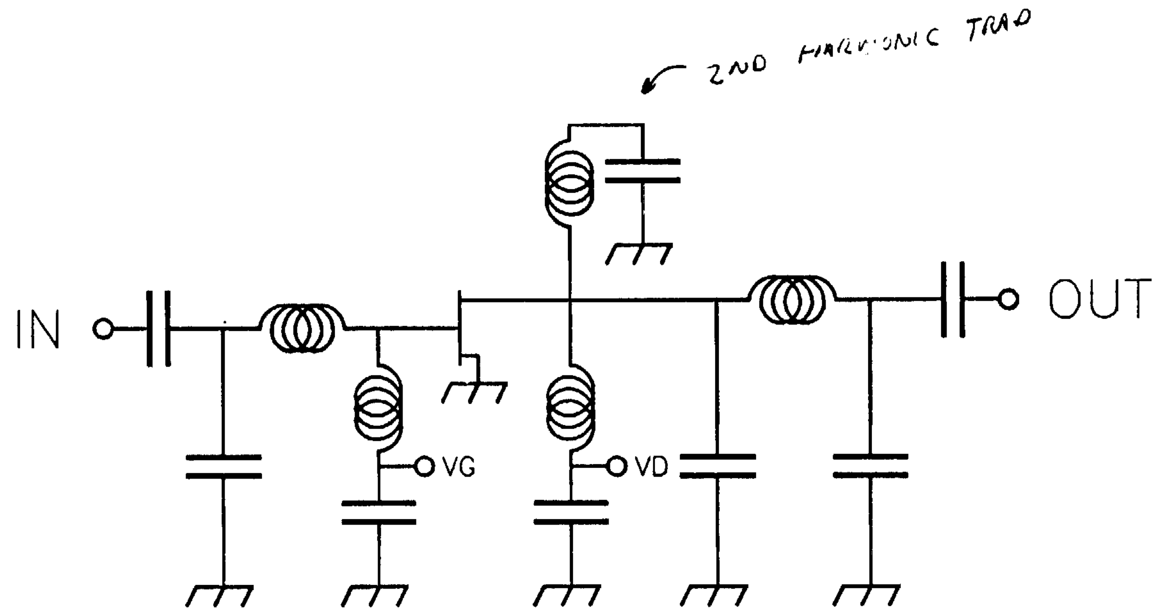
HIGH EFFICIENCY LOW COST MONOLITHIC MODULE FOR SARSAT DISTRESS BEACONS



SCHEMATIC DIAGRAM OF GaAs MONOLITHIC POWER AMPLIFIER OUTPUT STAGE

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PREDICTED PERFORMANCE OF GaAs MMIC POWER AMPLIFIER OUTPUT STAGE @ 406.025 MHz

	GAIN	OUTPUT POWER	POWER-ADDED EFFICIENCY
ALL ELEMENTS "ON-CHIP"	11.2dB	37.3dBm (5.4W)	62 %
POWER COMBINER "OFF-CHIP"	11.8dB	37.9dBm (6.2W)	72 %
POWER COMBINER & DRAIN RESONATOR / BIAS "OFF-CHIP"	12.5dB	38.6dBm (7.2W)	83 %

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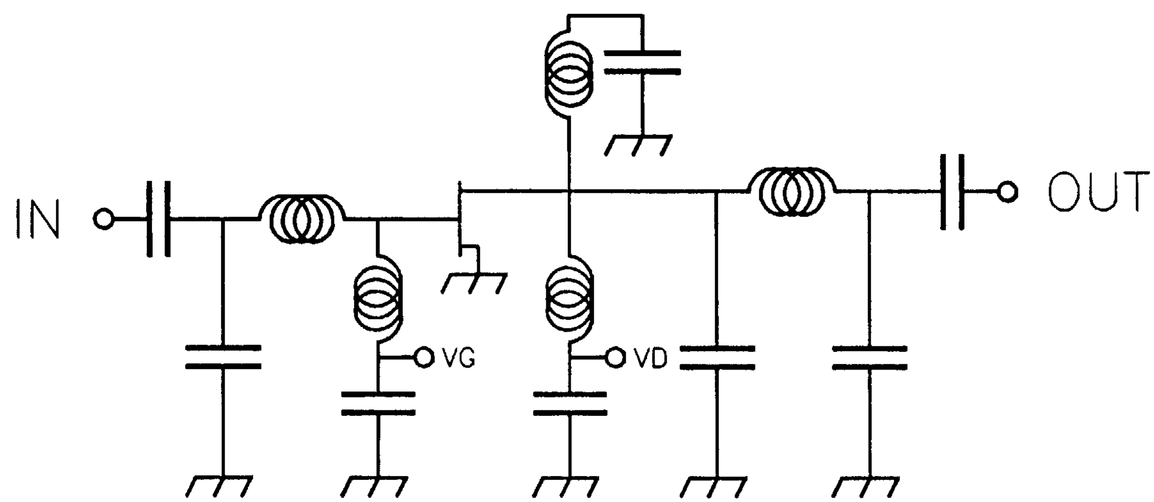

