

**CP2021 CONTROL PROCESSOR,  
AND 600 SERIES  
PROGRAMMABLE MICROWAVE  
INSTRUMENTS**

OPERATION AND MAINTENANCE  
MANUAL

Version 1.6

October 2020



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## GENERAL INFORMATION

### Warranty

Flann Microwave Ltd. warrants each product of its manufacture to be free from defects in material and workmanship. Our obligation under this warranty is limited to servicing or adjusting any products returned to our address for that purpose and to make good at our facility any part or parts thereof (power supplies, transistors, integrated circuits, batteries, diodes and displays) within one year after making delivery to the original purchaser and which in our examination shall disclose to our satisfaction to have been thus defective. Such returns must have prior authorization from Flann and must be returned as our detailed instructions with transportation charges prepaid. Warranty returns or repairs must first be authorized by Flann. Flann does not authorize any third party to assume for them any other liability in connection with the original sale than the foregoing. *Unauthorized tampering with sealed screws will invalidate the warranty and may result in damage to the product.*

### Design Changes

Flann Microwave Ltd. reserves the right to make changes in the design of its products without reference and without incurring any obligation to make the same alterations on products previously purchased.

### Specification Changes

Flann Microwave Ltd. reserves the right to change any specification noted herein without prior notice.

### Repairs

When wishing to return instruments for repairs, or for any other reason, please contact this Company for shipping instructions. To expedite repair service, it is important to provide type number, serial number and a detailed description of the reason, including all fault symptoms, for the return of the instrument.

***Flann Microwave Ltd.,  
Dunmere Road,  
Bodmin,  
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URL: www.flann.com***

## REGULATORY INFORMATION

### Declaration of Conformity

Manufacturer	Flann Microwave Ltd Dunmere Road Bodmin Cornwall PL31 2QL United Kingdom
Product	Control Processor Model Number: CP2021
European Standards	EN61000-6-1:2007 EN61010-1:2010 EN61010-2-201:2013/AC:2013
Technical File Number	TCF08

It is declared that the above product conforms to the essential requirements of the Electromagnetic Compatibility Directive 2004/108/EC and the Low Voltage Directive 2006/95/EC when used in accordance with the instructions for use, as detailed in the appropriate technical file.

Signed

Dr. James Watts  
For and on behalf of Flann Microwave Ltd.  
Date: 19 January 2015

### Waste Electrical and Electronic Equipment (WEEE) Regulations

Flann Microwave is registered with the United Kingdom Environment Agency as a supplier of electrical and electronic equipment, and makes the required declarations in accordance with WEEE Regulations.

**Where this product was supplied to a customer in the United Kingdom:**

When this product is at the end of its life, Flann Microwave will accept its return for safe disposal and recycling, if required by the Customer. Please contact Flann Microwave for full instructions before returning any WEEE. The return address is:

Flann Microwave Ltd  
Dunmere Road  
Bodmin  
Cornwall PL31 2QL  
Tel. 01208 77777

**Where this product was supplied to a customer outside the United Kingdom:**

Please follow local regulations regarding the disposal and recycling of WEEE, or contact your distributor for advice.

Flann Microwave Ltd can provide information on the materials used in this instrument to assist in their recycling or safe disposal.

## GETTING STARTED

In addition to a brief product description, this chapter covers the following topics:

- Unpacking your instrument.
- Power considerations and connecting the Control Processor to the power supply.
- Connecting the Control Processor to Microwave Instruments.
- Connecting the Control Processor to IEEE488 (GPIB) bus.
- Connecting the Control Processor to the USB interface.
- Environmental Conditions.
- Commissioning the Control Processor.

### Unpacking your instrument

This instrument has been carefully inspected both electrically and mechanically before being shipped from the factory. Perform an incoming inspection to check for signs of physical damage, missing contents, and to check that it passes its internal self-test (see Page 20). If any discrepancy is found, notify the carrier and Flann Microwave.

1. Inspect the shipping container for damage and keep the shipping materials until the inspection is complete.
2. Verify that the shipping container contains everything shown in Figure 1.
3. Make sure that the serial number on the Control Processor's rear panel matches that on the shipping documents.
4. Inspect the outside of the Control Processor and Programmable instruments for any signs of damage.
5. Verify that the Control Processor passes the internal self-tests (detailed later in this section).

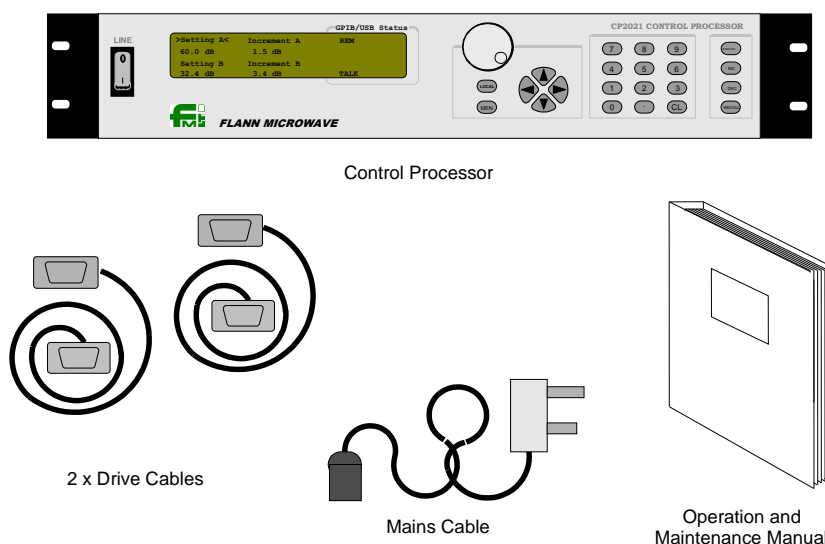


Figure 1: Contents of Shipping Container

## Product Description

Flann Programmable Attenuators and Phase Changers are well proven Precision Rotary Vane instruments driven by high-resolution stepper-motors, ensuring high accuracy and repeatability. The translation between the mechanical positioning of the instrument and the attenuation or phase shift is interpreted by the microprocessor based Control Processor.

The CP2021 is an upgrade of Flann's previous CP2020 and has been designed to satisfy the demand for high precision electronically controlled microwave instruments for use in Automated Test Environments and system applications. Great attention has been paid to all aspects of the microwave, mechanical, electrical and firmware design to achieve a unique standard of accuracy and reliability. **For use in a 19" rack system, remove the four feet using a 3mm hex key. Do not refit these screws.**

The Programmable Rotary Vane Attenuator (PRVA) and Programmable Rotary Vane Phase Changer (PRVPC) have been derived from the Company's highly successful series of manually operated rotary vane attenuators and phase changers that have been universally accepted in both government and commercial organisations alike.

## General Features

- Fully compatible with CP2020.
- Universal line input.
- Hot Swap Microwave instruments, no need to power-down the Control Processor to change instruments.
- GPIB Bus Control. Conforms to IEEE488.1 and IEEE488.2 Specifications.
- USB Interface. Conforms to USB 2.0 Specifications.
- Capable of HS488 high speed GPIB transmission up to 8 MB/s.
- Programmable GPIB command set. Change the Control Processor's GPIB command set to match your software. Backward compatibility to CP92, CP91, & CP82 control processors. Single 'CPEMU' command available to switch to CP92 command set.
- Programmable Microwave Instrument range now from 3.3GHz (WG11A; WR229) to 173GHz (WG29; WR6) in full microwave bandwidths.
- High Accuracy and Repeatability.
- The CP2021 can be placed into 'steps mode' to give greater control over instrument positioning.
- Built-in self-tests to check for any malfunctions in the Control Processor or attached Microwave Instruments.
- Error logs and diagnostic aids to help determine cause of failures.
- Improved and more comprehensible Error reporting.
- Velocity Sensitive Shuttle Wheel to enable quick positioning of instruments.
- Back lit LCD for clear visibility in any conditions.
- Temperature monitoring to prevent damage to internal components.
- Standard Drive Cable length up to 20 metres, with selectable Long Cable option giving up to 50 metres drive capability.
- Ability to upgrade to latest Firmware version from Flann website.



## INSTRUMENT SPECIFICATIONS

### Dimensions and Weight

The CP2021 is supplied in a 19" rack-mount case of standard 2U height plus feet.

Front Panel Height:	89mm
Overall Height with Feet:	110mm
Depth behind Front Panel:	320mm
Overall Depth including Handles:	375mm
Case Width:	432mm
Overall Front Panel Width:	482mm
Weight:	5.6kg

**Note:** Allow at least 80mm behind rear panel for cables and ventilation.

### Power Considerations

**This is a safety class 1 product (provided with a protective earth terminal). A non-interruptible safety earth ground must be provided from the main power source to the Control Processor power input terminals and power cord. Whenever the safety earth ground has been impaired, the instrument must be made inoperative and secured against any unintended operation. If this instrument is to be energised via an autotransformer (NOT RECOMMENDED) for voltage reduction, make sure that the common terminal is connected to the earth pole of the power source.**

### AC Line Power Requirement

Line Input:	90 – 264V a.c. (47 – 63 Hz)
Max Power:	120W
Line Fuse:	2.5A anti-surge, 20mm

### DC Supply Fuses

Logic +5V:	1A anti-surge, 20mm
Motor +32V:	3.15A anti-surge, 20mm

### Connecting the AC Line Supply

Locate the AC Line Input connector on the rear panel of the Control Processor (see Figure 2). Plug one end of the line cable supplied into this port and the other end into a suitable earthed supply.

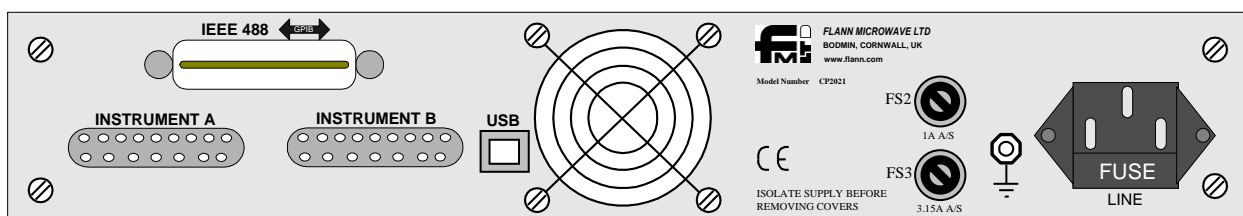


Figure 2: CP2021 Rear Panel

## Environmental Considerations

The Control Processor and Microwave Units are designed to operate in ‘non-hazardous’ areas. The environment in which the product is to be used is commercial, light industrial, either indoors or in a protected outdoor environment.

The operating environment must conform to the conditions shown in Table 1. Operation outside these ranges cannot be guaranteed and may pose dangerous implications to the operator or cause mechanical or electrical failure to the equipment. ***It is important to maintain adequate ventilation at the rear and side vents of the Control Processor at all times.***

Environmental Condition	Ranges
Line Input Range	90 – 264V AC (47 – 63 Hz)
Temperature Operating	0 to +40 degrees C
Temperature Non-Operating	-20 to +60 degrees C
Humidity operating (max)	90 % without condensation
Humidity Non-operating (max)	95 % without condensation

Table 1: Environmental Considerations

## COMMISSIONING THE CONTROL PROCESSOR

The Control Processor does not require connecting to any microwave instruments to power-up successfully, it will still run the internal tests with only the line power connected.

Turn the line switch on. The Control Processor should power up with no error messages displayed, indicating that the Control Processor has passed its internal diagnostics and is functioning properly.

If an instrument drive cable greater than 20m in length is being used, set the Long Cable Option to 'ON' for the relevant channel. Refer to the 'Long Cable' section on page 23.

NOTE: If an error message is displayed, or if the instrument does not appear to operate correctly, refer to 'Error Messages' in a later section of this manual (Page 47).

Once the instrument is functioning properly refer to the 'Quick Start' below.

In the documentation, front panel keys are represented by shaded print: **xxx**.

For example, "Press **INC 2 3 EXECUTE**" means you should press the **INC** key followed by the **2**, **3** and **EXECUTE** keys. The last key, **EXECUTE** terminates the command.

## Connecting the Control Processor to Microwave Instruments

The CP2021 is able to drive a maximum of two 5-phase motor-driven Programmable Instruments of any type. The firmware will automatically configure to each type of instrument connected. In order for the firmware to determine what type of microwave instrument is connected, all series 620, 621, and 670 instruments have a built-in identifier.

Connect the required microwave instrument(s) to the first available port on the rear of the control processor using the 25 way drive cables supplied. If no microwave instruments are available the instrument will still be able to be powered up and run its internal self-tests. **Observe the connection procedures detailed in the Installation Notes for each instrument type in Appendix A.**

## Compatibility with Older Microwave Instruments

The CP2021 can drive the microwave instruments shown in Table 2 when connected with a compatibility drive-cable, obtained from Flann Microwave.

Microwave Instrument Model
**610 Attenuator
**611 Attenuator
**660 Phase Changer

Table 2: Compatibility with Previous Series

This special cable converts from the 25-way D-Type connector on the back of the Control Processor to a 15- Way D-Type used on the older type instruments. This drive-cable also informs the Control Processor that an unknown instrument could be connected and invokes a menu for the user to select the correct Microwave Instrument connected to the Control Processor, as shown in Figure 3. See Appendix C for help in selecting the correct Microwave Instrument, including the section on GPIB/USB Programming on how to make this selection over the GPIB/USB.

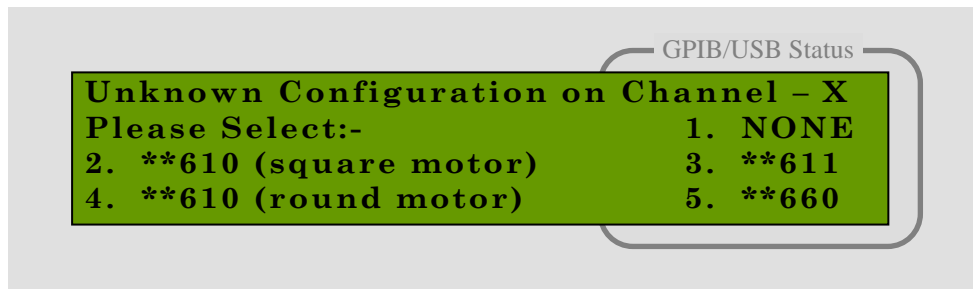


Figure 3: Compatibility Menu

## Limitations on using the Compatibility Drive Cable

The maximum cable length using this type of cable is 5 metres. Exceeding this length could lead to the optical reference signal generator producing incorrect information and possible drive problems leading to Error 4 being reported on the display and GPIB. **The Long Cable Option feature will be disabled.**

The Hot Swap feature ***cannot*** be used with a compatibility drive-cable, as the Control Processor is unable to determine the identity of the instrument. ***The Control Processor must be switched off before disconnecting any instruments that are connected with a compatibility drive cable.***

When the Microwave Instrument is connected using the compatibility cable the Control Processor is unable to restore any of the stored values relating to that instrument on power-up. For example the stored increment, optic disabling and high attenuation features will all revert to the factory defaults.

## Connecting to the IEEE488 bus (GPIB) or USB interface

The GPIB & USB interfaces provide the remote operator with the same control of the instrument available to the local operator, except for control over the line power switch. Remote control is maintained by a controlling computer that sends commands or instructions to, and receives data from, the Control Processor using the GPIB or USB. A complete description of these interfaces can be found in the Reference section of this manual.

For GPIB operation, locate the IEEE488 connector on the rear panel (see Figure 2, page 9). Connect a suitably screened IEEE cable to this port. The other end can be connected directly to the controlling computer or to any other device in the GPIB chain. Note: The cable length limitations for GPIB are: a total of 20 metres, with a maximum of 2 metres cable between any two devices.

For USB operation, locate the USB connector on the rear panel (see Figure 2, page 9). Connect a suitably screened USB cable to this port. Connect the other end to the controlling computer. Note: The cable length limitations for USB are: a total of 25 metres of cable, with a maximum of 5 metres to each device.

***Note that if both IEEE488 and USB are connected, the USB over-rides the IEEE488. Therefore the IEEE488 interface cannot be used once the USB has been connected and recognised by the controller.***

If you wish to use the CP2021 in an IEEE488 application where controller code has been written for a CP92/91/82, then the CP2021 can emulate the older style command set. See Appendix C for further details on how to enable this feature.

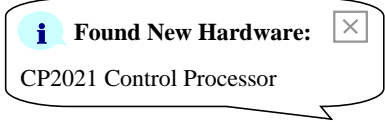

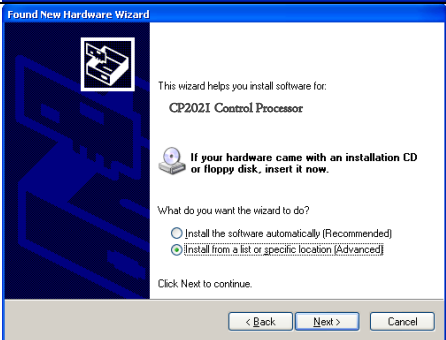
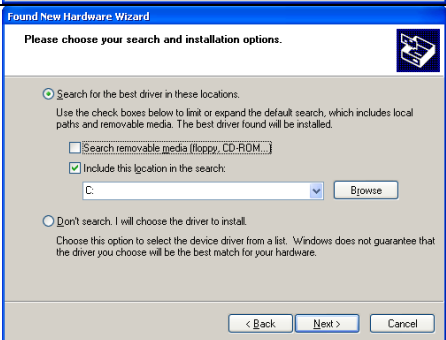
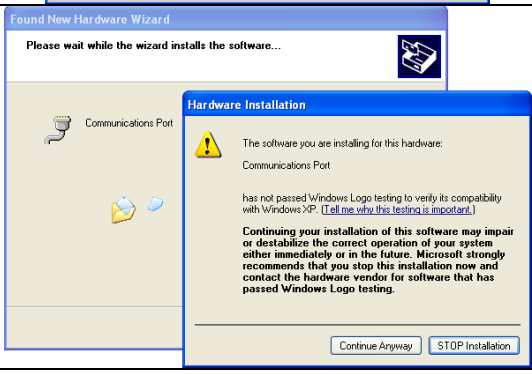
## GPIB Addresses

To communicate via the GPIB each device must have a unique address. To identify the address of other devices in the system check their relevant documentation.

