75000 Series C

Assembly-Level Service Manual

Keysight E1420B Universal Counter

Notices

Manual Part Number

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Safety Information

The following general safety precautions must be observed during all phases of operation of this instrument. Failure to comply with these precautions or with specific warnings or operating instructions in the product manuals violates safety standards of design, manufacture, and intended use of the instrument. Keysight Technologies assumes no liability for the customer's failure to comply with these requirements.

General

Do not use this product in any manner not specified by the manufacturer. The protective features of this product must not be impaired if it is used in a manner specified in the operation instructions.

Before Applying Power

Verify that all safety precautions are taken. Make all connections to the unit before applying power. Note the external markings described under "Safety Symbols".

Ground the Instrument

Keysight chassis' are provided with a grounding-type power plug. The instrument chassis and cover must be connected to an electrical ground to minimize shock hazard. The ground pin must be firmly connected to an electrical ground (safety ground) terminal at the power outlet. Any interruption of the protective (grounding) conductor or disconnection of the protective earth terminal will cause a potential shock hazard that could result in personal injury.

Do Not Operate in an Explosive Atmosphere

Do not operate the module/chassis in the presence of flammable gases or fumes.

Do Not Operate Near Flammable Liquids

Do not operate the module/chassis in the presence of flammable liquids or near containers of such liquids.

Cleaning

Clean the outside of the Keysight module/chassis with a soft, lint-free, slightly dampened cloth. Do not use detergent or chemical solvents.

Do Not Remove Instrument Cover

Only qualified, service-trained personnel who are aware of the hazards involved should remove instrument covers. Always disconnect the power cable and any external circuits before removing the instrument cover.

Keep away from live circuits

Operating personnel must not remove equipment covers or shields. Procedures involving the removal of covers and shields are for use by service-trained personnel only. Under certain conditions, dangerous voltages may exist even with the equipment switched off. To avoid dangerous electrical shock, DO NOT perform procedures involving cover or shield removal unless you are qualified to do so.

DO NOT operate damaged equipment

Whenever it is possible that the safety protection features built into this product have been impaired, either through physical damage, excessive moisture, or any other reason, REMOVE POWER and do not use the product until safe operation can be verified by service-trained personnel. If necessary, return the product to a Keysight Technologies Sales and Service Office for service and repair to ensure the safety features are maintained.

DO NOT block the primary disconnect

The primary disconnect device is the appliance connector/power cord when a chassis used by itself, but when installed into a rack or system the disconnect may be impaired and must be considered part of the installation.

Do Not Modify the Instrument

Do not install substitute parts or perform any unauthorized modification to the product. Return the product to a Keysight Sales and Service Office to ensure that safety features are maintained.

In Case of Damage

Instruments that appear damaged or defective should be made inoperative and secured against unintended operation until they can be repaired by qualified service personnel

CAUTION

Do NOT block vents and fan exhaust: To ensure adequate cooling and ventilation, leave a gap of at least 50mm (2") around vent holes on both sides of the chassis.

Do NOT operate with empty slots: To ensure proper cooling and avoid damaging equipment, fill each empty slot with an AXIe filler panel module.

Do NOT stack free-standing chassis: Stacked chassis should be rack-mounted.

All modules are grounded through the chassis: During installation, tighten each module's retaining screws to secure the module to the chassis and to make the ground connection.

WARNING

Operator is responsible to maintain safe operating conditions. To ensure safe operating conditions, modules should not be operated beyond the full temperature range specified in the Environmental and physical specification. Exceeding safe operating conditions can result in shorter lifespan, improper module performance and user safety issues. When the modules are in use and operation within the specified full temperature range is not maintained, module surface temperatures may exceed safe handling conditions which can cause discomfort or burns if touched. In the event of a module exceeding the full temperature range, always allow the module to cool before touching or removing modules from the chassis.

Safety Symbols

CAUTION

A CAUTION denotes a hazard. It calls attention to an operating procedure or practice, that, if not correctly performed or adhered to could result in damage to the product or loss of important data. Do not proceed beyond a CAUTION notice until the indicated conditions are fully understood and met.

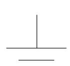
WARNING

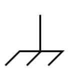
A WARNING denotes a hazard. It calls attention to an operating procedure or practice, that, if not correctly performed or adhered to, could result in personal injury or death. Do not proceed beyond a WARNING notice until the indicated conditions are fully understood and met.

Products display the following symbols:

 Warning, risk of electric shock

 Refer to manual for additional safety information.

 Earth Ground.

 Chassis Ground.

 Alternating Current (AC).

 Direct Current (DC)

Contents

3 E1420B Adjustments

4 Service

1 General Information

Introduction

This manual contains information required for testing, adjusting, and servicing the Keysight E1420B VXIbus Universal Counter. This introduction summarizes the chapter contents and gives you a usage guide followed by full performance specifications.

Manual Purpose And Contents Summary

The primary purpose of this manual is to provide assembly-level service instructions for rapid isolation and replacement of either the Al or A2 printed circuit assembly.The Keysight E1420B Assembly-Level service manual contents summary appears below followed by a brief guide to the usual maintenance tasks and corresponding chapters:·

- **Chapter 1: General Information** – Manual purpose, chapter contents summary, suggested manual chapter usage, and full performance specifications.·
- **Chapter 2: Performance Tests** – User procedures for verifying typical operation. Complete performance tests, operation verification test record, and full performance test record.
- **Chapter 3: Adjustments** – Complete Keysight E1420B adjustment procedures.
- **Chapter 4: Service** – Safety considerations, and ESD precautions. Recommended test equipment and identification of assemblies. Assembly-level diagnostic theory of operation. Diagnostic testing and troubleshooting procedures. Replacement of assemblies, exploded view, disassembly, and reassembly.
- **Chapter 5: Replaceable Parts** – Replaceable parts lists for all Keysight E1420B and E1420A assemblies. Exchange assembly information, ordering information, and special parts replacement considerations.
- **Appendix A: Connections, Configuration, and Installation** – Input signal connections and internal configuration jumper and switch settings. System addressing, interrupt priorities and defaults.·
- **Appendix B: Error Messages** – Error message codes, messages, and causes.
- **Appendix C: Command Summary** – Quick reference Common and SCPI operating command summaries.
- **Appendix D: High Throughput/Shared Ram** – Information for Option 040.

Manual Usage Guide

The organization of information in this manual follows the sequence of tasks needed to test, adjust, and if necessary repair the El420B Universal Counter to the assembly level (PCA - printed circuit assembly).

When the optional component-level information package (CLIP) is purchased, component-level repair can be carried out by properly trained service personnel. Choose the task you need to perform, then go to the appropriate chapter:

The maintenance tasks and their associated chapters are as follows:

- Service Manual Guide I E1420B Specifications:............................ Chapter 1
- Procedures to test the counter:...Chapter 2
- Procedures to adjust the counter:.. Chapter 3
- Procedures to repair the counter:... Chapter 4
- How to obtain assembly-level repair parts:.................................. Chapter 5
- Procedures for counter configuration/installation:......................Appendix A
- Error code information:... Appendix B
- Summary of counter operating commands:.............................. Appendix C
- Information for using Option 040,
  High Throughput I Shared RAM:...Appendix D

Manual Changes

This manual applies directly to Model El420B Universal Counters with serial number prefix 3401A and firmware revision number El420B,0,3401(*OPT? query response is "040" for Option 040). This section provides the information needed to adapt this manual to older versions of the Keysight El420B Universal Counter. The manual changes needed for a particular instrument configuration are determined by the serial prefix or complete serial number. The serial number for the Keysight El420B is located on the instrument's right-side cover-shield.

This manual also applies to the Keysight El420A Universal Counter with the exception of all information pertaining to the Attenuation (x1/x10), Option 040 - High Throughput/Shared RAM, the MEMory Subsystem, and any El420B PCAs.1-5.

Newer Instruments

As product changes occur, newer instruments may have a serial number prefix higher than 3401A. Manuals for the instruments may be supplied with an Update Supplement Package containing new/ replacement pages with the required new information. Replace/add affected pages as directed in the Update Supplement Pa.Ckage. Contact the nearest Hewlett-Packard Sales and Support Office (listed in the back of this manual) if the change information is missing.

Full Performance Specifications

The specifications for the El420B are described on the following pages.These specifications are the performance standards or limits against which the instrument can be tested. Performance test procedures for testable specifications are described in Chapter 2. Some performance parameters are called “typical” or noted as “characteristic(s)”. These values have no corresponding performance tests contained in Chapter 2.

Table 1-1 E1420B Specifications

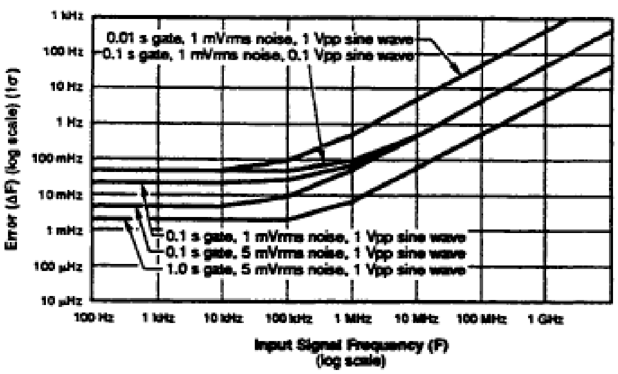
I. Operating Mode Specifications:

(Circled numbers indicate definition references, page 1-6.)

FREQUENCY 1,2

Range: .001 Hz to 200 MHz (100 MHz for input 2)
LSD①: (4 ns / Gate Time) * FREQ
Resolution: (See Graph 1)

$$\pm LSD \frac{\pm(1 \text{ ns rms} + 1.4 * \text{Trigger Error}③) * FREQ}{\text{Gate Time}}$$



Graph 1. Frequency Resolution Error: Noise on the input signal and internal uncertainties affects Frequency and Period measurements. For Period, invert the period (P) of the input signal ($F = \frac{1}{P}$), and find frequency error (ΔF). Period error $(\Delta P) = \left(\frac{\Delta F}{F}\right) \times P$.

Accuracy:
± Resolution ± Time Base Error②

PERIOD 1,2

Range: 10 ns to 1000 s (5 ns to 1000 s on Input 1)
LSD①: (4 ns / Gate Time) * PER
Resolution: (See Graph 1)

$$\pm LSD \frac{\pm(1 \text{ ns rms} + 1.4 * \text{Trigger Error}③) * PER}{\text{Gate Time}}$$

Accuracy:
± Resolution ± Time Base Error②

TIME INTERVAL 1→2 ⑦

Range: 1 ns to 1000 s (single-shot), 10 s (100 gate average)
LSD①: 1 ns (100 ps using 100 gate average)
Resolution:
± LSD ± Start Trigger Error③ ± Stop Trigger Error③ ± 1 ns rms†

Accuracy:
± Resolution ± Time Base Error②
± Trigger Level Timing Error④ ± Trigger Level Setting Error⑤ ± 2 ns.††

TIME INTERVAL DELAY 1→2 ⑦

Used with TI 1→2, a selectable delay can be inserted between START (Input 1 trigger) and STOP (Input 2 trigger). Electrical inputs during delay are ignored. Specifications are the same as TI 1→2.

Delay Range: 1 ms to 99.999 s (1 ms steps)
Delay Accuracy: ± 100 µs ± 0.05% * Delay Time

FREQUENCY RATIO 1/2,2/1

Specified for higher frequency signal connected to Numerator Input (i.e., to input 1 for Ratio 1/2).

Range: .001 Hz to 100 MHz (200 MHz on input 1 if divider is selected)

$$LSD① : \frac{4 * RATIO}{\text{Numerator Input FREQ} * \text{Gate Time}}$$

Resolution:

$$\pm LSD \pm \frac{\text{Denominator Input Trigger Error}③}{\text{Gate Time}} * RATIO$$

Accuracy: Same as resolution

TOTALIZE 1, 1 BY 2, 2 BY 1

Range: 0 to $1 \times 10^{12} - 1$ events
LSD①: 1 count of input signal
Resolution: ± 1 count
Accuracy: ± 1 count
NOTE: Input slew rate at trigger point of gating signal determines when the gate opens and closes. This is known as trigger level timing error.

RISE/FALL TIME 1

Range (10 s max with 100 gate Average):
× 1 Mode: 15 ns to 1000 s
× 10 Mode: 75 ns to 1000 s
LSD①: 1 ns (100 ps using 100 gate average)
Resolution:
± LSD ± Start Trigger Error③ ± Stop Trigger Error③ ± 1 ns rms†
Accuracy:
± Resolution ± Trigger Level Timing Error ④± Trigger Level Setting Error ± Time Base Error② ± 2 ns††
With Automatic Triggering:
Range:
× 1 Mode: 15 ns to 1 ms
× 10 Mode: for freq. ≥ 500 kHz, 75 ns minimum
for freq. < 500 kHz,150 ns minimum
Minimum Amplitude: 750 mV (× Attn) pk-pk
Frequency Range: 1 kHz to 20 MHz

† *100 ps using 100 gate average*

†† *Systematic error due to differential channel delay. Can be elminated with optimized measurement technique (offsets, cable length, etc.)*

* *Range (10 s maximum with 100 gate average): × 1 mode; 15 ns to 1000 s*
× 10 mode; for frequency > 500 kHz, 75 ns to 150 ns
for frequency > 1 kHz, 150 ns to 1000 s

Table 1-1 E1420B Specifications (continued)

POSITIVE, NEGATIVE PULSE WIDTH 1,2

Range: 5 ns to 1 ms
LSD①: 1 ns (100 ps using 100 gate average)
Resolution:
± LSD ± Start Trigger Error③ ± Stop Trigger Error③ ± 1 ns rms†

Accuracy:
± Resolution ± Trigger Level Timing Error④ ± Trigger Level Setting Error⑤ ± Time Base Error②
With Automatic Triggering:
Minimum Amplitude: 70 mV (× Attn) rms sine wave, 200 mV (× Attn) pk-pk
Frequency Range: 1 kHz to 20 MHz

MINIMUM, MAXIMUM, AC, DC VOLTAGES 1,2

Frequency Range: dc (Input 1 only), 1 kHz to 20 MHz
Dynamic Range:
dc signals: ± 10 V (× Attn)
ac signals: 200 mV (× Attn) pk-pk to 10.0 V (× Attn) pk-pk
Resolution:
Min, Max, AC/DC: 30 mV (× Attn)
Accuracy:
Min, Max: AC ± 50 mV (× Attn) ± 5% of pk-pk voltage (± 10% if × 10 mode)
DC; ± 50 mV (× Attn) ± 5% of pk-pk voltage (± 10% if × 10 mode)

II. Input Specifications:

INPUT 1 RANGE:

dc coupled: 0 to 200 MHz
ac coupled: 100 Hz to 200 MHz

INPUT 2 RANGE:

dc coupled: 0 to 100 MHz
ac coupled: 100 Hz to 100 MHz

SENSITIVITY 1,2 (MAX)

35 mV rms sine wave
100 mV pk-pk at a minimum pulse width of 5 ns

1 MΩ:

Dynamic Range (ac) . . . . 10 V (× Attn) peak to peak
Signal Operating Range (dc) . . . ± 10 Volts (× Attn)

50Ω:

Dynamic Range (ac) . . . . 10 V peak to peak
Signal Operating Range (dc) . . . . ± 5 Volts
AC + DC not to exceed 5 Vrms

TRIGGER LEVEL RANGE 1,2 (Not scaled by Attenuation Factor)

± 10.2 V with step size of 2.5 mV

TRIGGER LEVEL ACCURACY 1,2

± 30 mV (× Attn) ± 1% of trigger level
(Same as Autotrigger Level Accuracy)

AUTO TRIGGER

Can be selected to determine trigger levels for all measurements except totalize and Input 3 measurements.

Frequency Range: 1 kHz to 20 MHz
Minimum Amplitude: 70 mV (× Attn) rms sine wave, 200 mV (× Attn) pk-pk

EXTERNAL ARMING

Input: Front-panel BNC or VXIbus TTLTRIG lines
Minimum Start to Stop Time: 50 ns
Sensitivity: 500 mV pk-pk
Signal Operating Range: –5 V dc to +5 V dc
Dynamic Range: 500 mV to 5 V pk-pk

III. Option 010 TCXO Time Base Specifications

Frequency: 10 MHz
Stability:
Aging Rate: $< 1 \times 10^{-7}$/month
Temperature: $< 1 \times 10^{-6}$, 0 to 40°C (when set to offset frequency at 25°C)
Line Voltage: $< 5 \times 10^{-7}$ for 10% change
(Note that the TCXO is not specified between 40°C and 55°C.)

IV. Option 030 Input 3 Specifications

Measurements: Frequency, Ratio 3/1, Period
Range: 90 MHz to 2500 MHz
Resolution: Same as Frequency 1,2
Accuracy: Same as Frequency 1,2

FREQUENCY RATIO 3,1

Specified for higher frequency signal connected to Numerator Input (i.e., to input 3 for Ratio 3/1).

$$\text{LSD}^1 : \frac{4 * \text{Ratio}}{(\text{C–channel Freq}/64) * \text{gate–time}}$$

Sensitivity:
–25 dBm (12.5 mv rms) to 1 GHz
–20 dBm (22.5 mv rms) from >1 GHz to 1.8 GHz
–12 dBm (56.5 mv rms) from > 1.8 GHz to 2.5 GHz

Maximum Input Level: +7 dBm (500.6 mv rms)
Damage Level: +15 dBm (1.25v rms)
Dynamic Range: from minimum sensitivity spec to +7 dBm

V. Input Characteristics

HYSTERESIS 1,2 (@1 MHz)

Adjustable to:
MINimum (35 mVpk-pk)
MAXimum (100 mVpk-pk)
DEFault (60 mVpk-pk)

COUPLING 1,2

ac,dc

† *Resistance values are measured at dc and capacitance at 1 MHz.*

Table 1-1 E1420B Specifications (continued)

TRIGGER SLOPE 1,2

Independent selection of + or - slope

ATTENUATOR 1,2

× 1 or × 10 Nominal

IMPEDANCE 1,2

× 1: 1 MΩ shunted by < 30 pf or 50Ω†
× 10: 1 MΩ shunted by < 20 pf or 50Ω†

DAMAGE LEVEL 1,2

50Ω: 5 V rms
MΩ, × 1:

dc – 5 kHz:	250 V (dc + peak ac)
5 kHz – 175 kHz	8.75×10^5 Vrms Hz/FREQ
>175 kHz:	5 Vrms

1 MΩ, × 10:

dc – 50 kHz:	250 V (dc + peak ac)
50 kHz – 175 kHz:	8.75×10^6 Vrms Hz/FREQ
>175 kHz:	50 Vrms

COMMON INPUT:

All specifications are the same as separate operation except for the following:

Input 1 Range

Limited to 100 MHz

Impedance

× 1: 500 kΩ shunted by < 40 pf or 50Ω†
× 10: 1 MΩ shunted by < 20 pf or 50Ω†

EXTERNAL ARM:
Front panel ARM input or VXIbus TTLTRIG lines can be used to determine Start and/or Stop point of a measurement. External Arm can be used with all measurements except Totalize.
Range: 0 to 20 MHz
Trigger Levels: 0V (GND), 1.6V (TTL), –1.3V (ECL)
Slope: Independent Selection of START and STOP ARM slopes, +, –, or OFF.
Impedance: dc coupled. 1 MΩ shunted by < 20 pF†
Damage Level:
< 5 kHz: 40 V rms
> 5 kHz: 5 V rms

OPTION 030 INPUT 3:

Trigger Level: Fixed at 0 V
Impedance: ac coupled, 50Ω
Damage Level:+15 dBm (1.25 Vrms)

VI. Time Base Characteristics

Standard Time Base: Uses VXIbus CLK10 as default
External Reference Input: Front-panel BNC accepts 10 MHz, 500 mV to 5 V rms into 1 kΩ shunted by < 20 pF
External Reference Output: The option 010 TCXO Time Base signal can be routed out the front-panel BNC.
Signal: 10 MHz, Square wave into 50Ω, amplitude 400 mV (–0.2V to +0.2V).

VII. Gate Time Characteristics

Range: 1 ms to 99.999 seconds in 1 ms increments. (100 ms default)
Resolution: 1 ms
Accuracy: ± 100 µs ± (0.05% × Gate Time) + up to one period of input signal
100 Gate Average: 100 gates accumulated and average is returned. This adds an additional digit of resolution. It can be used with all functions except Totalize.
Gate Output: Can be routed to any one of the 8 VXIbus TTLTRIG lines. Level is low while gate is open during all measurements except Totalize.

VIII. Measurement Throughput Characteristics

(Definitions are located on page 1-6.)