SCHEMATIC DIAGRAM OF GaAs MONOLITHIC POWER AMPLIFIER DRIVER STAGE

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PREDICTED PERFORMANCE OF GaAs MMIC POWER AMPLIFIER DRIVER STAGE @ 406.025 MHz

GAIN	= 11.5 dB
OUTPUT POWER	= 27.8 dBm (610 mW)
POWER-ADDED EFFICIENCY	= 61 %

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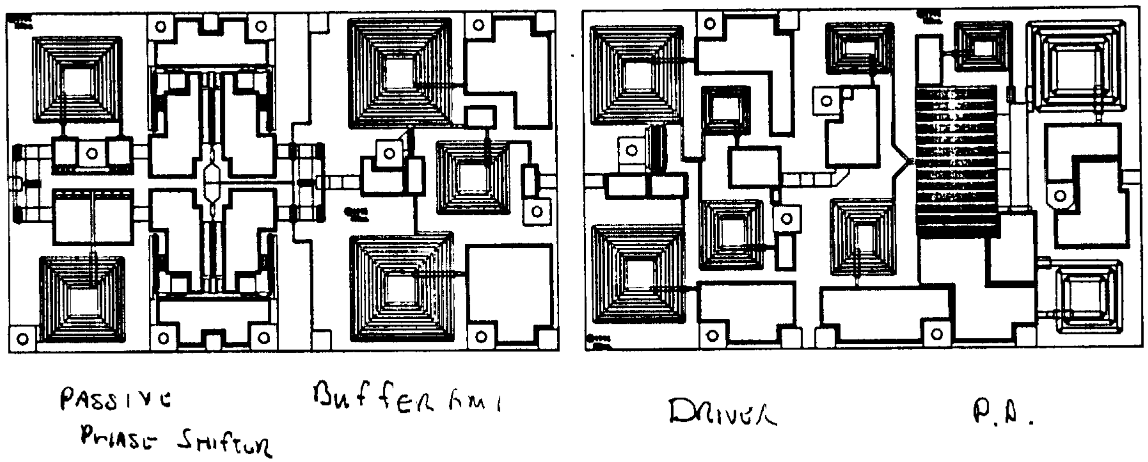

PEN PLOT OF SECOND ITERATION GaAs MONOLITHIC RF MODULE CHIP SET

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SIZE COMPARISON OF FIRST AND SECOND ITERATION RF MODULE CHIP SETS

FIRST ITERATION:

MODULATOR	BUFFER + DRIVER	OUTPUT STAGE
4.0 MM X 1.7 MM	3.3 MM X 2.6 MM	4.0 MM X 2.9 MM

TOTAL AREA: 27.0 MM^2

SECOND ITERATION:

