# Anritsu

4-port AutoCal ®
36584NF and 36584KF
Automatic VNMS Calibration Module

## User's Guide

**Automatic Calibrator for Anritsu
MS462XX Series Vector Network Measurement Systems**

产品中有毒有害物质或元素的名称及含量

| 部件名称 | 有毒有害物质或元素 | | | | | |
|---|---|---|---|---|---|---|
| | 铅<br>(Pb) | 汞<br>(Hg) | 镉<br>(Cd) | 六价铬<br>[Cr(VI)] | 多溴联苯<br>(PBB) | 多溴二苯醚<br>(PBDE) |
| 印刷线路板<br>(PCA) | × | ○ | × | × | ○ | ○ |
| 机壳、支架<br>(Chassis) | × | ○ | × | × | ○ | ○ |
| 其他（电缆、风扇、<br>连接器等）<br>(Appended goods) | × | ○ | × | × | ○ | ○ |

○：表示该有毒有害物质在该部件所有均质材料中的含量均在 SJ/T11363-2006 标准规定的限量要求以下。

×：表示该有毒有害物质至少在该部件的某一均质材料中的含量超出 SJ/T11363-2006 标准规定的限量要求。

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注）生产日期标于产品序号的前四码（如 S/N 0728XXXX 为 07 年第 28 周生产）。

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## General Information

## Operation

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Anritsu's obligation covers repairing or replacing products which prove to be defective during the warranty period. Buyers shall prepay transportation charges for equipment returned to Anritsu for warranty repairs. Obligation is limited to the original purchaser. Anritsu is not liable for consequential damages.

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# DECLARATION OF CONFORMITY

**Manufacturer's Name:**    ANRITSU COMPANY

**Manufacturer's Address:** Microwave Measurements Division
490 Jarvis Drive
Morgan Hill, CA 95037-2809
USA

declares that the product specified below:

      **Product Name:**    4 – port AutoCal

      **Model Number:**    36584KF

conforms to the requirement of:

    EMC Directive 89/336/EEC as amended by Council Directive 92/31/EEC & 93/68/EEC
    Low Voltage Directive 73/23/EEC as amended by Council directive 93/68/EEC

## Electromagnetic Interference:

Emissions:    CISPR 11:1990/EN55011: 1991 Group 1 Class A
EN 61000-3-2:1995 Class A
EN 61000-3-3:1995 Class A

Immunity:    EN 61000-4-2:1995/EN50082-1: 1997 - 4kV CD, 8kV AD
EN 61000-4-3:1997/EN50082-1: 1997 - 3V/m
ENV 50204/EN50082-1: 1997 – 3V/m
EN 61000-4-4:1995/EN50082-1: 1997 - 0.5kV SL, 1kV PL
EN 61000-4-5:1995/EN50082-1: 1997 - 1kV L-L, 2kV L-E
EN 61000-4-6:1994/EN61326: 1998 – 3V
EN 61000-4-8:1994/EN61326: 1998 – 3A/m
EN 61000-4-11:1994/EN61326: 1998 – 100% @ 20msec

## Electrical Safety Requirement:

Product Safety:    The Product Complies when used with Company supplied Power
Supply (tested to EN 60950)
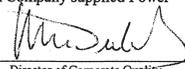
                                                   Director of Corporate Quality

Morgan Hill, CA    13 MAR 02
                                                   Date

European Contact: For Anritsu product EMC & LVD information, contact Anritsu LTD, Rutherford Close,
Stevenage Herts, SG1 2EF UK, (FAX 44-1438-740202)

# How to Use this Manual

This manual describes how to set up and use the 4-port **AutoCal**™ calibrator. After set up, all operation is guided by the MS462XX Vector Network Measurement System. Older series VNAs must use the associated software running on a Personal Computer equipped with the Windows operating system. Most of the documentation necessary to understand and use the **AutoCal** calibrator with older VNAs is provided on line and follows the standard form for HELP used with the Windows operating system.

This manual will describe the physical requirements, including test hardware setup, and use of the MS462XX menus necessary to set up and perform a measurement.

First-time users and maintenance supervisors should read the general material in Chapter 1. This chapter describes the basic operation of the instruments and the performance specifications of the **AutoCal** Module.