A. Short Speeds

Free-run: Up to 60 measurements / second

Switching: Up to 40 measurements / second

B. Comprehensive Single Reading Times:

1. Frequency/Period

a. 100 Hz signal, .1 Hz resolution (3 digits)
60 ms

b. 100 Hz signal, .0001 Hz resolution (6 digits)
60 ms

c. 10 MHz signal, 10 kHz resolution (3 digits)
24 ms

d. 10 MHz signal, 10 Hz resolution (6 digits)
25 ms

2. Totalize

a. 10 MHz signal, Time to read total (Fetch?)
9 ms

3. Ratio

a. 100 kHz signal, .0001 resolution (4 digits)
426 ms

b. 10 MHz signal, .0001 resolution (4 digits)
31 ms

4. Time Interval

a. 10 ms signal, 10 ns resolution (6 digits)
40 ms

b. 100 us signal, 100 ns resolution (3 digits)
21 ms

c. 100 us signal, 1 ns resolution (5 digits)
173 ms

5. Automatic Pulse Width

a. 5 ms signal, 5 ns resolution (6 digits)
290 ms

b. 50 us signal, 50 ns resolution (3 digits)
280 ms

6. Automatic Rise/Fall Time

a. 1 ms per, 6 Vpp, 1 us rt/ft, resolution 1 ns (3 digits) 284 ms

7. Voltage

a. 1 MHz, 6 Vpp, .06 V resolution (2 digits)
438 ms

† *Resistance values are measured at dc and capacitance at 100 MHz.*

Table 1-1 E1420B Specifications (continued)

C. Option 040

1. Frequency

a. 10 MHz, 1 ms gate time, "MIN" resolution
7.2 ms

2. Time Interval

a. 50 nsec, "MIN" resolution
6.2 ms

IX. General Characteristics

Memory: Ten measurement set-ups, including trigger levels, may be stored in memory and subsequently recalled. Set-ups are lost when power is removed from the instrument.
Programming Language: SCPI 1991.0
Operating Temperature: 0 to 55°C
Power Requirements:

DC Peak current (IPm):

+ 5 V= 2A
+ 12 V=0.25A
–12 V=0.15A
–5.2V=0.8A

Dynamic current (IDm):

+ 5 V= 0.15A
+ 12 V=0.01A
–12 V=0.02A
–5.2V=0.03A

Size: Occupies one slot of a C-size VXIbus cardcage.
234 mm H × 30.5 mm W × 340 mm D
(9.2 in H × 1.2 in W × 13.4 in D)
Weight: Net 1.5 kg (3.2 lb), Shipping 2.3 kg (5 lb)
VXIbus Revision Compliance: 1.3
Connectors: P1, P2
Device type: Message-based
Δ Pressure: 0.15 mm H_2O
Air flow: 1 liter/sec

Auto-Trigger:

Auto-trigger can be used to automatically set trigger levels at 50% point (10%,90% for Rise/Fall Time) of the input signal. The standard auto-trigger will evaluate the input signal, set the trigger level, measure and repeat. Single-measurement auto-trigger will evaluate the input signal only once, and then measure repeatedly, speeding up the process.

Trigger levels can be specified in Volts or percentage of signal height. Percentage trigger levels will activate the auto-trigger to evaluate the signal amplitude.

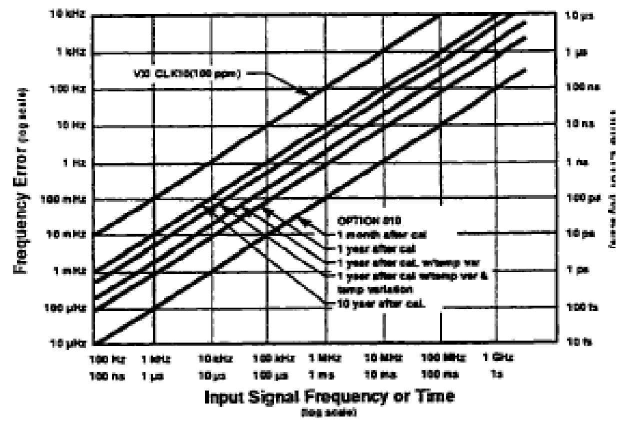
X. Definitions*

1. **LSD**

Unit value of Least Significant Digit. Calculations should be rounded to the nearest decade (i.e., 5 Hz becomes 10 Hz and 4 ns becomes 1 ns).

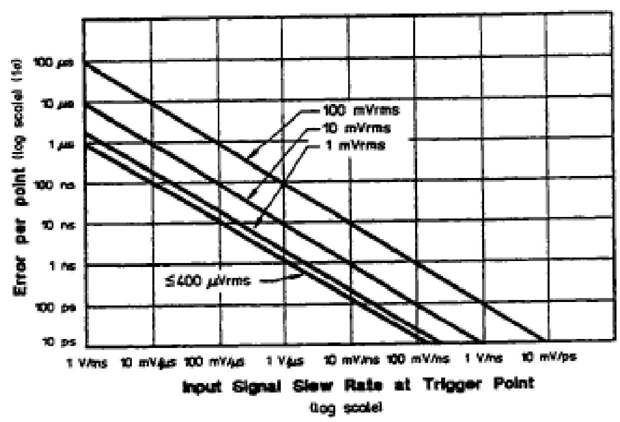
2. **Time Base Error** (See Graph 2)

Maximum fractional frequency change in the time base frequency due to all errors (aging, temperature, line voltage) multiplied by the measurement result.



Graph 2. Timebase Error: Crystal environment and aging affects all measurements.

3. **Trigger Error** (See Graph 3)



Graph 3. Input Noise Trigger Error: Noise on the input signal affects both the Start and Stop points of all time interval measurements.

$$TE = \frac{\sqrt{(ei)^2 + (en)^2}}{\text{Input Slew Rate at Trigger Point}}$$

ei = Effective rms noise of counter's input channel (500 µV typical)

en = rms noise of input signal for input bandwidth

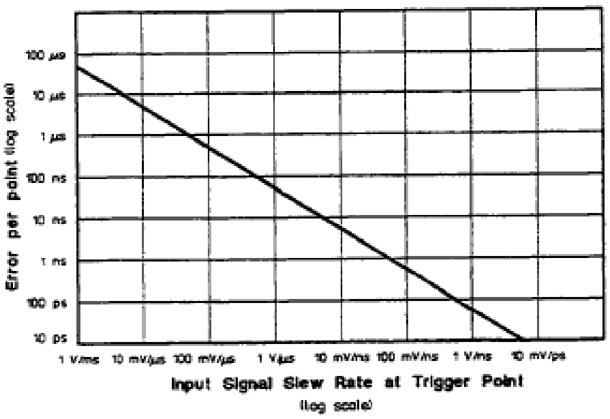
* *Note that rms values in operating mode specifications indicate 1σ confidence value. All graphs use 1σ confidence values. For 99.9% confidence, 3σ values are advised.*

Table 1-1 E1420B Specifications (continued)

4. **Trigger Level Timing Error** (See Graph 4)

   Larger of:

   0.5 hysteresis band / input slew rate at start trigger point[5]
   0.5 hysteresis band / input slew rate at stop trigger point[5]



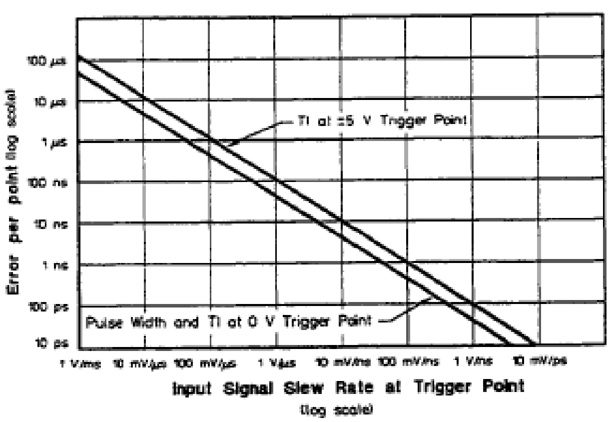
Graph 4. Trigger Level Timing Error: Affects the Start and Stop points of all time interval measurements. Total error is the larger of the two trigger point errors. (For sine waves, Slew rate at 50% level = 2 × π × frequency × amplitude, where amplitude is 1/2 of the peak-to-peak voltage.

5. **Trigger Level Setting Error** (See Graph 5)

$$\pm\frac{30\text{ mV} \pm 1\% \text{ of trigger level setting (TI only)}}{\text{input slew rate at start trigger point}^{5}}$$

$$\pm\frac{30\text{mV} \pm 1\% \text{ of trigger level setting (TI only)}}{\text{input slew rate at stop trigger point}^{5}}$$

   Note that rise/fall times use 10% and 90% points of signal for trigger points, unless programmed differently.



Graph 5. Trigger Level Setting Error: Affects both the Start and Stop points of all time interval measurements.

6. **Trigger Point and Hysteresis**

   Auto trigger disabled: trigger point = trigger level reading

   Auto trigger enabled: For all measurements except Rise/Fall Time,

$$\text{trigger points} = \frac{\text{Max peak} + \text{Min peak}}{2}$$

   For Rise/Fall Time,
   10% trigger point = .1 * max peak + .9 min peak

   90% trigger point = .9 * max peak + .1 min peak

   Min/Max voltage function is used to measure peaks.

$$\text{For X\% trigger point} = \left(\frac{X}{100}\right) \times \text{Max peak} + \left(1 - \frac{X}{100}\right) \times \text{Min peak}$$

7. Specifications for all TI and PW measurements in ×10 attenuation mode are only valid for trigger level settings between 20% and 80% of the input signal level pak-to-peak values.

XI. Measurement Throughput Definitions

A. **Short Speeds:** Quick indicator of maximum counter speeds.

   Setup: Embedded controller

   Signal: > 1 MHz ; signal does not limit speed of measurement.

   Gate: 1 ms; measurement << counter processing time.

   Triggering: Manual

   1. Free Run:

   Indicates speed of measuring and outputting results.Important if many measurements are made from one setup.

   Algorithm: Setup Frequency Measurement, then do multiple reads.

   2. Switching:

   Indicates speed of setup, measurement and output. Important if measurement mode or parameters are changed frequently.

   Algorithm:

   Setup Frequency Measurement, then make one read;
   Setup Time Interval Measurement, then make one read;
   Setup Period Measurement, then make one read;
   Repeat.

Table 1-1 E1420B Specifications (continued)

Setups:

Frequency setup: Input 1 AC, Neg Slope, 50Ω, Trig Level 0.2 V.
Time Interval setup: COMMON, Input 2 Pos Slope, 50Ω, Trig Level 0.2 V.
Period setup: Input 1 DC, Pos Slope, 1 MΩ, Trig Level –.35 V

B. **Comprehensive Single Reading Times:**

Single Reading Times indicate the times needed for command transfer, instrument setup, measurement, and result transfer.

Hardware Setup:

HP 9000 Series 300 computer (320)
HP E1405B Command Module
HP E1400B Cardcage

Software Setup: HPBASIC Version 5.xx

2 Performance Tests

Introduction

This appendix provides two separate groups of tests designed to check for proper operation of the Keysight E1420B VXIbus Universal Counter; functional tests and performance tests. The functional tests provide a quick method of verifying the basic functioning of the counter when its normal operation is in question. The more thorough performance tests are used to conduct a complete investigation of the instrument's electrical performance, using the specifications of Table 1-1 (Table 2-3 in this appendix) as the performance standards.

Important Topics

- Alternate Test Equipment
- Auto Frequency Measurement Test
- Auto Measurement Sensitivity, Range, and Accuracy
- E1420B Specifications Table
- External-Arm Input Test
- External-Arm Sensitivity, Range, and Minimum Start-to-Stop Time
- Functional Test Record
- Input 1/2: Measurement Sensitivity, Range, and Accuracy
- Input 3: Measurement Sensitivity, Range, and Accuracy
- Input Signal Conditioning Test
- Option Tests
- Power-up Self Test
- Ratio/Time-Interval Measurement Test
- Performance Test Record

Chapter Summary

Equipment Required

Equipment required for the performance tests is listed in Table 2-1, Recommended Test Equipment. Any substitutes to this recommended list are valid only if the substituted equipment satisfies all critical requirements of the recommended model(s) given in the table.Table 2-1. E1420B Recommended Test Equipment

Table 2-1 E1420B Recommended Test Equipment

Equipment	Critical Requirements	Recommended Model
For All Functional and Performance Tests:		
VXIbus Mainframe	Meets VXIbus System Specs, Rev. 1.3	HP 75000 Series C
Slot-0 Command Module	GP-IB or RS-232 to VXIbus compatible SCPI command language compatible	HP E14058
Interface Controller	GP-IB or RS-232 compatible	HP9000 Series 200/300
For Input 1 and Input 2 Functional and Performance Tests:		
Function Generator Signal Generator Pulse Generator BNC “T'' connector	Frequency Range: 0 20 MHz Output Level: 25 mVrms ⇒ 10 V p-p (With dc offset capability) - Resolution: 0.01 Hz Frequency Range: 100 MHz ⇒ 200 MHz Output Level: 25 mVrms ⇒ 100 mVrms Resolution: 0.1 Hz Internal Timebase w/ Ref. Output Period: 50 ns ⇒ 1.0 ms Min. Pulse Width: 20 ns Max. Output Level: 5 Vp-p 3% pulse parameter accuracy	HP 33258 HP 8663A HP 8161A HP 1250-0781
For Option 030 UHF Input 3 Functional and Performance Tests:		
Signal Generator	Frequency Range: 90 MHz .⇒ Per Spec Output Level: +0.5 ⇒ +2.5 dBm Resolution: 0.1 Hz Internal Timebase w/ Ref. Output	HP 8663A
Fixed Attenuator	Attenuation 10 dB	HP 8491A (Option 010)
Connectors: BNC(m) to N(m) N(f) to 8NC(f) N(m) to BNC(f)		 HP 1250-0082 HP 1250-1474 HP 1250-0780

Calibration Cycle

To maintain the E1420B within specified operating limits, the instrument should be checked using the full performance tests at least once each year. This annual time frame may be accelerated as demanded by specific environmental conditions and user needs. If installed, the optional TCXO reference oscillator must be checked and, if necessary, adjusted to a house frequency standard before beginning the performance tests. Refer to the TCXO Adjustment Procedure in Chapter 3 of this manual. Follow the preliminary instructions given in the INTRODUCTION and SAFETY CONSIDERATIONS paragraphs of Chapter 3.

Functional/Performance Test Records

Results of the functional tests may be recorded on a copy of the Functional Test Record (Table 2-2), which follows the functional test procedures. Results of the full performance tests may be recorded on a copy of the Performance Test Record (Table 2-4), which follows the performance test procedures.

NOTE **The software version of E1420B testing will record its own test results, then print these results on computer generated Functional/Performance Test Records.**

Test Procedure Considerations

The person performing the following tests must understand how to operate the specified test equipment. Equipment settings, other than for the Universal Counter, are stated in general terms. Unless otherwise specified, use straight (not 50 ohm feed-through) BNC connectors when applying input signals to the E1420B during performance testing. All cables, connectors, and adapters needed are also to be supplied by test personnel.

Only the SCPI command strings for the counter are given in the procedures. The user must send the string to the counter via a controller and command module. To make a measurement or read back a value, the user reads back a string from the output queue of the counter. The user must properly dimension strings to accept at least 20 characters as a query response to a measurement request. More details on configuring and operating the counter are given in Appendixes A and C of this manual.

CAUTION Throughout these testing procedures, the “*RST” command is used frequently to reinitialize the counter to its preset default values. Failure to issue the “*RST” command at the specified times (and only at these times) will result in testing errors, since the procedures are written to assume that the default values are present after sending the “*RST” command.

Software Implemented Full Performance Testing

Available upon order of the El420B assembly level service manual is a software program designed to expedite the Functional and Performance Testing processes for either the El420A or El420B. The program steps the user through any or all parts of El420AIB performance testing, sends pertinent SCPI commands to the counter, receives and analyzes measurements sent back from the counter, and helps the user configure the El420AIB and set up all test equipment input conditions. This software program, available in 5 1/4" or 3 1/2" floppy format, was written in Keysight BASIC for an Keysight 9000 Series 2001300 system communicating over Keysight-m with an Keysight El405B Command Module. The software part numbers are:3 1/2" disk, El420-13505, Rev 0,3401; 5 1/4" disc, El420-13506, Rev. 0,3401.

Functional Tests

The tests included here are not as thorough and rigorous as the full performance tests. This group of tests is intended to serve only as a method for giving the operator a high degree of confidence that the instrument is performing properly. No attempt is made to check the specifications of this instrument.

These tests are useful for incoming QA or as a first check on an instrument suspected of having a problem.

NOTE The following functional test procedures frequently call upon the use of a low amplitude (less than 10 v p-p) 10 MHz signal as a test input. This signal exists on the CLK 10 SM8 output of the Keysight £1405 Slot-0 command module, if present. This signal can also be generated by routing the TCXO timebase, if present, to the E14208 front panel lnt/Ext BNC output.

If neither of the above are available, the user must provide a signal source capable of generating a 1 v p-p sinusoidal signal at a frequency of 10 MHz. Example source: Keysight 33258.

CAUTION Before the E1420B is installed into the VXIbus Mainframe, make certain that the counter is properly configured as specified in Chapter 2 of this manual.Verify that the VXIbus Mainframe meets VXIbus System Specifications, Rev 1.3.

NOTE These tests only specify the command strings that need to be sent to the counter in word-serial protocol over the VX/bus. Procedures used in getting the command strings to the counter are controller and slot-0 dependent. See Appendixes A and C of this manual for details.

Preliminary Procedure

Use the following steps to set up the E1420B for functional testing:

1 Turn off power to the VXIbus Mainframe.

2 Plug the Keysight E1420B into an empty slot on the VXIbus Mainframe.

3 Turn on power to the VXIbus Mainframe.

4 Verify proper operation of the VXIbus slot-0 command module.

5 Generate an external sinusoidal signal at a frequency of 10 MHz and an amplitude of approximately 0.5 V peak (1 V p-p) with no dc offset.

6 For now, DO NOT connect this signal to the input channels of the Keysight E1420B.

Power-up Self-Test

Description: During the power-up sequence, the Keysight E1420B performs a diagnostic check of major components.

Procedure: Use the following steps to run the E1420B Self-test.

1 Cycle the VXIbus Mainframe power switch to ON.

Observe:

- **a** All E1420B front panel LED's light momentarily.
- **b** The “Failed” LED extinguishes after a few seconds, indicating successful completion of the self test.

2 Connect the 10 MHz test input signal to the Int/Ext. Reference BNC input of the E1420B.

3 Ask the counter to report its power-up status by sending the “*TST?” command to the E1420B.

Observe: The E1420B “Access” LED momentarily lights, acknowledging the counter's acceptance of the II *TST? n command.

4 Read the output string from the E1420B.

Observe: The result should be “+0”,which means “NO ERRORS”.

Test Record: Mark Pass or Fail on the Functional Test Record, line 1.

Here's what was Checked:

1 All LED's lighting indicates that all front panel LED's are operational.

2 The extinguished “Failed” LED indicates that the microprocessor, bus controller, latches, and ROM are functioning.

3 The ability of the command module to communicate with the counter, indicated by the lighting of the "Access” LED, shows that the controller is sending the appropriate control signals to the logical address occupied by the E1420B.

4 Reading back information from the counter indicates that the VXIbus interface and associated latches are functioning.

5 A “+0” message indicates that the diagnostic self-test has passed. The self-test verifies the following:

- ROM
- RAM
- MRC
- Interpolate
- Timebase presence
- Timebase selection circuitry
- Input amplifier/main board connector integrity

- Control latches and buffers

Failure: Any failures during the power-up self test will cause the “Failed” LED to remain lit. If the failure does not affect the microprocessor, bus controller, VXIbus interface, ROM, RAM, or associated latches, the output queue will contain a “+1” message indicating a need for further diagnostic testing. Further instructions on failure handling are given in Chapter 4 of this manual.

Auto Frequency Measurement Test

Description: This test checks the auto-triggering capability and frequency interpolation process of the E1420B.

NOTE This test requires a signal source capable of providing a 10 MHz 1 Vp-p sine wave with varying dc content. (Example: Keysight 33258.)

Procedure: Use the following steps to conduct the Auto Frequency measurement test.

1 Generate the 10 MHz signal of preliminary procedure Step 5 and give it an offset of +2 dc volts.
2 Connect this signal to Input 1 on the E1420B.
3 Reinitialize the Keysight E1420B by.sending “*RST”.
4 Configure the E1420B with the following command:

Description of Command	SCPI Command String
Place counter in auto-trigger mode	“EVEN:LEV:AUTO ON”

5 Make a frequency measurement on Input 1:

Description of Command	SCPI Command String
Measure Frequency Input 1	“MEASl:FREQ?”

Observe:

The Input 1 trigger LED should be flashing, and the frequency measurement should read 10 MHz, within the tolerance limits of the generated input signal.

Test Record: Mark Pass or Fail on the Functional Test Record Card, line 2.

Here's what was checked:

1 The interpolators which provide the accuracy of the frequency count. Defective interpolators could cause a reading error of +100Hz.
2 The auto-trigger functioning of the E1420B.

Failure: If this test does not cause the Input 1 trigger LED to flash and will not return a legitimate frequency reading, the probable cause of error is the auto-triggering circuitry.

If the test returns a measurement not consistent with the true input signal, then the frequency interpolators are most likely at fault and the Main Board is a candidate for replacement. Refer to the trouble shooting procedures found in Chapter 4 of this manual for more information.

Ratio Measurement Test

Description: This test uses a 10 MHz signal to drive the channel 1 and 2 input amplifiers in a test of the Multiple-Register Counter IC (MRC).

Procedure: Use the following steps to conduct the Ratio measurement test.

1 Connect the 1V p-p 10 MHz with no dc offset to Input 1.

2 Reinitialize the Keysight E1420B by sending “*RST”.

3 Configure the El420B with the following SCPI command:

Description of Command	SCPI Command String
Common input mode ON	“INP:ROUT COMM”

4 Measure the frequency ratio of Input 1 to Input 2.

Description of Command	SCPI Command String
Measure Frequency Ratio IN1/IN2	“MEAS:FREQ:RAT?”

Observe: The ratio measurement should return as l.OOOOOOOOOE+OO and both input trigger lights should be flashing.

Test Record: Mark Pass or Fail on the Functional Test Record Card, line 3.

Here's what was checked:

The operation of the internal count circuitry (contained in the MRC chip) and microprocessor math circuitry is checked using the ratio function.

Failure: Should this test fail, the MRC is the probable cause, and the Main Board is a likely candidate for replacement. Other circuit blocks involved are the channel 1 and 2 input amplifier circuitry, along with the measurement select-calculation-control block. Refer to the trouble shooting procedures found in Chapter 4 of this manual for more information.

Input Signal Conditioning Test

Description: This series of checks comprises a functional test of the input amplifier relays and circuitry associated with those relays.

NOTE This test requires a signal source capable of providing a 10 MHz 1 Vp-p sine wave with varying dc content. (Example: Keysight 33258)

Procedure: Use the following steps to conduct the Input Signal Conditioning test.

1 Connect the 10 MHz signal of preliminary procedure Step 5 to Input 1.

2 Reinitialize the Keysight E1420B by sending "*RST'.

3 Configure the Keysight E1420B with the following SCPI command string:

Description of Command	SCPI Command String
Common input mode ON	"INP:ROUT COMM"

Observe: The Input 1 and Input 2 trigger LED's should both be flashing. Steps 3 and 4 verify operation of the trigger level LED's.

