Bi-Directional Coupler

4267 Series

Operation Manual

Instruction Book Part Number 920-4267S Rev. A

Safety Precautions

The following are general safety precautions that are not necessarily related to any specific part or procedure, and do not necessarily appear elsewhere in this publication. These precautions must be thoroughly understood and apply to all phases of operation and maintenance.

WARNING

Keep Away From Live Circuits

Operating Personnel must at all times observe general safety precautions. Do not replace components or make adjustments to the inside of the test equipment with the high voltage supply turned on. To avoid casualties, always remove power.

WARNING

Shock Hazard

Do not attempt to remove the RF transmission line while RF power is present.

WARNING

Do Not Service Or Adjust Alone

Under no circumstances should any person reach into an enclosure for the purpose of service or adjustment of equipment except in the presence of someone who is capable of rendering aid.

WARNING

Safety Earth Ground

An uniterruptible earth safety ground must be supplied from the main power source to test instruments. Grounding one conductor of a two conductor power cable is not sufficient protection. Serious injury or death can occur if this grounding is not properly supplied.

WARNING

Resuscitation

Personnel working with or near high voltages should be familiar with modern methods of resuscitation.

Safety Symbols

WARNING
Warning notes call attention to a procedure, which if not correctly performed, could result in personal injury.

CAUTION
Caution notes call attention to a procedure, which if not correctly performed, could result in damage to the instrument.

The caution symbol appears on the equipment indicating there is important information in the instruction manual regarding that particular area

Note: *Calls attention to supplemental information.*

Warning Statements

The following safety warnings appear in the text where there is danger to operating and maintenance personnel, and are repeated here for emphasis.

WARNING
Never attempt to connect or disconnect RF equipment from the transmission line while RF power is being applied.
Leaking RF energy is a potential health hazard.

On page 3.

Safety Statements

USAGE

ANY USE OF THIS INSTRUMENT IN A MANNER NOT SPECIFIED BY THE MANUFACTURER MAY IMPAIR THE INSTRUMENT'S SAFETY PROTECTION.

USO

EL USO DE ESTE INSTRUMENTO DE MANERA NO ESPECIFICADA POR EL FABRICANTE, PUEDE ANULAR LA PROTECCIÓN DE SEGURIDAD DEL INSTRUMENTO.

BENUTZUNG

WIRD DAS GERÄT AUF ANDERE WEISE VERWENDET ALS VOM HERSTELLER BESCHRIEBEN, KANN DIE GERÄTESICHERHEIT BEEINTRÄCHTIGT WERDEN.

UTILISATION

TOUTE UTILISATION DE CET INSTRUMENT QUI N'EST PAS EXPLICITEMENT PRÉVUE PAR LE FABRICANT PEUT ENDOMMAGER LE DISPOSITIF DE PROTECTION DE L'INSTRUMENT.

IMPIEGO

QUALORA QUESTO STRUMENTO VENISSE UTILIZZATO IN MODO DIVERSO DA COME SPECIFICATO DAL PRODUTTORE LA PROZIONE DI SICUREZZA POTREBBE VENIRNE COMPROMESSA.

About This Manual

This manual covers the operating and maintenance instructions for the following models:

4267 Series

Changes to this Manual

We have made every effort to ensure this manual is accurate. If you discover any errors, or if you have suggestions for improving this manual, please send your comments to our Solon, Ohio factory. This manual may be periodically updated. When inquiring about updates to this manual refer to the part number and revision on the title page.

Literature Contents

Chapter Layout

Introduction — Describes the features of the Bird 4267 Series Bi-Directional Coupler.

Installation — Describes how to connect Bird 4267 Series Bi-Directional Coupler to the user's system, and software requirements.

RS-232 Utility — Describes how to use the RS-232 serial interface to access data stored on the coupler.

Maintenance — Lists routine maintenance tasks as well as customer service contact information.

Specifications — Table of the couplers specifications.