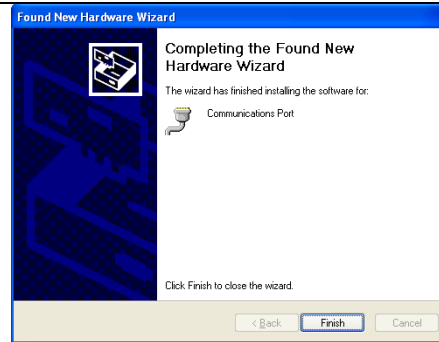
***The GPIB address of the Control Processor is set to a factory default of 4. If this address conflicts with a device already in the system do not connect the IEEE 488 cable to the rear of the CP2021. You will need to change the GPIB address before connecting the interface bus. See Page 17, Using the Menus, in the next chapter on how to set the GPIB address.***

## USB Driver Installation

The CP2021 Control Processor is supplied with a USB 2.0 communications interface which requires installation of the supplied driver on the computer. The driver supplied is compatible with Windows 2000, XP, XP 64bit, Vista, Vista 64bit and Windows 7. Windows XP installation is as follows:

<p>1. Start up the computer and connect a USB cable between the switch driver and computer. Power up the CP2021. The computer should identify the instrument and open the 'Found New Hardware Wizard':</p>	
<p>2. Select 'No, not this time' and press 'Next'</p>	
<p>4. Select 'Install from a list or specific location (Advanced)'.</p>	
<p>5. Select 'Include this location in the search' and Browse for the CP2021.inf driver file on CD. Then press 'Next'.</p>	
<p>6. The installer may warn about 'Windows Logo Testing'. The .inf installation file supplied makes use of drivers which are a part of Windows, so it is inherently compatible with Windows. Press 'Continue Anyway'.</p>	

7. When the installation is complete, the CP2021 will appear as a USB 'COM' port. Windows may allocate any COM number to the instrument, but on most systems it will be allocated COM7 or higher. It is possible to verify which port has been allocated to the CP2021 by checking the Windows Device Manager.



## Firmware Upgrades

Users will be able to upgrade to the latest version of the CP2021 firmware over the USB interface by following the instructions given in the Flann Microwave Ltd. website, [www.flann.com](http://www.flann.com).

A copy of the latest issue of this manual will also be available for download.



## 1. Selecting the Active Field

The Control Processor has three 'Active Fields' per channel. Arrows each side of a title on the Display indicates that that field is active. For example the first line of the display may show:-

"→Setting A← Increment A Stored A", this indicates that "Setting A" is the 'Active Field' and Channel A is the Active Channel. Numeric entries made on the keypad will only alter the values of this Field. The field remains active until another field is selected.

To change the Active Field press any of the arrow keys ▲, ►, ▼, or ◀, to move the cursor over the desired Field. Any front panel numeric entry can now be made in that field.

## 2. Shuttle Wheel

The shuttle wheel can be perceived as an electronic extension of the motor shaft. Rotating the shuttle wheel will rotate the stepper motor on the Microwave Instrument. The Shuttle Wheel is velocity sensitive, spinning it faster rotates the motor shaft further. The shuttle wheel cannot position the instrument beyond its normal range of settings. See page 23 *Shuttle Velocity* and page 31 *Shuttle Wheel Use* for details of altering the sensitivity and disabling the shuttle wheel.

## 3. GPIB/USB Status Indicators

The GPIB/USB status indicators show the current status of the controlling interface bus (either GPIB or USB) when the Control Processor is placed into a remote state. For more details on these Status Indicators see the Remote Programming section later in this manual (commencing on Page 33).

## 4. Numeric Entry

The numeric keypad is used to select digits and decimal point for numerical entries. The **EXECUTE** key is required to terminate the entry. The **CL** key will clear the last numerical entry only if the **EXECUTE** key has not been pressed.

## 5. **EXECUTE** Key

The **EXECUTE** key is a multiple function button, its function is to either terminate a numerical entry or to select a Menu setting. It is also used to acknowledge any errors or configuration changes if they occur.

## 6. Increment Keys

The **INC** and **DEC** keys are used to increase or decrease the setting of the microwave instrument by the increment value. For example pressing **DEC** will reduce the setting of the microwave instrument by the value stored under the 'Increment' field. These keys have built-in auto-repeat, i.e. holding down the key will perform multiple increments.

## 7. **RECALL** key

The **RECALL** key positions the selected Microwave Instrument to the value entered in the STORED Field.

For example, make **STORED** the Active Field (see page 16, *Selecting the Active Field*) and enter 1, 2, ., 3, **EXECUTE**. The value 12.3 will be stored for later use. To recall the value, press **RECALL**, the value 12.3 will be transferred into the SETTING Field of the selected instrument, and the instrument will be positioned to 12.3.

## 8. **LOCAL** Key

The local key returns the instrument to a local state. If the Control Processor has been programmed over the GPIB or USB, the device will have entered a remote state. This will inhibit front panel (local) control. Pressing **LOCAL** will take the Control Processor out of its remote state and permit local control. For more details on GPIB and USB control see the Remote Programming section commencing on Page 33.



## Using the Menus

The more specialised functions are contained within the menus. This section gives a brief outline of how to use the menus but does not go into the meaning of functions contained within. A working example is given on changing the GPIB address so that the unit can be connected to the GPIB without causing any conflicts.

To access the menu functions use the **MENU** button. The first menu level will be displayed. The menu level is shown in the top left-hand corner of the display.

To move up and down the menu levels use the **▲**, **▼** buttons. The **▼** button moves down the menu levels. i.e. 1 to 2 to 3 to .... The **▲** button moves up the menu levels i.e. 10 to 9 to 8 to ....

The maximum menu level is level 10, pressing the **□** button beyond this will have no effect. To make selections within the menus use the **◀**, **▶**, and the **EXECUTE** keys to confirm the selection.

To exit the menu, press either the **CL** button or the **MENU** button again.

### *Worked Example – Setting the GPIB address*

1. *If not in menu-mode (designated by Menu and a number in the top left-hand corner of the display) press **MENU**, the menu level will start at level 1.*
2. *Press **▼** until menu level 6 is reached. This is entitled GPIB ADDRESS.*
3. *The present address is displayed on the right. If this address conflicts with devices already on the bus or you wish to change it anyway, enter the new address using the numeric keypad. Note: the valid range of GPIB addresses is from 0 to 30. Entering a value outside this range will result in the entry being rejected.*
4. *Press **EXECUTE** to accept and terminate the entry.*
5. *If the numeric entry was a valid GPIB address the Present Address will update to the new value.*
6. *The new GPIB address is now set. There is no need to cycle the power to make the changes.*
7. *Press **CL** to exit the menus.*

## Positioning the Microwave Instruments

This section will give a brief outline on how to position the instruments to a user requested setting. To make use of this section requires at least one Microwave Instrument to be connected to the CP.

There are four ways to position the microwave instrument via the front panel.

- 1) Enter a value directly into the Setting Field and press **EXECUTE**.
- 2) Enter a value into the Increment Field then use the **INC** and **DEC** buttons.
- 3) Spin the shuttle wheel to set to the new position (see 'Shuttle Wheel Use', on page 31).
- 4) Recall a stored value.

### *Worked Example – Setting the Instrument to a value*

*Note: **Do not** attempt to set the Microwave Instrument with the manual drum, if fitted, when connected to the Control Processor. Always disconnect or power down the Control Processor before attempting to use the manual drum.*

1. Make 'Setting' the Active Field, on the required channel.
2. Enter a numerical value e.g. 12. (For standard range Attenuators this value should be between 0 and 60, and for Phase Changers this should be between 0 and 720).
3. Note how the display changes to 'Set A to' or 'Set B to' to indicate that **EXECUTE** has not yet been pressed.
4. If the value entered is correct, press **EXECUTE**. The instrument will position to the new value.
5. If the value entered was incorrect press **CL** then re-enter the numerical value.

### *Worked Example – Incrementing a Microwave Instrument*

1. Make 'Increment' the Active Field, on the required channel.
2. Enter a numerical value e.g. 1 (For Attenuators this value should be between 0 and 60, and for Phase Changers this should be between 0 and 720).
3. Note how the display changes to 'Set A Inc to' or 'Set B Inc to' to indicate that **EXECUTE** has not yet been pressed.
4. If the value entered is correct, press **EXECUTE** to store the new increment. Alternatively, immediate use of the **INC** or **DEC** keys will also cause the value to be stored.
5. Once values have been stored, pressing **INC** or **DEC** will cause the Microwave Instrument setting to increase or decrease by the amount stored in the increment field. These keys have built-in auto-repeat, i.e. holding down the key will perform multiple increments.

## SYSTEM DESCRIPTION

At the core of the Control Processor lies a 32-bit microcontroller that controls all aspects of its operation. The Microcontroller is programmed to derive the stepper motor waveforms and ramping profiles without the need for external logic. This enables complete configuration over the drive characteristics which, along with 'dynamic intelligent firmware' that can configure itself to the type of instrument connected, means that the CP2021 is able to drive all past and present models of 5-Phase programmable instruments. (A cable adapter is required for old models – refer to the Compatibility Drive Cable section on page 12).

The basic functions performed by the Control Processor are: -

- Synchronise the Microwave Instruments to the control electronics.
- Read the Instrument identity and configure itself accordingly.
- Set the Microwave Instrument to any position within the valid range for that instrument.
- Increment or decrement the Microwave Instrument by any value within the valid range.
- Monitor the motor's position sensors and indicate any errors that occur.
- Accept information from the IEEE-488 interface, USB interface, or front panel.
- Output information to the IEEE-488 or USB interface, and to the front panel display.

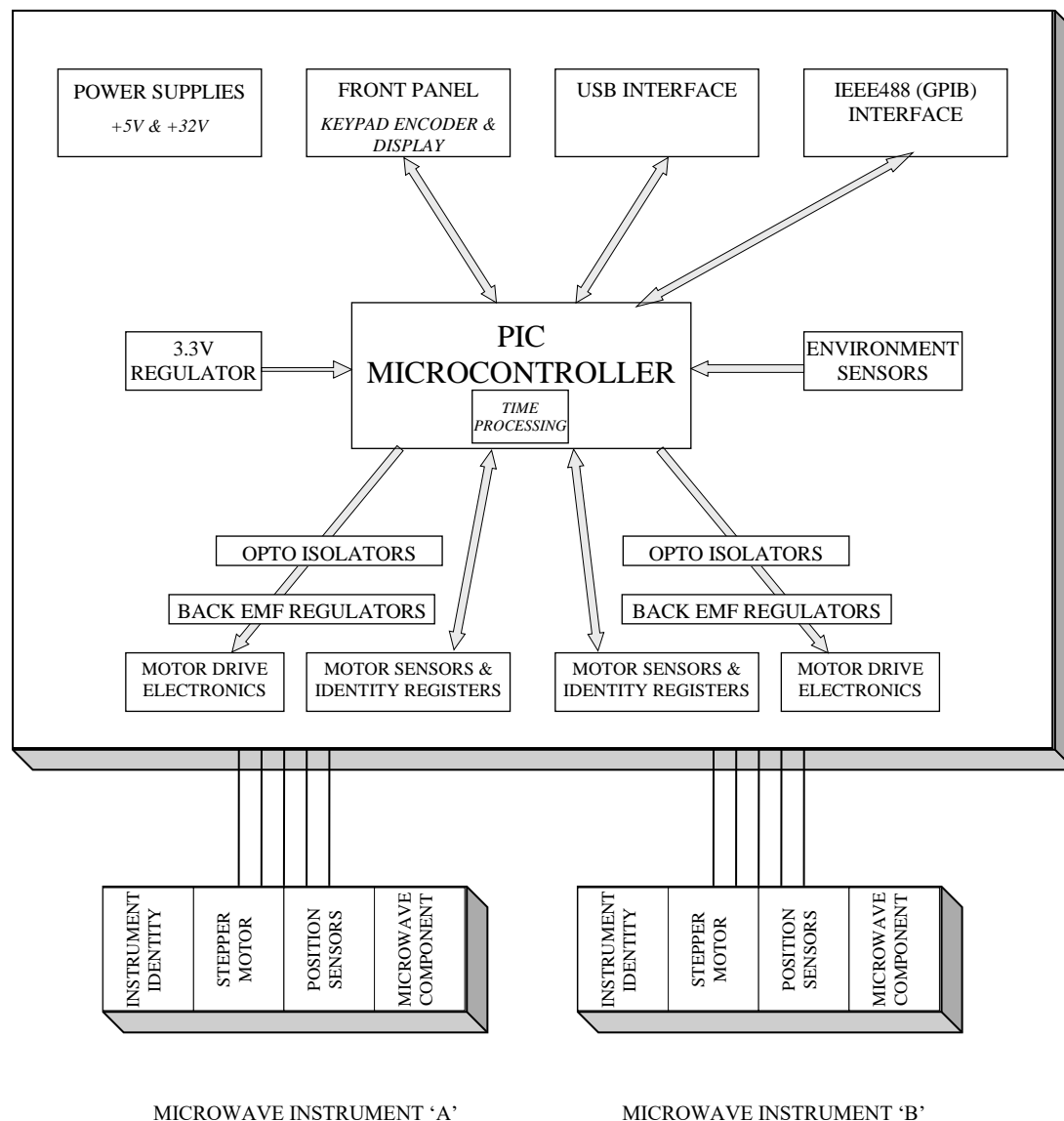


Figure 5: Simplified Block Diagram of the Control Processor

## REFERENCE SECTIONS

### System Functions and Features

#### Power up Procedure

When Power is supplied to the Control Processor it initially performs the built-in internal tests, these tests check the Central Processing Unit, the Arithmetic Logic Unit, the Time Processing Unit, the GPIB interface and the Keypad. Any errors that are detected at this stage are reported to the user, if possible, via the Front Panel Display. If the error is such that the system is unable to continue then a further error message will be generated and the processor will be halted. If the error is not fatal the system will continue with the power up sequence.

The Control Processor contains an audio transducer that is used to indicate any errors that occur during power up. See Table 3 below.

BEEPS	MEANING
1	Normal Start-up
2	Power on Reset Disabled
3	Static Supply Fail
4	Display Fail
5	CPU Fail
6	ALU Fail
7	32V Supply Fail
8	GPIB fail

Table 3: Power-On Self-Test Beeper Signals

If the Control Processor passes all internal tests it will then read the identity of the instruments connected to each channel. If the Power-On Reset is enabled it will then attempt to reset the instruments on each channel one at a time. If the Power-On Reset is disabled, a message will be displayed and the reset procedure will be halted until the user acknowledges that it is acceptable to continue.

If a Microwave Instrument is connected to Channel 'A', this will be the first to reset. (See the Microwave Instrument Reset Procedure on page 21 for details). If an instrument is detected on Channel 'B', this will then reset.

The Control Processor will then read any user configured conditions stored in the EEPROM and place these into the command queue. While these commands are being processed the display will be blank for a maximum of 2 seconds, depending upon the amount of user configuration data processed by the device.

If the 'Restore Settings' Flag has been set (refer to page 23) then the Control Processor will return the instruments to the settings stored when the power was removed (providing they are the same type of instruments that were connected at that time to the same channels).

The Power-On Flag is then cleared and the GPIB and USB interfaces enabled. This completes the power up procedure. The Control Processor is now ready for Local or Remote control.

## Microwave Instrument Reset Procedure

The Microwave Instrument reset is performed to reference the instrument to the control electronics. The instrument reset procedure is performed whenever the following situations occur:

- Power On (only if power-on reset is not disabled).
- RESET or \*RST is sent over the GPIB or USB.
- When an instrument is connected for the first time.
- Changing from Steps Mode to Value Mode (refer to page 22).
- A setting value is entered which is greater than the maximum setting of the instrument (except when the high attenuation feature for Programmable Attenuators has been activated).

Phase 1 of the reset procedure starts with the Control Processor driving the Microwave Instrument towards its maximum reference setting at a step rate dependant on the inertial load of the microwave instrument. Phase 1 is completed when the Microwave Instrument generates a maximum signal.

Phase 2, the Control Processor checks that the minimum and reference signals are not seen at the same time as the maximum signal.

Phase 3, the Control Processor then performs a search for the reference signal. During this time the Microwave Instrument is driven towards the expected reference position at a reduced steps rate. On finding the reference signal a search of the local area is performed to check that it has received a valid opto signal. This involves the instrument stepping past the reference signal and back a number of steps to ensure that the signal is present for one step only.

Errors are generated if any phase of the reset procedure produces unexpected results. For information on error codes and messages see the section on 'Error Codes and Messages' later in this manual.

If the procedure is completed without any errors being generated then the Microwave Instrument and Control Processor have been successfully initialised and are ready for use.

## Control Processor Features

This section details the features that the Control Processor offers. The features and functions can be accessed generally by three methods, Front Panel Control (Local), or via either GPIB or USB programming (remote) using a defined command.

With each feature or function detailed, the method of activating that function is given here for information. For further details on activating these functions see the relevant section on Front Panel Control or Remote Programming later in this manual.

Functions are either Channel Dependent or System Wide. i.e. a Command that is Channel dependent will only affect the active channel. A System Wide command will affect both channels. All enabled or disabled features are stored in EEPROM and automatically reinstated on power on.

**Steps Mode                      Menu level 1                      GPIB/USB command: SSET (value)**

This is a Channel dependent Command

This command places the Control Processor into steps machine mode. The display units will change from dB, or Degrees, to Steps. Any settings entered in the setting or increment fields will be used to position the motor by raw motor steps.

The setting field will show the number of motor steps the instrument has moved from the reference position.

This function can be employed if the user needs greater control over positioning of the Microwave Instruments. See Appendix A in reference to Attenuators or Phase Changers, for the relationship between Microwave Instrument Settings and raw motor steps, and for valid entries while in SETTING mode.

**Value Mode                      Menu level 1                      GPIB/USB command: VSET (value)**

This is a Channel dependent Command.

This function places the Control Processor into value mode. This is the normal operating mode of the Control Processor. Any settings entered in the setting or increment fields will be treated as either dB's, or Degrees, depending on the Microwave Instrument connected.

Note: If switching to Value Mode from Steps Mode the Control Processor will enter the Microwave Instrument Reset Procedure.

See Appendix A for valid entries while in VALUE mode.

**High Attenuation                      Menu level 2                      GPIB/USB command: HIGH ON/OFF**

This is a Channel dependent Command. Its default condition is disabled.

When this feature is enabled and an Attenuator is connected to the relevant channel, issuing a setting value that is outside the normal operating value of the instrument will no longer reset the instrument. Instead the instrument is positioned to its maximum attenuation position. This value for a 0-60 dB attenuator is approximately 85 dB. When in high attenuation the Front Panel display will show 'MAX' in the Setting Field. A query of the instrument position over the GPIB/USB when in high attenuation will also return 'MAX'. Increments or Decrements are not possible when the Microwave Instrument is set to MAX. Nor is it possible to increment to MAX. A setting inside the range of normal operation must be entered to return it to normal operation. The High setting feature has no effect if the instrument operating mode is set to steps.

This feature provides a much higher attenuation than is normally available.

**Optic Sensor****Menu level 3****GPIB/USB command: OPTO ON/OFF**

This is a Channel dependent Command. Its default condition is enabled.