4 Gradually increase the trigger levels of Input 1 and Input 2 until the trigger lights just go off. Use the following SCPI command strings to make the trigger levels increase:

Description of Command	SCPI Command String
Input 1,2: Trigger Level x.x V	"SENSl:EVEN:LEV x.x"
	"SENS2:EVEN:LEV x.x"

(where x.x is the trigger level value.)

5 Set the Keysight E1420B with the following SCPI commands:

Description of Command	SCPI Command String
Inputs 1,2 1 Mohm impedance	"INPl:IMP 1E6"
"INP2:IMP 1E6"Common input mode OFF	"INP:ROUT SEP"

Observe: The Input 1 trigger LED should be flashing and the Input 2 trigger LED should not be flashing.

6 Issue the following SCPI command to the E1420B:

Description of Command	SCPI Command String
Common Input Mode ON	"INP:ROUT COMM"

Observe: The Input 1 and Input 2 trigger LED's should both be flashing. Steps 5 and 6 check the input common/separate relay.

7 Change both input impedance levels to 50 ohms.

Description of Command	SCPI Command String
Input 1,2: 50 ohm impedance	"INP1:IMP 50" "INP2:IMP 50"

Observe: The Input 1 and Input 2 trigger LED's should both be off (not flashing). Steps 5 and 7 are aimed at checking the input impedance relays.

8 Reinitialize the Keysight E1420B by sending "*RST''.

9 Configure the Keysight E1420B with the following SCPI commands:

Description of Command	SCPI Command String
Inputs 1 and 2, ac coupling	"INP1:COUP AC" "INP2:COUP AC"

10 Use the following SCPI commands to turn on the x10 attenuator:

Description of Command	SCPI Command String
Inputs 1 and 2, attenuator x10	"INP1:ATT 10" "INP2:ATT 10"

11 Generate a 10 MHz signal with an amplitude of 3V rms.

12 Connect this signal to inputs 1 and 2 on the Keysight E1420B.

13 Measure the ac rms voltage of the input signal through the x10 attenuators by sending the following SCPI commands:

Description of Command	SCPI Command String
Measure ac rms voltage; Inputs 1 and 2.	"MEAS1:AC?" "MEAS2:AC?"

Observe: The Input 1 and 2 trigger LEDs should both be flashing, and the voltage measurement should return as 300 mV rms, within the tolerance limits of the generated input signal. Note that this test is verifying the x1/x10 attenuator relays, not the accuracy of the measurement process.

14 Use the following SCPI commands to return the Keysight E1420B attenuators to x1 operation:

Description of Command	SCPI Command String
Inputs 1 and 2, Attenuation x1.	"INP1:ATT 1" "INP2:ATT 1"

15 Measure the ac rms voltage of the signal through the x1 attenuator:

Description of Command	SCPI Command String
Measure ac rms voltage; Inputs 1 and 2.	"MEAS1:AC?" "MEAS2:AC?"

Observe: The Input 1 and 2 LEDs should be flashing and the voltage measured should return as 3.00 Vrms within the tolerance limits of the generated input signal.

16 Reinitialize the Keysight E1420B by sending "*RST".

17 Configure the E1420B with this SCPI command:

Description of Command	SCPI Command String
Common input mode ON	"INP:ROUT COMM"

18 Measure the Input 1 and 2 signal frequencies with these SCPI commands:

Description of Command		SCPI Command String
Measure Frequency:	Input 1	"MEAS1:FREQ?"
	Input 2	"MEAS2:FREQ?"

Observe: The measurements should read 10 MHz, within the tolerance limits of the external source. Note that this test is verifying the ac/dc relay, not the accuracy of the measurement process.

19 Carefully increase the dc offset level of the input signal until both Input 1 and Input 2 trigger lights stop flashing.

20 Issue the following SCPI commands to the E1420B:

Description of Command	SCPI Command String
Inputs 1,2: ac coupling	"INP1:COUP AC"
	"INP2:COUP AC"

Observe: The Input 1 and Input 2 trigger lights should resume flashing.

21 Measure frequencies with the following SCPI commands:

Description of Command		SCPI Command String
Measure Frequency:	Input 1	"MEAS1:FREQ? 1E7, 1"
	Input 2	"MEAS2:FREQ? 1E7,1"

Observe: The measurements should read 10 MHz, within the tolerance limits of the external source. Note that this test is verifying the ac/dc relay, not the accuracy of the measurement process.

Test Record: Mark Pass or Fail on the Functional Test Record Card, line 4.

Here's what was checked:

All input amplifier relays and associated circuitry.

Failure: The circuit blocks that are added to the testing process are the ac/dc relays, the 50/1 MΩ relays, the x1/x10 attenuator relays, and the common/separate relay. If any part of the preceding test fails, the Input Amplifier Board is a likely candidate for replacement. Refer to the trouble shooting procedures found in Chapter 4 of this manual for more information.

Time Interval Test

Description: This test uses the Time Interval function to verify proper slope switching and trigger level accuracy in the input amplifier assembly.

Procedure: Use the following steps to conduct the Time Interval test.

1 Connect the 10 MHz signal of preliminary procedure Step 5 to Input 1.

2 Reinitialize the Keysight E1420B by sending II *RST".

3 Configure the E1420B with the following SCPI command strings:

Description of Command	SCPI Command String
Common input mode ON	“INP:ROUT COMM"
Input 1 trigger on positive slope	"SENSl:EVEN:SLOP POS"
Input 2 trigger on negative slope	"SENS2:EVEN:SLOP NEG"

4 Measure the time interval from Input 1 to Input 2.

Description of Command	SCPI Command String
Measure Time Interval 1 ⇒ 2	"MEAS1:TINT?"

Observe: The measurement should be approximately 1/2 period of the input signal, or 50 ns.Performance Tests 2-11

5 Use the following SCPI commands to turn on x10 attenuation and ac coupling:

Description of Command	SCPI Command String
Inputs 1 and 2, ac coupling	"INP1:COUP AC;ATT 10"
and x10 attenuation.	"INP2:COUP AC;ATT 10"

6 Increase the signal amplitude to 3V rms.

7 Measure the interval from Input 1 to Input 2:

Description of Command	SCPI Command String
Measure Time Interval 1 ⇒ 2.	"MEAS1:TINT?"

Observe: The measurement should be approximately 1/2 period of the input signal, or 50 ns.

8 The preceding measurement was triggered to measure the positive portion of the 10 MHz input waveform. Now configure the Keysight E1420B to measure the negative portion by sending the following SCPI commands:

Description of Command	SCPI Command String
Reinitialze the counter.	"*RST"
Common input mode ON.	"INP:ROUT COMM"
Input 1 trigger on negative slope.	"SENS1:EVEN:SLOP NEG"
Input 2 trigger on negative slope.	"SENS2:EVEN:SLOP POS"

9 Once again measure the time interval from Input 1 to Input 2:

Description of Command	SCPI Command String
Measure Time Interval1 ⇒ 2.	"MEAS1:TINT?"

Observe: The measurement should be approximately 1/2 period of the input signal, or 50 ns.

10 Use the following SCPI commands to turn on the Keysight E1420B x10 attenuators:

Description of Command	SCPI Command String
Inputs 1 and 2, Attenuation x10.	"INP1:ATT 10" "INP2:ATT 10"

11 Measure the time interval from Input 1 to Input 2:

Description of Command	SCPI Command String
Measure Time Interval 1 ⇒ 2.	"MEAS1:TINT?"

Observe: The measurement should be approximately 1/2 period of the input signal, or 50 ns.

Description of Command	SCPI Command String
Reinitialize counter	"*RST"
Common input mode ON	“INP:ROUT COMM"
Input 1 trigger on negative slope	“SENS1:EVEN:SLOP NEG"
Input 2 trigger on positive slope	“SENS2 :EVEN:SLOP POS"

12 Once again measure the time interval from Input 1 to Input 2.

Description of Command	SCPI Command String
Measure Time Interval 1 ⇒ 2	"MEAS1:TINT?"

Observe: The measurement should be approximately 1/2 period of the input signal, or 50 ns.

NOTE Depending on distortion in the input signal, the preceding measurements may not be equal to exactly 1/2 of the 100 ns period. However, the two measurements should sum to one period of the input signal. (Allow for accuracy limits of the input source.)

Test Record: Mark Pass or Fail on the Functional Test Record, line 5.

Here's what was checked:

The trigger level and control circuitry in both x1 and x10 attenuator modes; particularly the slope switch control operation.

Failure: If the accuracy of the measurement(s) is slightly out of the specified range, the probable cause is the Input Board and the trigger level circuitry.

If the measurement is totally inaccurate (on the order of more than 50 ns), the probable cause is a malfunction in slope switching, which is controlled by the MRC on the Main Board. Refer to the trouble shooting procedures found in Chapter 4 of this manual for more information.

External Arm Input Test

Description: This test checks the front panel external arm input amplifier circuitry by configuring the arm to act as the gate for measuring a signal input on channel 1.

Procedure: Use the following steps to conduct the External Arm Input test.

1. Connect the 10 MHz signal of preliminary procedure Step 5 to Input 1 and the front panel BNC Arm Input using a BNC T-connector and two BNC cables of equal length.
2. Reinitialize the Keysight E1420B by sending "*RST".Performance Tests 2-13
3. Configure the E1420B with the following SCPI command strings:

Description of Command	SCPI Command String
Arm Input: Start, Stop on positive edges of External Source with an arm trigger level of 0 volts.	“ARM:STAR:SOUR EXT:LEV 0" “ARM:STAR:SLOP POS" “ARM:STOP:SOUR EXT:LEV 0" "ARM:STOP:SLOP POS"

Observe: The Arm input trigger LED should be flashing.

4. The E1420B is now configured to make measurements using the first positive edge of the arm input to open (start) the aperture gate, and the second positive edge of the arm input to close (stop) the gate; the aperture time is therefore the period of the arm input signal: 100 ns.
5. Now measure the frequency on Input 1.

Description of Command	SCPI Command String
Measure Frequency: Input 1	"MEAS1:FREQ?"

Observe: The Keysight E1420B returns 10 MHz with a resolution of ±1 MHz, within the tolerance limits of the external source. Note that this test is verifying the ability of the E1420B to trigger on an external Arm Input, not the accuracy of the measurement process.

Test Record: Mark Pass or Fail on the Functional Test Record Card, line 6.

Here's what was checked:

External Arm input circuitry on the Input Board.

Failure: The functional block being tested is the external arm input amplifier circuitry. If this test fails, the likely candidate for replacement is the Input Board. Refer to the trouble shooting procedures found in Chapter 4 of this manual for more information.

Option 010 TCXO Timebase Test

Description: This test uses the frequency ratio function to ensure proper installation and operation of the E1420B's optional TCXO internal timebase.

Preliminary Procedures: If you are running this test out of sequence with the previous functional tests, be sure to follow preliminary procedure Steps 1-4 for functional testing.

CAUTION After following preliminary procedures, ALLOW 30 MINUTES OF TCXO WARM UP TIME BEFORE ATTEMPTING THE FOLLOWING TEST!!!

Procedure: Use the following steps to conduct the TCXO Timebase test.

1 Connect the front panel Int/Ext Reference signal to Input 1.

2 Reinitialize the Keysight E1420B by sending "*RST".

3 Configure the E1420B with the following SCPI command strings:

Description of Command	SCPI Command String
Route TCXO timebase to front panel Int/Ext	"SENS:ROSC:SOUR INT"
Ref. as an output	"OUTP:ROSC:STAT ON"
Common input mode ON	"INP:ROUT COMM"

4 Measure the frequency ratio of Input 1 to Input 2.

Description of Command	SCPI Command String
Measure Frequency Ratio IN1/IN2	"MEAS:FREQ:RAT?"

Observe: The ratio measurement should return as 1.00000000E+00 and both input trigger lights should be flashing.

Test Record: Mark Pass or Fail on the Functional Test Record Card, line 7.

Here's what was checked:

1 The 10 MHz reference oscillator signal at the front panel connector is verified for TCXO sourcing.

2 The reference oscillator selection circuitry is exercised.

Failure: Should this test fail, first refer to the TCXO adjustment procedure found in Chapter 3 of this manual. Other possible sources of error are the reference oscillator selection circuitry, input amplifier circuitry, and internal count circuitry. Refer to the trouble shooting procedures found in Chapter 4 of this manual for more information.

Option 030, Input 3 Test

Description: The general functioning of Input 3 (Option 030) is checked by measuring a frequency within its specified range of 90 MHz to 2.5 GHz.

Requirements: Option 030 must be installed and a signal source capable of output between 90 MHz and 2.5 GHz must be provided.

Procedure: Use the following steps to conduct the option 030 Input 3 test.

1. Set the signal source to generate a frequency between 90 MHz and 2.5 GHz at 300 mV rms (+2.5 dBm).
2. Connect the signal source to the Keysight E1420B Input 3.
3. Reinitialize the counter by sending "*RST".
4. Measure the frequency on Input 3 with the following SCPI command string:

Description of Command	SCPI Command String
Measure Frequency: Input 3	"MEAS3:FREQ?"

Observe: The Keysight E1420B returns the generated frequency. Note that this test is checking the overall integrity of Input 3, not the accuracy.

Test Record: Mark Pass or Fail on the Functional Test Record Card, line 8.

Here's what was checked:

Basic operation of Input 3.

Failure: Refer to Chapter 4 of this manual. The functional block being tested is the Input 3 input amplifier circuitry. If this test fails, the likely candidate for replacement is the Input Amplifier board A2.

Table 2-2 Keysight E1420B Functional Test Record Card

FUNCTIONAL TEST RECORD				(Page 1 of 1)
Keysight E 14208 UNIVERSAL COUNTER				

Test Facility: ______________________________ Report Number: ______________________________

Serial Number: ______________________________ Ambient Temperature: ______________________ C

Customer: ______________________________ Relative Humidity: ______________________ %

Tested By: ______________________________ Line Frequency: ______________________ Hz

Date: ______________________________ Installed Options: 010 030 040 (Circle)

Notes: ______________________________ Calibration Test: pre post Circle one)

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Page No.	Description	Pass	Fail
C-5	Power-up Self Test	________	________
C-6	Auto Frequency Measurement Test	________	________
C-7	Ratio Measurement Test	________	________
C-8	Input Signal Conditioning Test	________	________
C-11	Time Interval Test	________	________
C-12	External Arm Input Test	________	________
C-13	Option 010 TCXO Timebase Test	________	________
C-14	Option 030 Input 3 Test	________	________

Full Performance Tests

The following procedures test the electrical performance of the Keysight E1420B VXIbus Universal Counter using the specifications in Table 1-1 as the performance standards. (Table 2-3 reproduces these specifications for your convenience.) The tests included here are more specific and exacting than the preceding functional tests. Perform these procedures to ensure that an instrument is operating at its full warranted performance during, but not limited to, the following events:

- incoming Quality Assurance
- the annual calibration cycle check
- following adjustment procedures
- after assembly-level replacement

These procedures were designed to be performed sequentially in order to fully test the Keysight E1420B. As in the functional tests, only the SCPI command strings for the counter are

given; see Test Procedure Considerations (page 2-3) for more information. A view of the general test setup used for all E1420B performance testing is shown in Figure 2-1.

NOTE **The resolution limits specified in the following procedures assume that the test equipment used is calibrated and operating at its performance limits. When this is not the case, problems can occur. For example, noise on an input signal will result in what seems to be an inaccurate measurement This condition must be considered when observed measurements do not agree with the performance test limits.**

Specifications Tested

All specifications listed in Table 2-3 (same as in 1-1) will be verified through the performance testing. However, each specification does not have a stand-alone test. Duplication of effort is avoided by noting that a single test can fully verify the functionality of a circuit block and that further tests of that circuit block are redundant and unnecessary.

Table 2-3 also gives a reference number to each specification being tested. Throughout the test procedures, these reference numbers will be used as a convenient method of telling the user exactly what specifications are checked in each successive test.

Summary of Tests:

1. Input 1/2: Measurement Sensitivity, Range, and Accuracy
2. External-Arm Sensitivity, Range, and Minimum Start-to-Stop Time
3. Auto Measurement Sensitivity, Range, and Accuracy
4. Input 3: Measurement Sensitivity, Range, and Accuracy

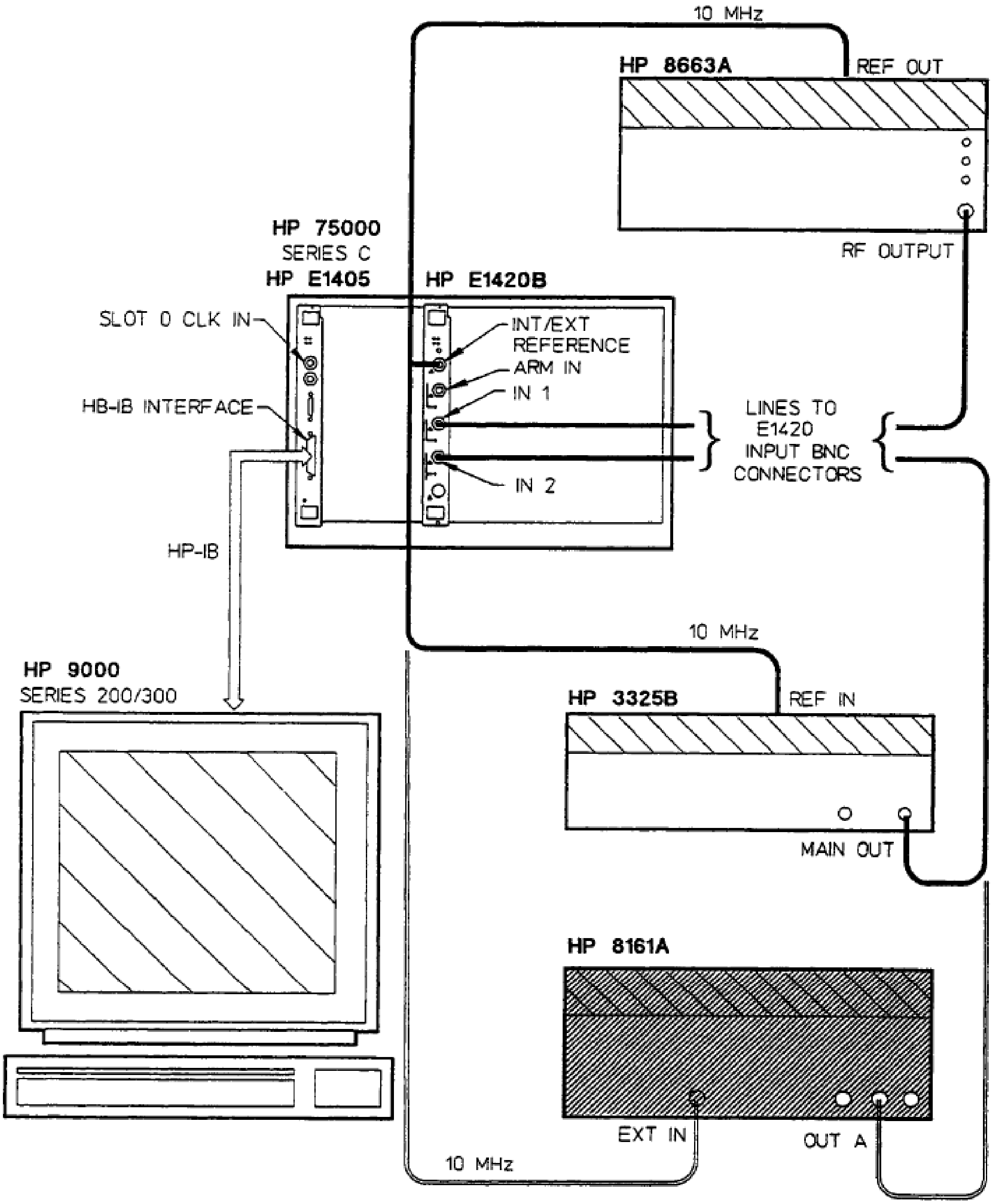


Figure 2-1 General Test Setup

Table 2-3 Keysight E1420B Optional Specifications Test List

Area Tested	Ref No.	Specification Tested
Inputs 1, 2:	1	Input 1 Range DC: 0 - 200 MHz
	2	Input 2 Range DC: 0 - 100 MHz
	3	Input 1 Range AC: 100Hz- 200 MHz
	4	Input 2 Range AC: 100 Hz- 100 MHz
	5	Sensitivity: 35 mV rms sine wave
	6	Dynamic Range: 100 mVpp - 10.0 Vp-p
	7	Common Input: range and accuracy
External Arm:	8	Range: 0 - 25 MHz
	9	Minimum Start/Stop Time: 50 ns
	10	Sensitivity: 500 mV p-p
	11	Dynamic Range: 500 mV p-p - 5 Vp-p
Measurement Ranges:	12	Measurement-dependent; see Table A-1
Measurement Accuracy:	13	Frequency Inputs 1,2
	14	Period Inputs 1,2
	15	Time Interval 1-2
	16	Ratio 1/2
	17	Totalize
Auto Trigger:	18	DC Coupled Range: 1 kHz- 20 MHz
	19	AC Coupled Range: 1 kHz- 20 MHz
	20	Minimum Amplitude: 70 mVrms Sine Wave
Automatic Measurement Range and Accuracy:	21	Rise/Fall Time 1
	22	Pulse Width 1

Uncertainties Analysis Method

The E1420B Performance Test Record Card contains a column that lists measurement uncertainties. This column represents an accumulation of uncertainties from the national standard to the instrument, taking both random and systematic uncertainties into account.When comparing measurement results to counter specifications, the person administering the test must allow compensation for measurement uncertainty. This means that if an obtained measurement falls outside of its specified Min/Max bounds (also listed on the performance test record card), yet is within the bounds of [true input ±measurement uncertainty], the measured value DOES conform to specification and DOES NOT constitute a failed test point.

For example:

Input_Signal	Min	Measured	Max	Meas._Uncer.	Test Status
100Hz	98Hz	103Hz	102Hz	±4Hz	Passed
100Hz	98Hz	105Hz	102Hz	±4Hz	Failed

NOTE For the E1420B performance tests, random uncertainties were figured using the RSS method, calculated to a confidence inteNal of 2 sigma (95%}.