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Chapter 1 Introduction

General Description

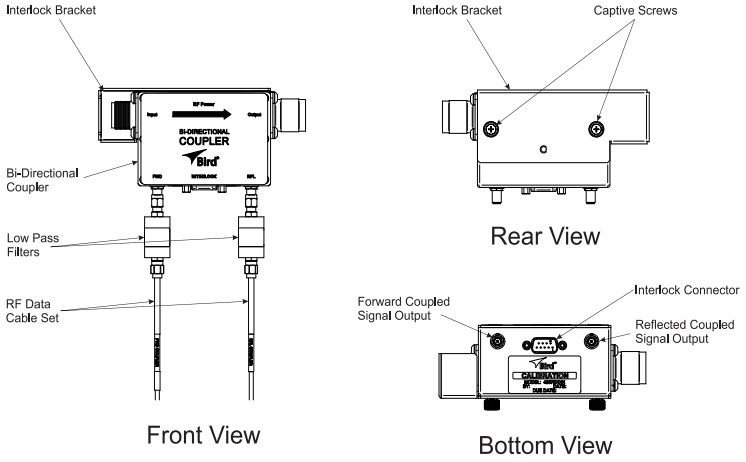
The 4267 Series Bi-Directional Coupler is a High-power dual directional coupler. Calibrated with filters and cables attached.

The input and output connectors of the Bird 4267 Series Bi-Directional Coupler are Bird Quick-Change type RF connectors, which allow the Coupler to be reconfigured with other Bird “QC” connectors. See Figure 1.

> **Note:** *Recalibration is required following any connector changes to guarantee rated accuracy.*

The coupler is equipped with an interlock system that prevents the main line RF input cable from being disconnected while RF power is present.

Figure 1 Bi-Directional Coupler



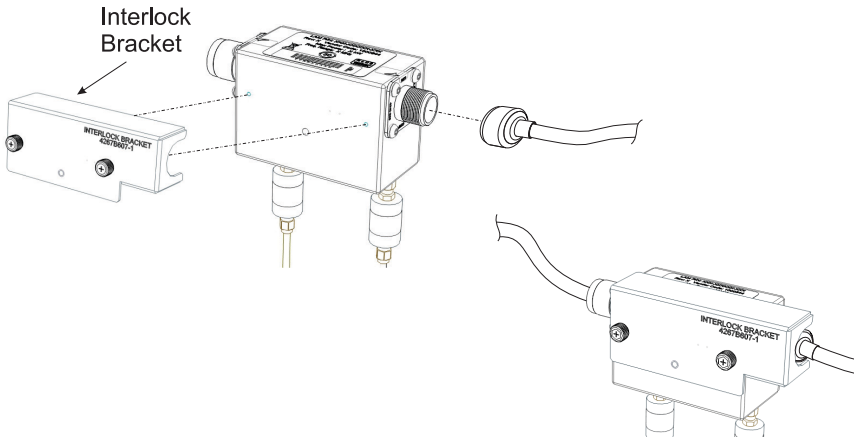
Interlock Switch

The 4267 coupler contains a normally open interlock switch for interlock control of the connected RF source. The bracket, when installed, closes the interlock circuit.

When installed, the interlock bracket ensures the RF input cable cannot be disconnected from the coupler's RF input connector, see Figure 2.

When the RF source is connected to the interlock circuit via the coupler's DB9 connector, if the interlock bracket is removed, the interlock circuit opens and the RF source is disabled.

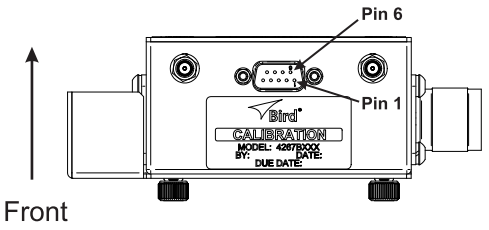
Figure 2 Interlock Bracket



Interlock wiring

The DB9 connector is used to connect the coupler's interlock circuitry to the RF Source. The internal interlock switch is connected to **Pin 1** and **Pin 6** of the DB9 connector. The interlock is normally open, attaching an interlock bracket to the coupler will close the interlock circuit.

Figure 3 Interlock Pinout



Installing the 4267 Bi-Directional Coupler

WARNING
Never attempt to connect or disconnect RF equipment from the transmission line while RF power is being applied.
Leaking RF energy is a potential health hazard.

1. Insert the 4267 Bi-Directional Coupler into a coaxial transmission line of 50 ohms nominal impedance.

   Note: *Connect the* 4267 *Bi-Directional Coupler to the RF line so that the arrow on the coupler points towards the load.*

2. Connect the Coupled Forward and reflected power cables.
   Torque SMA connectors to 3 - 5 in-lbs.

Install interlock bracket

Note: *Connect RF Cables to the input and output connectors of the coupler prior to performing this procedure.*

1. Connect the RF source interlock cable to the DB9 connector on the 4267 coupler. See "Interlock wiring" on page 2 for connector pinout.
2. Position the interlock bracket on the back of the coupler so the input connector is covered. See Figure 2 on page 2.
3. Tighten the two thumb screws to secure the bracket to the coupler.