This function enables the user to override the normal checking of the reference sensor in the Microwave Instrument. During normal operation the reference signal is checked at the expected location on the final rotation of the motor to ensure that the motor has not lost synchronisation.

This function can be turned off if the user needs a faster positioning time or if the Microwave Instrument's reference processing circuit has failed and the user still wishes to continue using the instrument.

**WARNING: If this feature is disabled the Control Processor has no way of checking that the instrument is at the setting shown on the Front Panel or GPIB/USB. The user should therefore leave this function enabled for all but exceptional cases.**

**Long Cable****Menu level 4****GPIB/USB command: LCABLE ON/OFF**

This is a Channel dependent Command. Its default condition is disabled.

When this feature is enabled the Control Processor will change the motor drive characteristics of the selected channel to enable the programmable instrument to be driven over a cable length of up to 50m. Note that the programmable instruments will be driven at a reduced speed when this option is selected.

**WARNING: Do not enable this feature when using drive cables of up to 20m length. To do so may impair operation of the stepper motor and drive components.**

**Restore Settings****Menu level 5****GPIB/USB command: HOLDSET ON/OFF**

This is a System Wide Command. Its default condition is disabled.

When this feature is enabled the Control Processor will be restored to the state it was in when the power was removed. This will involve the normal power up procedure followed by the instruments positioning to their settings prior to the power-down.

**NOTE:** The Restore Settings feature will only position the instrument if it is recognised as the same type of instrument that was connected when the power was removed.

**GPIB Address****Menu Level 6****GPIB Command: ADDRSET value**

This is a System Wide Command. Its default value is 4.

This function controls the Talk and Listen address of the GPIB interface. A valid entry is an address between 0 and 30 inclusive. Refer to Remote Programming later in this manual (commencing on page 33) for information on setting the GPIB address.

Values entered outside this range will be rejected.

**Shuttle Velocity****Menu Level 7**

This is a System Wide Command. Its default value is 5.

This value controls the sensitivity of the shuttle wheel. The higher the value (up to a maximum of 9) the smaller the shuttle movement required to position the Microwave instrument by the same rate. A value of zero will completely disable the shuttle wheel. As this function is purely a front panel control it has no associated GPIB/USB command.

### **Keypad Sounder      Menu Level 8      Local Keypad Command only: ON/OFF**

This is a local Keypad Command. Its default value is enabled.

This function allows the user to disable the sounder when performing data entry using the keypad. The Control Processor will continue to generate status and warning beeps during power-up and error detection.

### **Power-on Reset      Menu Level 9      GPIB/USB Command: PONRST ON/OFF**

This is a System Wide Command. Its default value is enabled.

This function allows the user to disable the reset that occurs when the Control Processor is switched on. The Control Processor will pause its normal power-on reset procedure until either the Front Panel **EXECUTE** button is pressed or the ERRACK command is sent over the GPIB or USB. **NOTE:** The Restored Settings Feature and Stored Increments cannot be processed when Power on Reset has been disabled.

### **Service:      Menu Level 10**

#### **Firmware Revision      Sub-Menu: Diagnostics      GPIB/USB Command: \*IDN?**

This lists the current firmware revision and model number of the Control Processor.

#### **View Error Log      Sub-Menu: Diagnostics      GPIB/USB Command: ERRLOG?**

This feature lists the internal error log that is held in non-volatile memory (EEPROM). The error condition, program counter and stack pointer of each fatal error is held in this log. The user cannot clear the error log. For descriptions of the error codes in the error log refer to the Error Codes and Messages section later in this manual (page 47).

#### **Stats      Sub-Menu: Diagnostics      GPIB/USB Command: PWRSTAT?**

This feature lists the number of times the processor has experienced a reset.

The field 'LINE' shows how many times the line supply has been cycled.

The field 'SOFT' shows how many times the software has restarted the system. This could occur if the user issues a 'reset to factory defaults' command.

The 'SYS' field shows the number of times that a fatal error has restarted the firmware.

The 'TOTAL' field will show the total number of times the firmware has been restarted.

### **Tests      Sub-Menu: Level 10**

This feature will test all aspects of the Microwave Instrument to determine if the instrument is electrically operating to specification. The results are displayed on the Front Panel LCD so there is no associated GPIB or USB command to perform this action. See the section on Instrument Errors (page 50) if problems are experienced running this test.

If the user is experiencing problems with the Control Processor as a system, this test can determine if the fault lies with the Microwave Instrument.

The Control Processor will only test the active channel. Ensure before running this test that the correct channel is selected. **NOTE:** The GPIB and USB leads should be disconnected during the test, as any controlling signal traffic could cause the test to produce erroneous results.



**Preset****Sub-Menu: Level 10** **GPIB/USB Command: FACTDEF**

This function restores the factory defaults.

Upon selection of this option the user is asked if they wish to continue with the pre-set. If the answer is No, the CP will exit the menu mode. If the answer is Yes, the user area of the non-volatile memory will be cleared. This will have the effect of restoring the factory defaults. The Control Processor will then perform a soft reset to action the changes. **Note that the GPIB address will now revert to the factory default setting (4).**

**Programmable GPIB command set** **GPIB Command: LEARN string**

The Control Processor is able to accept a GPIB command to change the default names for the Instrument Commands. For example the default commands for changing the active channel are CHAN A and CHAN B. If this is not suitable they can easily be changed to, for example, SAT 1 and SAT 2.

This function is supplied so that if the CP2021 replaces another manufacturer's equipment, the GPIB command set can be modified to match the instrument it is replacing. This saves time in having to change any of the controller's code.

Also offered is a compatibility mode that emulates the command set of the CP92, CP91, and CP82 control processors, so that the CP2021 can be used alongside its predecessors without need for changing the controller code.

**The CP2021 command set is totally compatible with that of the former CP2020.**

See GPIB/USB programming section later in this manual for information regarding the Programmable Command set (page 45) and Appendix C.

**Note:** This command is not relevant for users of the USB interface.

**Programmable Titles** **GPIB/USB Command: TITLE A|B "string"**

This feature allows the default title of Setting A and Setting B to be changed to the user's preference.

For example the Titles could be changed to MOTOR\_1 and MOTOR\_2. The string can be up to nine characters long. Refer to the GPIB/USB programming section starting on page 33.

NOTE: The GPIB/USB parser ignores white spaces and all incoming text is converted to uppercase.

### **Hot Swap Microwave Instruments**

#### **This facility is only available with Programmable Instruments with 25-way connectors**

Microwave Instruments can be connected and removed at any time without the need for powering down the Control Processor, *except when a compatibility drive cable is connected*. See the Appendix C section on compatibility with older instruments.

Upon detection of an instrument change a message will be displayed on the front panel followed by five fast beeps from the internal sounder. The INSTCC bit (bit 3) will also be set in the ESRB (Event Status Register B), (see GPIB/USB programming section starting on page 33 for further details).

The user must accept this configuration change either via front panel, GPIB, or USB before being able to continue. If a new instrument has been connected the firmware will reconfigure itself to drive the new instrument and then enter the Microwave Instrument Reset Procedure.

**Note: Microwave Instruments must not be disconnected while the motor is positioning. Doing so may cause damage to the internal components of the Control Processor.**

### **HS488 High Speed GPIB data transfer**

The Control Processor supports HS488, a high-speed data transfer protocol. This function has to be enabled by the controlling computer by sending a multiline message to the CP2021. When enabled, depending on GPIB cable lengths and the ability for the controller to receive HS488, GPIB data transfer can be increased to a maximum of 8 MB/s. See page 35 for information on how to initialise the HS488.

### **Real-Time Temperature Monitoring**

The Control Processor continually checks the internal temperature of the chassis. If the temperature reaches limits that could cause damage to internal components, the Control Processor will shut down the drive circuits to reduce power dissipation. It will signal that this has been done by issuing a warning to the user via the GPIB/USB status structure and on the front panel display (see page 48).

### **Audio Transducer**

The Control Processor contains an audio transducer that is used to indicate any errors that occur. The signals produced by the transducer during normal running are shown in Table 5 below. Note that these signals are different from the Power on Self-test signals given earlier in Table 4, and that the keypad entry sounder can be switched off under Menu option 8.

BEEPS	SPEED	MEANING
1	FAST	Normal Keypad Entry
3	SLOW	Static Supply Failed
4	SLOW	Display Failed
5	FAST	Instrument Change
6	SLOW	Over Temperature
7	SLOW	32V Supply Failed

Table 5: Warning Beeps

## Front Panel Control (Local)

This section covers the local or front panel control. It provides a reference to all the commands and functions available to the user via the local interface. This section covers the following topics:

- Understanding the Display
  - Active Fields
- Key layout and functions
  - Selecting the Active Field
- Shuttle Wheel use
- Understanding the menus

Manual operation is only possible when the instrument is in local mode. The instrument is in local mode when the “REM” indicator is not displayed in the GPIB/USB status window. Local is the default mode at power-up. If the CP is in REMOTE mode the **LOCAL** button will return the instrument to the local state.

There may be cases where an error condition occurs and the error message covers the GPIB status indicators. If, therefore, the front panel fails to respond to user input, press the LOCAL key to ensure the Control Processor is in local state. N.B. Pressing **LOCAL** may not return the instrument to the LOCAL state if the Control Processor has been placed into LOCAL LOCKOUT. Pressing **LOCAL** will have no effect under this condition (see relevant documentation for your controller).

## Understanding the Display

During normal operation (i.e. not in menu mode) the display is split into two key areas, these are designated Channel A and Channel B. See Figure 6 below.

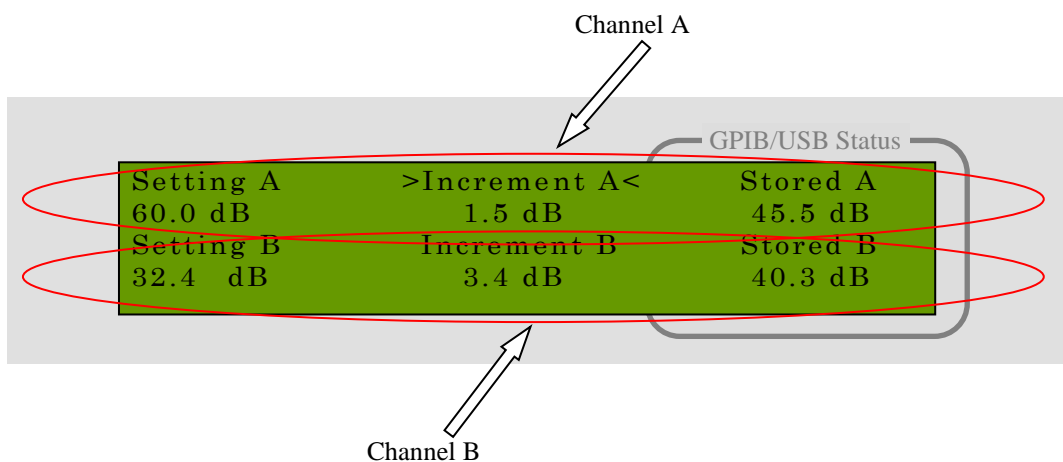


Figure 6: Display Layout

The top section displays information relating to the Microwave Instrument connected to Channel A and the bottom section displays information relating to the Instrument connected to Channel B.

Each section is divided into three subsections. These are termed ‘fields’. If an arrow highlights a field on each side (as ‘Increment A’ below), then this field is termed the Active Field.

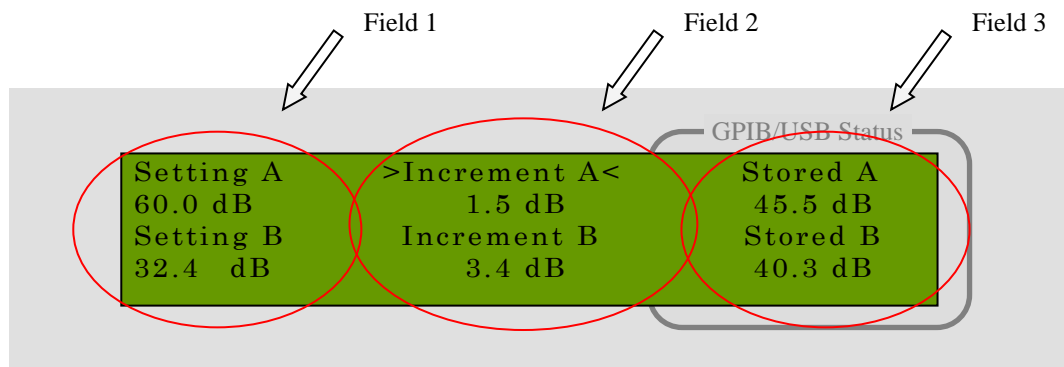


Figure 7: Display Subsections

Figure 7 shows the three subsections of the display. Field 1 is designated the Setting Field, Field 2 the Increment Field and Field 3 the Stored Field. As arrows are either side of the Increment Field in Figure 7 then it can be said that ‘Increment A’ is the Active Field in this example.

## Active Fields – Descriptions

### Setting Field

This field shows the current setting of the Microwave Instrument. While in value mode, this may be in decibels (dB) or degrees (°) dependent upon the type of instrument connected to that channel. In steps mode, 'Stp' will be displayed, see page 22 for more details. The units following the value will indicate which is the case.

Valid terminated numerical entries made in this field this will result in a Microwave Instrument positioning to the new setting. A value entered which is higher than the normal operating range of the instrument will cause that channel to enter the Microwave Instrument Reset Procedure. However if the High Attenuation feature is enabled in menu level 2 the instrument will be placed into ‘High Attenuation’. See Control Processor Features, page 23, for more information on entering high attenuation.

For Example pressing 1, 2, ., 4, EXECUTE will result in the selected instrument positioning to 12.4, this could be decibels or degrees depending on the type of Microwave Instrument connected to that channel. Note: when the instrument is positioning, a double-headed arrow appears next to the setting. This indicates that the Control Processor is currently positioning that Channel, and that the setting is currently under change. While this is happening the Control Processor is unable to accept any other command until the repositioning cycle is completed.

When a numerical entry is made into this field and before the EXECUTE terminator is pressed, the title for the display will change to ‘Set A to’. This indicates that:

- a) The number shown in this field is not the instrument setting.
- b) The EXECUTE key has not yet been pressed.

It is possible to enter a numerical entry into this field and switch to another field without pressing the EXECUTE key to terminate the entry. This will cause the entry to be cleared and the active field to change. If an error is made whilst entering the required setting, pressing CL will delete the entry.

Refer to Appendix A, for valid settings for each type of Microwave Instrument.

### Increment Field

This field shows the stored increment setting. This may be in dB's or degrees depending upon the type of Microwave Instrument connected to that channel. The units following the value will indicate which is the

case. The stored increment is used to increment or decrement the Setting Field when the **INC** or **DEC** button is pressed.

An **□**(out of range) symbol will be displayed if the user tries to increment or decrement the instrument by a value smaller than the minimum possible increment of that type of instrument.

For Example,

- 1) Connect an attenuator to Channel A, and make 'Setting A' the active field.
- 2) Set the attenuation to 60 dB
- 3) Make 'Increment A' the active field
- 4) Set the increment to 0.01 dB
- 5) Press **DEC**

Result: 0.01 dB is smaller than the minimum decrement at this setting. The Control Processor will therefore decrement by the smallest possible value. In this case this would be 0.1 dB. The display will show the **□** symbol to indicate that the increment was out of range.

When a numerical entry is made into this field and before the **EXECUTE** terminator is pressed, the title for the display will change to 'Set A Inc to'. This indicates that the number shown in this field is not the stored increment setting and that the **EXECUTE** key has not yet been pressed.

It is possible to enter a numerical entry into this field and switch to another field without pressing the **EXECUTE** key to terminate the entry. This will cause the entry to be cleared and the active field to change. If an error is made whilst entering the required setting, pressing **CL** will delete the entry.

A shortcut is available if the user wants to store an increment that is to be used straight away. Instead of pressing say 2, 3, ., 1, **EXECUTE**, **DEC**. The user can omit the **EXECUTE** button. The **INC** or **DEC** buttons will automatically terminate the numerical value in the Increment field.

Refer to Appendix A, for valid Increment settings for each type of Microwave Instrument.

### **Stored Field**

This field is used to store a setting so that the user may return the Microwave Instrument to that setting at any time.

For example, make STORED the Active Field and enter 5, 2, ., 3, **EXECUTE**. The value 52.3 will be stored for later use. To recall the value, press **RECALL**, the value 52.3 will be transferred into the SETTING Active Field and the Microwave Instrument setting will become 52.3.

When a numerical entry is made into this field and before the **EXECUTE** terminator is pressed, the title for the display will change to 'Store Value'. This indicates that the number shown in this field is not the stored setting and that the **EXECUTE** key has not yet been pressed. This field then becomes unterminated and will remain with the title 'Store Value' until that field is made active again and **EXECUTE** or **CL** is pressed.

It is possible to enter a numerical entry into this field and switch to another field without pressing the **EXECUTE** key to terminate the entry. This will cause the entry to be cleared and the active field to change. If an error is made whilst entering the required setting, this may also be deleted by pressing **CL**.

A value outside the range will be rejected, with the exception of the case when a PRVA is attached. A stored setting of 99 will be accepted and can be used to **RECALL** the instrument to the 'MAX' setting if the High Attenuation mode is set. Otherwise, the Attenuator will perform a reset to the reference setting.

## Key Layout and Functions

Figure 8 shows the front panel keypad layout.

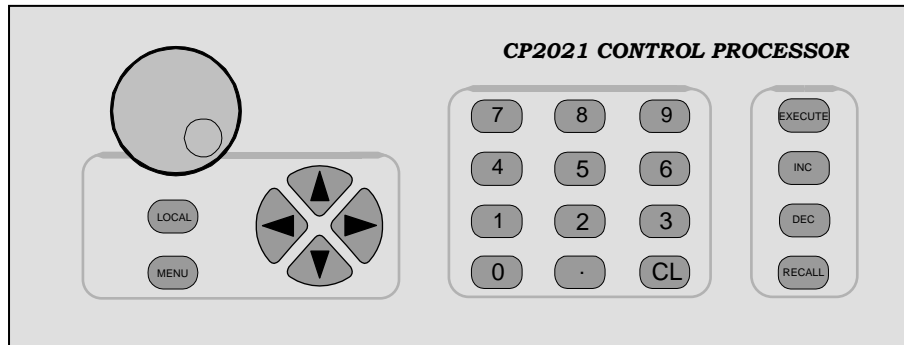


Figure 8: Keypad layout

### **Numeric Data Entry Keys 0 to 9, ., CL**

These keys are used to change the values of settings in the Active Field. They are used in the same way as the data entry keys on a calculator. A terminator is required to end the data entry; this is the **EXECUTE** button, see below. The **CL** key is used to clear incorrect data.

### **Terminator key EXECUTE**

The **EXECUTE** key is a multiple function button, its functions are to either terminate a numerical entry or to select a Menu setting. It is also used to acknowledge any errors or configuration changes if they occur.