Alternate Test Equipment

Test equipment other than that specified in Table 2-1 may be used only if the critical specifications of each test can still be accurately checked. If alternate test equipment is used, adjust the tolerance limits to reflect actual test equipment specifications. Note that to comply with MIL-STD-45662A calibration system requirements, the test equipment being used should be at least four (4) times more accurate than the instrument making the test measurement.

CAUTION Before the E1420B is installed into the VXIbus Mainframe,v erify that the counter is properly configured as specified in Appendixes A and C of this manual.Verify that the VXIbus Mainframe meets the specifications of the VXIbus System Specifications, Rev 1.3.

NOTE These tests only specify the command strings that need to be sent to the counter in word-serial protocol over the VXIbus. These strings must be sent exactly as they appear in the test procedures for the performance tests to be considered valid.

Procedures used in getting the command strings to the counter are controller and slot-0 dependent. See Appendix A and C of this manual for details.

Preliminary Procedure

Use the following steps to set up the E1420B for full performance testing:

1. Turn off power to the VXIbus Mainframe.
2. Plug Keysight E1420B into the VXIbus Mainframe.
3. Turn on power to the VXIbus Mainframe.
4. Connect 10 MHz reference output of the Keysight 8663 Signal Generator (back panel) to the E1420B Int/Ext Reference BNC input and all valid testing equipment external reference frequency inputs, as shown in Figure 2-1.
5. Verify proper operation and port addressing of the Slot-0 command module and the Keysight E1420B Universal Counter. Refer to "Internal Configuration" of Appendix A for details.

Input 1/2: Measurement Sensitivity, Range, and Accuracy Tests

Description:

The input frequency range and sensitivity of the E1420B is tested, along with the dynamic range and accuracy of all critically specified non-auto measurements.

Specifications Tested:

Referring to the reference numbers of Table 2-3, this test verifies:

1, 2- Inputs 1, 2 dc range
3, 4 - Inputs 1, 2 ac range
05 - Sensitivity
06 - Dynamic range
07 - Common input specifications
12 - Non-auto measurement ranges

Accuracy of:

13 - frequency,
14- period,
15- time interval,
16 - ratio, and
17 - totalize measurements

Equipment Used:

3325B Synthesizer/Function Generator
8663A Synthesized Signal Generator

Input Condition A:

35 mV rms @ 10Hz @ Zin=50 ohm @ dc coupling

Procedure A:

1 Use the Keysight 3325B to generate a 35 mV rms sine wave at a frequency of 10Hz.

2 Connect this signal to Input 1 on the E1420B.

3 Reset the counter by sending "*RST" as a command string. This will automatically set the counter input defaults to 50 ohm input impedance and dc coupling. This will also set trigger levels to 0.0 V.

4 Program the E1420B to use the 10 MHz external signal of preliminary procedure Step 4 as its timebase by issuing the following SCPI command:

Description of Command	SCPI Command String
Route external timebase to E1420B	"SENS:ROSC:SOUR EXT"

5 Configure the E1420B to operate on its maximum sensitivity (minimum hysteresis) setting.

Description of Command	SCPI Command String
Maximum input sensitivity	"SENS:EVEN:HYST MIN"

6 Measure the frequency on Input 1.

Description of Command	SCPI Command String
Measure Frequency: Input 1	"MEASl:FREQ? DEF,DEF"

Verify: That the counter measures a frequency of 10.000 000 0 Hz± 0.1 Hz.

7 Record the measurement on the Performance Test Record Card, line 1.

8 Change the input connection from Input 1 to Input 2.

9 Measure the frequency on Input 2.

Description of Command	SCPI Command String
Measure Frequency: Input 2	"MEAS2:FREQ? DEF,DEF"

Verify: The counter measures 10.000 000 0 Hz ±0.1 Hz.

10 Record the measurement on the Performance Test Record Card, line 2.

Input Condition B:

35 mV rms @ +100mV dc @ 100 Hz @ Zin=50 ohm @ ac coupling

Procedure B:

1 Use the Keysight 3325B to generate a 35 mV rms sine wave with a dc level of +100 millivolts at a frequency of 100 Hz.

2 Connect the signal to Input 2 on the E1420B.

3 Reset the counter by sending the "*RST" command.

4 Program the E1420B to use the 10 MHz external signal of preliminary procedure Step 4 as its timebase by issuing the following SCPI command:

Description of Command		**SCPI Command String**
Route external timebase to E1420B		"SENS:ROSC:SOUR EXT"

5 Configure the Keysight E1420B to use maximum sensitivity, ac coupling, 50 ohm input impedance, and a trigger level of O.OV (trig level will default to 0.0V, Zin to 50 ohms after "*RST" command).

Description of Command		**SCPI Command String**
Maximum input sensitivity		"SENS:EVEN:HYST MIN"
Use ac coupling	Input 1	"INP1:COUP AC"
	Input 2	"INP2:COUP AC"

6 Measure the frequency on Input 2.

Description of Command		**SCPI Command String**
Measure Frequency:	Input 2	"MEAS2:FREQ? DEF,DEF"

Verify: The counter measures a frequency of 100.000 000 Hz ±0.1 Hz.

7 Record the measurement on the Performance Test Record Card, line 3.

8 Change the input connection from Input 2 to Input 1.

9 Measure the frequency on Input 1.

Description of Command		**SCPI Command String**
Measure Frequency:	Input 1	"MEASl:FREQ? DEF,DEF"

Verify: The counter measures 100.000 000 Hz ±0.1 Hz.

10 Record the measurement on the Performance Test Record Card, line 4.

Input Condition C:35 mV rms@ 200 MHz @ Zin=50 ohm @ dc coupling

Procedure C:

1 Use the Keysight 8663A to generate a 35 mV rms (100 mVp-p) signal at 200 MHz.

2 Connect the signal to Input 1 on the El420B.

3 Reset the counter by sending the "*RST" command.

4 Program the E1420B to use the 10 MHz external signal of preliminary procedure Step 4 as its timebase by issuing the following SCPI command:

Description of Command		**SCPI Command String**
Route external timebase to E1420B		"SENS:ROSC:SOUR EXT"

5 Configure the E1420B to operate on its maximum sensitivity (minimum hysteresis) setting.

Description of Command		**SCPI Command String**
Maximum input sensitivity		"SENS:EVEN:HYST MIN"

6 Measure the frequency on Input 1.

Description of Command		SCPI Command String
Measure Frequency:	Input 1	"MEASl:FREQ? 2E8,DEF"

Verify: The counter measures a frequency of200.000 000 M:Hz ±14Hz.

7 Record the measurement on the Performance Test Record Card, line 5.

Input Condition D:

35 mV rms @ 100 M:Hz @ Zin=50 ohm @ dc coupling

Procedure D:

1 Use the Keysight 8663A to generate a 35 mV rms (100 mVp-p) signal at 100 MHz.

2 Connect the signal to Input 2 on the E1420B.

3 Reset the counter by sending the "*RST" command.

4 Program the E1420B to use the 10 MHz external signal of preliminary procedure Step 4 as its timebase by issuing the following SCPI command:

Description of Command	SCPI Command String
Route external timebase to E1420B	"SENS:ROSC:SOUR EXT"

5 Configure the E1420B to operate on its maximum sensitivity (minimum hysteresis) setting.

Description of Command	SCPI Command String
Maximum input sensitivity	"SENS:EVEN:HYST MIN"

6 Measure the frequency on Input 2.

Description of Command	SCPI Command String
Measure Frequency on Input 2	“MEAS2:FREQ? DEF,DEF"

Verify: The counter measures a frequency of 100.000 000 MHz ±3Hz.

7 Record the measurement on the Performance Test Record Card, line 6.

Input Condition E:

10.0 Vp-p @ 20 MHz@ Zin=50 ohm @ dc coupling

Procedure E:

1 Set the Keysight 3325B to generate a 10.0 volt peak-to-peak sinusoidal signal with no dc offset at a frequency of 20 MHz.

2 Connect this signal to Input 1 on the E1420B.

3 Reset the counter by sending the "*RST" command.

4 Program the E1420B to use the 10 MHz external signal ofprelimina.zy procedure Step 4 as its timebase by issuing the following SCPI command:

Description of Command	SCPI Command String
Route external timebase to E1420B	"SENS:ROSC:SOUR EXT"

5 Configure the Keysight E1420B to operate in COMMON input mode:

Description of Command	SCPI Command String
Common input mode ON	"INP:ROUT COMM"

6 Measure the period on Input 1.

Description of Command	SCPI Command String
Measure Period: Input 1	"MEASl:PER? DEF,DEF"

Verify: The counter measures a period equal to 50.000 000 ns ±250 E-15 s.

7 Record the measurement on the Performance Test Record Card, line 7.

8 Without reinitializing OR changing input connections, measure the period on Input 2.

Description of Command	SCPI Command String
Measure Period: Input 2	"MEAS2:PER? DEF,DEF"

Verify: The counter measures 50.000 000 ns ±250 E-15 s.

9 Record the measurement on the Performance Test Record Card, line 8.

10 Without reinitializing, configure the E1420B to have Input 2 trigger on the negative slope of the input signal.

Description of Command	SCPI Command String
Trigger on negative slope: Input 2	"SENS2:EVEN:SLOP NEG"

11 Measure the Time 1 ⇒ 2 interval, using the 100 Gate Average mode.

Description of Command	SCPI Command String
Set 100 Gate Average	"SENS:AVER ON"
Measure Time Interval	"MEASl:TINT? DEF,DEF"

Verify: The counter measures a time interval of25.0 ns ±2.9 ns.

12 Record the measurement on the Performance Test Record Card, line 9.

13 Without reinitializing, measure the ratio of Input 1 to Input 2.

Description of Command	SCPI Command String
Set 100 Gate Average OFF	SENS:AVER OFF"
Measure Ratio of IN 1/IN 2	“MEAS:FREQ:RAT? DEF,DEF"

Verify: The counter measures the ratio as 1.000 000 0 ±0.000 000 1.

14 Record the measurement on the Performance Test Record Card, line 10.

External Arm Range, Sensitivity, and Minimum Start-to-Stop Time Tests

Description: The external arm input is characterized.

Specifications Tested: Referring to the reference numbers of Table 2-3, this test verifies:

08- Range
09 - Minimum Start to Stop Time
10 - Sensitivity
11 - Dynamic Range (lower limit)

Equipment Used:

3325B Synthesizser/Function Generator
8663A Synthesized Signal Generator
8161A Programmable Pulse Generator

Input Condition A:

Input 1: 100 mV rms @ 100 MHz @ Zin=50 ohm @ dc coupling
Arm Input: 500 mV p-p @ 10Hz @ pulse width= 50 ms

Procedure A:

1. Use the Keysight 8663A to generate a 100 mV rms (280 mVp-p signal) at a frequency of 100 :MHz and no dc offset.
2. Configure the Keysight 3325B to generate a 500 mVp-p SQUARE wave at a frequency of 10Hz with no dc offset.
3. Connect the 8663A output signal to Input 1 on the E1420B.
4. Connect the 3325B output signal to the Arm Input on the E1420B.
5. Reset the counter by sending the "*RST" command.
6. Program the E1420B to use the 10 :MHz external signal of preliminary procedure Step 4 as its timebase by issuing the following SCPI command:

Description of Command	SCPI Command String
Route external timebase to E14208	"SENS:ROSC:SOUR EXT"

7. Configure the E1420B to be armed externally, with an Ann Input trigger level of 0 V. Then set the arm to START on the positive slope of the external source, and STOP on the internal gate time.

Description of Command	SCPI Command String
Externally armed, trigger level = OV	“ARM:STAR:SOUR EXT;LEV 0"
Arm start on external positive slope	"ARM:STAR:SLOP POS"
Arm stop on internal gate time	"ARM:STOP:SOUR IMM"

8. The E1420B is automatically placed in its "Wait-for-Arm" state (continuous mode). The counter should now operate on a 100 ms gate time (default internal), triggered by the rising edges of the 10 Hz input ann signal.

9 Measure the frequency on Input 1.

Description of Command	**SCPI Command String**
Measure Frequency on Input 1	"MEASl:FREQ? DEF,DEF"

Verify: The counter measures a frequency of 100.000 000 :MHz ±3Hz.

10 Record the measurement on the Performance Test Record Card, line 11.

Input Condition B:

Input 1: 100 mV rms @ 100 :MHz@ Zin=50 ohm @ dc coupling
Arm Input: 5.0 Vp-p @ 20 :MHz @ pulse width = 20 ns

Procedure B:

1 Use the Keysight 8663A to generate a 100 mVrms (280 mVp-p) signal at a frequency of 100 MHz and no dc offset.

2 Set the Keysight 8161A Channel A Output to the following:

High Level = +2.5 V
Low Level = -2.5 V
Period = 50 ns (f=20 MHz)
Pulse Width = 20 ns
Leading Edge (Rise Time) = 1.3 ns
Trailing Edge (Fall Time) = 1.3 ns

3 Connect the 8663A output signal to Input 1 on the E1420B.

4 Connect the 8161A output signal to the Arm Input on the E1420B.

5 Reset the E1420B by sending the "*RST" command.

6 Program the E1420B to use the 10 MHz external signal of preliminary procedure Step 4 as its timebase by issuing the following SCPI command:

Description of Command	**SCPI Command String**
Route external timebase to E1420B	"SENS:ROSC:SOUR EXT"

7 Configure the counter to be armed externally, once again using a trigger level of 0 volts. Then set the arm to START on the first positive slope of the external source, and STOP on the second positive slope of the external source.

Description of Command	**SCPI Command String**
Externally armed, trigger level= OV	"ARM:STAR:SOUR EXT;LEV 0" ARM:STOP:SOUR EXT;LEV 0"
Arm start on external positive slope	"ARM:STAR:SLOP POS"
Arm stop on external positive slope	"ARM:STOP:SLOP POS"

8 Once again, the E1420B is in its continuous "Wait-for-Arm" state. Now the counter's aperture time will essentially be the period of the input arm signal.

9 Measure the frequency on Input 1.

Description of Command	SCPI Command String
Measure Frequency on Input 1	"MEASl:FREQ? DEF,DEF"

Verify: The counter measures a frequency of 100 MHz ±1.5 MHz.10. Record the measurement on the Performance Test Record Card, line 12.

2-26. Auto Measurement Sensitivity, Range, and Accuracy Tests

Description: The frequency range, signal sensitivity, and measurement accuracy of all critically specified auto measurements is tested.

Specifications Tested: Referring to the reference numbers of Table 2-3, this test verifies:

18 - Auto Trigger dc range
19 -Auto Trigger ac range
20 - Auto Trigger Sensitivity

Accuracy of auto measurement:

21- rise/fall time and,
22 - pulse width

Equipment Used:

8161A Programmable Pulse Generator
8663A Synthesized Signal Generator

Input Condition A:

750 mVp-p@ 1 kHz @ pulse width= 0.5 ms @ rise time/fall time= 15 ns

Procedure A:

1 Set the Keysight 8161A Channel A Output to the following:

High Level= + 0.75 V
Low Level = 0.0 V Period= 1.0 ms (f=1 kHz)
Pulse Width = 0.5 ms
Leading Edge (Rise Time) = 15 ns
Trailing Edge (Fall Time) = 15 ns

2 Connect this signal to Input 1 on the E1420B.

3 Reset the counter by sending the "*RST" command.

4 Program the E1420B to use the 10 MHz external signal of preliminary procedure Step 4 as its timebase by issuing the following SCPI command:

Description of Command	SCPI Command String
Route external timebase to E1420B	"SENS:ROSC:SOUR EXT"

5 Measure the rise time of the input signal by issuing the following SCPI command:

Description of Command		**SCPI Command String**
Measure Rise Time	Input 1	"MEAS:RTIM? DEF,DEF"

Verify:The counter measures a rise time of 15 ns ±9.5 ns.Performance Tests 2-29

6 Record the measurement on the Performance Test Record Card, line 13.

7 Change the input coupling from dc to ac.

Description of Command		**SCPI Command String**
Use ac coupling	Input 1	"'INPl:COUP AC"

8 Measure the fall time of the input signal using the following command:

Description of Command		**SCPI Command String**
Measure Fall Time	Input 1	"MEAS:FTIM? DEF,DEF"

Verify: The counter measures a fall time of 15 ns ±9.5 ns.

9 Record the measurement on the Performance Test Record Card, line 14.

Input Condition B:

70 mV rms@ 100 MHz @pulse width= 5 ns

Procedure B:

1 Use the Keysight 8663A to generate a 70 mV rms (200 mVp-p) signal at a frequency of 100 MHz.

2 Connect this signal to Input 1 on the E1420B.

3 Reset the counter by sending the "*RST" command.

4 Program the E.1420B to use the 10 MHz external signal of preliminary procedure Step 4 as its timebase by issuing the following SCPI command:

Description of Command		**SCPI Command String**
Route external to E1420B	timebase	"SENS:ROSC:SOUR EXT"

5 Measure the positive pulse width of the input signal, using the 100 Gate Average mode.

Description of Command	**SCPI Command String**
Set 100 Gate Average	"SENS:AVER ON"
Measure positive pulse width Input 1	"MEAS:PWID? DEF,DEF"

Verify: The counter measures a pulse width of 5.0 ns ±2.6 ns.

6 Record the measurement on the Performance Test Record Card, line 15.

2-27. (Option 030) Input 3: Sensitivity, Range, and Accuracy Tests

Description: The input frequency range and sensitivity of the E1420B Option 030 Input 3 is tested, along with the dynamic range and accuracy of the Input 3 frequency measurement.

Specifications Tested: Refer to Table 1-1, Keysight E1420B Specifications, for the Input 3 critical specifications.

Equipment Used:

Keysight 8663A Synthesized Signal Generator
Keysight 8491A Option 010 10 dB Coaxial Fixed Attenuator

Procedure:

1. Set the Keysight 8553A to generate a sinusoidal signal at 90 MHz with an amplitude of +0.5 dBm. This amplitude will provide 75 mV rms to Input 3 when using the 10 dB attenuator.
2. Connect this signal to Input 3 of the E1420B through the 10 dB attenuator, as shown in Figure 2-2. The 10 dB attenuator is used here for impedance matching.

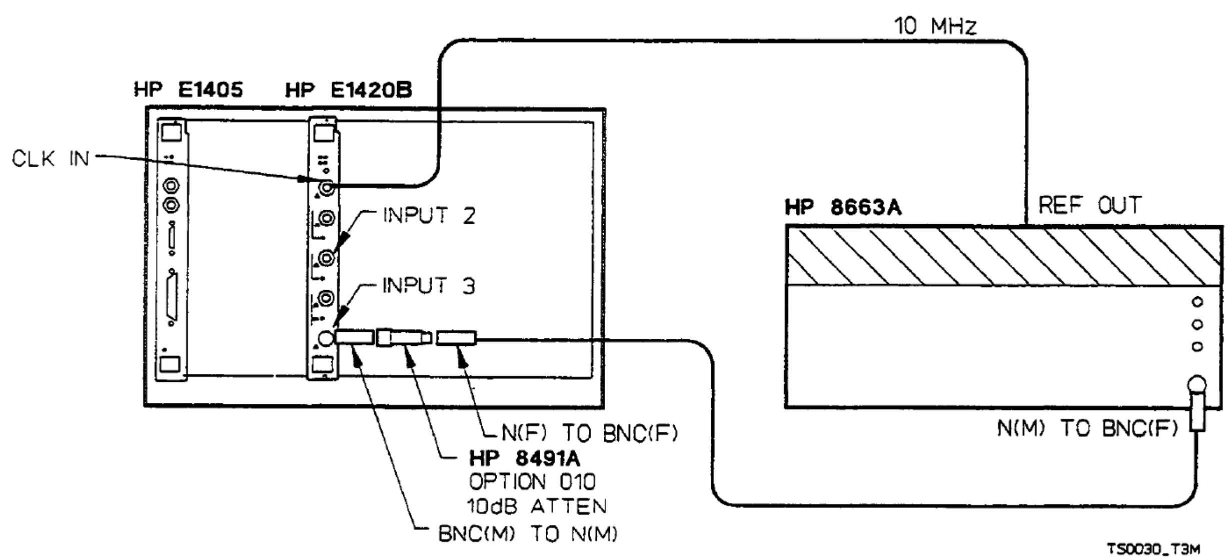


Figure 2-2 Option 030 Test Setup

3. Reset the counter by sending the "*RST" command.
4. Program the E1420B to use to use the 10 MHz external signal of preliminary procedure Step 4 as its timebase by issuing the following SCPI command:

Description of Command		SCPI Command String
Route external timebase to E1420B		"SENS;ROSC:SOUR EXT"

5 Measure the frequency on input 3 by issuing this SCPI command:

Desccription of Command		SCPI Command String
Measure Frequency:	Input 3	“MEAS3:FREQ? 9E7,DEF"

Verify: the Keysight E1420B measures a frequency of 90.000 000 MHz ±2Hz.

6 Record the measurement on the Performance Test Record Card, line 16.

7 Change the 8663A frequency to 2.5 GHz (keep the amplitude the same, at +0.5 dBm).

8 Measure the frequency on Input 3:

Description of Command		SCPI Command String
Measure Frequency:	Input 3	"MEAS3:FREQ? 2.5E9,DEF"

Verify: The Keysight E1420B measures a frequency of 2.500 000 00 GHz ±20Hz.

9 Record the measurement on the Performance Test Record Carde, line 17.

10 Change the 8663A frequency back to 90 MHz with an amplitude of -15 d.Bm. This amplitude will provide 12.6 mV rms to Input 3 when using the 10 dB attenuator, and verifies the maximum input sensitivity.

11 Measure the frequency on Input 3:

Description of Command		SCPI Command String
Measure Frequency:	Input 3	"MEAS3:FREQ? 9E7,DEF"

Verify: The Keysight E1420B measures a frequency of 90.000 000 MHz ±2Hz.

12 Record the measurement on the Performance Test Record Card, line 18.

13 Change the 8663A frequency to 1.5 GHz with an amplitude of -10 dBm This amplitude will provide 22.36 mv rms to Input 3 when using the 10 dB attenuator, and verifies the maximum input sensitivity at the mid-range frequency values.