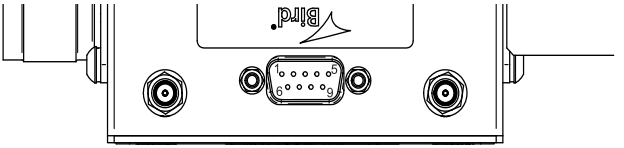
The interlock connector can, in addition to providing interlock capability, be used to access the calibration data stored in the coupler. The coupler stores the calibration data for the coupler in non-volatile memory and provides an RS-232 serial interface and a protocol that may be used to read the model, serial number and calibration data stored on the coupler.

Interlock Connector (RS-232)

Note: *DB-9 cable must supply 5V on pin 9 when using the interlock connector as a serial interface to communicate with the coupler.*

The Interlock Connector carries serial ASCII data between the 4267 and a PC. Pin numbers and connection descriptions are given in Figure 4.

Figure 4 DB-9 RS-232 Connector



Pin	Description
1	Interlock
2	Transmit Output, RS-232 data signal
3	Receive Input, RS-232 data signal
4	not connected
5	Data Signal Ground
6	Interlock
7	shorted internally to pin 8
8	shorted internally to pin 7
9	5 VDC

Note: *DB-9 cable must supply 5V on pin 9 when using the interlock connector as a serial interface to communicate with the coupler.*

RS-232 Port Setup

RS232 serial interface configuration

- 115,200 bps,
- 8 bits,
- 1 stop bit,
- no parity
- no flow control.

This configuration is fixed in the firmware and cannot be modified. Operate the serial interface as follows:

- Connect the 4267 to the computer's serial port with a DB-9 cable. *Do not use a null modem adapter.*
- To use a terminal program, configure it for 115,200 baud, 8 data bits, 1 stop bit, no parity, and no handshake. Set the preferences so that echo is off and line feeds are not appended to output transmission.
-

Protocol

The protocol has two layers: Transport and Data

Transport Layer

The transport is SLIP (Serial Line Internet Protocol). SLIP is defined in terms of Internet datagrams, but is suitable for transmission of any data via a byte serial link (such as RS232).

In order to use SLIP, we will construct a Payload Packet from Payload Data as follows:

Payload Data — Any arbitrary data structure to be transported via SLIP.

Checksum — Fletcher16 checksum (16 bits). See the Wikipedia article and the c source code implementation in the VSG Timing Module for details.

The Payload Packet will be used to construct a SLIP Frame for transmission of the data over the serial link. SLIP defines four reserved 8 bit codes as follows (taken from the Wikipedia link above)

Name	Hex Code	Description
END	0xC0	Marks the beginning and end of a frame
ESC	0xDB	Marks the beginning of a two byte (16 bit) escape sequence
ESC_END	0xDC	Together with ESC, replaces all occurrences of END (0xC0) in the payload data packet
ESC_ESC	0xDD	Together with ESC, replaces all occurrences of ESC (0xDB) in the payload data packet

SLIP byte stuffing

The beginning and end of a SLIP frame are marked with the END code. Since the END code could occur in an arbitrary payload, SLIP replaces END with the two byte escape sequence, ESC ESC_END, in the data stream. And since the ESC code could also occur in an arbitrary payload, SLIP also replaces ESC with the two byte escape sequence, ESC ESC_ESC, in the data stream. This procedure, sometimes known as byte stuffing, guarantees framing detection in the serial stream without any restriction of potential data values. The use of byte stuffing means that in theory the payload may expand to 2x the input length (if the payload contained only END and ESC codes), but in practice the expansion is much less. ASCII payloads for example never contain the END or ESC codes.

A SLIP frame:

END (0xC0)	Modified Payload Packet	END (0xC0)

A possible algorithm for transmitting a SLIP frame is as follows:

1. Acquire the payload data.
2. Compute the fletcher16 checksum of the payload data and append it to the end.
3. Transmit END (0xC0) to mark the beginning of the frame.
4. Transmit the payload and checksum with the following modifications:
    a. If the next byte is END (0xC0), transmit the two byte escape sequence ESC, ESC_END (0xDB, 0xDC).
    b. If the next byte is ESC (0xDB), transmit the two byte escape sequence ESC, ESC_END (0xDB, 0xDD).
5. Transmit END (0xC0) to mark the end of the frame.