MODULATOR WITH BUFFER	2-STAGE AMPLIFIER
4.1 MM X 2.5 MM	4.1 MM X 2.5 MM

TOTAL AREA: 20.5 MM^2

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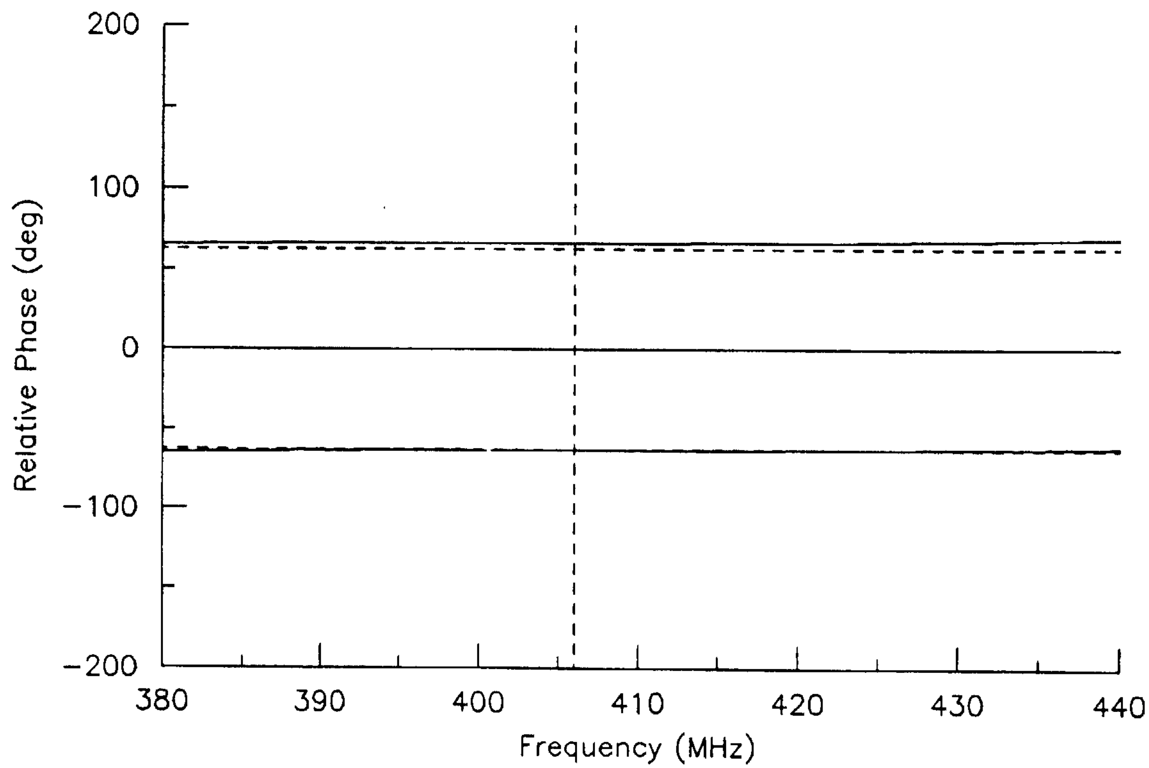

MEASURED PHASE STATES OF A GaAs MONOLITHIC PHASE MODULATOR

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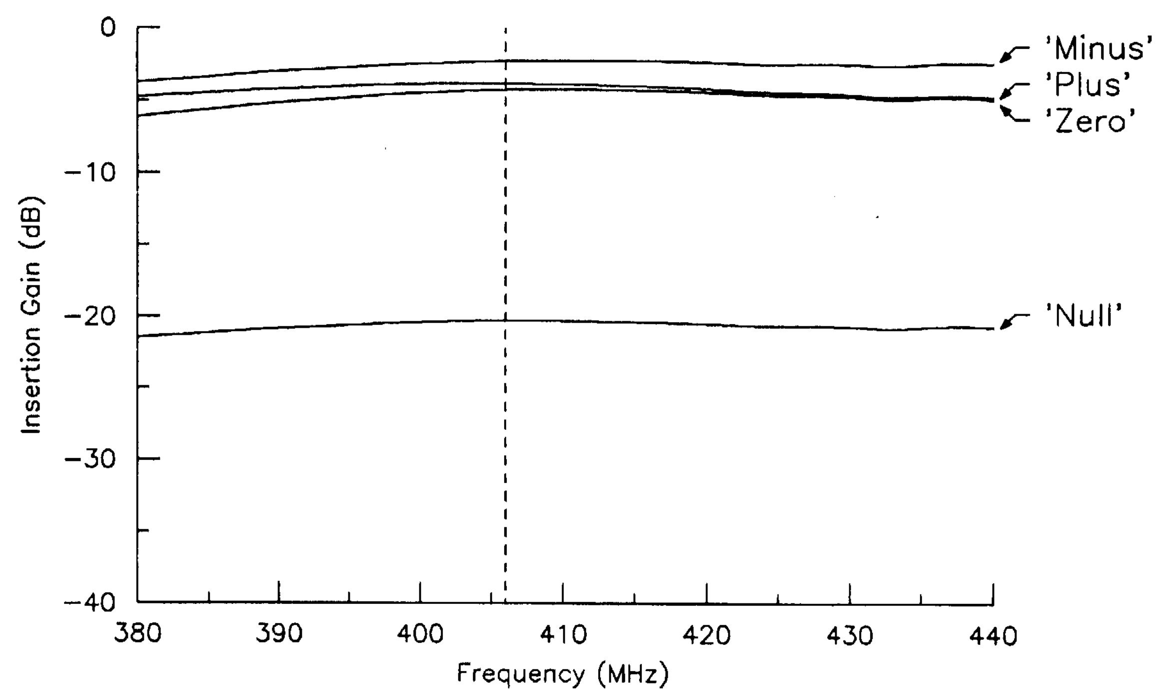