14 Measure the frequency on Input 3:

Description of Command		SCPI Command String
Measure Frequency:	Input 3	"MEAS3:FREQ? 1.5E9,DEF"

Verify: The Keysight E1420B measures a frequency of 1.500 000 000 GHz ±2 Hz.

15 Record the measurement on the Performance Test Card, line 19.

16 Change the 8663A frequency to 2.5 GHz with an amplitude of -2 dBm. This amplitude will provide the 55.17 mV rms to Input 3 when using the 10 dB attenuator, and verifies maximum sensitivity.

17 Measure the frequency on Input 3:

Desccription of Command		SCPI Command String
Measure Frequency:	Input 3	"MEAS3:FREQ? 2.5E9,DEF"

Verify: The Keysight E1420B measures a frequency of2.500 000 000 GHz ±20Hz.

18 Record the measurement on the Performance Test Record Card., line 20.3

E1420B UNIVERSAL COUNTER

Test Facility: ____________________

Serial Number: ____________________

Customer: ____________________

Tested By: ____________________

Date: ____________________

Notes:____________________

Report Number: ____________________

Ambient Temperature: ____________________C

Relative Humidity: ____________________%

Line Frequency: ____________________Hz

Installed Options: ☐ 010 ☐ 030 ☐ 040

____-Calibration Test: ☐ pre ☐ post

Test Equipment Used:

Description	Model No.	Trace No.	Cal Due Date
1. Function Generator	______	______	______
2. Signal Generator	______	______	______
3. Pulse Generator	______	______	______
Option 030 Equipment:			
4. UHF Signal Generator	______	______	______
5. Fixed Attenuator	______	______	______
Other Equipment:			
6. ______	______	______	______
7. ______	______	______	______
8. ______	______	______	______
9. ______	______	______	______
10. ______	______	______	______

Serial No.________ Report No.________ Date________

Page No.	Test Description	No.	Reading	Specified Minimum		Measured Result		Specified Maximum		Meas. Uncer.
2-21	**Input Range and Sensitivity; Measurement Range and Accuracy (Inputs 1 and 2 only)**									
	Input conditions:									
	35 mVrms, 10 Hz, 50 ohm, DC	1	Freq 1	9.9500000	Hz	______	Hz	10.0500000	Hz	±0.1 Hz
	35 mVrms, 10 Hz, 50 ohm, DC	2	Freq 2	9.9500000	Hz	______	Hz	10.0500000	Hz	±0.1 Hz
	35 mVrms (+100 mV DC), 100 Hz, 50 ohm, AC	3	Freq 2	99.950000	Hz	______	Hz	100.050000	Hz	±0.1 Hz
	35 mVrms (+100 mV DC), 100 Hz, 50 ohm, AC	4	Freq 1	99.950000	Hz	______	Hz	100.050000	Hz	±0.1 Hz
	35 mVrms, 200 MHz, 50 ohm, DC	5	Freq 1	199,999,988	Hz	______	Hz	200,000,012	Hz	±14 Hz
	35 mVrms, 100 MHz, 50 ohm, DC	6	Freq 2	99,999,998	Hz	______	Hz	100,000,002	Hz	±3 Hz
	10.0 Vp-p, 20 MHz, 50 ohm, DC	7	Per 1	49.999998	ns	______	ns	50.000002	ns	$\pm 250\times10^{-15}$ s†
	10.0 Vp-p, 20 MHz, 50 ohm, DC	8	Per 2	49.999998	ns	______	ns	50.000002	ns	$\pm 250\times10^{-15}$ s†
	10.0 Vp-p, 20 MHz, 50 ohm, DC	9	T-Int *	22.4	ns	______	ns	27.6	ns	±2.9 ns
	10.0 Vp-p, 20 MHz, 50 ohm, DC	10	Ratio	0.9999999		______		1.0000001		$\pm 1\times10^{-7}$
2-26	**External Arm Range, Sens. and Min. Start to Stop Time**									
	Input conditions:									
	100 mVrms, 100 MHz, 50 ohm, DC									
	Arm Input conditions:									
	500 mVp-p, 10 Hz, pw = 50 ms	11	Freq 1	99,999,998	Hz	______	Hz	100,000,002	Hz	±3 Hz
	5.0 Vp-p, 20 MHz, pw = 20 ns	12	Freq 1	88	MHz	______	MHz	112	MHz	±15 MHz
2-29	**Automatic Measurement Range, Sensitivity, and Accuracy**									
	Input conditions:									
	750 mVp-p, 1 kHz, pw = 0.5 ms tr = tf = 15 ns	13	Tr 1	6	ns	______	ns	24	ns	±9.5 ns
	750 mVp-p, 1 kHz, pw = 0.5 ms tr = tf = 15 ns	14	Tf 1	6	ns	______	ns	24	ns	±9.5 ns
	70 mVrms, 100 MHz, pw = 5 ns	15	PW 1*	2.8	ns	______	ns	7.2	ns	±2.6 ns
2-31	**Input 3: Input Range and Measurement Accuracy**									
	Input conditions:									
	75 mVrms, 90 MHz	16	Freq 3	89,999,998	Hz	______	Hz	90,000,002	Hz	±2 Hz
	75 mVrms, 2 GHz	17	Freq 3	2.49999998	GHz	______	GHz	2.50000002	GHz	±20 Hz
	–25 dBm, 90 MHz	18	Freq 3	89,999,998	Hz	______	Hz	90,000,002	Hz	±2 Hz
	–20 dBm, 1.5 GHz	19	Freq 3	1.49999998	Hz	______	Hz	1.50000002	GHz	±20 Hz
	–12 dBm, 2.5 GHz	20	Freq 3	2.49999998	GHz	______	Hz	2.50000002	GHz	±20 Hz

* Measurement taken using 100 Gate Average mode.
† High measurement uncertainty due to accuracy limits of input source.

3 E1420B Adjustments

Introduction

This chapter describes the adjustments required to maintain the Keysight E1420B's operating characteristics within specification. Adjustments should be made when required, such as after a performance test failure or when components are replaced that may affect an adjustment. If the adjustments are to be considered valid, the Keysight E1420B line input voltage must be within +5% to -10% of normal.

Where to Find Important Topics

Chapter Summary

Equipment Required

The test equipment required for the adjustment procedures is listed in Table 2-1, Recommended Test Equipment, in Chapter 2 of this manual. Substitute test equipment may be used if it meets or exceeds the required characteristics listed in the table. (An additional DVM and dual-trace oscilloscope are required for the MRC power supply and TCXO adjustments respectively.)

Adjustment Locations

Adjustment locations are identified in Figure 3-1, Keysight E1420B Adjustment Locations. All adjustments, except for the TCXO standard timebase adjustment, must be made with the right side cover removed. The TCXO adjustment is made through the front panel hole labeled lOMHzAdj.3-6.

Safety Considerations

This chapter contains warnings and cautions that must be followed for your protection and to avoid damage to the equipment.

WARNING **Maintenance described herein is performed with power supplied to the instrument and protective covers removed. Such maintenance should be performed only by service-trained personnel who are aware of the hazards involved (for example, fire and electrical shock). Where maintenance can be performed without power applied, the power should be removed. Before any repair is completed, ensure that all safety features are intact and functioning, and that all necessary parts are connected to their protective grounding means.**

CAUTION Electronic components and assemblies can be permanently degraded or damaged by electrostatic discharge while performing the maintenance described herein.Ensure that instrument maintenance procedures are performed only at static safe work stations providing proper grounding for service personnel.

Adjustment Procedures

The following adjustment procedures apply to three areas of the Keysight E1420B: Al, A2, and optional Timebase oscillator (A1Y1 TCXO). The required order of adjustment is listed in Table 3-1 and includes the adjustment name, purpose, and control.

Table 3- 1 E1420B Adjustments

NAME ADJUSTMENT		PURPOSE	ORDER OF PERFORMANCE
1 Input Amplifier Offset Adjustment	DIAGnostics Subsystem Control	Calibrates trigger level offset voltage	1
2 Input Amplifier Fullscale Adjustment	DIAGnostics Subsystem Control	Calibrates triggering dynamic range	2
3 MRC Power Supply Adjustment	A1R22	Sets +3V Supply for MRC (A1U31}.	3
4 MRC Bias Adjustment	A1R42, A1R35	Sets dc bias level on MRC inputs channel A and B.	4
5 TCXO Timebase Adjustment (Option 010)	A1Y1	Sets TCXO timebase to exact specified frequency.	May be performed anytime.

NOTE Before making any A1, A2, or TCXO adjustments, allow at least 15-30 minutes for the Keysight E1420B to warm up. A 30-minute warm-up period is recommended especially for the TCXO adjustments.

Input Amplifier Offset Adjustment

The input amplifier offset adjus1ment sets the correct offset voltages for both trigger level circuits within input channels 1and 2. The procedure requires two 500 dummy loads for each of the front- panel Input channel BNCs (1and 2). To perform this adjustment, proceed as follows:

1 Connect the 50Ω dummy loads to the Input channel 1 and 2 BNC connectors.
2 Execute the SCPI El420B "DIAGnostics:CALibrate:OFFSet? BOTH" command string. (The execution time for this adjustment is approximately five minutes.)
3 Successful completion of the adjustment is indicated when the counter returns the "CHAN1 OFFSET PASS, CHAN2 OFFSET PASS".
4 Disconnect the 50Ω dummy loads from Input channels 1and 2.

Input Amplifier Full-Scale Adjustment

The input amplifier full-scale adjustment sets the correct hysteresis for both trigger level circuits within channels 1and 2 to ensure correct triggering across the entire dynamic range of the input amplifiers. The procedure requires the use of a +5V power source accurate to ±10mv. To perform this adjustment, proceed as follows:

1. Connect a +5V power source to both Input channels 1and 2.
2. Execute the SCPI El420B "DIAGnostics:CALibrate:FULLscale? BOTH" command string. (The execution time for this adjustment is approximately five minutes.)
3. Successful completion of the adjustment is indicated when the counter returns the "CHAN1 FULL PASS, CHAN2 FULL PASS".
4. Disconnect the +5V power source from Input channels 1and 2.

MRC Supply Adjustment

The only power supply in the El420B which requires adjustment is the +3 volt supply for the MRC (U31) on the AI motherboard. To perform this adjustment, proceed as follows:

1. Connect the negative terminal of a DVM (Keysight3466A or equivalent) to chassis ground (left-side-top frame member) of the counter. Connect positive terminal of the DVM to the +3V test point (TPW3) located beside A1R22 on the Al assembly. (TPW3 is a 2-pole test point with a GND connection.)
2. Adjust A1R22 for a DVM reading of 3.000 Vdc (+20 mV).

NOTE

If the MRC supply cannot be adjusted to the required level check the voltages at the VXIbus backplane to confirm that the other power supply voltages of the counter are at their proper levels.

MAC Bias Adjustment

The MRC bias adjustment sets the dc bias level on MRC Inputs A and B. This adjustment ensures best count accuracy for both positive and negative event transitions.

MRC Inputs A and B

The MRC Input A and B dc biasing levels are optimized at two frequencies on the positive and negative slopes of the input signal (interactive adjustments). Use the following procedures to make these adjustments:

1 Use the Keysight 8663A to generate a signal with a frequency of 70 MHz and an amplitude of 28.0 mV ±0.3 mV.

2 Place the E1420B in the VXI cage (VXlbus connectors firmly seated), then turn the VXI power switch on.

3 Connect the 8663A timebase OUT (rear panel) to the El420B front panel Int/Ext reference input.

4 Connect the 8663A output signal to Input channel 1 on the E1420B.

5 Configure the E1420B with the following commands:

Description of Command	**SCPI Command String**
Route external timebase to E1420B	“SENS:ROSC:SOUR EXT"
Common input mode ON	"INP:ROUT COMM"
Maximum input sensitivity	“SENS:EVEN:HYST MIN"

6 Make frequency measurements on Inputs 1 and 2 of the E1420B, making certain to read the output queue of the counter between each measurement.

Description of Command		SCPI Command String
Measure Frequency:	Input 1	"MEASl:FREQ? DEF,DEF"
	Input 2	"MEAS2:FREQ? DEF,DEF"

Verify: The counter measures frequencies of 70 MHz ±4Hz.

7 Switch the E1420B slope settings from positive to negative:

Description of Command		**SCPICommand String**
Trigger on negative slope:	Input 1	“SENS1:EVEN:SLOP NEG"
	Input 2	"SENS2:EVEN:SLOP NEG"

8 Repeat step 6, again verifying the accuracy of the measurements.

9 Change the 8663A input frequency to 104 MHz, leaving the amplitude as is.

10 Repeat steps 6-8, Verifying the counter returns measurements of: 104 MHz ±4Hz.

11 If any of the eight (8) measurements above do not pass the verification step, complete procedures 12-16. Otherwise, the MRC bias adjustments are functioning correctly and need no further modification.

12 Turn the VXIbus power OFF.

13 Remove the E1420B from the VXI cage and remove the right side panel to expose the A1 motherboard PCA and MRC bias adjustments, channel A - R42 (for Input 1) and channel B- R35 (for Input 2).

14 Recall which E1420B Input channel (1="A'', or 2=''B", or both) gave an inaccurate measurement in any of steps 6-10 above, and adjust A1R42 and A1R35 accordingly. Refer to Figure 3-1 for assistance in locating the MRC bias adjustments.

15 Replace the right side cover on the E1420B.

16 Repeat procedures 1-15 above until both Inputs 1and 2 on the E1420B return qualified measurements at both input frequencies and both input trigger slopes.

TXCO Adjustment (Optional Timebase)

Two procedures are given for adjustment of the TCXO standard timebase. If operation of the counter is only at 25 °C (78 °F - room temperature), then adjust the oscillator frequency as close as possible to 10 MHz. If the operation of the counter will be over the full temperature range of 0 °C to 50 °C, then the TCXO must be offset by the amount labeled on its cover. The offset keeps the TCXO frequency within the manufacturer's specifications over the entire temperature range. The TCXO standard timebase is factory-set for use at 25 °C. Refer to Figure 3-2 for timebase adjustment setup.

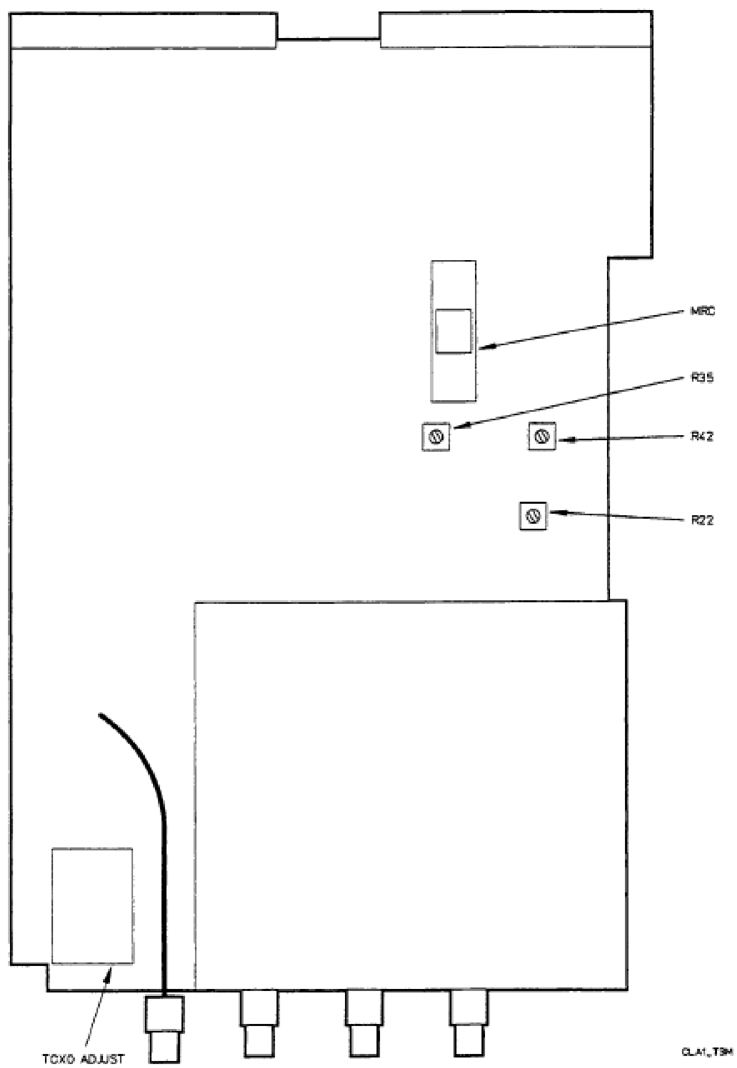


Figure 3-3 E1420B Adjustment Locations

NOTE Allow the TCXO in the instrument to warm up for a minimum of 30 minutes before making either TCXO adjustment.

To adjust the TCXO Timebase for the average room-temperature environment, (25°C) proceed as follows:

1 Connect a house standard (10 MHz reference frequency) to the EXTERNAL TRIG INPUT of an oscilloscope (generic dual-trace 10 MHz oscilloscope) and set the main triggering to EXTERNAL. Connect the E1420B front panel Int/Ext Reference Connector to the Channel A input of the oscilloscope. (See Figure 3-2.)

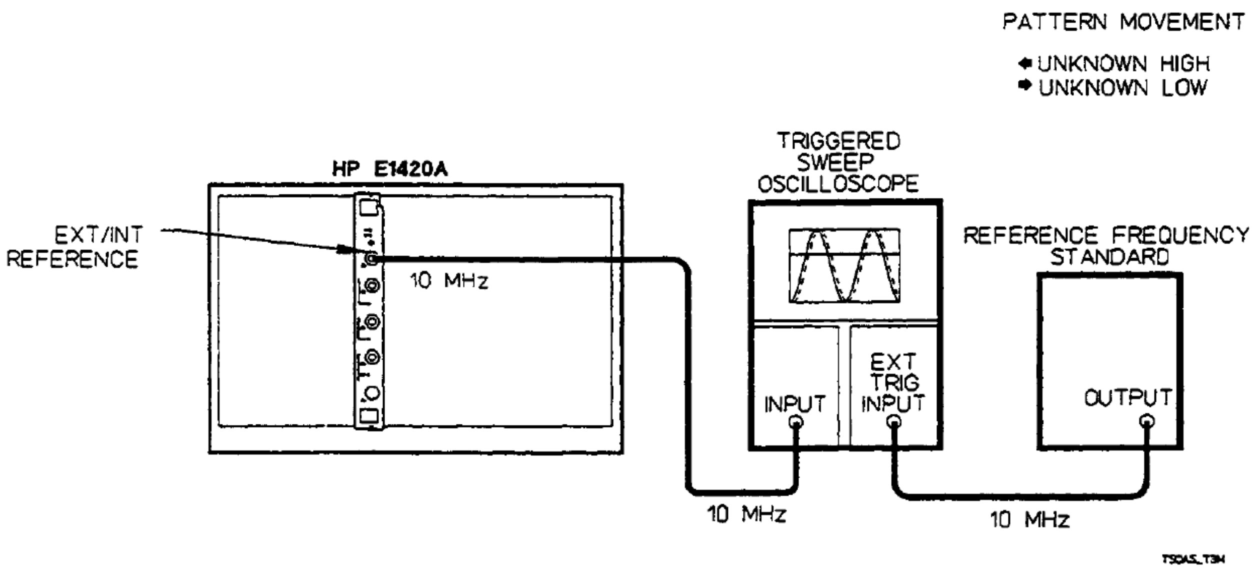


Figure 3-4 Oscillator Adjustment Setup

2 Configure the E1420B with the following SCPI command strings:

Description of Command	SCPI Command String
Route TCXO time base to front panel	"SENS:ROSC:SOUR INT"
lnt/Ext Reference BNC as an output signal.	"OUTP:ROSC:STAT ON"

3 Insert a tuning wand through the 10 MHz Adj hole in the front panel of the E1420B and into the tuning screw of the TCXO {Yl) on the TCXO Assembly. Adjust the TCXO for a minimum sideways movement of the signal on the oscilloscope display.

4 By timing the sideways movement (in em/second) of the signal on the oscilloscope display, the accuracy of the timebase can be determined based on the oscilloscope sweep speed, as shown in Table 3-2. This completes the adjustment of the TCXO for use at 25°C.

Table 3- 2 Sweep Movement Versus Calibration Accuracy

Movement	Sweep Speed			Notes
	1 μs/cm	0.1 μs/cm	0.01 μs/cm	
1 cm/S	$1x10^{-6}$	$1x10^{-7}$	$1x10^{-8}$	Time scope trace
1 cm/10s	$1x10^{-7}$	$1x10^{-8}$	$1x10^{-10}$	movement with second
1 cm/100s	$1x10^{-8}$	$1x10^{-9}$	$1x10^{-10}$	hand of watch or clock.

To adjust the TCXO Timebase for proper operation over its entire operating temperature range (0°C to 50°C), proceed as follows:

1 Remove the Keysight E1420B component cover (right side), locate the TCXO, and record the frequency offset (printed on the TCXO component cover) on paper.

2 Replace the Keysight E1420B component cover, turn the mainframe power switch to ON, and let the instrument warm up for at least 30 minutes.

3 Connect a house standard (10 MHz reference frequency) to the external reference input of a high resolution counter (such as an Keysight5384A Frequency Counter) (10 MHz IN/OUT BNC connector).

4 Connect the E1420B Int/Ext Reference BNC on the front panel to the Keysight 5384A Channel A Input BNC connector.

5 Configure the E1420B with the following SCPI command strings:

Description of Command	SCPI Command String
Route TCXO timebase to front panel	"SENS:ROSC:SOUR INT"
lnt/Ext Reference BNC as an output signal.	"OUTP:ROSC:STAT ON"

6 Set the Keysight 5384A to FREQ A, 1 second GATE TIME.

7 Insert a tuning wand through the 10 MHz Adj hole in the front panel of the E1420B and into the tuning screw of the TCXO (Y1) on the TCXO Assembly. Adjust the TCXO frequency to 10 MHz ±the offset labeled on the cover of the TCXO. For example, if the offset is labeled +3.5 Hz, the TCXO should be adjusted for a frequency of 10.0000035 MHz on the 5384A display at a room temperature of 25 °C. This completes the adjustment of the TCXO with offset for use at 0 °C to 50 °C.