**Important Usage Note**

Refer to the MS462XX Operation Manual, Chapter 9, when using **AutoCal** with the MS46XX Vector Network Measurement System.

# Chapter 1
# General Information

## Introduction

This manual will describe how to set up and use the 4-port **AutoCal** module. Once set up, the use of the module will be illustrated through discussion of the Scorpion® MS462XX firmware and associated help screens. Some detailed information can be found in the Scorpion operation manuals and application guides. Throughout this manual, the term **AutoCal** will refer to the model series listed below. Individual models will be referred to by model number. This manual covers two models: the 36584NF and 36584KF, which are for use with the Scorpion MS462XX Vector Network Measurement System (VNMS).

| Model | Frequency Range | Connector |
|---|---|---|
| 36584KF | 10 MHz to 9 GHz | K Female, four ports |
| 36584NF | 10 MHz to 9 GHz | N Female, four ports |

## Description

The **AutoCal** module provides an automatic system for fast, repeatable high-quality calibrations of a Vector Network Measurement System. The **AutoCal** module is inserted between the VNMS test ports to perform the calibration.

The 4-port **AutoCal** module uses electronic switches to exchange the internal calibration standards while providing for excellent repeatabil-

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ity. Isolation standards are not included in the module, but isolation calibration steps can be performed by using external terminations.

A standard RS-232 serial cable is used to connect the **AutoCal** module to a Scorpion MS462XX VNMS or 37000 series VNA. Power is supplied by a connecting cable from a universal power supply (+5 Vdc, +15 Vdc, and -15 Vdc) that is supplied with the module. A power on/off switch is not provided, but the power supply output cable should be connected to the **AutoCal** module **prior** to the line cord on the power supply being connected to the wall outlet.

Test Port Cable Converters (Anritsu series 36583) are used during and after the calibration process to establish the desired test port connector type and sex.

Refer to the MS462XX Operation Manual, Chapter 9, when using **AutoCal** with a Scorpion VNMS.

# Calibrations

The 4-port **AutoCal** module can be used to perform 1, 2, 3 and 4-port calibrations on any Scorpion VNMS. Four-port calibrations can only be performed on 4-port VNAs, but calibrations using fewer ports than the instrument are always permitted.

The **AutoCal** port connectors are all female. This matches the configurations used most often during measurements. If other connector matings are needed, phase equal insertables can be used and are available as 375XR/1 in sets of five. Contact Anritsu for more details or for information on different connector types.

# System Requirements

**Network Analyzer:**

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- Anritsu MS462XX, with system software version 1.15 or later for automatic operation

- 2-port auto calibrations require a 2-port Scorpion minimum

- 2 and 3-port auto calibrations require a 3-port Scorpion minimum

- 1, 2, 3 and 4-port auto calibrations can only be performed on the 4-port MS462XD. Certain special calibration types may also be possible depending on the firmware version. Refer to the MS462XD documentation

**AutoCal:**

- Anritsu 4-port **AutoCal** Module

- Power Supply with Attached Cable

- Serial Interface Cable

- **AutoCal** Disk with Characterization File

# Definitions

The following terms are used in explaining the calibration procedures using the **AutoCal** module:

## Thru

A *thru* is a connection of the two test ports where the transmission path is of modest or low loss when used during calibration. Two kinds of thru connections are defined for the **AutoCal** calibration: (1) a *Calibrator thru* is an internal path through the calibrator. (2) a *True thru* is a direct cable connection between the test ports, with no intervening connectors. The calibrator thru is not as accurate as a true thru, so you have the option of using the more accurate method, if necessary. The 4 port **AutoCal** module contains internal thru paths that are normally used during a calibration. True thrus can be used in lieu of the internal thrus in some calibrations for small improvements in transmission tracking accuracy. This is available only in some firmware versions; contact Anritsu for more information.

## Isolation

For certain measurements that require accurate $S_{21}$ or $S_{12}$ readings for very small values of those parameters, an *isolation* step is required to characterize the leakage of the VNMS and test setup. Isolation is sometimes used to improve the dynamic range by mathematically reducing the effects of leakage. This calibration step is optional and can be performed by using the external calibration standards (see the MS462XX Operation Manual). Since the Scorpion's internal leakage is very small, the step does not usually help very much. However, if the cable setup from the VNMS is leaking, there are cases when the isolation step can be helpful.