### **Increment Keys INC, DEC**

The **INC** and **DEC** keys are used to Increment and Decrement the setting of the microwave instrument. For example, pressing **DEC** will reduce the setting of the microwave instrument by the value stored under the 'Increment' field. These keys have built-in auto-repeat; holding down the key will perform multiple increments.

### **RECALL Key**

The **RECALL** key places values entered in the STORED Field into the SETTING Field.

For example, make STORED the Active Field and enter 1, 2, ., 3, **EXECUTE**. The value 12.3 will be stored for later use. To recall the value, press **RECALL**, the value 12.3 will be transferred into the SETTING Field of the selected instrument and the Microwave Instrument will be driven to 12.3.

## **LOCAL Key**

The local key returns the instrument to a local state. If the Control Processor has been programmed over the GPIB or USB the device will have entered a remote state, which will inhibit front panel (local) control. Pressing **LOCAL** will take the Control Processor out of its remote state and permit local control. For more details on GPIB AND USB control see the Remote Programming section on page 33.

N.B. Pressing **LOCAL** will not return the instrument to the LOCAL state if the Control Processor has been placed into LOCAL LOCKOUT. Pressing **LOCAL** will have no effect under this condition (see relevant documentation for your controller).

## **Cursor Keys**

The cursor keys are used to select the active field and to make selections within the menus.

## **Selecting the Active Fields**

The Control Processor has three ‘Active Fields’ for each channel. An arrow each side of the title block highlights the active field. For example the first line of the display may show  
” →Setting A← Increment A Stored A”, this indicates that “Setting A” is the ‘Active Field’ and that Channel A is the Active Channel. Numeric entries made on the keypad will only alter the values of this Field. A field remains active until another field is selected.

To alter the Active Field press any of the cursor keys , , ,  , to move the cursor to the desired Field.

## **Shuttle Wheel Use**

The shuttle wheel can be seen as an electronic extension of the motor shaft. Turning the shuttle wheel will turn the motor on the active channel. The resultant setting will be shown in the Setting field.

The instrument can only be positioned within its normal operation range. The shuttle wheel is disabled if the Instrument is at the ‘High Attenuation’ setting.

The shuttle wheel only performs this one task. It is disabled when the Control Processor is placed into remote or local lockout via the GPIB or USB, or the sensitivity is set to 0, or the Control Processor is in menu mode (see page 24 for further details).

The shuttle wheel is velocity sensitive. The sensitivity can be set in menu level 7. Values of 1 to 9 set the level of sensitivity. The higher the value, the greater the Microwave Instrument movement. A value of 0 disables the action of the shuttle wheel. The factory default setting is 5.

The shuttle encoder will enter ‘Sleep’ mode if it is not used for a period greater than ten seconds. The encoder will re-awaken when it senses that the wheel has been rotated by a defined amount. This ‘Dead Zone’ prevents false movement of the microwave instruments by an accidental knock or vibration of the Control Processor.

## Understanding the Menus

Pressing the MENU button on the front panel will cause the Control Processor to enter menu mode level 1. From here the more specialist functions of the Control Processor become available. Figure 9 shows the menu structure.

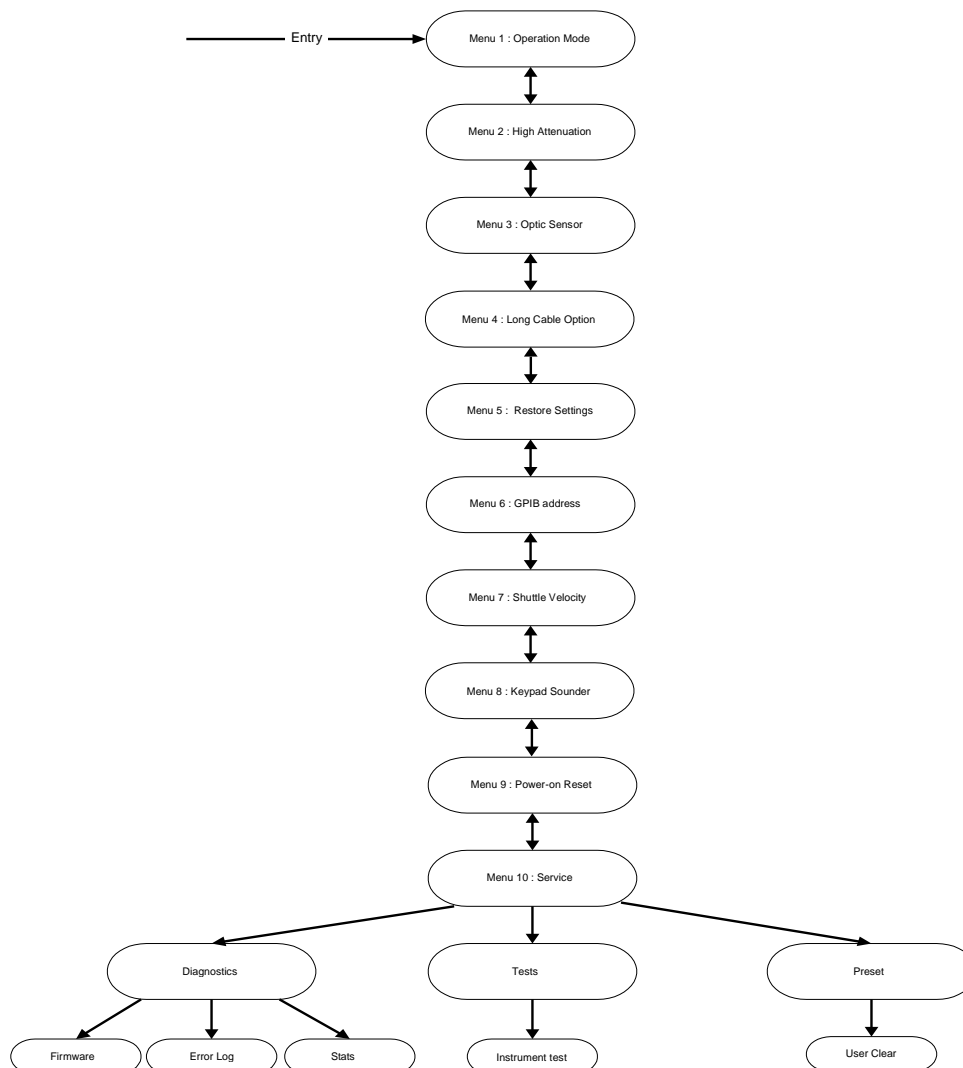


Figure 9: Menu Structure

The layout for most of the menus has the same format. The current state of the menu function is shown on the right hand side of the display, separated by a line. A change of state will be reflected by this current state on the right hand side being updated.

While in menu mode the cursor-up and cursor-down keys move through the menu levels and the cursor-left and cursor-right keys make selection changes, with the EXECUTE key activating the changes. The double arrows used to show the Active Field when not in menu mode, are now used to show the current selection.

Some of the menu levels are one-way, i.e. pressing the up button will not return you to the level above. These are shown in Figure 9 by single headed arrows.

The details of each function in the menu are covered in Control Processor Features (pages 22 to 25).

Pressing either **CL** or **MENU** will exit the menu mode.



## Remote Programming (GPIB or USB)

**The CP2021 command set is totally compatible with that of the former CP2020.**

This section contains the information required to control the CP2021 over the GPIB (ANSI/IEEE Std 488) and USB interfaces, and covers the following topics:

- Implementation of IEEE488.1 and IEEE488.2
- Front Panel Indicators
- GPIB restrictions
- HS488, High Speed Communications Protocol
- Status Reporting Structure
- GPIB Command Set
- GPIB Further Information
- Learn Set, Backwards Compatibility

### How the GPIB Works

The GPIB uses a party-line bus structure in which up to 15 devices can be connected on one continuous bus. The interface consists of 16 signal lines and 8 ground lines in a shielded cable. With this cabling system, many different types of devices may be connected in parallel. Every GPIB device must be able to perform one or more of the following interface functions.

#### ***Talker***

A talker is capable of sending device-dependent data when it has been addressed to talk. There can be only one talker at any given time. The CP2021 is a talker when it sends setting or instrument data over the bus.

#### ***Listener***

A listener is capable of receiving device-dependent data when it has been addressed to listen. There can be up to 14 listeners at any one time. The CP2021 is a listener when controlled by a computer over the bus.

#### ***GPIB Bus Structure – Data Bus***

The data bus consists of eight bi-directional lines that are used to transfer data from one device to another. Programming commands and data are typically encoded on these lines in ASCII. Every byte that is transferred over the GPIB undergoes a handshake to ensure valid data is received.

#### ***GPIB Bus Structure – Handshake Lines***

A three-line handshake scheme co-ordinates the transfer of data between talkers and listeners. This technique forces data transfer to occur at the speed of the slowest device and ensures data integrity in multiple listener transfers. This handshake is generally performed transparent to the user.

## Implementation of IEEE488.1, IEEE488.2, and USB

The CP2021 may be addressed as a Talker and/or Listener and includes the following ANSI/IEEE Std 488 Interface Functions:

<i>SH1</i>	<i>Source Handshake</i>	<i>Complete Capability</i>
<i>AH1</i>	<i>Acceptor Handshake</i>	<i>Complete Capability</i>
<i>T5</i>	<i>Talker</i>	<i>Basic Talker, Serial Poll, Talk Only, Unaddressed on MLA, Send END or EOS</i>
<i>L3</i>	<i>Listener</i>	<i>Basic Listener, Listen Only Mode, Unaddressed on MSA and LPAS, Detect END or EOS</i>
<i>SR1</i>	<i>Service Request</i>	<i>Complete Capability</i>
<i>RL1</i>	<i>Remote Local</i>	<i>Complete Remote/Local Capability</i>
<i>PP0</i>	<i>Parallel Poll</i>	<i>No Capability</i>
<i>DC1</i>	<i>Device Clear</i>	<i>Complete Capability</i>
<i>DT0</i>	<i>Device Trigger</i>	<i>No Capability</i>
<i>C0</i>	<i>Controller</i>	<i>No Capability</i>
<i>E2</i>	<i>Electrical Interface</i>	<i>Three-State Drivers</i>

## Remote Control Front Panel Indicators

The front panel display of the Control Processor has an area reserved for GPIB/USB status information during remote operation. When in Local this area is used by the Stored Value Field. This area conveys information on the state of the remote interface.

The following indicators can be shown when controlled over the GPIB interface:

<b>REM</b>	The CP2021 is in remote state.
<b>TALK</b>	The CP2021 is addressed to talk.
<b>LSTN</b>	The CP2021 is addressed to listen.
<b>LOCK</b>	The CP2021 has been placed into local lockout mode.
<b>SRQ</b>	The CP2021 is requesting service from the controller.
<b>COMP</b>	The CP2021 is in compatibility mode or a non-compliant user command set is installed (PMUS OFF).
<b>USER</b>	An IEEE488.2 compliant user command set has been installed.

The following indicators can be shown when controlled over the USB interface:

<b>REM</b>	The CP2021 is in remote state.
<b>TX</b>	The CP2021 is addressed to talk.
<b>RX</b>	The CP2021 is addressed to listen.

## GPIB Restrictions

<b>Number of Interconnected Devices</b>	15 Maximum, including Controller.
<b>Interconnection Path/ Maximum Cable Length</b>	20 metres overall or 2 metres per device, whichever is less.
<b>Message Transfer Scheme</b>	Byte-serial/bit-parallel asynchronous data transfer using a 3-line handshake system. HS488 uses a non-interlocked handshake protocol. (See section on HS488).
<b>Data Rate</b>	Maximum of 8 MB/s with HS488 over limited distances with tri-state drivers. Actual data rate is dependent upon the transfer rate of the slowest device involved.
<b>Address Capability</b>	Primary Addresses: 31 Talk, 31 Listen (Addresses 0 to 30). A maximum of 1 Talker and 14 listeners at one time.

## USB Restrictions

<b>Number of Interconnected Devices</b>	127 Maximum, using a tiered system structure.
<b>Maximum Cable Length</b>	5 metres per device, 25 metres overall.
<b>Protocol</b>	Serial.
<b>Data Rate</b>	480 Mbits/s.

Refer to the full specifications available from [www.usb.org](http://www.usb.org)

## HS488, High Speed Communications Protocol

HS488 enables transfer rates that are substantially faster than the IEEE488.1 standard transfer rates. In small systems the raw transfer rate can be up to 64 Mbits/s. The faster raw transfer rates improve throughput in systems where devices send long blocks of data. The physical limitations of the cabling system however, limit the transfer rate.

### **Compatibility with IEEE488.1 Devices**

HS488 devices are compatible with IEEE 488.1 devices. IEEE 488.1 devices and HS488 devices can exist in the same system and they communicate with each other using IEEE488.1 protocols.

A controller does not need to be capable of HS488 non-interlocked transfers. While ATN is true, a Controller sources multiline messages to HS488 devices just as it sources multiline messages to any IEEE488.1 devices.

Addressed HS488 devices detect whether other addressed devices are also HS488 compatible without the Controller's action.

The HS488 Acceptor Handshake and Source Handshake interface functions depend on several time delays. Some of these delays are a function of the total system cable length.

The controller must communicate this system configuration data to the CP2021 after power on. If no configuration information is sent then the Control Processor defaults to the normal IEEE488 transfer speed.

To configure the CP2021 for HS488, the Controller must source two multiline messages while ATN is true. (See the controller documentation for details of sending multiline messages.)

The first message is the CFE message. The controller sends the CFE message by driving a bit pattern (1F hex) that the IEEE488.1 standard does not define on the data signal lines. The CFE message enables HS488 devices to interpret the SCG message that follows. The second message is a Secondary Command Group message that contains the configuration data. The Secondary Command has the bit pattern 6n hex, where n is the cable length in metres of the system.

For Example, sending	Multiline	1F (hex)
	Multiline	64 (hex)

Will inform the CP2021 that 4 metres of cable are in the system. The CP2021 will then configure the GPIB interface to make best use of the interface.

## Status Reporting Structure

Figure 10 shows the status reporting structure of the CP2021. Tables 6 to 10 on the following page describe the status bits of each register.

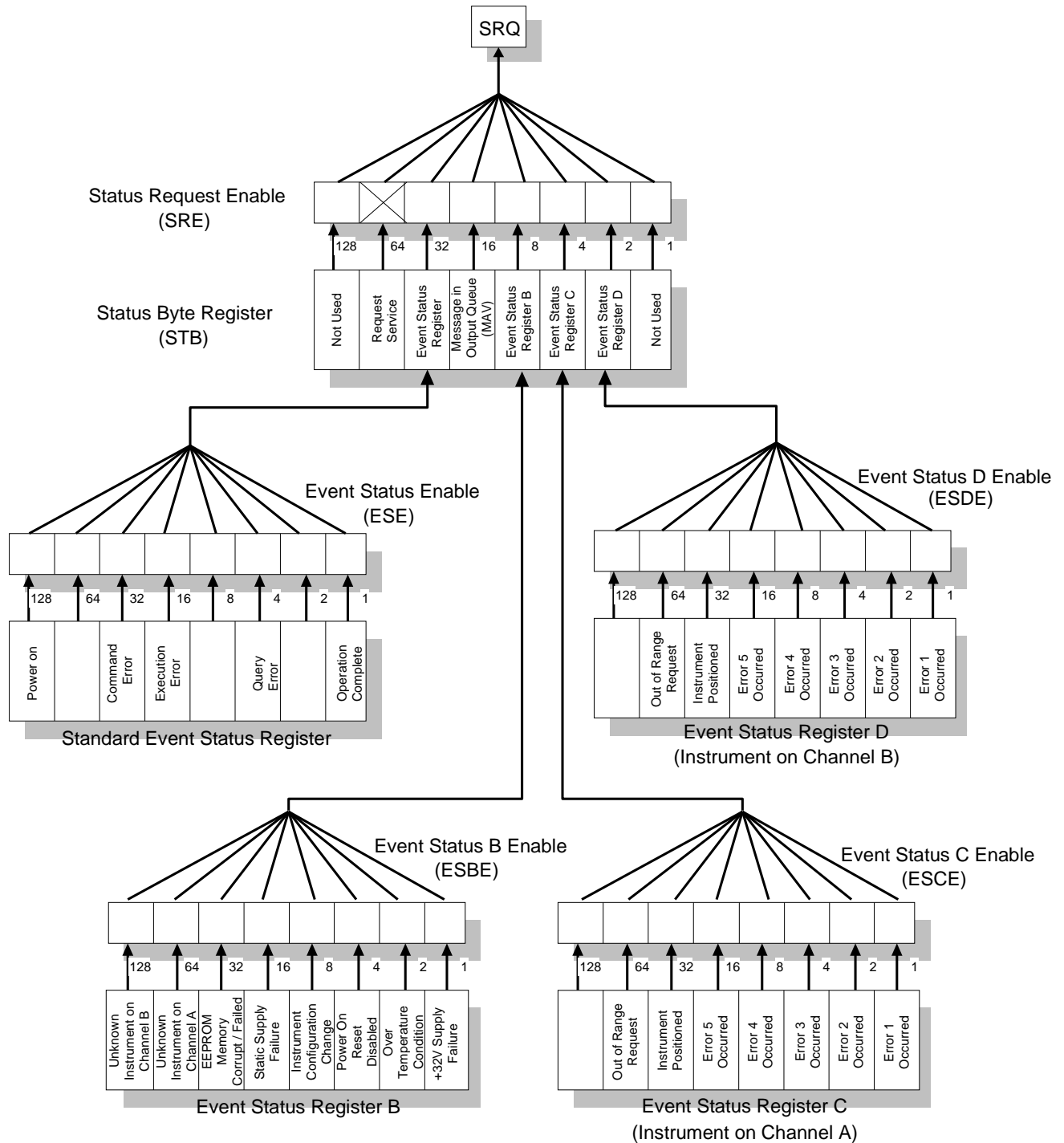


Figure 10: Status Reporting Structure

Bit	Name	Description
1	Check Event Status Register D	One of the enabled bits in the event status register D has been set
2	Check Event Status Register C	One of the enabled bits in the event status register C has been set
3	Check Event Status Register B	One of the enabled bits in the event status register B has been set
4	Message in output queue	A command has prepared information to be output, but has not yet been read
5	Check Event Status Register	One of the enabled bits in the event status register has been set
6	Request Service	One of the enabled status byte bits is causing an SRQ

Table 6: Status Bit Definitions of the Status Byte (STB)

Bit	Name	Description
0	Operation Complete	A command for which OPC has been enabled has completed
2	Query Error	The Control Processor has been addressed to talk, but there is nothing in the output queue to transmit
4	Execution Error	A command was received that could not be executed. Commonly due to invalid operands
5	Command Error	A GPIB command had incorrect syntax error (spelling or use)
7	Power-On	A power-on sequence has occurred since the last read of the register