4 Service

Introduction

This chapter provides the information required to perform assembly-level repair on the Keysight E1420B Universal Counter module. Module repair consists of troubleshooting and replacement of an isolated defective assembly followed by performance testing and adjustment (if necessary).

Where To Find Important Topics

Chapter Summary

Safety Considerations And Symbols

Refer to page iii for a list of Safety considerations and symbols used in this manual. A1though this instrument has been designed in accordance with international safety standards, this chapter contains information, cautions (ESD precautions), and warnings that must be followed to ensure safe operation and to retain the instrument in safe condition. Service instructions (and associated adjustment procedures) requiring removal of the instrument covers are for use by service-trained personnel only.

Electrostatic Discharge Precautions

Electronic components and assemblies in the Keysight E1420B can be permanently degraded or damaged by electrostatic discharge (ESD). Use the following precautions when servicing the instrument:

1. ENSURE that static sensitive devices or assemblies are serviced at static safe work stations providing proper grounding for service personnel.
2. ENSURE that static sensitive devices or assemblies-are stored in static shielding bags or containers.
3. DO NOT wear clothing subject to static charge buildup, such as wool or synthetic materials.
4. DO NOT handle components or assemblies in carpeted areas.
5. DO NOT remove an assembly or component from its static shielding protection until you are ready to install it.
6. AVOID touching component leads. (A1ways handle by the packaging when possible.)

Recommended Test Equipment

Test equipment recommended for testing and troubleshooting the Keysight E1420B is listed in Table 2-1. Substitute equipment may be used if it meets or exceeds the required characteristics listed in this table.

Identification Of Assemblies

Printed-circuit assemblies (PC.As) in this instrument (See Figure 4-3) have three identification numbers: an assembly part number, a revision letter, and a production code. The assembly (PCA) part number has ten digits (such as 05361-60001) and is the primary identification. A1l assemblies with the same part number are interchangeable. When a production change is made on an assembly that makes it incompatible with previous assemblies, the part number is changed.

Revision letters (A,B, etc.) denote changes in printed-circuit layout. For example, if a capacitor type is changed (electrical value may remain the same) and requires different spacing for its leads, the printed-circuit layout is changed and the revision letter is incremented to the next letter. The production code is a four-digit seven-segment number used for production purposes.

Assembly-level Diagnostic Theory Of Operation

This section provides assembly-level diagnostic theory of operation and is based on the block diagrams shown in Figures 4-1 and 4-2. These diagrams illustrate the operation of the Keysight E1420B diagnostics.

Figures 4-1 and 4-2 may be used to supplement the optional Component-Level Information Package that provides schematic diagrams, component locater drawings, and component-level parts lists. Two assemblies are described: the A1 motherboard PCA and the A2 input board PCA.

A1 Motherboard PCA

The A1 Motherboard PCA controls all measurement functions and all VXIbus command and data communication processes. See Figure 4-1 for examples of diagnostic commands associated with A2 PCA.

A2 Input Amplifier PCA

The A2 Input Amplifier PCA receives and conditions input signals, then triggers measurements on channels 1 and 2. See Figure 4-2 for examples of diagnostic commands associated with A2PCA.

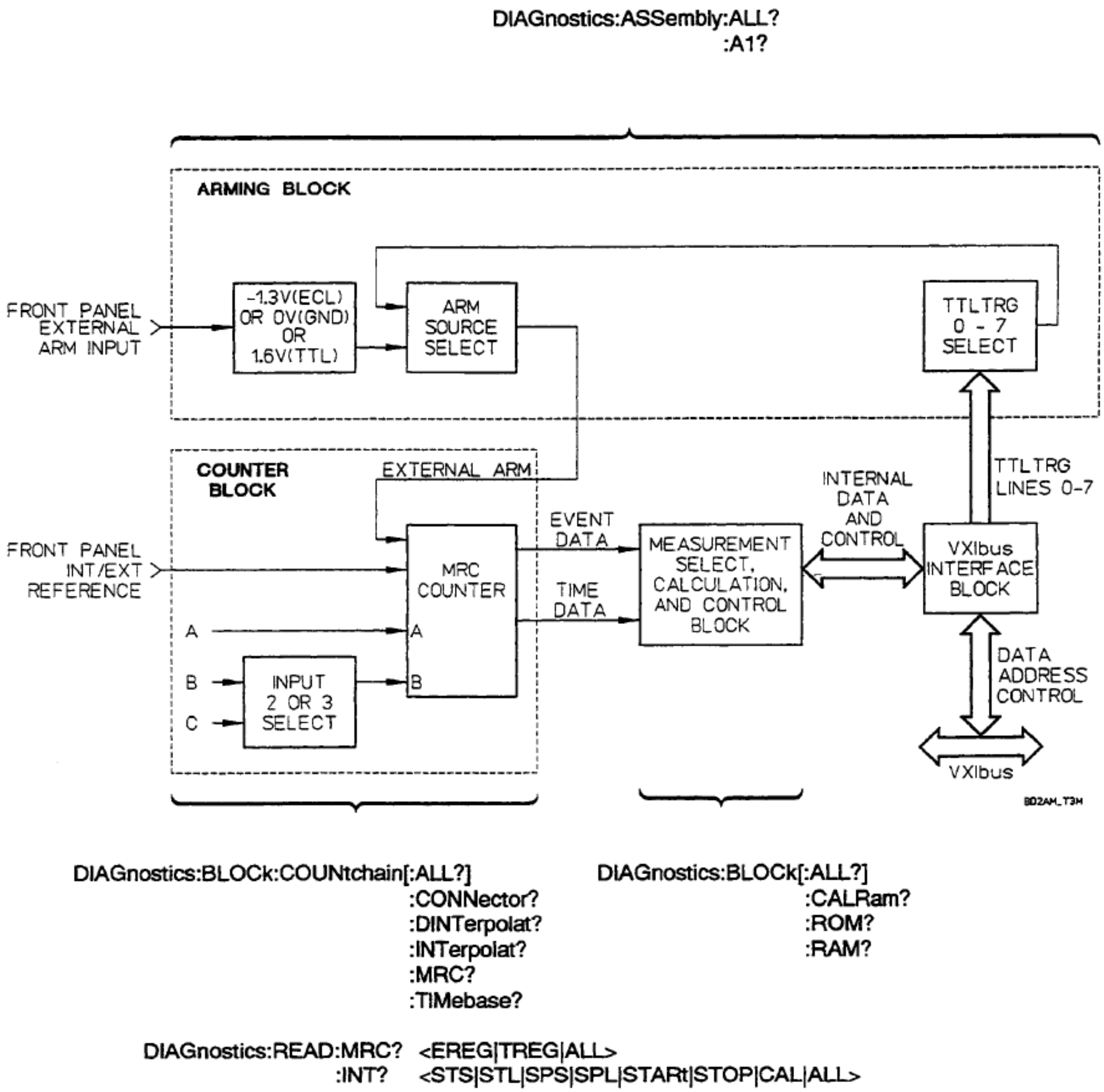


Figure 4-1 A1 Motherboard PCA Block Diagram

DIAGnostics:CALibrate:OFFSet?
:FULLscale?

DIAGnostics:ASSembly:ALL?
:A2?

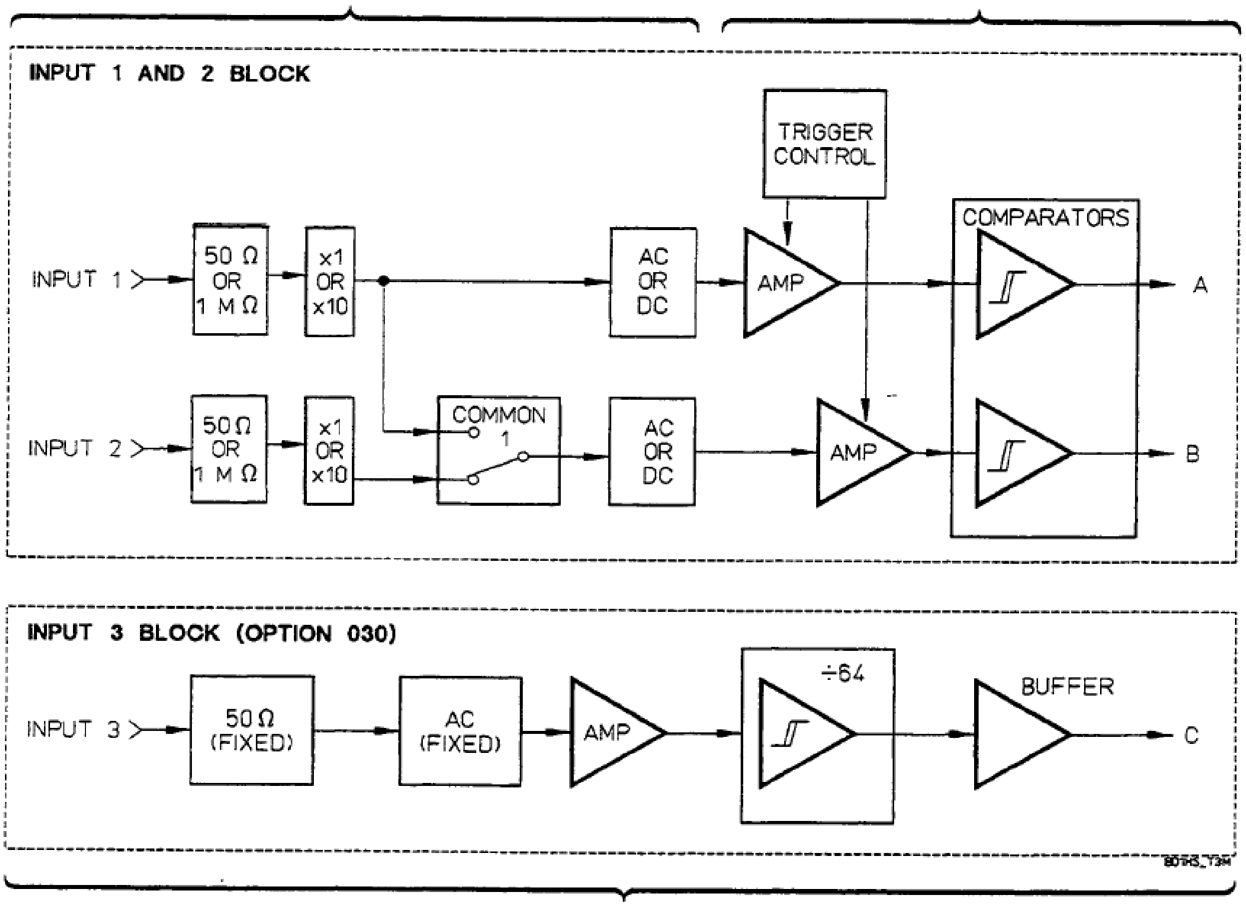


Figure 4-2 A2 Input Amplifier PCA Block

How-to-repair The Keysight E1420B

The following paragraphs provide information on troubleshooting and replacing assemblies in the Keysight E1420B Universal Counter. The repair strategy for the E1420B is to identify and replace a failed printed-circuit assembly (PCA). The repair strategy also requires system-level integrity and correct operation of the built-in power-up self-test and diagnostics.

After a failed PCA has been identified and replaced, the counter must be tested using the Keysight E1420B performance tests (chapter 2) and if necessary adjusted (chapter 3) to ensure proper operation.

Troubleshooting Strategy

Before troubleshooting the counter, be sure the problem has been isolated to the counter module by verifying the VXIbus mainframe, Slot 0 functionality, Keysight-IB interface, and system instrument controller (whether embedded or external). Use this strategy to diagnose and repair the counter:

- Make your troubleshooting decisions by observation of front panel LED indicators and self-test/diagnostic test results displayed via the instrument controller.
- These observations can provide fault symptoms that are used to identify suspect failed PCAs. If the problem still exists after replacing a suspect PCA, the most likely cause of the failure is interconnections between assemblies or the VXIbus backplane.
- Use the Keysight E1420B SCPI diagnostic options along with the troubleshooting procedures to isolate a suspected failure to either the AI or A2 PCA(s).

Diagnostic Testing

Diagnostic testing for the Keysight E1420B is performed every time the counter is powered up (self-test) and by software selection via the instrument controller (SCPI-based diagnostic routines available to the user). A1l diagnostics require a minimum set of correctly functioning hardware. The VXIbus mainframe must supply +5V to the counter to power the VXIbus interface and the counter's microprocessor. In addition, Slot 0 functionality must be present along with an operational instrument controller (either external Keysight-IB or embedded).

The diagnostic tests are described in the following paragraphs. Verification of repair after replacement is accomplished when the instrument controller/front panel LED indicators no longer demonstrate a self-test or power distribution failure. If the instrument controller demonstrates continued task-specific or intermittent performance failures, then a software malfunction is suspect.

Power-on Self-test

The power-on self-test checks all major hardware functions within the Keysight E1420B. The following circuit elements are tested every time power is applied to the counter. Table 4-lists these elements along with their corresponding subroutine zn.nemonics by test sequence order. Appendix B provides a listing of all Keysight E1420B error messages. Errors -331 through -335 are specific for Self-test hardware failure.

Table 4-1 Power-on Self-test Subroutines

Order	Mnemonic	Hardware Block
1	ROM?	Read Only Memory
2	RAM?	Random Access Memory
3	CALRam?	Calibration RAM
4	DINTerpolat?	Delay Interpolator
5	MRC?	Multiple Register Counter
6	INTerpolat?	Interpolators
7	TIMebase?	CLK10 Timebase Signal Presence
8	CONNector?	A1 to A2. Edge Connector

Running Power-on Self-test

You can use the following procedures to run the E1420B Self-test:

1 Cycle the VXIbus mainframe power switch to ON.Observe:

- **a** A1l E1420B front-panel LEDs light momentarily.
- **b** The “Failed” LED extinguishes after a few seconds, indicating successful completion of the Self-test.

2 Connect a 10-MHz reference standard to the Int/Ext Reference BNC on the E1420B front panel. Send the Self-test query command *TST?.

Observe:

- **a** The results of the test are placed in the output queue indicating whether or not the counter completed Self-test without any detected errors.1

NOTE If a 1O-MHz reference standard is not available, the Slot 0 CLK 10 resource may be routed from the Clk Out connector on the Command Module's faceplate to the lnt!Ext Reference BNC on the E1420B. An SMB(f)-to-BNC(f) connector with a BNC cable would be required.

3 Ask the counter to report its power-up status by sending the “*TST?” command to the E1420B.

Observe:

a The “Access” LED momentarily lights, acknowledging the counter's acceptance of the “*TST?” command.

b The result reported to the controller should be “0” (No errors).

Diagnostic Subsystem

The user-callable diagnostic subroutines for the E1420B are accessed via SCPI as options and parameters of the :DIAGnostic root command. The structure and syntax of the E1420B diagnostic subsystem tree is as follows:

Syntax	Parameters
:DIAGnostics	
:CALibrate	
:OFFSet?	<BOTH>
:FULLscale?	<BOTH>
:ASSembly	
:ALL?	
:A1?	
:A2?	
:BLOCk	
[:ALL?l	
:CALAam?	
:ROM?	
:RAM?	
:COUNtchain	
[:ALL?l	
:CONNector?	
:DINTerpolat?	
:INTer;polat?	
:MRC.	
:TIMebase?	
:READ	
:MRC?	<EREGITREGIALL>
:INT?	<STS\SiLISPSISPLISTARtiSTOPICALIALL>
:UFAIL[?]	<OFF OIONI1> (N/A for Query)

:CALibrate

The DIAGnostics:CALibrate command causes the counter to perform calibrations of key parameters on the input amplifiers.

- :CALibrate:OFFSet? - performs offset calibration on input amplifiers for both channel 1and channel2. Requires grounding the channel being calibrated. Successful completion of the calibration returns "PASSED OFFSET CH1, PASSED OFFSET CH2".
- :CALibrate:FULLscale? - performs full scale calibration on both input amplifiers.Requires input of precision (+5V) DC supply voltage to the channels being calibrated. Successful completion of the calibration returns "PASSED FULLSCALE CH1, PASSED FULLSCALE CH2".

:ASSembly

The DIAGnostics:ASSembly command causes the counter to perform all diagnostics applicable on an assembly-level basis. The diagnostics provide a means of isolating hardware faults to either the A1 main motherboard printed-circuit assembly (PCA) or the A2 input amplifier PCA.

- **:ASSembly:ALL?** - performs diagnostics on both the input amplifier PCA (A2) and the main motherboard PCA (A1). See the A1 and A2 diagnostic descriptions for information concerning tested hardware.
- :**ASSembly:A1?** - performs diagnostics for the main motherboard A1PCA These include Calibration RAM, ROM, RAM, MRC, Interpolators, and timebase. If repeated failures occur for one or more of these hardware elements, then replacement of the A1 PCA is indicated.
- **:ASSembly:A2?** - performs diagnostics for the input amplifier A2 PCA. These diagnostics test the interface elements with A1. If repeated failures occur, then replacement of the A2 PCA is indicated.

Successful completion of the ASSembly diagnostics returns "PASSED, <A1| A2 | ALL>". If a diagnostic fails, the counter returns "FAILED" along with the failed blocks separated by commas. For example, "FAILED, ALL, ROM, INT" would indicate that the ROMs and count interpolators failed the Self-test.

:BLOCk

The DIAGnostics:BLOCk command causes the counter to perform all diagnostics applicable on a functional-block basis. The power-up default for this command is "ALL?". The other choices are CALRam?, ROM?, RAM? and COUNtchain.

Successful completion of BLOCk command tests is indicated by the "PASSED" response. The only exception to this is the COUNtchain node which requires an additional query option. The choices available are :ALL?, CONNector? (A1to A2 connectors), MRC? (Multiple Register Counter IC), INTerpolat? (Start/Stop Measurement Interpolators), DINTerpolat? (Delay Start/Stop Measurement Interpolators), and TIMebase? (Proper operation of CLK10 or TCXO option).

NOTE If the external timebase source is selected, using "SENS:ROSC:SOUR EXT", a reference timebase of 10 MHz must be connected to the lnt|Ext BNC in order to run the diagnostic "DIAG:BLOCK:ALL?”.

A1l query options (except MRC?, INTerpolat?, and DINTerpolat?) will return only "PASSED" or "FAILED" results. The MRC?, INTerpolat?, and DINTerpolat? queries return messages containing measurement data for their internal registers.

READ:MRC?

The READ:MRC? <EREG ITREG> query returns the value of the E register (ereg parameter), the T register (treg parameter), or both registers for the last measurement as follows:

- **EREG** – returns the count in the E (or Events) register, each, count equivalent to one zero crossing (event) of the input signal.
- **TREG** – returns the count in the T (or Time) register, each count equivalent to 100 ns.
- **ALL** – returns the EREG value first, followed by the TREG value.

READ:INT?

The READ:INT? <STS I STL I SPS I SPL I STARt I STOP I CAL I ALL> query returns an interpolator calibration and/or measurement value for the following parameters:

- **STS** – returns the start interpolator value for short calibration,
- **STL** – returns the start interpolator value for long calibration,
- **SPS** – returns the stop interpolator value for short calibration,
- **SPL** – returns the stop interpolator value for long calibration,
- **STARt** – returns the start interpolator value for measurement (The value should be between STS and SPL.),
- **STOP** – returns the stop interpolators value for measurement (The value should be between SPS and SPL.),
- **CAL** – returns calibration values in listed order (sts, sps, stl, sp]),
- **ALL** – returns all the calibration values and values for measurement as follows: sts, sps, stl, spl, start, and stop.

UFAil[?]

The DIAGnostics:UFAil <OFF I 0 I ON | 1> enables the counter to execute the next diagnostic command in a continuous loop. When turned ON, the next diagnostic is executed continously until halted (Device Clear is received) or until a failure occurs. The DIAGnostic: UFAIL? query returns the state of UFAIL.

This command is useful for troubleshooting intermittent faults within A1 or A2. The following SCPI message strings would run all diagnostics until halted, or until a failure is detected:

"DIAG:UFAIL 1"	(Begin continuous looping),
"DIAG:ASS:ALL?"	(Run all diagnostics for A1 and A2)

Running Selected Diagnostic Subroutines

The following examples show how to select and call the primary diagnostic subroutine nodes:

a DIAG:BLOCk[:ALL]?, CALRam?, ROM?, RAM?, or COUNtchain[:ALLJ?
Use this command to check the requested functional block and place a pass or fail message into the queue.

b DIAG:ASS[:ALLJ?, A1?, or A2?
Use this command to check the requested assembly and place a pass or fail message into the queue.

c DIAG:UFAIL 1
Use this command option to modify the effect of :DIAG commands, causing them to cycle continuously through the requested diagnostic subroutines.

Troubleshooting Procedure

The following text contains the assembly-level troubleshooting procedure for the Keysight El420B. The specific goal is to determine if the failure is caused by A1 Motherboard PCA, A2 Input Amplifier PCA, or neither. The procedure includes the following items:

- Observations you should make (Trouble Symptoms and Test Results).
- SCPI/Common Commands you should send to the counter/controller.
- Specific SCPI diagnostic options/parameters you should call.

SYMPTOM I. Front Panel Failed LED is ON.(Device reported failure)

1 **ACTION**: Send "*CLS" (Clear Status) to the address occupied by the E1420B.

2 **ACTION**: Send “*IDN?" to the E1420B and read reply.

3 **OBSERVATION**: If "Hewlett-Packard Company, E1420B,0, 3401" is received, then both the counter's processor and VXIbus interface are functioning correctly. If nothing is received, jump to step 22.

4 **ACTION**: Determine if A1 or A2 is causing observed failure.

5 **ACTION**: Send "*TST?", then send "SYS:ERR?", and reaclreply.

6 **OBSERVATION**: If "Input Connector" fails:

7 **ACTION**: Check connector for bent pins or bad connection.

8 **ACTION**: Attempt to realign pins/restore connection if possible.