To Receive a SLIP frame, the procedure is as follows:

1. Look for END (0xC0). Discard all bytes received until END (0xC0) is detected.
2. Process all bytes received, in sequence, as follows:

a. If the new byte is END (0xC0), the frame is complete. Discard the END and continue to process the payload packet.

b. If the new byte ESC (0xDB), discard it and replace the following byte as follows:

   i. If the following character is ESC_END (0xDC), store END (0xC0).

   ii. If the following character is ESC_ESC (0xDD), store ESC (0xCB).

c. If the new byte is neither END nor ESC, store it and continue to process received bytes.

3. After the complete payload packet has been received and processed, compute the Fletcher16 checksum of the entire packet (with the original fletcher16 checksum appended).
   a. If the resulting checksum is 0, the packet is valid.
   b. If the resulting checksum is not 0, the packet is somehow compromised.
4. Extract the protocol version, and coupler model, serial number, and calibration data as needed.

Data Layer

The Data layer of the protocol is comprised of a set of host requests and coupler responses.

Host Request Definition:

Header (8 bytes)	Request Data (0 to 118 bytes)

Host Response definition:

Header (8 bytes)	Response Data (0 to 118 bytes)

Header Definition:

Function (uint32_t)	Status (uint32_t)

Function — Function is unsigned 32 bit (uint32_t) and is one of the following values:

Function	Code Value
Echo	0x00000000
getRevision	0x00000001
getJSON	0x00000002

Status — Status is unsigned 32 bit (uint32_t) and is one of the following values:

Status	Code Value
OK	0x00000000
Invalid Function	0x00000001
Checksum Failed	0x00000002
EEPROM Checksum Failed	0x00000003

RS-232 Commands

Echo

Request:

- Echoes the request and any attached data back to the sender. Used to test the connection.
  - ✓ Function: 0
  - ✓ Status: 0
  - ✓ Data: Arbitrary (0 to 118 bytes).

Response:

- ✓ Function: 0
- ✓ Status: 0
- ✓ Data: Same as received (0 to 118 bytes).

getRevision

Request:

- Requests the firmware revision of the coupler.
  - ✓ Function: 0x00000001
  - ✓ Status: 0
  - ✓ Data: Null (0 bytes).

Response:

- ✓ Function: 0x00000001
- ✓ Status: 0 or error code
- ✓ Data: UTF-8 string indicating the coupler firmware revision. If an error is reported, the data is null (0 bytes).

getJSON

Request:

- Requests the calibration JSON file for the coupler.
  - ✓ Function: 0x00000002
  - ✓ Data: Null (0 bytes).
  - ✓ Response: getJSON Response

Response:

- ✓ Function: 0x00000002
- ✓ Status: 0 or Error Code
- ✓ Data: JSONFileObject. If an error is reported, the data is null (0 bytes).

JSONFileObject

- A UTF-8 string containing a complete JSON object. From the perspective of the coupler, the content is arbitrary. The coupler merely stores and retrieves the file.

See the separate JSON schema and example files for details of the JSON structure.

JSON schema


```
{
 "$schema": "http://json-schema.org/draft/2019-09/schema",
 "title": "Bi-Directional Coupler Model XXXXAXXX-XX",
 "type": "object",
 "required": ["version", "modelName", "serialNumber", "calibrationData"],
 "properties": {
  "version": {
   "type": "number",
   "description": "Version of this Bird Coupler JSON Schema"
  },
  "modelName": {
   "type": "string",
   "description": "Coupler model name."
  },
  "serialNumber": {
   "type": "string",
   "description": "Coupler serial number."
  },
  "calibrationData": {
   "type": "array",
   "description": "Array containing the complete calibration data array for the
                   coupler.",
   "items": {
    "type": "object",
    "properties": {
     "frequencyMHz": {
      "type": "number",
      "description": "Frequency in MHz for this calibration vector"
     },
     "sParameters": {
      "type": "array",
```

```
        "description": "Array of 16 s-parameters for the coupler at the specified
                        frequency (s11,s12,...,s43,s44).",
        "items": {
          "type": "object",
          "properties": {
            "parameterName": {
              "type": "string",
              "description": "Name of the specific s-parameter (ie's11', 's12',
                              etc)."
            },
            "magnitude": {
              "type": "number",
              "description": "Magnitude in dB of the s-parameter value."
            },
            "phase": {
              "type": "number",
              "description": "Phase angle in radians of the s-parameter value."
            }
          }
        },
        "minItems": 16,
        "maxItems": 16,
      }
    },
    "minItems": 33,
    "maxItems": 33,
  }
 }
}
```

Chapter 4 Maintenance

The 4267 Series Bi-Directional Coupler is of very rugged construction and requires little care and maintenance.