Table 7: Status Bit Definitions of the Standard Event Status Register (ESR)

Bit	Name	Description
0	Motor Drive Supply failure	The +32V motor drive power supply has failed
1	Over-Temperature Condition	The system has been halted due to the internal temperature of the chassis rising above the maximum limit
2	Power-on reset has been disabled	Power-On reset has been disabled and the Control Processor is waiting for the command to continue
3	Instrument Configuration Change	A Microwave Instrument has been connected or removed
4	Motor Holding Supply failure	The +5V holding supply to the instrument motors has failed
5	EEPROM failed or corrupt	The data in the EEPROM memory has become corrupt or cannot be accessed
6	Unknown Instrument on A	The Control Processor was unable to identify the instrument on channel A (see section on compatibility with older instruments in Appendix C, Page 65)
7	Unknown Instrument on B	The Control Processor was unable to identify the instrument on channel B (see section on compatibility with older instruments in Appendix C, Page 65)

Table 8: Status Bit Definitions of Event Status Register B (ESRB)

Bit	Name	Description
0	Error Code 1	Channel A has produced an Error code 1. See section on Instrument Errors p 50-52
1	Error Code 2	Channel A has produced an Error code 2. See section on Instrument Errors p 50-52
2	Error Code 3	Channel A has produced an Error code 3. See section on Instrument Errors p 50-52
3	Error Code 4	Channel A has produced an Error code 4. See section on Instrument Errors p 50-52
4	Error Code 5	Channel A has produced an Error code 5. See section on Instrument Errors p 50-52
5	Instrument A has Positioned	The instrument connected to Channel A has been positioned
6	Out of Range Request	A setting value has been requested that is above the maximum settable value for the instrument and has caused a reset of this channel

Table 9: Status Bit Definitions of Event Status Register C (ESRC)

Bit	Name	Description
0	Error Code 1	Channel B has produced an Error code 1. See section on Instrument Errors p 50-52
1	Error Code 2	Channel B has produced an Error code 2. See section on Instrument Errors p 50-52
2	Error Code 3	Channel B has produced an Error code 3. See section on Instrument Errors p 50-52
3	Error Code 4	Channel B has produced an Error code 4. See section on Instrument Errors p 50-52
4	Error Code 5	Channel B has produced an Error code 5. See section on Instrument Errors p 50-52
5	Instrument B has Positioned	The instrument connected to Channel B has been positioned
6	Out of Range Request	A setting value has been requested that is above the maximum settable value for the instrument and has caused a reset of this channel

Table 10: Status Bit Definitions of Event Status Register D (ESRD)

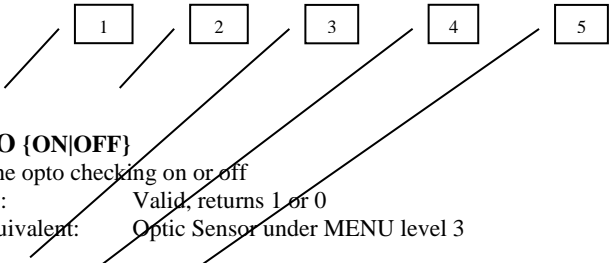
## Notes on Status Registers:

- The value of the status register will return to zero after being read.
- The Enable Register Masks can be saved into EEPROM memory to be reinstated at power-on. See the PSC command in the GPIB/USB commands section on page 44.

## GPIB/USB Command Set

This section details the commands available over the GPIB or USB, and the valid operands that may accompany them.

### Notation

- 
- 1** **OPTO {ON|OFF}**  
Sets the opto checking on or off  
Query: Valid, returns 1 or 0  
FP equivalent: Optic Sensor under MENU level 3
- 2** **VSET [*value*]**  
Switches to value mode and sets the Microwave Instrument to the value  
Query: Valid, returns setting  
FP equivalent: Enter a value in the Setting Field
- 3** **Value** 0 to 99.99 (dB) for an Attenuator, 0 to 999.8 for a Phase Changer
- 4** Program code commands are not case sensitive, i.e. upper and lower case characters are equivalent.
- 5** Characters enclosed in the {} brackets are qualifiers attached to the root mnemonic. There can be no spaces or symbols between the root mnemonic and its appendage. e.g. {ON|OFF} shows that either ON or OFF can be attached to the root mnemonic.
- A constant, a pre-assigned simple or complex numeric, or string variable transferred to the Control Processor. A space may be inserted between it and the root mnemonic. Square brackets ( [ ] ) show that the enclosed information is optional
- 'Query: Valid' indicates that the command can be queried.
- FP equivalent indicates the method of achieving the same command via the front panel.

For example, the OPTO command has three possible applications: -

1. **OPTO ON** - Switch on the Opto checking on the active channel
2. **OPTO OFF** - Switch off the Opto checking on the active channel
3. **OPTO?** - Query the present state of the OPTO checking function

A semicolon (;) is the recommended terminator for each program command. A line feed can also serve as a terminator. For Example, either of the following commands is acceptable:

```
OUTPUT CP2021; "CHANA;VSET45;"
OUTPUT CP2021; "CHANA;VSET45"
```

### Query Commands

For instrument state commands, append the question mark character (?) instead of the {ON|OFF} to interrogate the state of the functions. The Control Processor responds to the query with a "1" or a "0" to indicate On or Off, respectively. For a settable function such as VSET *value*, using VSET? causes the Control Processor to respond to the query by sending the function's current value.

Examples of using the query command

```
OUTPUT CP2021; "ISET?"
ENTER CP2021; I
PRINT I
```

## GPIB/USB Device Commands

### **ADDRSET *value* (GPIB only)**

Changes the GPIB primary address to *value*

Query: Valid, returns the GPIB address

FP equivalent: Under menu level 6, GPIB ADDRESS

**Value** 0 to 30, default 4. The address cannot be set outside this range. The GPIB address change will take place upon parsing the command. It is not necessary to cycle the power.

### **CHAN{A|B}**

Changes the active channel to be Channel A (CHANA) or Channel B (CHANB)

Query: Valid, returns 1 for Channel A active, 2 for Channel B active

FP equivalent: ▲, ▼ buttons.

### **CPEMU (GPIB only)**

Sets the instrument to the CP92 command structure (see the following section on page 45 for details)

Query: Invalid

FP equivalent: None available

### **DEC**

Decrease Microwave Instrument setting by the stored Increment

Query: Invalid

FP equivalent: DEC button

### **ERRACK**

Acknowledges any system errors or system messages that are preventing further operation of the Control Processor. Sending this message before a system error is reported will result in the Active Channel being Reset.

Query: Invalid

FP equivalent: EXECUTE button

### **ERRLOG?**

Outputs the error log

Query: Valid, returns a string of up to 1.2K in length

FP equivalent: Under Diagnostics Menu, ERROR LOG.

### **ESBE *value***

Enable specific bits in the Event Status Register B

Query: Valid, returns the enable mask for register ESRB

FP equivalent: None available

**Value** 0 to 255

### **ESCE *value***

Enable specific bits in the Event Status Register C

Query: Valid, returns the enable mask for register ESRC

FP equivalent: None available

**Value** 0 to 255

### **ESDE *value***

Enable specific bits in the Event Status Register D

Query: Valid, returns the enable mask for register ESRD

FP equivalent: None available

**Value** 0 to 255

### **ESRB?**

Request the value of the ESRB register

Query: Valid, returns the Event Status Register B value, a value from 0 to 255

FP equivalent: None available

**ESRC?**

Request the value of the ESRC register

Query: Valid, returns the Event Status Register C value, a value from 0 to 255

FP equivalent: None available

**ESRD?**

Request the value of the ESRD register

Query: Valid, returns the Event Status Register D value, a value from 0 to 255

FP equivalent: None available

**FACTDEF**

Restore the Control Processor to Factory Defaults

Query: Invalid

FP equivalent: Under Diagnostics menu, PRESET.

**HIGH {ON|OFF}**

Sets the high attenuation feature on or off

Query: Valid, returns 1 or 0

FP equivalent: High Attenuation under MENU level 2

**HOLDSET{ON|OFF}**

Returns the Microwave Instruments to the position when power was removed

Query: Valid, returns 1 or 0

FP equivalent: Menu level 5, RESTORE SETTINGS

**INC**

Increase the Microwave Instrument Setting by the stored Increment

Query: Invalid

FP equivalent: **INC** button

**INSTIDA?**

Outputs the string identifier for the type of instrument connected on Channel A

Query: Valid, returns a string identifier of up to 40 characters

FP equivalent: Displayed on the front panel when instrument connected

**INSTIDB?**

Outputs the string identifier for the type of instrument connected on Channel B

Query: Valid, returns a string identifier of up to 40 characters

FP equivalent: Displayed on the front panel when instrument connected

**ISSET *value***

Sets the Stored Increment to *value*

Query: Valid, returns stored Increment

FP equivalent: Enter a value in the Increment Field

**Value** 0 to 60.0 (dB) for an attenuator, 0 to 720.0 (degrees) for a phase changer

**LCABLE {ON|OFF}**

Changes the motor drive characteristics to enable operation using a drive cable of 20 - 50m

Query: Valid, returns 1 or 0

FP equivalent: Menu level 4, LONG CABLE OPTION

**LEARN string (GPIB only)**

Program a new command set into the Control Processor (see the following section on page 45 for details)

Query: Invalid

FP equivalent: None available

**String** Maximum of 100 characters



**MODE?**

Outputs the current operating mode

Query: Valid, returns either 0 for VALUE MODE or 1 for STEPS MODE

FP equivalent: Indicated by the units on the display

**NORML (GPIB only)**

Returns the Control Processor to the default command set if a custom command set has been programmed

Query: Invalid

FP equivalent: None available

**OPTIONA value**

Informs the Control Processor of the Identity of the Microwave Instrument on Channel A. Used only when a compatibility drive cable is being used. See Appendix C for details..

Query: Invalid

FP equivalent: Selection from displayed menu

*Value* 1 to 5

**OPTIONB value**

Informs the Control Processor of the Identity of the Microwave Instrument on Channel B. Used only when a compatibility drive cable is being used. See Appendix C for details.

Query: Invalid

FP equivalent: Selection from displayed menu

*Value* 1 to 5

**OPTO {ON|OFF}**

Sets the opto checking on or off

Query: Valid, returns 1 for on, or 0 for off

FP equivalent: OPTIC SENSOR under MENU level 3

**OUTLRN? (GPIB only)**

Outputs the learned command set and the current command mode

Query: Valid, returns the learned command set followed by the current command set (either USER1 for a user command set, or NORML for the default command set). Maximum length 110 characters.

FP equivalent: None available

**PONRST{ON|OFF}**

Enables or Disables the Power-On reset

Query: Valid, returns 1 for on, or 0 for off

FP equivalent: Menu level 9, POWER-ON RESET

**PWRSTAT?**

Outputs the power-up statistics

Query: Valid, returns a string of 50 characters maximum

FP equivalent: Diagnostics menu, under STATS

**RECALL**

Sets the instrument to the value retained in the stored setting (see STORE command below)

Query: Invalid

FP equivalent: Pressing the Recall button

**RESET**

Resynchronise the instrument on the active channel

Query: Invalid

FP equivalent: Enter a value in the Setting field higher than the normal operating area of the Microwave Instrument

**SSET [*value*]**

Switches to Steps mode and sets the Microwave Instrument to *value*

Query: Valid, returns number of steps from reference

FP equivalent: Select STEPS from Menu level 1

**Value** -150 to 8574 for an attenuator, -18000 to 18000 for a phase changer

**STORE *value***

Saves the Stored Setting as *value*

Query: Valid, returns stored setting

FP equivalent: Enter a value in the Stored Field

**Value** 0 to 99.99 (dB) for an Attenuator, 0 to 999.8 (degrees) for a Phase Changer, or 0 to 9999 if in Steps mode

**TITLEA “string”**

Changes the default title for the Setting Field on Channel A

Query: Invalid

FP equivalent: None available

**String** Maximum of 9 characters enclosed by quotes (“ ”) or (‘ ’). Alphabetic characters will be converted to upper case on the display

**Note:** Any spaces included in “string” will be discarded when parsed

**TITLEB “string”**

Changes the default title for the Setting Field on Channel B

Query: Invalid

FP equivalent: None available

**String** Maximum of 9 characters enclosed by quotes (“ ”) or (‘ ’). Alphabetic characters will be converted to upper case on the display

**Note:** Any spaces included in “string” will be discarded when parsed

**USER1 (GPIB only)**

Sets the instrument to the learnt command structure (see the following section, page 45 for details)

Query: Invalid

FP equivalent: None available

**VSET [*value*]**

Switches to value mode and sets the Microwave Instrument to *value*

Query: Valid, returns setting

FP equivalent: Enter a value in the Setting Field

**Value** 0 to 99.99 (dB) for an Attenuator, 0 to 999.8 (degrees) for a Phase Changer

## GPIB/USB Command Summary

Command	Suffix	Action	Query
Instrument Commands			
CHAN	A	Select channel A	✓
CHAN	B	Select channel B	✓
INC		Increase setting by stored increment	
DEC		Decrease setting by stored increment	
VSET	Value	Switches to value mode and sets to value	✓
SSET	Value	Switches to steps mode and sets to value	✓
ISSET	Value	Stores increment in the present operating mode	✓
RESET		Reinitialise the instrument on the active channel	
OPTO	ON/OFF	Switch opto checking on or off on the active channel	✓
MODE?		Outputs the current operating mode	✓
HIGH	ON/OFF	Enable or disable the high attenuation feature	✓
LCABLE	ON/OFF	Switch the Long Cable Drive option on or off on the active channel	✓
OPTIONA	Value	Used for defining identity of Microwave Instrument on A	
OPTIONB	Value	Used for defining identity of Microwave Instrument on B	
RECALL		Returns the instrument to the stored setting (see below)	
STORE	Value	Store a setting determined by value (mode dependent)	✓
System Commands			
INSTIDA?		Returns the type of instrument connected to channel A	✓
INSTIDB?		Returns the type of instrument connected to channel B	✓
TITLEA	Title	Set a new title for channel A	
TITLEB	Title	Set a new title for channel B	
PWRSTAT?		Returns the power-up statistics	✓
FACTDEF		Return to factory defaults, clears the user EEPROM	
ERRACK		Error acknowledge	
ERRLOG?		Returns the error log	✓
PONRST	ON/OFF	Enable/Disable power-on reset	✓
HOLDSET	ON/OFF	Return instrument to last power-on condition	✓
Other Commands			
LEARN (NOT USB)	String	Learn the following string as a NEW GPIB command set	
ESRB?		Request the value of the ESRB register	✓
ESBE	Value	Set the value of the ESBE enable register	✓
ESRC?		Request the value of the ESRC register	✓
ESCE	Value	Set the value of the ESCE enable register	✓
ESRD?		Request the value of the ESRD register	✓
ESDE	Value	Set the value of the ESDE enable register	✓
OUTLRN? (NOT USB)		Outputs the learnt command set	✓
ADDRSET (NOT USB)	Value	Change the GPIB address of the CP	✓
CPEMU (NOT USB)		Switch to CP92, CP91, and CP82 command structure	
USER1 (NOT USB)		Switch to non-standard learnt User Command Set	
NORML (NOT USB)		Selects the built in IEEE488.2 command set	

## IEEE 488.2 and USB 2.0 Common Commands

Command	Function
*IDN?	Returns the identity string of the Control Processor e.g. FLANN MICROWAVE,CP2021,0,V1.0
*RST	Performs a Device Reset.
*TST?	Executes an internal self-test and returns the test result (0 = pass, >0 = fail).
*OPC	Sets the Operation Complete bit in the Standard Event Status Register when all pending selected device operations are complete
*OPC?	Places a "1" in the Output Queue when all selected pending operations are complete, which in turn will cause the MAV (Message Available) summary message to be generated. Note that the MAV bit will remain active during a Serial Poll, but reading the Status Byte will cause the MAV bit to return to 0.
*CLS	Clears all Event Registers summarised in the status byte.
*ESE value	Sets the enable bits in the Standard Event Enable Register
*ESE?	Returns the value of the Standard Event Enable Register
*ESR?	Returns the value of the Standard Event Register
*SRE value	Sets the bits in the Service Request Enable Register
*SRE?	Returns the value of the Service Request Enable Register
*STB?	Return the status byte, will not clear a SRQ if service is being requested
*PSC value	Sets the power-on-status-clear flag. When set false (value 0), the event status enable registers are restored to the values when power was removed.
*PSC?	Returns the state of the power-on-status-clear flag

## GPIB/USB Further Information

The Control Processor contains a 400 character input buffer. However, a single program message must not be longer than 200 characters in any one transmission. Program Messages exceeding this length may be rejected or truncated. The output buffer is 1500 characters to allow for the transmission of the error log block data. Querying the error log twice in any one-program message could result in a Query Error as the output buffer may overflow.

A user-initiated address change (GPIB only) will be recognised by the device upon parsing the command; there is no need to cycle the power to instigate the new address.

The Control Processor state at power-on will depend upon the state of the PSC (\*PSC?) flag, the restored setting flag (HOLDSET?), and the power-on reset flag (PONRST?). The PSC flag determines whether Event Status Enable Registers ESE, ESBE, ESCE, ESDE and SRE are restored upon start-up.

The HOLDSET flag determines if the Microwave Instruments are returned to their previous settings on power-on. The PONRST flag determines whether the Control Processor enters the Microwave Instrument reset procedure on start-up.

The error log query will generate more than one response message, its total length may be up to 1.2 Kbytes of data. The format of the error log is FAULT\_TYPE; ERROR CODE.

The OUTLRN query (GPIB only) may produce two response messages if a command set has been programmed.

All query commands generate a response when parsed and not when read by the controller. No commands are coupled as the Control Processor processes commands sequentially. This also implies that the \*OPC? command will generate a response when parsed, as all previous commands will have been completed.

The \*TST? command will cause the Control Processor to carry out its internal self tests, which include checking the Central Processing Unit, the Arithmetic Logic Unit, the GPIB controller, and the keypad. A response of zero indicates that the tests were completed without failure. See error codes later in this manual for interpreting non-zero responses.

## Programmable Command Set – GPIB only

The Control Processor is able to accept a command to change the default names for some of the Instrument Commands. For example the default commands for changing the active channel are CHANA or CHANB, if this is not suitable it can easily be changed to say SAT A or SAT B.

This function is supplied so that if the CP2021 replaces another manufacturer's equipment, the command set can be modified to match the instrument it is replacing, thus removing the need to change the controller's code.

Also offered is a compatibility mode that emulates the command set of the CP92, CP91, and CP82 control processors, allowing the CP2021 to be used alongside its predecessors without need for changing the controller code. The CP2021 accepts the entire command structure of the CP2020.