MEASURED INSERTION LOSS OF A GaAs MONOLITHIC PHASE MODULATOR

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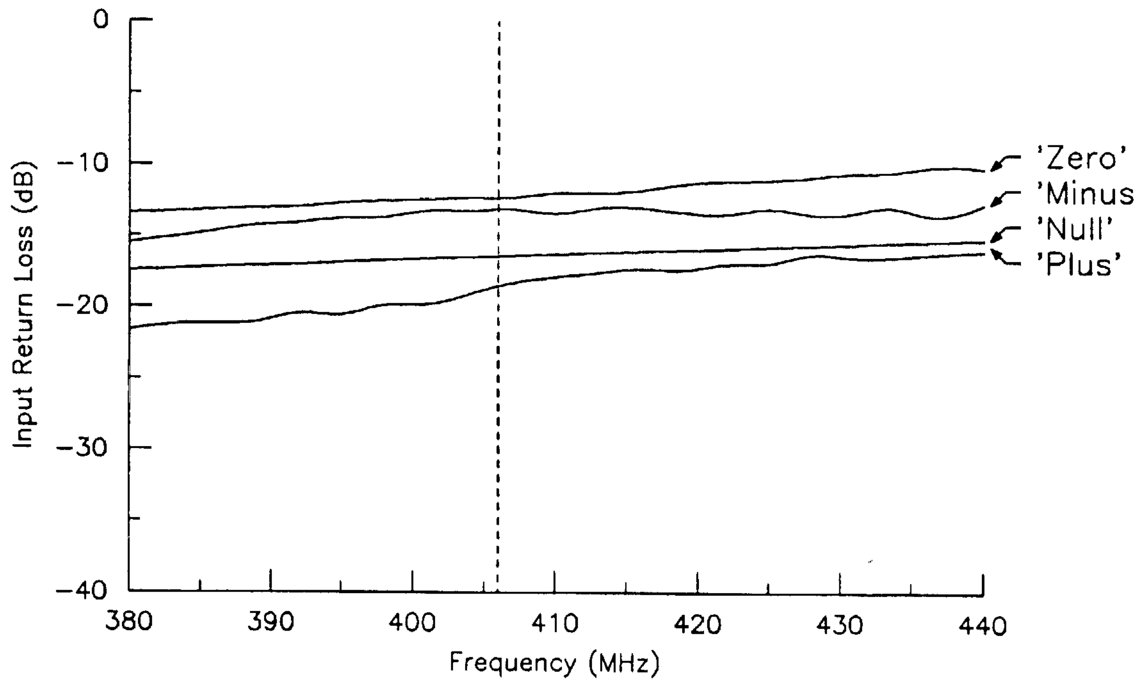

MEASURED INPUT RETURN LOSS OF A GaAs MONOLITHIC PHASE MODULATOR

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MEASURED PERFORMANCE OF A GaAs MONOLITHIC PHASE MODULATOR

State	Gain	Phase Shift
1 (V_{c1}= 0, V_{c2} =0)	-20.2 dB	-0.15 Rad.
2 (V_{c1}=-5, V_{c2}= 0)	-2.2 dB	-1.10 Rad.
3 (V_{c1}= 0, V_{c2}=-5)	-3.8 dB	+1.16 Rad.
4 (V_{c1}=-5, V_{c2}=-5)	-4.2 dB	Reference

OUTPUT VSWR < 1.2:1

OUTPUT LEVEL @ 1 dB "GAIN" COMPRESSION +14 dBm

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MEASURED PERFORMANCE OF TWO-STAGE GaAs MONOLITHIC POWER AMPLIFIERS

	CHIP "A"	CHIP "B"
Power Output	5.6 Watts	7.0 Watts
Gain	25.3 dB	28.3 dB
Power-Added Efficiency	59 %	56 %

SUPPLY VOLTAGE = 9 VOLTS

OFF-CHIP OUTPUT TUNING

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CONCLUSIONS & RECOMMENDATIONS

* HIGH EFFICIENCY GaAs MMIC POWER AMPLIFIER DEMONSTRATED:

OUTPUT POWER	> 5 WATTS
ASSOCIATED GAIN	> 25 dB
POWER-ADDED EFFICIENCY	~ 60 %

* MONOLITHIC GaAs PHASE MODULATOR WITH VERY ACCURATE PHASE SHIFTS DEMONSTRATED
* ALL PROGRAM TASKS COMPLETED & ALL PROGRAM GOALS MET AND/OR EXCEEDED
* TWO SETS OF GaAs MONOLITHIC POWER AMPLIFIERS AND PHASE MODULATORS DELIVERED TO NASA
* PROOF OF CONCEPT FOR LOW COST HIGH PERFORMANCE SARSAT DISTRESS BEACONS DEMONSTRATED
* LOW RISK PHASE III PROGRAM FOR FINAL MMIC ITERATION AND BEACON INTEGRATION RECOMMENDED