Maintenance of the Bi-Directional Coupler is normally limited to cleaning. Protect the RF connectors against the entry of dust and dirt by keeping them covered when the unit is disconnected from the transmission line.

Customer Service

Any maintenance or service procedure beyond the scope of those in this chapter should be referred to a qualified service center.

If the unit needs to be returned for any reason, request an Return Material Authorization (RMA) through the Bird Technologies website. All instruments returned must be shipped prepaid and to the attention of the RMA number.

Bird Service Center
30303 Aurora Road
Cleveland (Solon), Ohio 44139-2794
Fax: (440) 248-5426
E-mail: *bsc@birdrf.com*

For the location of the Sales Office nearest you, visit our Web site at:

http://www.birdrf.com

Shipment

Should you need to return the Bi-Directional Coupler, use the original shipping package if possible. If the original package is not available, use a heavy duty corrugated box with shock-absorbing material around all sides of the unit to provide firm cushion and to prevent movement in the container. The container should be properly sealed.

Chapter 5 Specifications

Frequency Range 4267B000 4267B030 4267B050	 0.9 – 1.1 MHz 12.88 – 14.24 MHz 12.88 – 14.24 MHz
Maximum Average Power	6 kW
Maximum Peak Power	10 kW
Maximum Voltage Rating	2340 V_{pk}
Calibration Power	+5 dBm (VNA calibration)
Measurement Type	Thru-Line Directional Power Waves
Coupling Magnitude (S31, S42)[1] 4267B000 4267B030 4267B050	 -60.5 ± 1 dB -60.5 ± 1 dB -60.5 ± 1 dB
Coupling Magnitude Flatness[1] 4267B000 4267B030 4267B050	 ± 0.3 dB max over frequency range ± 0.1 dB max over frequency range ± 0.1 dB max over frequency range
Coupling Magnitude Measurement Data	Provided at 33 points over coupler frequency range
Coupling Magnitude Data Accuracy (2σ)	± 1.3 % (with VNA calibration)
Coupling Phase[1] S31(phase) – S42(phase)	± 10° max, ± 2° max variation over frequency range
Coupling Phase Measurement Data	Provided at 33 points over coupler frequency range
Coupling Phase Data Accuracy (2σ)	± 0.5° (with VNA calibration)
Directivity	33 dB min
Main Line Load Mismatch Tolerance	See Figure 5 on page 16.
Coupled Output Load Mismatch Tolerance	Up to 1.05:1 VSWR
Coupling Stability (Excluding Connector Wear)	± 0.25 % target (limited by ± 1.3 % VNA uncertainty)
Unit to Unit Coupling Data Accuracy	± 0.5 % target (limited by ± 1.3 % VNA uncertainty)
Warm-Up Time for Specified Accuracy	15 minutes with CW power applied at 1700 W
Main Line Insertion Loss	-0.05 dB max (calibration data may show more loss due to adapters)

Main Line Return Loss	-40 dB max
Coupled Output Return Loss[1] 4267B000 4267B030 4267B050	 -10 dB max -15 dB max -15 dB max
Main Line Connector Type 4267B000 4267B030 4267B050	 Source (input): HN (f), QC type Load (output): HN (m), QC type Source (input): HN (f), QC type Load (output): HN (m), QC type Source (input): 7/16 DIN (f), QC type Load (output): 7/16 DIN (m), QC type
Coupled Outputs	Analog Output (50-Ohm), 1x-Fwd Voltage, 1x-Rev Voltage
Coupled Outputs Connector Type	SMA Female
Interlock Type	Contact closure, normally open
Interlock Connector & Pinout	9-pin D-sub, male, pins 1 & 6

1 These specifications include the performance of the lowpass filters and cables. Specifications may be different if these components are replaced.