The commands that can be changed are:

- CHAN{A|B}
- INC
- DEC
- VSET *value*
- SSET *value*
- ISET *value*
- RESET

The IEEE488.2 specification defines the separator between program message units (PMUS) as a semicolon (;), i.e. "CHANA;RESET". To enable backward compatibility to the previous range of control processors, the program message unit separators can be disabled. When the program message unit separator has been disabled the LCD display will indicate this by showing 'COMP' in the GPIB status area. Otherwise 'USER' will be displayed to indicate that the factory default command set is no longer active.

The format for the learn string is as follows:

### **LEARN**

Followed by

**Channel A select Command**

**Channel B select Command**

**Increment Command**

**Decrement Command**

**Value Field/Mode Select Command**

**Increment Field Select Command**

**Steps Field/Mode Select Command**

**Reset Command**

**Program Message Unit Separator selection**

Each command has to be separated by an underscore (\_)

For Example, to learn the default command set the following could be sent

**LEARN\_CHAN A\_CHAN B\_INC\_DEC\_VSET\_ISET\_SSET\_RESET\_PMUS ON**

To learn the CP88/91/92 command set the following could be sent.

**LEARN\_A\_B\_+\_ \_V\_I\_SSET\_R\_PMUS OFF**

The CP2021 accepts the CPEMU command which automatically sets the entire CP82/91/92 LEARN string to save the user having to enter the above.

If the user has already entered a command set that is different from the normal string, and the 'NORML' command has been used to revert to the standard CP2021 command set, it is possible to switch back to the entered command set by sending the USER1 command.

## Programmable Command Set (Continued)

When the program message unit separators have been turned off, the CP2021 will accept the 'S' command that was used in the CP91/92 command set. This will allow the Control Processor to accept commands such as 'AV43S' without producing any syntax errors. The command 'AV43S' is identical to the IEEE488.2 command 'CHANA;VSET43'.

When the PMUS has been turned off the GPIB interface function takes on a different characteristic and is no longer IEEE488.2 compliant. See the notes below on this subject.

**The programmed command set is stored in EEPROM and is restored on start-up. To return to the default command set, send 'NORML' over the GPIB.**

To determine which command set is active and what replacement commands, if any, have been programmed, send the command 'OUTLRN?' over the GPIB. The response will be in the form of the Programmed Learn String followed by either 'USER1' or 'NORML'. NORML indicates the default command set is active.

### Notes on using the Programmable Command Set **with PMUS ON**

- All replacement commands must not exceed 8 characters in length and suffixes must not exceed 5 characters
- No two commands can be the same
- All commands must start with a letter
- The replacement CHAN commands must be at least two characters long. i.e. 'A' and 'B' are not valid. 'MOT1' and 'MOT2' are examples of valid commands
- All other IEEE488.2 common commands remain unchanged.

### Notes on using the Programmable Command Set **with PMUS OFF (COMPATIBILITY MODE)**

- The IEEE488.2 common commands are not supported in this mode.
- The Command for changing the default titles (TITLE{A|B}) of the CP2021 is not supported in this mode.
- All replacement commands must not exceed 8 characters in length and suffixes must not exceed 5 characters.
- No two commands can be the same.
- Addressing the device to talk will return the Setting Value of the Active Channel.
- The underlying IEEE488.2 Status Structure remains unchanged. The user will, however, no longer have access to the Registers.
- If the parser detects a syntax error then the entire contents of the input buffer are cleared.
- Only *NRI* number format is supported, sending for example 1.2E+2 will cause a syntax error.
- Parsing of commands will take approximately 20% longer.
- The format of the status byte changes to emulate the CP91/92 status byte.

For further information on using the compatibility mode and the CP92 Status byte, see Appendix C.

## ERROR CODES AND MESSAGES

To assist in the detection of equipment malfunction, the Control Processor generates various error codes and messages to enable the user to identify the cause of failure. The Error Message is displayed on the front panel and, if relevant, in the Event Status Registers. Once an Instrument error has been detected, all setting requests to that channel will be rejected until the error is acknowledged.

### Self-Test Errors

<b><i>CPU REGISTER FAILURE HAS OCCURRED</i></b>	One of the CPU internal registers has failed
<b><i>ALU FAILURE HAS OCCURRED</i></b>	The Arithmetic Logic Unit has failed
<b><i>GPIB INTERFACE ERROR #31-39</i></b>	Initialisation of the GPIB chip was not successful
<b><i>GPIB INTERFACE ERROR #40-45</i></b>	DCR register failure
<b><i>GPIB INTERFACE ERROR #46-47</i></b>	SPMR register failure
<b><i>GPIB INTERFACE ERROR #48-51</i></b>	Internal Counters have failed
<b><i>GPIB INTERFACE ERROR #52-70</i></b>	FIFO buffers or GPIB to CPU data corruption
<b><i>KEYBOARD ERROR #1-9 HAS OCCURRED</i></b>	One of the keys 1-9 was held down during power on
<b><i>KEYBOARD ERROR #10 HAS OCCURRED</i></b>	Key '.' was held down during power on
<b><i>KEYBOARD ERROR #11 HAS OCCURRED</i></b>	Key 'EXECUTE' was held down during power on
<b><i>KEYBOARD ERROR #12 HAS OCCURRED</i></b>	Key 'CL' was held down during power on
<b><i>KEYBOARD ERROR #14 HAS OCCURRED</i></b>	Key 'LOCAL' was held down during power on
<b><i>KEYBOARD ERROR #15 HAS OCCURRED</i></b>	Key 'MENU' was held down during power on
<b><i>KEYBOARD ERROR #16 HAS OCCURRED</i></b>	Key 'INC' was held down during power on
<b><i>KEYBOARD ERROR #17 HAS OCCURRED</i></b>	Key 'DEC' was held down during power on
<b><i>KEYBOARD ERROR #18 HAS OCCURRED</i></b>	Key '◀' was held down during power on
<b><i>KEYBOARD ERROR #19 HAS OCCURRED</i></b>	Key '▶' was held down during power on
<b><i>KEYBOARD ERROR #20 HAS OCCURRED</i></b>	Key 'RECALL' was held down during power on
<b><i>KEYBOARD ERROR #21 HAS OCCURRED</i></b>	Key '▲' was held down during power on
<b><i>KEYBOARD ERROR #22 HAS OCCURRED</i></b>	Key '▼' was held down during power on
<b><i>KEYBOARD ERROR #23 HAS OCCURRED</i></b>	Key '0' was held down during power on
<b><i>KEYBOARD ERROR #24 HAS OCCURRED</i></b>	More than one key was held down during power on
<b><i>A FATAL ERROR HAS OCCURRED. SYSTEM HALTED PLEASE RETURN UNIT FOR SERVICE</i></b>	A fatal error has occurred that has made the system unstable. The processor has been halted.

## Operational Errors

### **WARNING – EEPROM corrupt. Stored Values Will be Lost. EXECUTE TO CONTINUE**

This error indicates that all user programmed set-up information will be lost as the Control Processor re-initialises the Non-volatile EEPROM area. Possible causes of this error could be switching the unit off during motor positioning, or some other fatal error that causes the Control Processor to shut down or re-boot without warning.

### **WARNING – Over Temperature Condition. DC Drive Halted - CYCLE POWER TO RESTART**

The internal temperature of the chassis has exceeded safe operating levels. The DC drive has been suspended and holding current to the motors has been disabled. This will reduce power dissipation inside the chassis and allow the temperature to fall to acceptable limits. Refer to the section on Environmental Conditions on page 10 for recommended operating temperature range.

Ensure that the cooling fan mounted on the rear panel is fully operational, then switch off the Control Processor. Ensure that there is adequate clearance to provide good ventilation around the Control Processor case. Wait a few minutes before applying the power again.

### **WARNING – Static Supply Has Failed. SYSTEM HALTED**

A failure of the Motor Holding Supply has been detected. This supply is protected by an internal resettable fuse. Switch off and wait a few minutes before applying the power again. If this error recurs frequently the Control Processor must be returned for service.

### **WARNING – No 32V Supply Detected. Check Fuse On Rear Panel. SYSTEM HALTED**

A failure of the +32V Motor Drive Supply has been detected. This supply is protected by fuse FS3 on the rear panel. Switch the CP2021 off and check the integrity of the fuse. If it has failed, replace it with a similar 3.15A anti-surge fuse. If this failure recurs the Control Processor must be returned for service.

### **Information – Instrument Configuration Changed. EXECUTE TO CONTINUE**

The Control Processor has detected that a Microwave Instrument has been removed or connected. Pressing **EXECUTE**, or sending ERRACK over the GPIB or USB, will accept the configuration change. Normal operation will then be restored.

### **Power-on Reset Disabled. Instrument States Unknown. EXECUTE TO SYNCHRONISE**

The power-on reset has been disabled (Menu 9 or PONRST OFF over the bus). Pressing the **EXECUTE** key, or sending ERRACK over the GPIB or USB, will allow the power-on reset to continue.

*If returning the unit for service or repair, please give full details of error codes and messages that have been generated, as corruption or failure of the non-volatile RAM circuit will result in loss of the relevant information that has been stored in the error log.*



## Error Log Errors

The following lists the descriptions of errors that may be found in the error log. There is no need to return the unit for service if errors exist in the log. Only if the errors are repetitive and causing operational failures should the unit be returned. All recorded errors are stored for future service reference and cannot be cleared by the user.

<b>OVRTMP</b>		The Control Processor has detected that the temperature within the Control Processor has exceeded the safe operating limits
<b>KEYBOARD</b>	<b>1 – 24</b>	A keyboard error has occurred. Refer to the Self-Test Errors list on page 47 for explanations of the various error codes
<b>GPIB</b>	<b>31 - 70</b>	A GPIB error has occurred. Refer to the Self-Test Errors list on page 47 for explanations of the various error codes
<b>32V FAIL</b>		A failure of the +32V Motor Drive supply has been detected
<b>STA FAIL</b>		A failure of the Motor Holding (Static) supply has been detected
<b>NONE</b>		No error conditions have been recorded

## Instrument Errors

### **ERROR #1 : CHANNEL (A or B) INSTRUMENT ERROR PRESS EXECUTE TO RESET THIS CHANNEL**

Error 1 can only occur during a Microwave Unit Reset.

Error 1 will be generated if Phase 1 of the Microwave Unit Reset ends without detection of the Maximum signal.

#### ***Phase 1 of the Microwave Unit Reset:***

- Starts on receipt of the RESET command, or at power-on, or when an Instrument is connected.
- Consists of stepping the motor at medium speed towards the Maximum signal generator looking for the Maximum signal.
- Ends on detection of the Maximum signal or when the motor has driven a predefined number of steps.

#### ***Possible causes of repeated Error 1:***

- The Maximum signal generator is not set to operate within the limits of motor movement.
- Mechanical or electrical failure of the Maximum signal generator or wiring, causing the Maximum signal to remain low.
- Electrical or mechanical failure of the motor drives.

### **ERROR #2 : CHANNEL (A or B) INSTRUMENT ERROR PRESS EXECUTE TO RESET THIS CHANNEL**

Error 2 can only occur during a Microwave Unit Reset.

Error 2 will be generated if Phase 2 of the Microwave Instrument Reset ends with detection of the Minimum or Optic Reference signal while the maximum signal is still present.

#### ***Phase 2 of the Microwave Unit Reset:***

- Starts on error free completion of Phase 1.
- Consists of testing the Optic Reference signal and the Maximum and Minimum signals.
- Ends when the test is complete.

#### ***Possible causes of repeated Error 2:***

- Mechanical or electrical failure of the Maximum signal generator or wiring, causing the Maximum signal to remain permanently high.
- Mechanical or electrical failure of the Minimum signal generator or wiring, causing the Minimum signal to remain permanently high.
- Mechanical or electrical failure of the Optic Reference signal generator or wiring, causing the Optic Reference signal to remain permanently high.

**ERROR #3 : CHANNEL (A or B) INSTRUMENT ERROR  
PRESS EXECUTE TO RESET THIS CHANNEL**

Error 3 can only occur during a Microwave Unit Reset.

Error 3 will be generated if Phase 3 of the Microwave Unit Reset ends with failure to detect the Optic Reference signal.

***Phase 3 of the Microwave Unit Reset:***

- Starts on error free completion of Phase 2.
- Consists of stepping the motor slowly towards the Optic Reference signal generator looking for the Optic Reference signal.
- Ends on detection of the Optic Reference signal or when the motor has stepped a predefined number of steps.

***Possible causes of repeated Error 3:***

- Mechanical or Electrical failure of the Optic Reference signal generator causing the Optic Reference signal to remain low.
- Mechanical failure or faulty adjustment causing the Optic Reference signal to be out of phase with the motor steps.

**ERROR #4 : CHANNEL (A or B) INSTRUMENT ERROR  
PRESS EXECUTE TO RESET THIS CHANNEL**

Error 4 can only occur during Microwave Unit Repositioning, and only if OPTO CHECKING is ON.

Error 4 will be generated if OPTO CHECKING is ON and the software fails to detect the Optic Reference signal at the predefined motor step during repositioning.

***Microwave Unit Repositioning:***

- Starts on receipt of the VSET command, or the INC command, or the DEC command.
- Consists of moving the motor N steps in direction D, stopping en-route to test for the presence of the Optic Reference signal at a predefined motor step, (If OPTO CHECKING is OFF then the Optic Reference signal will always be regarded as present), and testing for the absence of the Maximum signal or Minimum signal (depending upon direction D) before each step.
- Ends when N steps have been moved or an error is generated. (No E4 error can be generated if OPTO CHECKING is OFF.)

***Possible causes of frequent Error 4:***

- Intermittent Optic Reference signal generator output.
- Optic Reference signal out of phase with motor steps.
- Excessive motor wear causing motor to lose steps.
- Increased mechanical loading on the motor.
- A drive cable of over 20m is connected but the Long Cable Option has not been set. Refer to page 23

**ERROR #5 : CHANNEL (A or B) INSTRUMENT ERROR  
PRESS EXECUTE TO RESET THIS CHANNEL**

Error 5 can only occur during Microwave Unit Repositioning.

Error 5 will be generated if the instrument is instructed to set to HIGH ATTENUATION, or the instrument is asked to position to a setting that is negative of the reference in steps mode, and the instrument does not support this feature (some early \*\*610 instruments will not position sufficiently negative of the reference. The unit can be returned for adjustment if this feature is required).

Error 5 will be generated if the Maximum signal or the Minimum signal is detected during Microwave Unit Repositioning. Microwave Unit Repositioning is defined under ERROR #4 above.

***Possible causes of repeated Error 5:***

- Wrongly adjusted Maximum or Minimum or Optic Reference signal generator.
- Intermittent Maximum or Minimum signal generator fault.

**Instrument Self-Test Errors****MINIMUM SENSOR IS OUTSIDE SPECIFICATION**

The minimum reference signal generator is set below the minimum recommend limit. This is unlikely to affect the calibration of the Microwave Instrument. If the Instrument is not generating E5 errors during normal operation there is no need to return the instrument for service.

**MAXIMUM SENSOR IS OUTSIDE SPECIFICATION**

The maximum reference signal generator is set above the maximum recommend limit. This will not affect the calibration of the Microwave Instrument. If the Instrument is not generating E1 errors during the reset procedure there is no need to return the instrument for service.

**MAXIMUM SENSOR POSITION WILL NOT ALLOW HIGH ATTENUATION FEATURE**

The instrument's maximum limit sensor does not support HIGH ATTENUATION operation. Trying to set the instrument to MAX will result in an ERROR #5. An error will also be reported when trying to move an amount negative of the reference while in steps mode. If you wish to use the instrument in HIGH ATTENUATION mode it should be returned to the manufacturer for adjustment.

**OPTO SENSOR SIGNAL IS INVALID**

The optic reference generator in the Microwave Instrument is not operating correctly. The Control Processor is having difficulty determining the true reference position. This can affect the Calibration of the instrument, however the Control Processor will make an intelligent prediction about the true reference so that the unit can still be used. The unit should be returned to the manufacturer for service to correct the fault.

**OPTO SENSOR IS OUTSIDE SPECIFICATION**

The settle time of the Optic Reference generator is outside the recommended limits. This will not affect the calibration of the Microwave Instrument, as the Control Processor will wait for the Optic reference signal to settle before continuing. This may mean a very slight delay in repositioning of the instrument. Only if the Microwave Instrument is generating E4 errors during normal operation should it be returned to the manufacturer for service.

## Appendix A – Programmable Instruments

### Programmable Rotary Vane Attenuators

Each Programmable Rotary Vane Attenuator (PRVA) has three constituent parts

- *Microwave Rotary Attenuator*
- *Position Sensors*
- *Precision Stepper Motor*

#### Microwave Vane Rotary Attenuator

Each attenuator consists of two low-SWR rectangular-to-circular transitions and a rotating circular waveguide centre-section. The three sections are fitted with high stability, high attenuation elements which ensure close agreement of the attenuation to the theoretical law. The attenuation is directly related to the angular position of the attenuating element in the circular section (*i.e. it follows the law  $40 \log \sec \theta$* ) and is insensitive to frequency changes; variations of phase with attenuation are negligible. Choking of the rotating joints is employed to minimise RF leakage. The circular waveguide section is driven, via reduction gearing, by a precision stepper motor. To rotate the attenuator centre section through 90 degrees would require a motor movement of exactly 8750 steps. However, the attenuation change between 0dB and 60dB is executed in precisely 8574 steps.

Mechanical fail-safe end-stops are fitted to all units.

#### Radio Frequency Specifications

Table A-1 and A-2 show the specifications for the 61\* and 62\* range of instruments.

Model	Frequency Range GHz	Waveguide			Insertion Loss dBs (Approx)	Max Input Power W	Flange to Flange length mm
		WG	R	WR			
11A6**	3.30 – 4.90	11A	40	229	0.5	10.0	687
126**	3.94 – 5.99	12	48	187	0.5	10.0	560
136**	4.64 – 7.05	13	58	159	0.5	9.0	520
146**	5.38 – 8.18	14	70	137	0.5	8.0	420
156**	6.58 – 10.0	15	84	112	0.5	6.0	340
166**	8.20 – 12.5	16	100	90	0.5	4.0	300
176**	9.84 – 15.0	17	120	75	0.5	3.0	276
186**	11.0 – 18.0	18	140	62	0.5	2.0	250
196**	14.5 – 22.0	19	180	51	0.5	2.0	250
206**	17.6 – 26.7	20	220	42	0.8	1.0	250
216**	21.7 – 33.0	21	260	34	0.8	1.0	225
226**	26.4 – 40.1	22	320	28	1.0	0.7	175
236**	33.0 – 50.1	23	400	22	1.0	0.7	140
246**	39.3 – 59.7	24	500	19	1.0	0.7	134
256**	49.9 – 75.8	25	620	15	1.0	0.5	100
266**	60.5 – 92.0	26	740	12	1.5	0.3	89
276**	73.8 – 112	27	900	10	1.5	0.3	89
286**	92.3 – 140	28	1200	8	2.0	0.2	89

Table A-1: Programmable Attenuator RF Specifications

<b>Standard Attenuation Range:</b>	0dB to 60dB
<b>*Transition Time (full range):</b>	1.1 seconds approx. – see note*
<b>Minimum dB Increments</b>	0.01 from 0-21dB 0.02 from 21-30 dB 0.05 from 30-48 dB 0.1 from 48-60 dB
<b>Accuracy:</b>	1% or 0.01dB whichever is the greater.
<b>Operating Temperature Range:</b>	+5°C to +35°C
<b>SWR:</b>	WG11A - WG26 Less than 1.15 WG27 – WG29 Less than 1.20

Table A-2: PRVA Specifications

\*The transition time is quoted for model 620 attenuators. This is increased by 20% for model 621 attenuators. Also add 30% for both models when the Long Cable option has been selected.