## VNMS Measurement Averaging Factor

This is the averaging factor used within the VNMS to determine the number of samples taken during a calibration. Default values are provided for the various standards with the general rule being higher averaging for measurements with lower signal-to-noise ratios (for example, match measurements on loads or thrus). This factor is set by the VNMS menu:

```
Avg/Smooth Menu
```

## VNMS Video IF Bandwidth

The video IF bandwidth is the measurement bandwidth of the VNMS that can be changed both during a calibration and during a measurement. The default value is 1 kHz, but it can be increased for faster measurements (and slightly higher trace noise and noise floor) or decreased for better dynamic range. In conjunction with VNMS averaging above, this determines the calibration or measurement time and usually does not have to be changed for the calibration. This setting is the same as the value set by using the VNMS menu:

```
Video IF BW
```

## Characterization File

Each calibrator module has a file containing data which characterizes each standard in the calibrator. This file also contains information (identification number, start and stop frequencies) concerning the capabilities of the calibrator. Each characterization file has the extension ".acd." When modules are changed, you must open the appropriate new characterization file using the VNMS menus (see Chapter 2):

```
File | Open Characterization File...
```

# Performance Specifications

Specified Temperature Range:        23 °C ± 3 °C ambient

Operating Temperature Range:       0 to 50 °C

Storage Temperature:               -20 °C to +70 °C

Re-characterization Period:         6 months

Frequency Range:                  10 MHz-9 GHz (36581NNF)

Module Connectors:              N Female (3658NF)
                                       K Female (36584KF)

Corrected Directivity:

| | |
|---|---|
| 10 to 1000 MHz | >40 dB |
| 1000 to 3000 MHz | >40 dB |
| 3000 to 6000 MHz | >35 dB |
| 6000 to 9000 MHz | >33 dB |

Corrected Source Match:

| | |
|---|---|
| 10 to 1000 MHz | >40 dB |
| 1000 to 3000 MHz | >38 dB |
| 3000 to 6000 MHz | >35 dB |
| 6000 to 9000 MHz | >33 dB |

# *Chapter 2*
# *Operation*

## Introduction

This chapter describes the set up and operation of the **AutoCal** calibration module and how to perform a calibration. The characterization process is also described, although it is optional for most users.

Refer to the MS462XX Operation Manual, Chapter 9, when using **AutoCal** with the MS462XX Vector Network Measurement System.

## Physical Setup

Figure 2-1 (next page) shows an illustration of the connections necessary to perform an automatic calibration using the **AutoCal** module. These include:

- Power supply (includes a cord set that connects the power supply to the wall outlet and an attached cord that goes to the **AutoCal** module)

- Serial cable connected from the **AutoCal** module to the rear panel of the Scorpion

- RF cables connected from the Scorpion to the **AutoCal** module

There is no on-off switch provided on the **AutoCal** module. When power is connected to the **AutoCal** module, the LED labeled POWER should come on immediately. The second LED, labeled OPERATE, should come on in about five minutes, after the internal temperature

control oven has stabilized. The internal temperature is held within a 5 °C window.

The RF cable connections will be dependent on the type of calibration being done and on the port assignments. The default connections are as follows:

- **AutoCal** port X connects to VNMS port 1
- **AutoCal** port A connects to VNMS port 2
- **AutoCal** port B connects to VNMS port 3
  (used for 3 or 4-port calibrations)
- **AutoCal** port C connects to VNMS port 4
  (used only for 4-port calibrations)

Only some of these port combinations will be used with 2 and 3-port Scorpions. If a reflection-only calibration is being performed, then only one port combination is required (only possible with some firmware versions). If a port is not being used (on either the VNMS or the **AutoCal** module), nothing needs to be connected to it.