Calibration

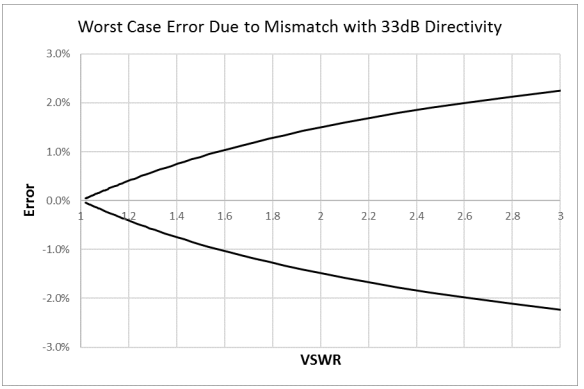
Factory Calibration	NIST Traceable
Calibration Cycle	6 months recommended
Field Calibration	None Required
Calibration Certificate	All units must be shipped with a Certificate of Compliance and Calibration
Calibration Data	33 calibration points spaced linearly over the frequency range, comprised of 4-port S-parameter data (in dB/ang format). Data is stored in on-board memory and available via RS232 interface through the 9-pin D-sub connector. Data is measured with lowpass filters and cables included.
Serial Communication Pinout	
Pin 1	Interlock
Pin 2	Transmit Output, RS-232 data signal
Pin 3	Receive Input, RS-232 data signal
Pin 4	not connected
Pin 5	Data Signal Ground
Pin 6	Interlock
Pin 7	shorted internally to pin 8
Pin 8	shorted internally to pin 7
Pin 9	5 VDC

Note: *DB-9 cable must supply 5V on pin 9 when using the interlock connector as a serial interface to communicate with the coupler.*

Physical and Environmental

Operating Temperature	+15 to +35 °C (+59 to +95 °F)
Storage Temperature	-20 to +70 °C (-4 to +158 °F)
Dimensions, Nominal	3.19” L x 6.24” W x 2.26” H (includes interlock bracket, excludes cables and filters)
Weight	Approximately 2 lbs.
RoHS	Required
Compatible Devices	50-Ohm oscilloscope input or ADC Input (± 1 V max)
Standard Accessories	None
Included Interlock Bracket 4267B000 4267B030 4267B050	 4267B607-1 4267B607-1 4267B607-2
Included Low Pass Filters 4267B000 4267B030 4267B050	 5A4267-1, qty 2 (Mini-Circuits SLP-1.9+) 5A4267-2, qty 2 (Mini-Circuits SLP-15+) 5A4267-2, qty 2 (Mini-Circuits SLP-15+)
Included RF Cable Assembly	4267A006-1 (12 ft SMA-m to SMA-m dual cable assembly)

Figure 5 Main Line Load Mismatch Tolerance



Limited Warranty

All products manufactured by Seller are warranted to be free from defects in material and workmanship for a period of one (1) year, unless otherwise specified, from date of shipment and to conform to applicable specifications, drawings, blueprints and/or samples. Seller's sole obligation under these warranties shall be to issue credit, repair or replace any item or part thereof which is proved to be other than as warranted; no allowance shall be made for any labor charges of Buyer for replacement of parts, adjustment or repairs, or any other work, unless such charges are authorized in advance by Seller.

If Seller's products are claimed to be defective in material or workmanship or not to conform to specifications, drawings, blueprints and/or samples, Seller shall, upon prompt notice thereof, either examine the products where they are located or issue shipping instructions for return to Seller (transportation-charges prepaid by Buyer). In the event any of our products are proved to be other than as warranted, transportation costs (cheapest way) to and from Seller's plant, will be borne by Seller and reimbursement or credit will be made for amounts so expended by Buyer. Every such claim for breach of these warranties shall be deemed to be waived by Buyer unless made in writing within ten (10) days from the date of discovery of the defect.

The above warranties shall not extend to any products or parts thereof which have been subjected to any misuse or neglect, damaged by accident, rendered defective by reason of improper installation or by the performance of repairs or alterations outside of our plant, and shall not apply to any goods or parts thereof furnished by Buyer or acquired from others at Buyer's request and/or to Buyer's specifications. Routine (regularly required) calibration is not covered under this limited warranty. In addition, Seller's warranties do not extend to the failure of tubes, transistors, fuses and batteries, or to other equipment and parts manufactured by others except to the extent of the original manufacturer's warranty to Seller.

The obligations under the foregoing warranties are limited to the precise terms thereof. These warranties provide exclusive remedies, expressly in lieu of all other remedies including claims for special or consequential damages. SELLER NEITHER MAKES NOR ASSUMES ANY OTHER WARRANTY WHATSOEVER, WHETHER EXPRESS, STATUTORY, OR IMPLIED, INCLUDING WARRANTIES OF MERCHANTABILITY AND FITNESS, AND NO PERSON IS AUTHORIZED TO ASSUME FOR SELLER ANY OBLIGATION OR LIABILITY NOT STRICTLY IN ACCORDANCE WITH THE FOREGOING.