9 **ACTION**: Send "*TST?" again, then send "SYS:ERR?", and read reply.

10 **OBSERVATION**: If "Input Connector" fails again:

11 **ACTION**: Replace A2 Input board PCA.

12 **OBSERVATION**: If "CONNector?", "MRC?", or "TIMebase?" fails:

13 ACTION: Perform adjustments and re-evaluate.

14 OBSERVATION: If failure persists:

15 ACTION: Replace A1 Motherboard PCA.

16 ACTION: Send "*TST?" again, then send "SYS:ERR?", and read reply.

17 OBSERVATION: If previous failure(s) recur:

18 ACTION: Replace A2 Input board PCA.

19 ACTION: Send "*TST?" again, then send "SYS:ERR?", and read reply.

20 OBSERVATION: If anything else fails:

21 ACTION: Replace A1 Motherboard PCA.

22 OBSERVATION: If nothing is received an/or a bus timeout occurs: either the A1 Motherboard PCA or the User Interface is at fault.

23 ACTION: Determine if the User Interface or the A1 PCA requires repair or replacement.

24 ACTION: Send "*CLS" (Clear Status) to the address occupied by the E1420B.

25 OBSERVATION: If Access LED lights:

26 ACTION: Replace A1 Motherboard PCA.

27 OBSERVATION: If a problem persists, check the following:

28 ACTION:

- **a** Verify that the controller is communicating with the Slot 0 module by running the Slot 0 Diagnostic.
- **b** Verify that the controller can address another VXIbus module by attempting communication with a different module.
- **c** Verify the Keysight E1420B logical address.
- **d** Ensure that there are no addressing conflicts with other VXIbus modules in the mainframe.
- **e** Move the Keysight E1420B to another slot.
- **f** Use a different address for the E1420B module.
- **g** Remote all other VXIbus modules from the mainframe except the Slot 0 and E1420B modules.
- **h** Unless the Access LED lights, the problem is not on Keysight E1420B.

SYMPTOM ll. Front Panel Failed LED is OFF. (User reported failure)

1 ACTION: Send "*CLS" (Clear Status) to the address occupied by the E1420B.

2 ACTION: Send "*IDN?" to the E1420B and read reply.

3 OBSERVATION: If "Hewlett-Packard Company, E1420B,0,.3401" is received, and the indicated failure is Analog range, sensitivity, or input conditioning:

4 **ACTION**: Perform Functional Test and Performance Tests as needed to assess A2 Assembly status.

5 **ACTION**: Perform adjustments on A1 and A2 PCAs. (Execute all :CALibrate command options/chapter 3 procedures.).

6 **ACTION**: Replace A2 Input board PCA for any proven failures.

7 **OBSERVATION**: If failure persists:

8 **ACTION**: Perform Functional Test and Performance Tests and use as a guide for replacement of the A1 motherboard PCA.

9 **OBSERVATION**: If nothing is received and a bus timeout occurs:

10 **ACTION**: Send "*CLS" (Clear Status) to the address occupied by the E1420B.

11 **OBSERVATION**: If Access LED lights:

12 **OBSERVATION**: If Access LED lights:

13 **ACTION**: Replace the A1 Motherboard PCA

14 **OBSERVATION**: If problem persists, check the following:

15 **ACTION:**

- **a** Verify that the controller is communicating with the Slot 0 module by running the Slot 0 Diagnostic.
- **b** Verify that the controller can address another VXIbus module by attempting communication with a different module.
- **c** Verify the Keysight E1420B logical address.
- **d** Ensure that there are no addressing conflicts with other VXIbus modules in the mainframe.
- **e** Move the Keysight E14208 to another slot.
- **f** Use a different address for the E1420B module.
- **g** Remove all other VXIbus modules from the mainframe except the
- **h** Slot 0 and E1420B modules.
- **i** Unless the Access LED lights, the problem is not on Keysight E1420B.

Replacement Of Assemblies

The following paragraphs explain how to replace the A1 and A2 PCAs.

A1 Motherboard PCA

Use this procedure and refer to Figure 4-3 to replace the A1 Motherboard Assembly:

1 Ensure that the following procedure takes place in an ESD safe area and that the ESD considerations are observed.

2 Remove all front-panel BNC connector mounting nuts.

3 Remove the counter's right-side module cover by unscrewing the six flat screws that secure it to the A1Motherboard.

4 Carefully slide the A1 assembly (A2 still attached) to the right approximately 114 inch, then lift-up and away from the two locater key-way pins (attached to the inside of the left-side module cover). At this point, the front-panel BNC connectors slide out the rear of the front panel.

5 Remove the A2 PCA (if necessary) by carefully separating their common edge connectors.

6 Install the replacement A1PCA by reversing the order of steps 1-5 above.

A2 Input Amplifier PCA

Use this procedure and refer to Figure 4-3 to replace the A2 Input Amplifier Assembly:

1 Complete steps 1-5 of the A1 replacement procedure listed above.

2 Install the replacement A2 PCA on A1by joining it at the common A1/A2 edge connectors.

3 Complete A2 PCA replacement by reversing the order of steps 1-5 of the A1replacement procedure listed above.

Disassembly and Reassembly

The following procedures provide information for disassembling and reassembling the Keysight E1420B for troubleshooting and repair.

Disassembly

Use the following procedure and refer to Figure 4-3 to disassemble the Keysight E1420B Universal Counter:

1. Complete steps 1-5 of the A1 PCA replacement procedure.
2. Separate the left-side module cover from the front-panel assembly by removing the two small screws that enter the left-side module cover.

Reassembly

Re-assemble the counter by reversing the order of the Disassembly procedure steps 1 and 2.

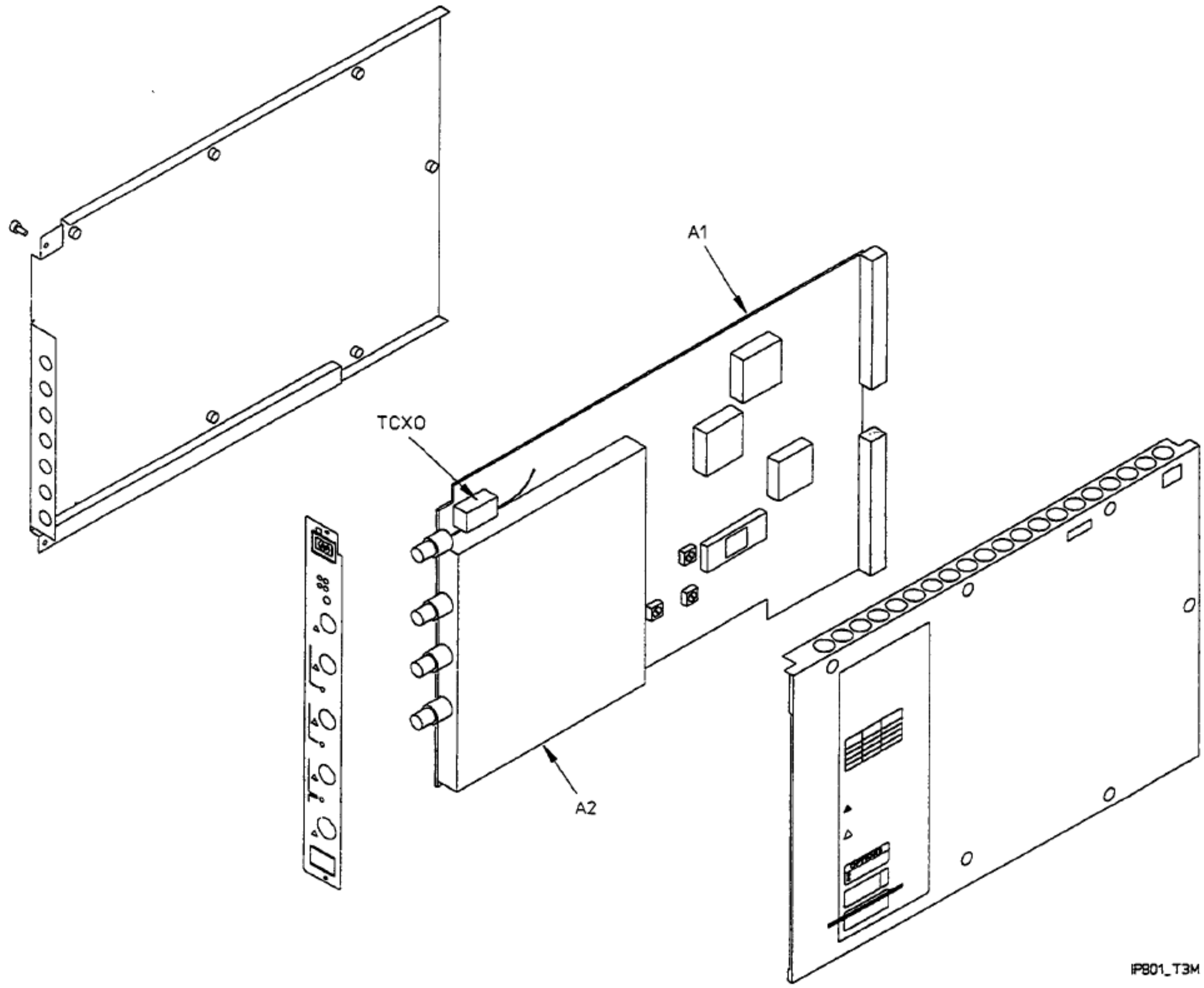


Figure 4-3 Keysight E1420B Exploded View

5 Replaceable Parts

Introduction

This chapter contains information for ordering parts. Table 5-1 lists abbreviations and reference designators used in the parts list and throughout the service manual. Table 5-2 lists all replaceable parts for the Keysight E1420B and its option.

Where To Find Important Topics

Chapter Summary

Exchange Assemblies

The assemblies within the instrument that may be replaced on an exchange basis include Al, A2, and the optional TCXO timebase oscillator. The factory repaired and tested exchange assemblies are available only on a trade-in basis; therefore, the defective assemblies must be returned for credit. For this reason, assemblies required for spare parts stock must be ordered by their "new assembly" part numbers.

Abbreviations and Reference Designations

Table 5-1 lists abbreviations and reference designations used in the parts list, and in the service manual. In some cases, two forms of the abbreviations are used, one all in capital letters, and one with partial or no capitals. This occurs because the abbreviations in the parts list are in capital letters only, while other abbreviation forms, with lower case and upper case letters, may be used in other parts of the service manual.

Replaceable Parts List

Table 5-2 lists the assembly-level replaceable parts and is organized as follows:

1. Electrical assemblies in alphanumeric order by reference designation.
2. Chassis hardware and mechanical parts in alphanumeric order by reference designation.

The information given for each part consists of the following:

1. The Hewlett-Packard part number.
2. Part number check digit (CD).
3. The total quantity (Qty) of each individual part.
4. The description of the part.

The total quantity for each part used within the counter is given only once at the first appearance of the part number in the list.

How To Order A Part

Hewlett-Packard wants to keep your parts ordering process as simple and efficient as possible. Think of the process as having the following steps:

- Identifying the part and the quantity that you want
- Determining the ordering method to be used and contacting Hewlett-Packard.

Parts Identification

To identify the part(s) you want, first refer to the replaceable parts lists (Tables 6-2 and 6-3) in this chapter.

When ordering from Hewlett-Packard, the important numbers to note from the Parts List are the Keysight Part Number and part-number check digit (in the "CD" column), and the quantity of the part you want.

If the part you want is NOT identified in the manual, you can call on Hewlett-Packard for help (see the following section ("Contacting Hewlett-Packard"). Please have the following information at hand when you contact Keysight for help:

- Instrument Model Number (example "Keysight E1420B").
- Complete instrument Serial Number (example "1234A56789"). Information about where to find the serial number is given in the preface of this manual in the "HOW TO USE THIS MANUAL" section.
- Description of the part and its use.
- Quantity of the part required.

Contacting Keysight

Depending on where you are in the world, there are one or more ways in which you can get parts or parts information from Keysight.

- **Outside the United States**, contact your local Keysight sales office. Keysight sales offices are listed at the back of this manual.
- **Within the United States,** we encourage you to order replacement parts or request parts information directly by telephone or mail from the Keysight Support Materials Organization, using the telephone numbers or address listed below. (You can also contact your local Keysight sales office. Keysight sales offices are listed at the back of this manual.)

Reference Designators

REFERENCE DESIGNATIONS

A	= assembly
AT	= attenuator, isolator, termination
B	= fan, motor
BT	= battery
C	= capacitor
CP	= coupler
CR	= diode; diode thyristor; varactor
DC	= directional coupler
DL	= delay line
DS	= annunciator; signaling device audio or visual; lamp; LED
E	= miscellaneous electrical part
F	= fuse
FL	= filter
H	= hardware
HY	= circulator
J	= electrical connector stationary portion, jack
K	= relay
L	= coil; inductor
LS	= audible alarm; audible signaling device; buzzer; transducer
M	= metre
MP	= miscellaneous mechanical part
P	= electrical connector, movable portion; plug
Q	= transistor; SCR; triode thyristor
R	= resistor
RT	= thermistor
S	= switch
T	= transformer
TB	= terminal board
TC	= thermocouple
TP	= test point
U	= integrated circuit; microcircuit
V	= electron tube
VR	= voltage regulator; breakdown diode
W	= cable; transmission path; wire; jumper
X	= socket
Y	= crystal unit-piezo-electric
Z	= tuned cavity; tuned circuit

ABBREVIATIONS

A	= ampere
ac	= alternating current
ACCESS	= accessory
ADJ	= adjustment
A/D	= analog-to-digital
AF	= audio frequency
AFC	= automatic frequency control
AGC	= automatic gain control
AL	= aluminum
ALC	= automatic level control
AM	= amplitude modulation
AMPL	= amplifier
APC	= automatic phase control
ASSY	= assembly
AUX	= auxiliary
AVG	= average
AWG	= american wire gauge
BAL	= balance
BCD	= binary-coded decimal
BD	= board
BE CU	= beryllium copper
BFO	= beat frequency oscillator
BH	= binder head
BKDN	= breakdown
BP	= bandpass
BPF	= bandpass filter
BRS	= brass
BWO	= backward wave oscillator
CAL	= calibrate
ccw	= counterclockwise
CER	= ceramic
CHAN	= channel
cm	= centimeter
CMO	= cabinet mount only
COEF	= coefficient
COM	= common
COMP	= composition
COMPL	= complete
CONN	= connector
CP	= cadmium plate
CRT	= cathode ray tube
CTL	= complementary transistor logic
CW	= continuous wave
cw	= clockwise
D/A	= digital-to-analog
dB	= decibel
dBm	= decibel referred to 1mW
dc	= direct current
deg	= degree (temperture interval or difference)
...°	= degree (plane angle)
°C	= degree Celsius (centigrade)
°F	= degree Fahrenheit
°K	= degree Kelvin
DEPC	= deposited carbon
DET	= detector
diam	= diameter
DIA	= diameter (used in parts list)
DIFF AMPL	= differential amplifier
div	= division
DPDT	= double-pole, double-throw
DR	= drive
DSB	= double sideband
DTL	= diode-transistor logic
DVM	= digital voltmeter
ECL	= emitter-coupled logic
EMF	= electromotive force
EDP	= electronic data processing
ELECT	= electrolytic
ENCAP	= encapsulated
EXT	= external
F	= farad
FET	= field-effect transistor
F/F	= flip-flop
FH	= flat head
FIL H	= fillister head
FM	= frequency modulation
FP	= front panel
FREQ	= frequency
FXD	= fixed
g	= gram
GE	= germanium
GHz	= gigahertz
GL	= glass
GND	= ground(ed)
H	= henry
h	= hour
HET	= heterodyne
HEX	= hexagonal
HD	= head
HDW	= hardware
HF	= high frequency
HG	= mercury
HI	= high
HP	= Hewlett-Packard
HPF	= high pass filter
HR	= hour (used in parts list)
HV	= high voltage
Hz	= hertz
IC	= integrated circuit
ID	= inside diameter
IF	= intermediate frequency
IMPG	= impregnated
in	= inch
INCD	= incandescent
INCL	= include(s)
INP	= input
INS	= insulation
INT	= internal
kg	= kilogram
kHz	= kilohertz
kΩ	= kilohm
kV	= kilovolt
lb	= pound
LC	= inductance-capacitance
LED	= light-emitting diode
LF	= low frequency
LG	= long
LH	= left hand
LIM	= limit
LIN	= linear taper (used in parts list)
lin	= linear
LK WASH	= lock washer
LO	= low; local oscillator
LOG	= logarithmic taper (used in parts list)
log	= logarithmic
LPF	= low pass filter
LV	= low voltage
m	= metre (distance)
mA	= milliampere
MAX	= maximum
MΩ	= megohm
MEG	= meg (10^6) (used in parts list)
MET FILM	= metal film
MET OX	= metal oxide
MF	= medium frequency; microfarad (used in parts list)
MFR	= manufacturer
mg	= milligram
MHz	= megahertz
mH	= millihenry
mho	= conductance
MIN	= minimum
min	= minute (time)
...′	= minute (plane angle)
MINAT	= miniature
mm	= millimeter
MOD	= modulator
MOM	= momentary
MOS	= metal-oxide semiconductor
ms	= millisecond
MTG	= mounting
MTR	= meter (indicating device)
MUX	= multiplexer
mV	= millivolt
mVac	= millivolt, ac
mVdc	= millivolt, dc
mVpk	= millivolt, peak
mVp-p	= millivolt, peak-to-peak
mVrms	= millivolt, rms
mW	= milliwatt
MY	= mylar
μA	= microampere
μF	= microfarad
μH	= microhenry
μmho	= micromho
μs	= microsecond
μV	= microvolt
μVac	= microvolt, ac
μVdc	= microvolt, dc
μVpk	= microvolt, peak
μVp-p	= microvolt, peak-to-peak
μVrms	= microvolt, rms
μW	= microwatt
nA	= nanoampere
NC	= no connection
N/C	= normally closed
NE	= neon
NEG	= negative
nF	= nanofarad
NI PL	= nickel plate
N/O	= normally open
NOM	= nominal
NORM	= normal
NPN	= negative-positive-negative
NP0	= negative-positive zero (zero temperature coefficient)
NRFR	= not recommended for field replacement
ns	= nanosecond
NSR	= not separately replaceable
nW	= nanowatt
OBD	= order by description
OD	= outside diameter
OH	= oval head
OP AMPL	= operational amplifier
OPT	= option
OSC	= oscillator
OX	= oxide
oz	= ounce
Ω	= ohm
P	= peak (used in parts list)
PAM	= pulse-amplitude modulation
PC	= printed circuit
PCM	= pulse-code modulation; pulse-count modulation
PDM	= pulse-duration modulation
pF	= picofarad
PH BRZ	= phosphor bronze
PHL	= phillips
PIN	= positive-intrinsic-negative
PIV	= peak inverse voltage
pk	= peak
PL	= phase lock
PLL	= phase-lock loop
PLO	= phase lock oscillator
PM	= phase modulation
PNP	= positive-negative-positive
P/O	= part of
POLY	= polystyrene
PORC	= porcelain
POS	= positive; position(s) (used in parts list)
POSN	= position
POT	= potentiometer
p-p	= peak-to-peak
PP	= peak-to-peak (used in parts list)
PPM	= pulse-position modulation
PREAMPL	= preamplifier
PRF	= pulse-repetition frequency
PRR	= pulse-repetition rate
ps	= picosecond
PT	= point
PTM	= pulse-time modulation
PWM	= pulse-width modulation
PWV	= peak working voltage
RC	= resistance capacitance
RECT	= rectifier
REF	= reference
REG	= regulated
REPL	= replaceable
RF	= radio frequency
RFI	= radio frequency interference
RH	= round head; right hand
RLC	= resistance-inductance-capacitance
RMO	= rack mount only
rms	= root-mean-square
RND	= round
ROM	= read-only memory
R&P	= rack and panel
RWV	= reverse working voltage
S	= scattering parameter
s	= second (time)
...″	= second (plane angle)
S-B	= slow-blow fuse (used in parts list)
SCR	= silicon controlled rectifier; screw
SE	= selenium
SECT	= sections
SEMICON	= semiconductor
SHF	= super-high frequency
SI	= silicon
SIL	= silver
SL	= slide
SNR	= signal-to-noise ratio
SPDT	= single-pole, double-throw
SPG	= spring
SPL	= special
SPST	= single-pole, single-throw
SR	= split ring
SSB	= single sideband
SST	= stainless steel
STL	= steel
SQ	= square
SWR	= standing-wave ratio
SYNC	= synchronize
T	= timed (slow-blow fuse)
TA	= tantalum
TC	= temperature compensating
TD	= time delay
TERM	= terminal
TFT	= thin-film transistor
TGL	= toggle
THD	= thread
THRU	= through
TI	= titanium
TOL	= tolerance
TRIM	= trimmer
TSTR	= transistor
TTL	= transistor-transistor logic
TV	= television
TVI	= television interference
TWT	= traveling wave tube
U	= micro (10^{-6}) (used in parts list)
UF	= microfarad (used in parts list)
UHF	= ultra-high frequency
UNREG	= unregulated
V	= volt
VA	= voltampere
Vac	= volts ac
VAR	= variable
VCO	= voltage-controlled oscillator
Vdc	= volts dc
VDCW	= volts, dc, working (used in parts list)
V(F)	= volts, filtered
VFO	= variable-frequency oscillator
VHF	= very-high frequency
Vpk	= volts peak
Vp-p	= volts peak-to-peak
Vrms	= volts rms
VSWR	= voltage standing wave ratio
VTO	= voltage-tuned oscillator
VTVM	= vacuum-tube voltmeter
V(X)	= volts, switched
W	= watt
W/	= with
WIV	= working inverse voltage
WW	= wirewound
W/O	= without
YIG	= yttrium-iron-garnet
Zo	= characteristic impedance

NOTE

All abbreviations in the parts list will be in upper case

MULTIPLIERS

Abbreviation	Prefix	Multiple
T	tera	10^{12}
G	giga	10^{9}
M	mega	10^{6}
k	kilo	10^{3}
da	deka	10
d	deci	10^{-1}
c	centi	10^{-2}
m	milli	10^{-3}
μ	micro	10^{-6}
n	nano	10^{-9}
p	pico	10^{-12}
f	femto	10^{-15}
a	atto	10^{-18}