Certain other port assignments may be possible; consult the help screens on the instrument or the latest application notes (11410-00214 and 11410-00288) for details.
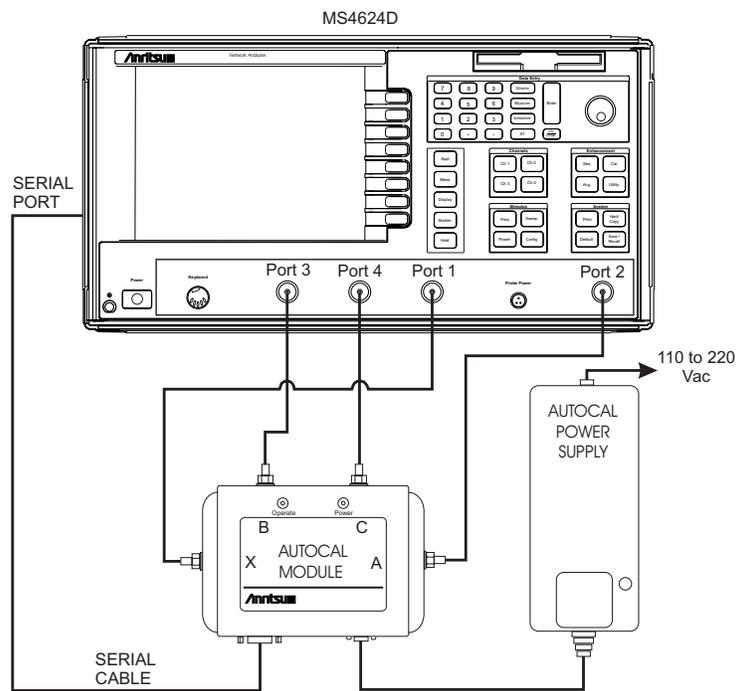
*Figure 2-1.*    *4-port AutoCal Measurement Setup*

# Software Operation

Software operation falls into three broad categories: calibration, assurance, and characterization. Calibration is the process of calibrating the instrument using the **AutoCal** module. Assurance is the process of validating a calibration by the measurement of a standard within the module and the comparison of the measurement results with those previously stored. Characterization is the process of characterizing the **AutoCal** module based on a good calibration obtained by other means. This is typically done by the manufacturer at the time of shipment and then periodically thereafter. The user is free to perform a characterization as well, although specifications may not apply.

## Calibration

The characterization file for the module must first be loaded. This typically comes on a floppy from the factory, but if the user performed the characterization, the file may exist on the hard disk of the MS462XX or elsewhere. The file name must be of the format Sxxxxxxx.ACD where xxxxxxx is typically the serial number of the module. The file name must start with an S and be no more than eight characters in length; the ACD file extension is automatically added. The characterization file may be loaded from the VNMS Characterization Data menu as follows:

```
Save-Recall | Recall | AutoCal
```

The calibration can then be performed. The cables should be connected as described in the previous section with the proper number of cables connected depending on the calibration type selected:

- Full 2-port cal: 1-X, 2-A
- Full 3-port cal: 1-X, 2-A, 3-B
- Full 4-port cal: 1-X, 2-A, 3-B, 4-C

Other calibration types and port assignments may be possible. Consult the latest application notes (11410-00214 and 11410-00288) for more information.

Typically, the cables will all end in male connectors so that they may connect directly to the **AutoCal** module. This was done since many DUTs are composed of all female connectors. If this is not the case, then Phase Equal Insertables (PEIs) may be used on one or more of the cables during calibration and measurement for adaptation. Consult the application note *Three and Four Port S-parameters* (11410-00279) for more information or contact the factory. PEIs are available as Option 1 on the 375XR series of manual calibration kits and may be purchased without a calibration kit.

Once connected (and the OPERATE LED is illuminated), the calibration can be started by proceeding to the calibration menu and selecting **AutoCal** along with the appropriate calibration type. The number of averages may be adjusted here if necessary (see Chapter 1 for definitions), but the default values are usually adequate. Isolation averaging may also be selected here or the isolation step may be omitted (this is the default). Note the port assignment on these menus to be sure that the module is connected correctly. When prompted, hit enter and the various standards within the module will be sequentially measured and the calibration coefficients computed. For more information on the calibration computation process, consult the application notes *Three and Four Port S-parameters* (11410-00279) or *AutoCal* (11410-00258). Once completed, the calibration can be saved to the hard disk or a floppy disk for later recall. Refer to the MS462XX Operation Manual for details.