## Position Sensors

The position sensors in the PRVA provide three signals, i.e.: “Maximum”, “Minimum” and “Reference”, which are defined as follows:-

<b>MAXIMUM</b>	A TTL signal which goes high when the attenuator is driven approximately 220 steps past the 60dB setting, stays high all the way to the mechanical end-stop, and is low at all other times.
<b>MINIMUM</b>	A TTL signal which goes high when the attenuator is driven approximately 200 steps past the 0dB setting, stays high all the way to the mechanical end-stop, and is low at all other times.
<b>REFERENCE</b>	A TTL signal that is high when the attenuation is 60dB and every 500 steps throughout the range, and is high for one step only.

The “Maximum” and “Minimum” position sensors are mounted on the circular waveguide section of the attenuator; the “Reference” position sensor is located on the motor drive shaft.

## Manual Readout Drums

The \*611 and \*621 series of Microwave Instruments are fitted with manual readout drums. These drums should be used only as an indication of the actual setting of the instrument, as the setting on the Control Processor and that shown on the manual drum may not exactly agree. Wherever possible the value for the setting of the instrument should be taken from the Control Processor.

**The manual readout drum must not be turned when the Control Processor is connected and powered up.** Operation of the attenuator may be impaired by such action. Remove the power and disconnect the attenuator if manual operation is required. **Note that continuous manual operation may cause damage to the motor.**

## Precision Stepper Motor

The attenuator is fitted with a five-phase stepper motor giving precisely repeatable steps without gearing. Individual step accuracy is approximately +/- 3 minutes of arc and errors are not cumulative. The motor output shaft is coupled through a backlash-free flexible joint to a reduction gear unit and the waveguide centre section.

<b>Stepping Rate:</b>	max of 8500 steps/sec in this application
<b>Rotation:</b>	Bi-directional.
<b>Winding</b>	5-phase, 10-wire
<b>Winding Resistance:</b>	1.7 ohms
<b>Rated Current:</b>	1.2A maximum per winding
<b>Total current:</b>	1.25A (two windings energised)
	1.35A (three windings energised)

Table A-3: Stepper Motor Characteristics

## Valid Setting Values

The minimum increment of the Attenuator is 0.01 between 0 and 21dB, 0.02 between 21 and 30dB, 0.05 between 30 and 48dB and 0.1 between 48 and 60dB. Attempting to set the instrument above the normal range will result in either of the following:

- 1) If the High Attenuation feature is switched off then the Microwave Instrument Reset will be actioned.
- 2) If the High Attenuation feature is switched on then the Microwave Instrument will position to the 'maximum attenuation' setting. This is approximately 85dB.

If a setting is requested that demands higher accuracy than the Microwave Instrument can achieve, the Control Processor will set to the nearest possible value. For example, if a setting of 58.2432dB is sent, then the Microwave Instrument will position to 58.2dB, i.e. to the nearest 0.1dB setting possible.

In steps mode of operation the instrument can be positioned between -150 and 8574 steps from reference, see below.

## Steps to Attenuation

The CP2021 is capable of switching into steps mode to give the user greater control over the attenuator. See the section on Front Panel Local Control (page 27) for details on how to select steps mode. The relationship between steps-from-reference and attenuation, and attenuation to steps-from-reference is shown below.

Atten := 63dB

$$8574 - \frac{70 \cdot 360}{0.72 \cdot 2\pi} \cdot \arccos\left(\frac{1}{\frac{\text{Atten}}{10^{40}}}\right) = -27.769 \text{ Steps}$$

Steps := -28 Steps

$$40 \cdot \log\left[\frac{1}{\cos\left[\frac{(8574 - \text{Steps}) \cdot 0.72}{70} \cdot \frac{2 \cdot \pi}{360}\right]}\right] = 63.027 \text{ dB}$$

## Installation Notes

The Flann Microwave Programmable Attenuators are very high precision instruments whose accuracy can be impaired by careless handling and installation. Especially robust units can be provided to special order.

- All models are provided with M6 threaded fixing holes in their base-plates.
- The greatest care must be taken to ensure that the instrument casing is not subject to distortion caused by attachments to mounting faces. Individual shimming at the mounting holes is recommended.
- Mating waveguide flanges must be flat, clean, and be capable of touching on their full mating surfaces with the instrument flanges. Do not use excessive force when tightening screws, apply light pressure only.
- It is necessary to maintain an adequate airflow around the unit so that the upper temperature rating is not exceeded.
- Dust covers must be fitted across waveguide apertures at all times when mating waveguides are not bolted to the flanges. Very small gaps separate the static and moving parts of the Programmable Attenuator, dust and grit will seriously impair operation.
- Do not use the Programmable Attenuator's to hang other components on, or hang the Programmable Attenuator on either of its flanges. **SUPPORT CORRECTLY.**

Deviating from the operating instructions and connectivity described in this manual, or operating the instrument outside the designated environmental conditions, may invalidate the EU Declaration of Conformity (see the Regulatory Information on page 6).



## Programmable Rotary Vane Phase Changer

A Programmable Rotary Vane Phase Changer has three constituent parts:

- *Microwave Phase changer*
- *Position Sensors*
- *Precision Stepper Motor*

### Microwave Rotary Phase Changer

The Programmable Phase Changer units incorporate an orthodox Rotary Vane Phase Changer circular centre section which is driven, via reduced gearing, by a precision stepper motor. A reflective optic system, coupled to the drive shaft generates pulses that are used to provide exact reference levels of phase change.

Each Phase Changer consists of two low-VSWR rectangular-to-circular waveguide transitions, two quarter-wave plates and a rotating circular waveguide section.

The input waveguide transition leads in turn to a quarter-wave plate section that converts a plane polarised wave to a circular polarisation. The circular centre of the instrument, which embodies a half-wave plate, is rotated to achieve variation of phase. A similar combination of quarter-wave plate section and transition returns the wave to plane polarisation.

The phase reference of the circularly polarised wave is related to the angular position of the half-wave plate, i.e. rotating the plate through 360 mechanical degrees results in a phase change of 720 electrical degrees. It therefore follows that unlimited change of phase in either forward or reverse direction is attainable.

### Position Sensors

The position sensors in the PRVPC provide signals for initialisation and positional reference. Their functions are as follows:

#### COARSE POSITION SENSOR

This unit provides an internal TTL signal that goes high approximately 60 steps past the reset position, remains high for about 10 steps, and is low at all other times, the output of this sensor is used to enable the 'RESET REFERENCE SENSOR'

#### RESET REFERENCE SENSOR

This unit provides a TTL output signal which goes high approximately 60 steps past the reset position as long as the enable signal from the 'Coarse Position Sensor' is present, and remains high for approximately 7 steps. This signal is only used during instrument reset, and is ignored by the Control Processor at all other times, thus allowing continuous bi-directional operation.

#### POSITION REFERENCE SENSOR

This unit provides a TTL output signal which is high when the phase angle is zero degrees and every 500 steps throughout the range, and is high for one motor step only.

## Precision Stepper Motor

The Phase Changer is fitted with a five-phase stepper motor giving precisely repeatable steps without gearing. Individual step accuracy is approximately  $\pm 3$  minutes of arc and errors are not cumulative. The motor output shaft is coupled through a backlash-free flexible joint to a reduction gear unit and the waveguide centre section.

Stepper Motor Characteristics are shown in Table A-4.

<b>Stepping Rate:</b>	max of 8500 steps/sec in this application
<b>Rotation:</b>	Bi-directional.
<b>Winding:</b>	5-phase, 10-wire
<b>Winding Resistance:</b>	1.7 ohms
<b>Rated Current:</b>	1.2A maximum per winding
<b>Total current:</b>	1.25A (two windings energised)
	1.35A (three windings energised)

Table A-4: Stepper Motor Characteristics

## Radio Frequency Specifications

Table A-5 and A-6 shows the specifications for both the 660 and 670 range of instruments

Model	Frequency Range GHz	Waveguide			Insertion Loss dBs(Approx)	Max Input Power W	Accuracy deg
		WG	R	WR			
11A6*0	3.30 – 4.90	11A	40	229	1.0	10.0	3
126*0	3.94 – 5.99	12	48	187	1.0	10.0	3
136*0	4.64 – 7.05	13	58	159	1.0	10.0	3
146*0	5.38 – 8.18	14	70	137	1.0	10.0	3
156*0	6.58 – 10.0	15	84	112	1.0	10.0	3
166*0	8.20 – 12.5	16	100	90	1.0	10.0	3
176*0	9.84 – 15.0	17	120	75	1.0	5.0	3
186*0	11.0 – 18.0	18	140	62	1.0	5.0	4
196*0	14.5 – 22.0	19	180	51	1.0	4.0	4
206*0	17.6 – 26.7	20	220	42	1.0	3.0	4
216*0	21.7 – 33.0	21	260	34	1.0	2.5	4
226*0	26.4 – 40.1	22	320	28	1.0	2.0	4
236*0	33.0 – 50.1	23	400	22	1.0	1.5	4
246*0	39.3 – 59.7	24	500	19	1.5	1.0	4
256*0	49.9 – 75.8	25	620	15	1.5	0.7	5
266*0	60.5 – 92.0	26	740	12	2.0	0.5	5
276*0	73.8 – 110	27	900	10	2.5	0.3	6
286*0	92.3 – 140	28	1200	8	3.0	0.2	6

Table A-5: Programmable Phase Changer RF Specifications

<b>Phase Change Range</b>	Unlimited (Forward or Reverse direction)
<b>Maximum Step Rate</b>	8500 steps / sec
<b>Minimum Phase Change:</b>	0.2 degree (i.e. 1 motor step)
<b>Operating Temperature range:</b>	+5°C to +35°C
<b>SWR:</b>	WG11A – WG17 Less than 1.25
	WG18 – WG22 Less than 1.30
	WG23 – WG26 Less than 1.50
	WG27 – WG29 Less than 1.75

Table A-6: PRVPC Specifications

## Valid Setting Values

The Phase Changer can be set in 0.2 degree steps between 0 and 720 degrees. Trying to set the instrument outside the normal range will result in the Microwave Instrument Reset Procedure being actioned.

If a setting is requested that demands higher accuracy than the Microwave Instrument can achieve, the Control Processor will set to the nearest possible value. For example if a request of 360.43 is sent the Microwave Instrument will position to 360.4 degrees.

## Steps to Phase Change

The CP2021 is capable of switching into steps mode. See the section on Front Panel Local Control for details on how to select steps mode. The relationship between steps from reference and phase change is 0.2 degrees phase change per step.

## Installation Notes

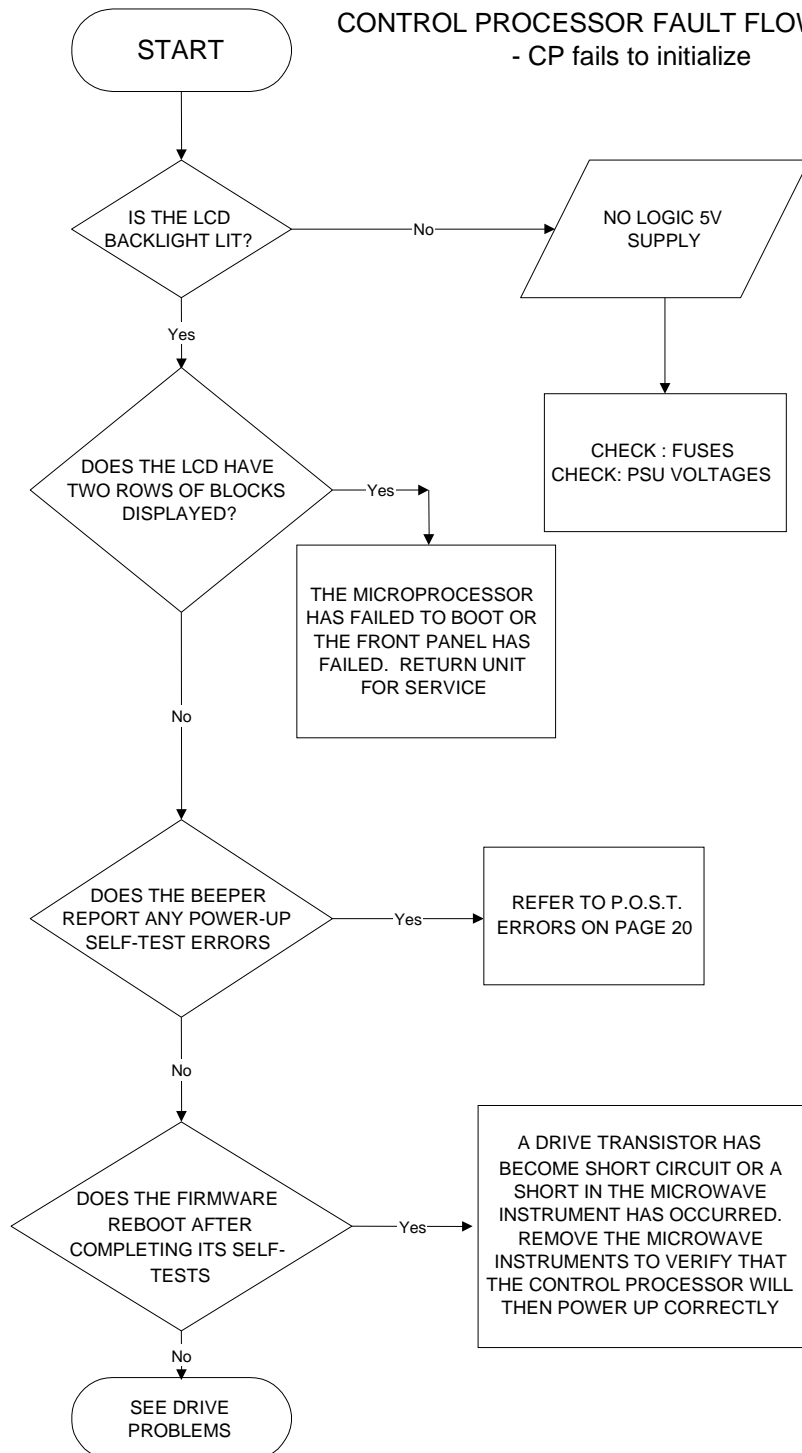
The Flann Microwave Programmable Rotary Vane Phase Changers are very high precision instruments whose accuracy can be impaired by careless handling and installation. Especially robust units can be provided to special order.

- All models are provided with M6 tapped fixing holes in their base-plates.
- The greatest care must be taken to ensure that the phase changer casing is not subject to distortion caused by attachments to mounting faces. Individual shimming at the mounting holes is recommended.
- Mating waveguide flanges must be flat, clean and be capable of touching on their full mating surfaces with the phase changer's flanges. **Do not** use excessive force when tightening screws, light pressure only.
- It is necessary to maintain an adequate airflow around the unit so that the upper temperature rating is not exceeded.
- Dust covers must be fitted across waveguide apertures at all times when mating waveguides are not bolted to the flanges. Very small gaps separate the static and moving parts of the Microwave Instrument, dust and grit will seriously impair operation.
- Do not use the Phase Changer to hang other components on, or hang the Phase Changer on either of its flanges. **SUPPORT CORRECTLY.**

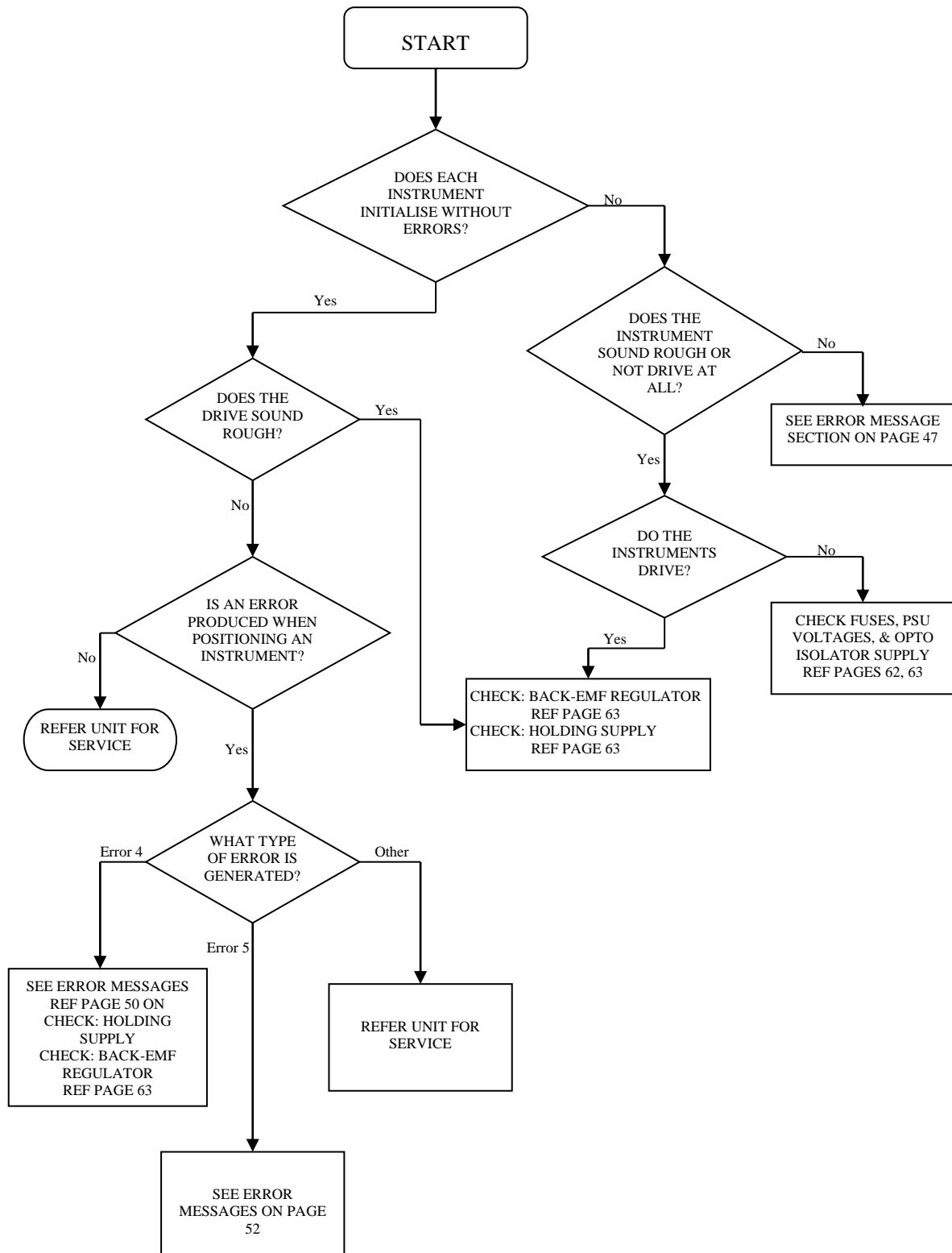
Deviating from the operating instructions and connectivity described in this manual, or operating the instrument outside the designated environmental conditions, may invalidate the EU Declaration of Conformity (see the Regulatory Information on page 6).