## Assurance

Assurance may or may not be available depending on the firmware version, see the latest application guide or consult the factory. The assurance process is a quick method of validating a calibration. A standard of intermediate match and insertion loss is built into the **AutoCal** module and measured at the time of characterization. Assurance is invoked by using the menus:

**Utility │ Diagnostics │ AutoCal Assurance**

The item is then measured again and the results are compared to those of the original measurement. If they agree within computed uncertainties, then the assurance algorithm will report that the test passed. If the test has not passed, the module may not be properly connected or the characterization has drifted out of specification. If checking the connections and cables does not help, then a re-characterization (either by the user or by the factory) may be required.

The issue of calibration uncertainties in general, and **AutoCal** uncertainties specifically, are addressed in separate application notes. Consult the factory or your sales representative for more information.

## Characterization

The characterization is performed by the factory at time of manufacture and then typically re-characterized every six months. The user may also perform the re-characterization if the module is operated in a harsh environment or if they desire a higher characterization point density in a given frequency range.

To help understand the last point, note that factory characterization must be done over the full frequency range of the module (10 MHz to 9 GHz) using the maximum calibration point count (1601). As a result, auto calibrations performed over smaller frequency ranges will have a

smaller point density than may be desired. The resulting interpolation error is typically very small, but if this is an issue, the user can perform a characterization over a smaller frequency range (or ranges if a few are used) with the desired point count by doing one of the following:

- Perform a high quality manual calibration over the desired frequency range with the desired point count. Remember that the **AutoCal** is a transfer standard and the resulting calibration will only be as good as the original characterization calibration. Depending on the connector types, use PEIs or non-zero length thrus (consult *Three and Four Port S-parameters*). Consider using sliding loads in the 365X series of calibration kits or the higher performance fixed loads of the 375XR calibration kits.

- Perform a characterization process by measuring the various standards in the **AutoCal** module sequentially by using the menus:

  **Utility | AutoCal Characterization**

  The **AutoCal** module must be connected as indicated by the port assignment. When completed, the characterization file can be saved to the hard disk or a floppy disk. Remember the file name must be of the form Sxxxxxxx.ACD where the .ACD extension will be automatically added.

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# Manual Control

The standards within the **AutoCal** module can be manually selected by using the VNMS menu sequence:

**Utility │ Diagnostics │ AutoCal Assurance**

Figure 2-2, below, shows the two manual control menus.

```
    AUTOCAL ASSURANCE                          SELECT CAL
     MANUAL CONTROL                             STANDARD

     CONNECT PATH
      ▶PORT X-A                                   OPEN


       PORT X-B                                   SHORT


       PORT X-C                                 ▶LOAD


     SELECT                                       THRU
     CAL STANDARD
                                                ASSURANCE


     PERFORM
     ASSURANCE

     HELP         OFF                          HELP         OFF


     RETURN                                    RETURN
```

***Figure 2-2.***    *4-port AutoCal Measurement Setup*

The first menu (on the left) allows you to select a path or perform the assurance measurement. The second menu (on the right) is accessed by pressing the VNMS softkey:

**Select Cal Standard**

This is where the individual calibration standards can be selected.

Figure 2-3, below, shows the internal connections within the **AutoCal** module. Although the reflection standards are labeled open, short, and load, these are just convenient designators for three distinct complex impedances. Since the **AutoCal** module is a transfer standard, the exact impedances are not important as long as they are stable and distinct. An error message will appear if the **AutoCal** module is not connected and powered when selecting these standards. The calibration standard type will always be the same for the two ports of the selected path.
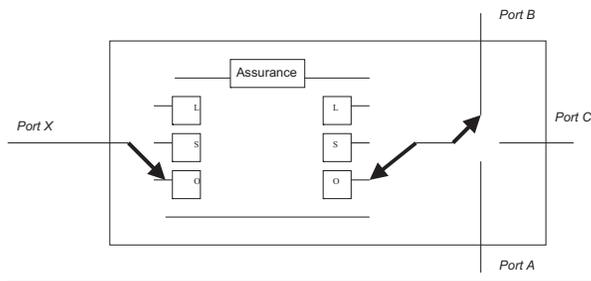


*Figure 2*-*3.*    *4-port AutoCal Block Diagram*

## Characterization Files

The **AutoCal** program begins by displaying the VNMS Characterization Files dialog window. The **AutoCal** module looks for all files in the current directory with the extension ".acd" and displays them in a list box in the Characterization Files dialog window. One characterization file must be chosen to correspond to the specific **AutoCal** module to be used.

The unique Module ID number for the currently selected file will be displayed together with the maximum and minimum frequency that can be used in the calibration.

To accept the configuration displayed, and to proceed with the calibration procedure, click the Command Button:

> `ACCEPT`

If you wish to allow files from other directories or files with extensions other than ".acd" to be included in the list, click the Command Button:

> `BROWSE`

This brings up the standard Windows Open File dialog box.

To access detailed instructions and explanations, click the Command Button:

> `HELP`

To return without taking an action, click the Command Button:

> `CANCEL`

## Setup Dialog Box

The Setup dialog box follows the characterization.

Setup allows a choice of calibration to be performed. The five possible test configurations are presented in a pull-down window with the current selection highlighted. Parameters that do not apply to the selected configuration are shown in gray and do not respond to the selection.

Note that you are required to choose the connection port configuration. A valid calibration may be performed with either VNMS port connected to either **AutoCal** port. Terminals LEFT and RIGHT on the **AutoCal** module may be connected to Port 2 and Port 1 on the VNMS, although the usual connection is to Port 1 and Port 2, respectively.

Similarly, you are required to choose the type of Thru connection to be used, either the internal Thru built into the Calibrator or a manually connected True Thru.

If appropriate, you will be offered a choice for an Isolation Averaging calibration. If you choose to enable this test, you may take the default value or choose an averaging factor from the list.

To proceed with the automatic calibration, click the command button:

    `CALIBRATE`

The associated HELP shows a complete description of the setup requirements and related topics.

# Pin Depth Specifications

The depth of the connectors center pin is a critical specification, which if not met, can cause damage to mating connectors. Table 2-1 provides pin-depth specifications for associated **AutoCal** connectors.

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**Table 2-1.**    *Pin Depth Specifications*

| Device | Connector | Pin Depth (inches) |
|---|---|---|
| 3658XXX | K-Female | +0.0000 to -0.005 |
| 3658XXX | K-Male | +0.0000 to -0.005 |
| 3658XXX | N-Female | [0.207] (+0.000, -0.005)* |
| 3658XXX | K-Female | [0.207] (+0.000, -0.005)* |
| 32K50 32KF50 | K-Male (cable side) | Negative Indication |
|  | K-Female | +0.0000 to -0.0005 |
|  | K-Male (DUT side) | +0.0000 to -0.0005 |
| 32L50 32LF50 | K-Male (cable side) | Negative Indication |
|  | 3.5mm-Female (DUT side) | +0.006 to -0.008 |
|  | 3.5mm-Male (DUT side) | +0.006 to -0.008 |
| 32S50 32SF50 | K-Male (cable side) | Negative Indication |
|  | SMA-Female (DUT side) | +0.0005 to -0.0015 |
|  | SMA-Male (DUT side) | +0.0005 to -0.0015 |

*Gauging Type N Connectors: The actual value of a Type N master gauge block will always vary to some degree from the desired nominal value. The re-corded measured value of the master gauge must be observed when calibrat-ing the Pin Depth Gauge to the desired nominal value. Although the **AutoCal** Module Pin Depths are not critical, this information may be helpful in the mea-surement of Type N mating components. Examples are shown in Figure 2-2 on the following page.

*Example 1:*

**FEMALE MASTER GAUGE BLOCK (protrusion)**

Desired nominal value:          0.2070

***Case1***  Actual value of master gauge: 0.2071
Protrusion is 0.0001 more than desired.
The gauge should be set to indicate +0.0001.

***Case2***  Actual value of master gauge: 0.2069
Protrusion is 0.0001 less than desired
The gauge should be set to indicate -0.0001.

*Example 2:*

**MALE MASTER GAUGE BLOCK (cavity)**

Desired nominal value:          0.2070

***Case1***  Actual value of master gauge: 0.2071
The cavity is 0.0001 deeper than desired.
The gauge should be set to indicate -0.0001.

***Case2***  Actual value of master gauge: 0.2069
The cavity 0.0001 shallower than desired.
The gauge should be set to indicate +0.0001.

**Figure 2-2.**    *Pin Depth Examples*

**NOTES**

Anritsu