## Appendix B – Service

### Fault Finding



# CONTROL PROCESSOR FAULT FLOW CHART – CP Drive Problems

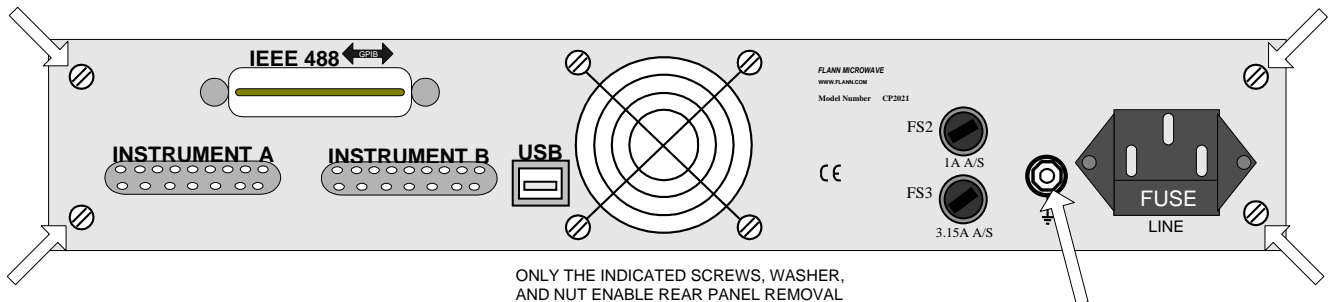


## Removing the Covers

### **OBSERVE FULL ANTI-STATIC PRECAUTIONS AT ALL TIMES**

Switch off the Control Processor and disconnect the Line Supply, GPIB cable and Drive cables from the rear panel. Remove the handles and rear corner supports (two screws in each). Remove the four screws and earth-stud nut that secure the rear over-panel, as shown below, and carefully ease the panel off. Remove the front and rear chassis feet, then remove the four cover retaining screws near the foot locations. The covers can then be removed by sliding towards the rear of the chassis.

Fitting is the reversal of the above. Ensure that the covers are located in the front and rear slots, and do not tighten the screws until all have been fitted, so that correct alignment is assured.



## Checking Fuses

If the CP2021 fails to start at power up, first check the 2.5A anti-surge line fuse. This is located on the rear panel of the Control Processor and is incorporated in the filtered line input connector. Secondly, if relevant, check the fuse in the supply plug.

FS2 protects the logic power supply, and is a 1A anti-surge fuse.

FS3 protects the motor drive supply, and is fitted with a 3.15A anti-surge fuse.

The Motor Holding Supply is protected by PSW1, a resettable fuse mounted internally on the main control PCB, and should not normally cause any problems. If however this is suspect, replace it with a compatible 4A polyfuse.

## Checking the Power Supply Voltages

Remove the cover of the Control Processor as described above. Connector J1, located at the front left hand side of the board is the main power inlet for the PCB. Connect the line supply **with care, as high voltages will be present on the power supplies, including the cases**. Connect the ground lead of a DMM to Pin 4 of J1, the following voltages should be present on the other pins: -

Pin Number	Description	Voltage
1	Power Fail - optional	Not Used
2	Ground (Logic)	0V
3	Logic Supply	+5V +/- 200mV
4	Ground (Logic)	0V
5	Ground (Motor)	0V
6	Motor Drive	+32V +/- 3V
7	Ground (Motor, Holding)	0V
8	Primary Holding Supply	+5V +/- 200mV
9	No Connection	
10	No Connection	

Table B-1: Connector J1, Pins and Voltages

## Checking the Holding Supply

Remove the covers of the Control Processor as described above. The holding supply is derived from the Primary Holding Supply (Pin 8 on J1) via a constant current generator. To check the output of the constant current generator (i.e. the holding supply) connect a DMM between pin 7 on J1 and the anode of D11 for Instrument A and D12 for instrument B. Note that this supply is protected by a resettable, 4Amp Polyswitch PSW1.

Reconnect the Line Supply and switch on the Control Processor. **WARNING: Exercise extreme caution as high voltages will be present on the power supplies, including the cases.** With no instruments connected this voltage should be between 4.5V and 5.2V. If an instrument is connected and has been initialised then this voltage will drop to approx. 2V - 3V depending upon the type of instrument and the drive cable length.

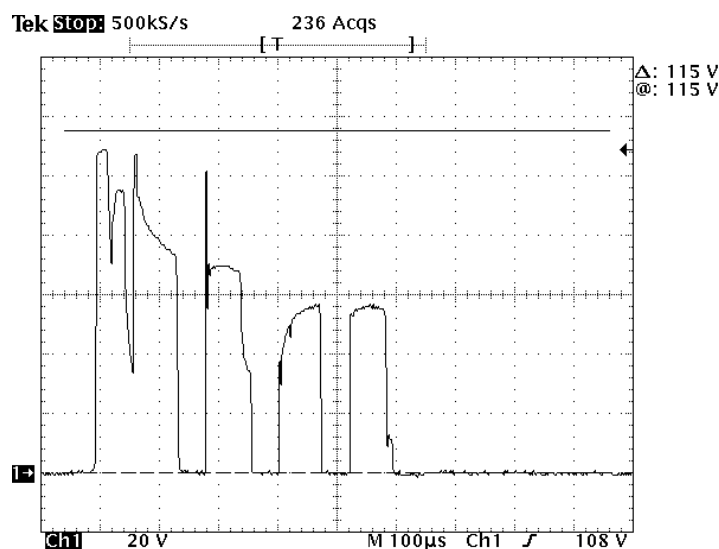
## Checking the Opto-isolator Supply

**Disconnect the line supply** and remove the covers of the Control Processor as described above. The supply to the opto-isolators is derived from the Motor Drive (Pin 6 of J1). To determine if the supply is present, connect a DMM between Pin 5 on J1 and the positive end of ZD2 (located near connector J10).

Reconnect the Line supply and switch on. **WARNING: Exercise extreme caution as high voltages will be present on the power supplies, including the cases.** The voltage should be between 4.6V and 5.2V. A voltage outside this range indicates that the Opto-isolator supply has failed. Return the unit for repair.

## Checking the Back-EMF Regulating Circuit

Disconnect the line supply and remove the covers of the Control Processor as described above. The Zener Diodes ZDA and ZDB control the level of the back EMF of the stepper motors. If a Zener diode fails the instrument will not drive correctly and may stall generating Error messages. To check that the circuit is functioning correctly, connect an Instrument to Channel A. Connect an oscilloscope Probe to the tab of Q1. Set the oscilloscope to positive trigger, amplitude 20V/div, and time-base of 100 $\mu$ s/div. Switch on the Control Processor and allow the instrument to reset. **WARNING: Exercise extreme caution as high voltages will be present on the power supplies, including the cases.** Send the Microwave Instrument to 0 dB (or 719 degrees for a phase changer). The following trace should be seen on the oscilloscope:



The most important aspect of the trace is the maximum voltage seen, the shape of the waveform is not so important. The maximum voltage must not exceed 115V, nominally 107V. A higher voltage indicates that

the Zener diode is open circuit and must be replaced. If the maximum voltage seen is approximately 32V then the Zener diode has become short circuit and must be replaced. To check Channel B, measure the voltage on the tab of Q6.

## Drive Cable Connections

Pin Number	Description	Pin Number	Description
1	5V Identity Detect	14	Phase 5 Common
2	Motor Phase 5	15	Phase 4 Common
3	Motor Phase 4	16	Phase 3 Common
4	Motor Phase 3	17	Phase 2 Common
5	Motor Phase 2	18	Phase 1 Common
6	Motor Phase 1	19	Logic 0V
7	Logic +5V	20	Logic 0V
8	MAX signal	21	No Connection
9	MIN signal	22	No Connection
10	OPTO signal	23	Identity Line 2
11	Identity Line 1	24	Identity Line 4
12	Identity Line 3	25	Linked to 13
13	Linked to 25		

Table B-2: Drive Cable, Pinout



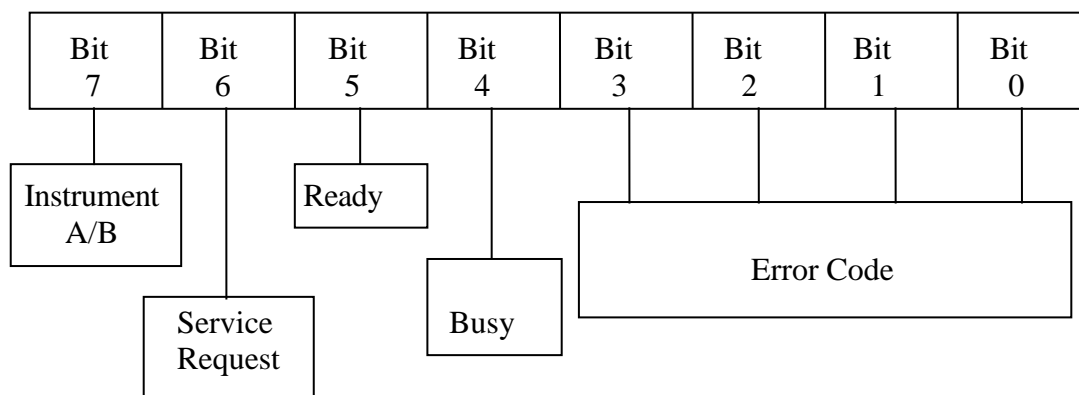
## Appendix C – Compatibility Issues

### Command Set (GPIB only)

The CP2021 will emulate the CP92, CP91 and CP82 range of control processors either by sending the LEARN string over the GPIB (*LEARN\_A\_B\_+\_V\_I\_SSET\_R\_PMUS OFF*), or by sending the CPEMU command. This will allow the user to use the CP2021 on an existing test bench without having to change any of the controller code. Refer to page 45.

Once the Learn string or CPEMU command has been sent the CP2021 will be able to accept different control commands and the SPOLL structure will change to emulate the CP92/91/82. To return to the normal built-in command set, send NORML over the GPIB. To switch back to the learnt command set, send the USER1 instruction over the GPIB.

The SPOLL structure for compatibility mode is shown below.



When the CP is ready to receive new instructions, Bit 5 (Hex 20) is logic level 1.

When the CP is busy, i.e. when changing the setting of the attenuator, Bit 4 (Hex 10) is logic level 1.

The four least significant bits of the Status Byte are reserved for the Error Code associated with the selected attenuator. An Error Code of zero is normal and signifies that no error has been detected.

When Channel “A” is selected, BIT 7 (Hex 80) of the Status Byte is logic level 0.

When Channel “B” is selected, BIT 7 (Hex 80) of the Status Byte is logic level 1.

When the CP generates a Service Request, Bit 6 (Hex 40) of the Status Byte is logic level 1.

The commands that represent a valid program message are listed below, together with the equivalent CP2021 command where available.

Command	Equivalent CP2021	Action
A	CHAN A	Select Channel A
B	CHAN B	Select Channel B
V	VSET	Value Select
S	N/A	Set to value
-	DEC	Decrement
+	INC	Increment
R	RESET	Reset the active channel
K0, K1	N/A	Disable, Enable SRQ on READY
G0, G1	N/A	Disable, Enable SRQ on ERROR

Table C-1: Command Set, Part 1

## Command Set (Continued)

There are, however, a number of limitations in this emulation and these must be evaluated before using the CP2021 in a CP92/91/82 application.

The following commands are available in the CP92/91/82, but are not supported by the CP2021 in compatibility mode or have different command names.

Command	Action	Reason
C	Resynchronise to a value	The CP2021 cannot be forced to adjust its reference.
D	Display Setting	No function on CP2021 as Settings are always displayed.
E	Display Stored Inc	No function on CP2021 as Stored Increments are always displayed.
H0,H1	Enable/Disable Front Panel	Was used to speed up CP92 by disabling display, no longer a restriction on CP2021.
L, N	Lamp Test	No LED's to lamp test on CP2021.
Q0,Q1	High Attenuation Feature	Use HIGH ON/OFF to enable/disable this feature. Or change via the front panel.
P0,P1	Enable/Disable Opto Checking	Use OPTO ON/OFF to enable/disable this feature. Or change via the front panel.
Z	Clear NVRAM	Use FACTDEF command, or select from the front panel.

Table C-2: Command Set, Part 2

- The IEEE488.2 common commands are not supported in this mode.
- The command for changing the default titles (TITLE{A|B}) of the CP2021 is not supported in this mode.
- Addressing the device to talk will return the Setting Value of the Active Channel.
- The underlying IEEE488.2 Status Structure remains unchanged. The user will, however, no longer have access to the Registers.
- If the parser detects a syntax error then the entire contents of the input buffer is cleared.
- Only *NRI* number format is supported; sending for example 1.2E+2 will cause a syntax error.
- The CP2021 will accept a terminated string of a numeric value as a valid command to position the instrument, i.e. '34.3' will cause the active channel to set to 34.3. This differs from the CP92/91/82 command which requires an 'S' to terminate the sequence, i.e. '34.3S'. However, as the CP2021 does not use the 'S' command, it can be omitted.

## Instrument Compatibility

The CP2021 firmware is dynamic, it is self-configuring, dependent upon the type of Microwave Instrument connected at its ports. To do this, all \*\*620, \*\*621, and \*\*670 series of programmable instruments have a built-in identifier. Older models of Programmable Instrument can be driven by the CP2021 but require the use of a 'compatibility drive-cable'.

This special cable converts from the 25-way D-Type connector on the back of the Control Processor to a 15-Way D-Type used on the older type instruments. This drive-cable also informs the Control Processor that an unknown instrument could be connected and invokes a menu for the user to select the correct Microwave Instrument connected to the Control Processor, as shown in figure C-1. A selection must be made either via the front panel, or over the GPIB or USB before the system will continue. ***Note that when this cable is used, 'hot-swapping' is not permitted. The power must be switched off when connecting older type instruments.***

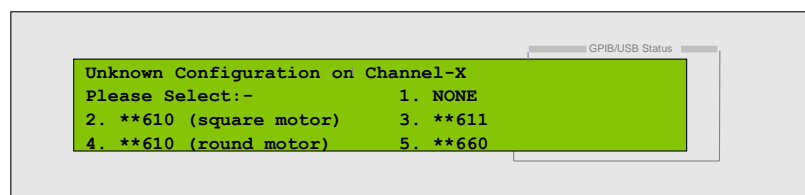


Figure C-1. Compatibility Menu

## Choosing the Correct Instrument Type

It is important to make the correct selection from the menu. Choosing the wrong series may not damage the unit but may result in operational errors, as the drive characteristics for each type are different. For example, choosing \*\*610 instead of \*\*611 could generate errors as the motor will reposition too rapidly. The series number of the Programmable Instrument is the second part of the model number. For example, the silver identification label may show 22610. The first two digits represent the waveguide size and should therefore be disregarded. The following three digits give the series number.

Series \*\*610 was supplied with two different types of motor, the 'round' and 'square' type. The square type superseded the round type in 1995. Figure C-2 shows the difference between the two types.

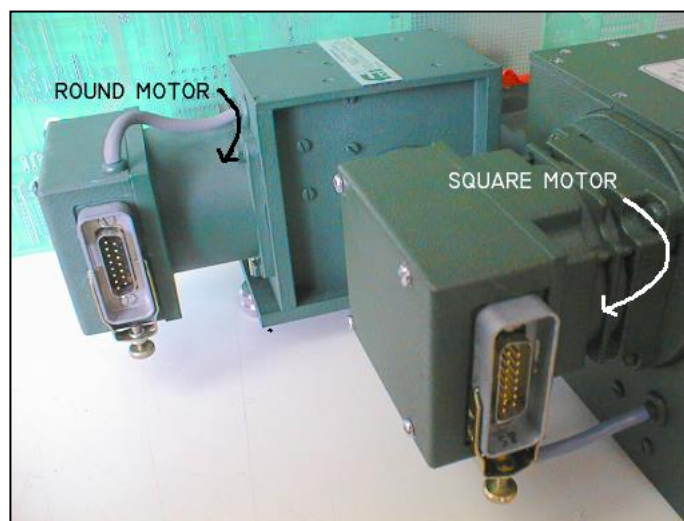


Figure C-2: 610 and 611 Motor Types

## Front Panel Selection

To select the required model number press either **1**, **2**, **3**, **4** or **5** on the numeric key pad, a terminator is not required. A second menu will be displayed to allow the user to validate the selection. Press **EXECUTE** to confirm the selection or **CL** to return the display to the previous menu for re-selection.

## GPIO/USB Selection

To select the required model over the GPIO or USB send the command **OPTION {A/B} value**.

**Value** represents the following selections:

- 1 No Instrument is connected
- 2 \*\*610 series Attenuator with the square motor is connected
- 3 \*\*611 series Attenuator with readout drum is connected
- 4 \*\*610 series Attenuator with the round motor is connected
- 5 \*\*660 series Phase Changer is connected

For example, to select series \*\*611 with manual readout drum, connected on channel-A, send **OPTIONA3**. Event Status Register B bits 6 and 7 indicate if the Control Processor is waiting for this selection to be made. See page 41 for details on this GPIO command.

## Limitations on using the Compatibility Drive Cable

The maximum cable length using this type of cable is 5 metres. Exceeding this length could lead to the optic signal generator producing incorrect information and possible drive problems.

The Hot Swap feature cannot be used with a compatibility drive-cable, as the Control Processor is unable to determine the identity from the instrument. ***The Control Processor must be switched off before disconnecting any instrument that requires a compatibility drive cable.***

When a Microwave Instrument is connected using the compatibility cable, the Control Processor is unable to restore any of the stored values relating to that instrument on power-up. For example the stored increment, optic disabling and high attenuation features will all revert to the factory defaults.