Replaceable Parts

Table 5-1 Standard Instrument Replaceable Parts for the E1420A

Ref Des	Keysight P/N	CD	Qty	Description
A1	E1420-60006	1	1	New E1420A Motherboard (SIN 3039A00101 through 178)
A1	E1420-69006	9	(1)	Exchange E1420A Motherboard
A1	E1420-60007	4	1	New Opt. 01o Motherboard (SIN 3039A00101 through 178)
A1	E1420-69021	2	(1)	Exchange E1420B Option 010 Motherboard
A2	53310-60002	0	1	New E1420A Standard Input Bd (SIN 3110A00209 and above)
A2	53310-690025	8	(1}	Exchange E1420A Standard Input Board
A2	3310-60004	2	1	New E1420A Option 030 Input Board
A2	53310-69004	0	{1)	Exchange E1420A Option 030 Input Board
A1U12	E1420-80004	5	1	EPROM, E1420A Standard and Option 030
A1U13	E1420-80005	6	1	EPROM, E1420A Standard and Option 030
H1	E1420-00001	4	1	Front Panel
H2	E1420-00002	5	1	Top Shield
H3	E1420-00003	6	1	Bottom Shield
H4	E1400-84106	6	1	Top Handle Kit
H5	E1400-84105	5	1	Bottom Handle Kit
H6	0515-1107	3	2	Screw, M2.5 LK 8.0L PO
H7	0515-1127	7	6	Screw, M3.0 LK 25.L FO
H8	0515-1351	9	2	Screw, M2.5 LK 8.0L FO
H9	0515-1968	4	2	Screw, M2.5 X 11
H10	0590-1251	6	5	Captive Nut, Spc 15/32-32
	8160-0686	6	1	RFI Strip, Fingers
	05355-60103	4	1	Cable, Pulse Output
	53310-00013	7	1	Shield, Input Amp
	53310-00012	6	5	Shield Wall, Input Amp
	6960-0002	4	1	Hole Plug, .5-in (Option 030)

Standard Instrument Replaceable Parts

Table 5-2 Standard Instrument Replaceable Parts for the E1420B

Ref Des	Keysight P/N	CD	Qtv	Descriotion
A1	E1420-60020	3	1	New E1420B Motherboard
A1	E1420-69020	1	(1)	Exchange E1420B Motherboard
A1	E1420-60021	4	1	New E1420B Option 010 Motherboard
A1	E1420-69021	2	(1)	Exchange E1420B Option 010 Motherboard
A2	53310-60008	6	1	New E1420B Standard Input Board
A2	53310-69008	4	(1)	Exchange E1420B Standard Input Board
A2	53310-60009	7	1	New E1420B Option 030 Input Board
A2	53310-69009	5	(1)	Exchange E1420B Option 030 Input Board
A1U12	E1420-80031	8	1	EPROM, Standard (E1420B)
A1U13	E1420-80032	9	1	EPROM, Standard (E1420B)
A1U12	E1420-80033	0	1	EPROM, Option 040 (E1420B)
A1U13	E1420-80034	1	1	EPROM, Option 040 (E1420B)
H1	E1420-00006	9	1	Front Panel
H2	E1420-00007	0	1	Top Shield
H3	E1420-00002	5	1	Bottom Shield
H4	E1400-84106	6	1	Top Handle Kit
H5	E1400-84105	5	1	Bottom Handle Kit
H6	0515-1107	3	2	Screw, M2.5 LK 8.0L PO
H7	0515-1127	7	6	Screw, M3.0 LK 25.L FO
H8	0515-1351	9	2	Screw, M2.5 LK 8.0L FO
H9	0515-1968	4	2	Screw, M2.5 X 11 Captive
H10	0590-1251	6	5	Nut, Spc 15/32-32
	8160-0686	6	1	RFI Strip, Fingers
	05355-60103	4	1	Cable, Pulse Output
	53310-00013	7	1	Shield, Input Amp (Option 030)
	53310-00012	6	5	Shield Wall, Input Amp (Option 030}
	6960-0002	4	1	Hole Plug, .5-in (Option 030}

A E1420B Connections, Configuration, and Installation

Introduction

This appendix briefly explains the counter's front-panel features, and shows how to configure the module hardware for use in a VXIbus mainframe. The chapter contains the following information and sections:

Where To Find Important Topics

Appendix Summary

Connectors and Indicators

The Keysight E1420B front panel has four signal connectors (five if Option 030 High Frequency Channel 3 is installed), seven LED indicators, and one adjustment. Front panel signal connectors are discussed first, followed by a short description of the indicators, adjustment, and on-board switches and jumpers. Figure A-1 shows the front panel connectors, indicators, and adjustment.

Front Panel Signal Connectors

The front panel signal connectors are all standard BNC providing up to three Input channels for signal measurement, one Arm Input for measurement synchronization, and a 10-MHz Timebase Input/Output connection for timebase synchronization. A BNC connector replaces a front-panel plug cover when Option 030 High Frequency Channel 3 Input is installed. The basic characteristics of these inputs are explained following a description of input power.

Maximum Input Power

The maximum allowable input voltage for all front panel inputs should not exceed 5 volts rms when x1. attenuation is active.

CAUTION **Input voltages in excess of 5 volts rms may cause permanent front-end hardware damage when x1 attenuation is active (default).**

Input 1 and 2

Inputs 1 and 2 are the main measurement channels of the counter. They can be used for all specified measurement functions from dc to 200 and 100 MHz respectively. Input impedance is selectable for either 50 Ω or 1 MΩ. Input attenuation is selectable as x1 or x10. Input coupling is selectable between ac or dc. The input channels can be used independently or together depending on measurement functions and needs.

Input 3, Option 030

Input 3 is the optional high frequency channel and is used for frequency, period, or ratio measurements as specified in Table 1-1. Input impedance is fixed at 50 Ω and coupling is ac only.

ARM Input

The Arm Input is used to provide a synchronizing signal to the counter that can start and/or stop the measurement process. Input impedance is 1 MΩ with dc coupling. Input trigger level is programmable between 0cV (GND), 1.6 V (TTL), -1.3 V (ECL). The Arm Input frequency range is dc to 20 MHz.

INT/EXT Reference

The Int/Ext Reference connector can be used to lock the counter's circuits to an external timebase input. Input level is nominally 0.2 volts p-p into a 1.1 kΩ load.

Send the following SCPI program message commanding the E1420B to select EXT input as its timebase signal through the front panel Int/Ext Reference BNC connector:

OUTPUT @E1420B;•SENS:ROSC:SOUR EXT"

If you want to program the counter to output its high stability timebase (Option 010) through the front-panel Int/Ext Reference BNC connector, send the following SCPI program message:

OUTPUT 70906;"0UTP:ROSC:STATe ON"

You can turn OFF this timebase output by sending either the *RST or "OUTP:ROSC:STATe OFF"program messages to the counter.

Warm-up

At power-up, the E1420B uses the VXIbus CLKlO as its timebase reference, hence no warm-up is needed. If the optional TCXO timebase is present and selected, a thirty minute warm-up period is recommended before making any measurement.

Front Panel Indicators And Adjustment

The counter's front panel has seven LED indicators that provide information about normal operation and errors. A single Timebase frequency reference adjustment provides fine-tuning of the optional TCXO timebase oscillator.

The seven LED indicators provide the following:

- **INPUTS**: Three green LEDs, located adjacent to each Input connector, flash to indicate signal arming and triggering. Channels 2 and 3 share the same LED and cannot be used for measurements at the same time.
- **GATE**: A green LED to indicate when the measurement gate is open.
- **ACCESS**:A green LED to indicate data transfer across the counter's VXIbus interface.
- **FAILED**: A red Failed LED to indicate a non-recoverable VXIbus error or failed Self-test.
- **ERROR**: A red Error LED to indicate that an error is present in the counter's error queue.

VXIbus Connectors

Two 96 pin (Pl and P2) connectors serve as the VXIbus electrical interface connection. See Figure A-1 for an end-on view of the Pl and P2 edge connectors.

If you need information about pin-out designation and signal functions, refer to page A-4/5, Table A-1/2, or the VMEbus Specification: Rev. C.1 for Pl connector pin-outs, and the VXIbus Specification: Rev. 1.3 for P2 connector pin-outs.

CAUTION Do not touch the connector pins. Take care to prevent accidental damage to the connector pins.

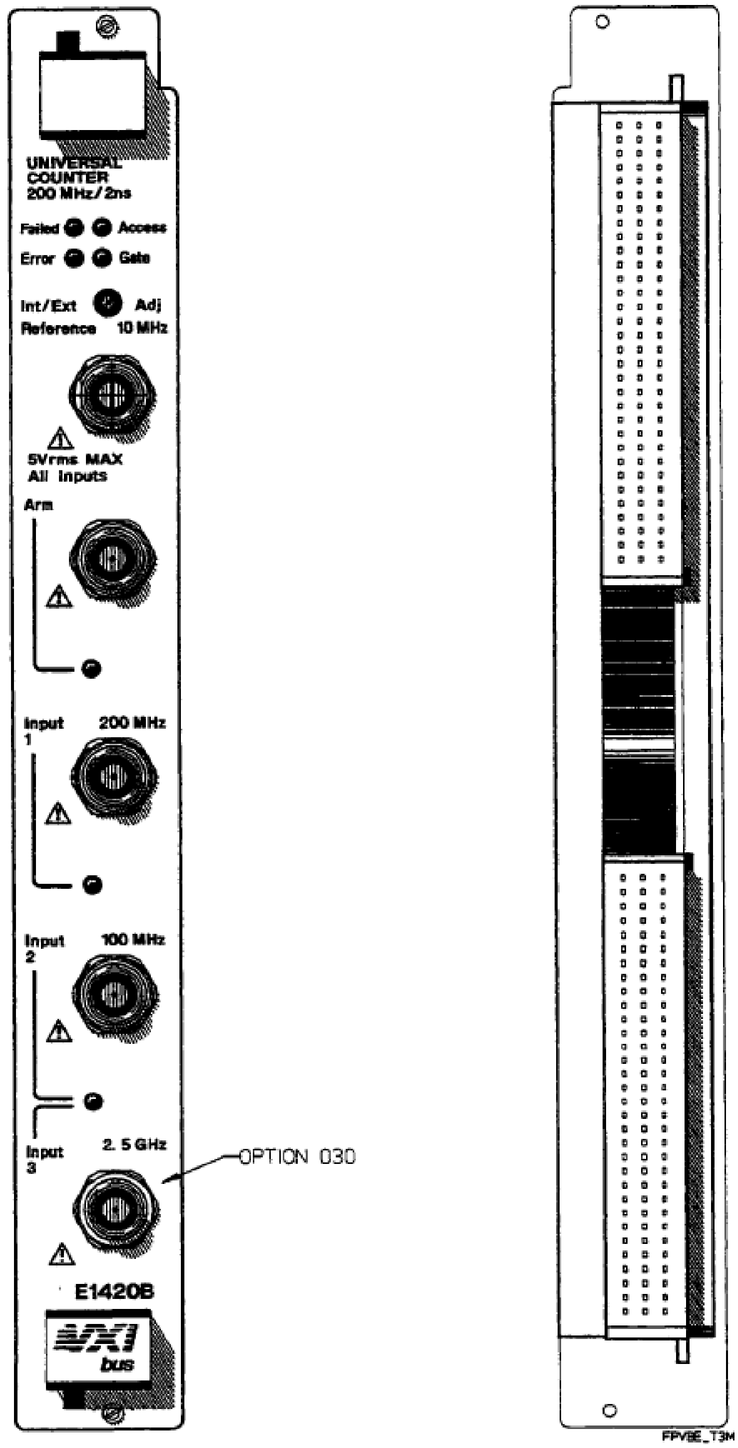


Figure A-1 Front Panel and VXIbus Edge Connectors

Table A-1 VXIbus Edge Connector Pl Pin Assignment

PIN NUMBER	ROW a SIGNAL MNEMONIC	ROW b SIGNAL MNEMONIC	ROW c SIGNAL MNEMONIC
1	D00	BBSY*	DO8
2	D01	BCLR*	D09
3	D02	ACFAIL*	D10
4	D03	BGOIN*	D11
5	D04	BGOOUT*	D12
6	D05	BG11N*	D13
7	D06	BG10UT*	D14
8	D07	BG21N*	D15
9	GND	BG20UT*	GND
10	SYSCLK	G31N*	SYSFAIL*
11	GND	BG30UT*	BERR*
12	DS1*	BRO*	SYSRESET*
13	DSO*	BR1*	LWORD*
14	WRITE*	BR2*	AM5
15	GND	BR3*	A23
16	DTACK*	AMO	A22.
17	GND	AM1	A21
18	AS*	AM2	A20
19	GND	AM3	A19
20	lACK*	GNO	A18
21	lACKIN*	SERCLK(1)	A17
22	lACKOUT*	SERDAT*(1)	A16
23	AM4	GND	A15
24	A07	IRQ7*	A14
25	A06	IRQ6*	A13
26	A05	IRQ5*	A12
27	A04	IRQ4*	A11
28	A03	IRQ3*	A10
29	A02	IRQ2*	A09
30	A01	IRQ1*	AOS
31	-12V	+5VSTDBY	+12V
32	+5V	+5V	+5V

An asterisk (*) following the signalname of signals which are level-significant denotes that the signal is true or valid when the signal is low.

An asterisk (*) following the signalname of signals which are edge-significant denotes that the actions initiated by that signal occur on a high-to-low transition.

Table A-2 VXIbus Edge Connector P2 Pin Assignment

PIN NUMBER	ROW a SIGNAL MNEMONIC	ROW b SIGNAL MNEMONIC	ROW c SIGNAL MNEMONIC
1	ECLTRGO	+5V	CLK10+
2	-2V	GND	CLK10-
3	ECLTRG1	RSV1	GND
4	GND	A24	-5.2V
5	LBUSAOO	A25	LBUSCOO
6	LBUSA01	A26	LBUSC01
7	-5.2V	A27	GND
8	LBUSA02	A28	LBUSC02
9	LBUSA03	A29	LBUSC03
10	GND	A30	GND
11	LBUSA04	A31	LBUSC04
12	LBUSA05	GND	LBUSC05
13	-5.2V	+5V	-2V
14	LBUSA06	D16	LBUSC06
15	LBUSA07	D17	LBUSC07
16	GND	D18	GND
17	LBUSA08	D19	LBUSC08
18	LBUSA09	D20	LBUSC09
19	-5.2V	D21	-5.2V
20	LBUSA10	D22	LBUSC10
21	LBUSA11	D23	LBUSC11
22	GND	GND	GND
23	TTLTRGO*	D24	TTLTRG1*
24	TTLTRG2*	D25	TTLTRG3*
25	+5V	D26	GND
26	TTLTRG4*	D27	TTLTRG5*
27	TTLTRG6*	D28	TTLTRG7*
28	GND	D29	GND
29	RSV2	D30	RSV3
30	MODID	D31	GND
31	GND	GND	+24V
32	SUMBUS	+5V	-24V

An asterisk (*) following the signal name of signals which are level-significant denotes that the signal is true or valid when the signal is low.

An asterisk (*) following the signal name of signals which are edge-significant denotes that the actions initiated by that signal occur on a high-to-low transition.

Internal Configuration

The following paragraphs provide you with information needed to configure the counter hardware logical address and bus grant/request priority. On-board switch settings and jumpers are explained along with the factory shipped counter address and bus grant/request priority level settings.

Logical Address Configuration Procedure

The logical address switch (LADDR) factory setting is 48. (No two VXIbus modules within the same mainframe can have the same address.) You can change the switch setting by following the procedure listed below. Valid address values are from 0 to 240 (selected value must be a multiple of 8). The correct address value must be set before the counter is installed in a VXIbus mainframe.

Defining The Instrument Address

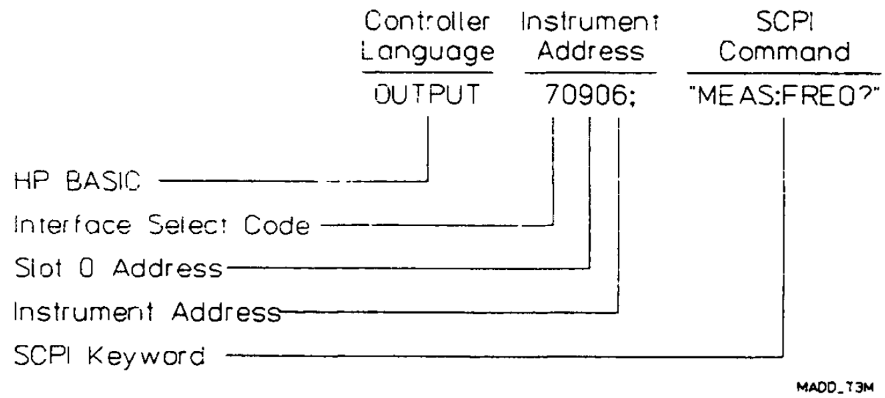
You need to specify a primary and secondary address to define the Universal Counter's GP_IB address. The primary address includes the Interface Select Code (ISC) and the Slot 0 address. The secondary value addresses the counter within the mainframe.

Primary Address = ISC and Slot 0 address
(ISC range = 00 through 09)
(Slot 0 address range = 00 through 30)

Typically, the ISC is set to 7 and the Slot 0 address to 09 for primary address 709. (Valid selections are between 1 and 12.)

Secondary Address = (Logical Address)/8
(Logical Address is set on the counter card with the logical address switch)

The counter is shipped from the factory with logical address 48; secondary address 6 (secondary address= 48/8 = 6). (Valid secondary selections are between 0 and 30.) The instrument address is the primary address and secondary address combined. For the above examples, the instrument address is 70906. This address is listed below as part of a typical program statement to show how the component parts make up the whole address:



If you need to set the counter's address, use the following procedure:

1 Locate the logical address 8-pin DIP switch bank located on the right side of the counter module. See Figure A-2 for the switch location and address selection.

2 Set the logical address switch for the correct address. Each individual switch is open when depressed to the "0" position and closed when depressed to the "1" position.

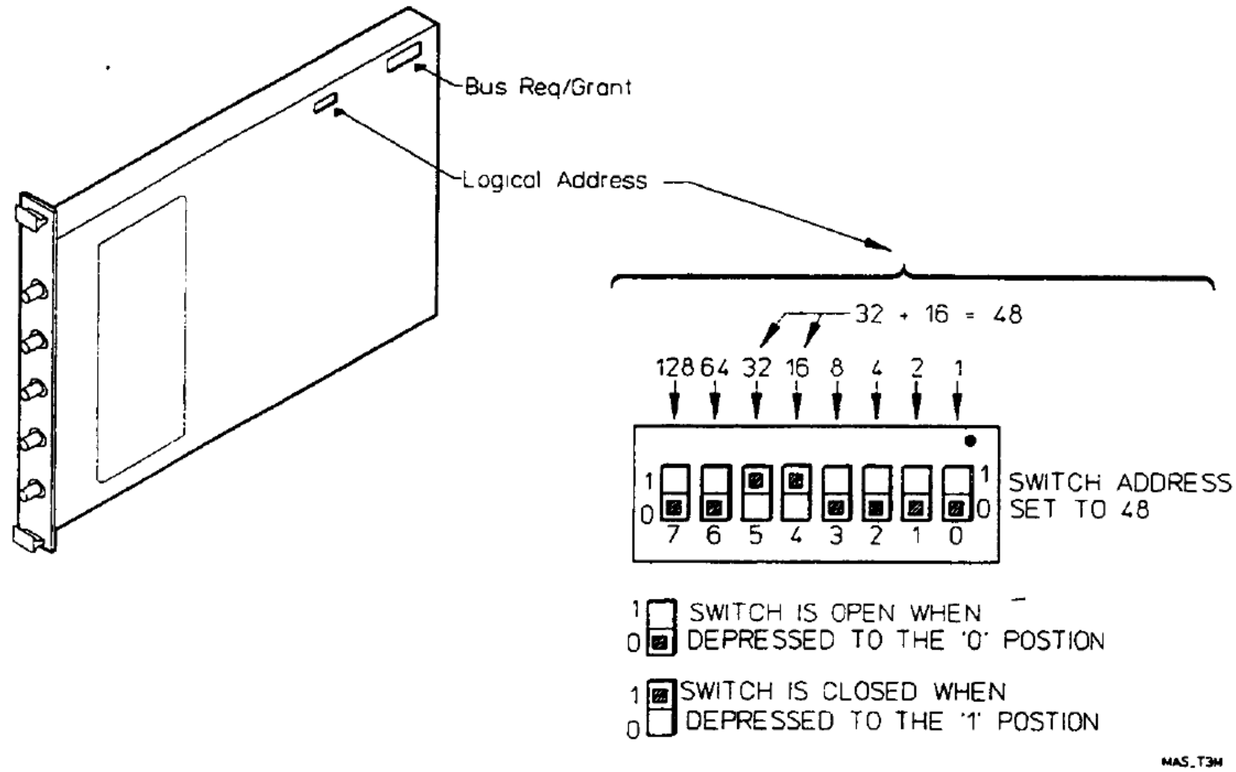


Figure A-2 E1420B Address Switch Location and Selection

Bus Grant and Request Configuration Procedure

The Keysight E1420B message-based communication supports four levels of prioritized bus arbitration (BRO through BR3). The counter is shipped with the highest bus grant/request level setting: BR 3. The Bus Grant/Request level is configured via six Bus Grant/Request configuration jumpers. The jumpers are correctly configured at the factory. They typically need not be changed unless a particular module within the mainframe requires a different data interface priority than other modules.

If you suspect that these jumpers are incorrectly placed, use the following procedure to check/correct the jumper placement:

1 Locate the bus grant/request jumpers located on the top-right side of the counter module adjacent to the PI connector. See Figure A-3 for the jumper location and level selection.
2 Move the jumpers to the new bus grant/request position. See Figure A-3 for the individual jumper priority positions. The top right side of the figure shows the correct factory setting (priority level The bottom right side shows how to change the jumpers for priority level 1.

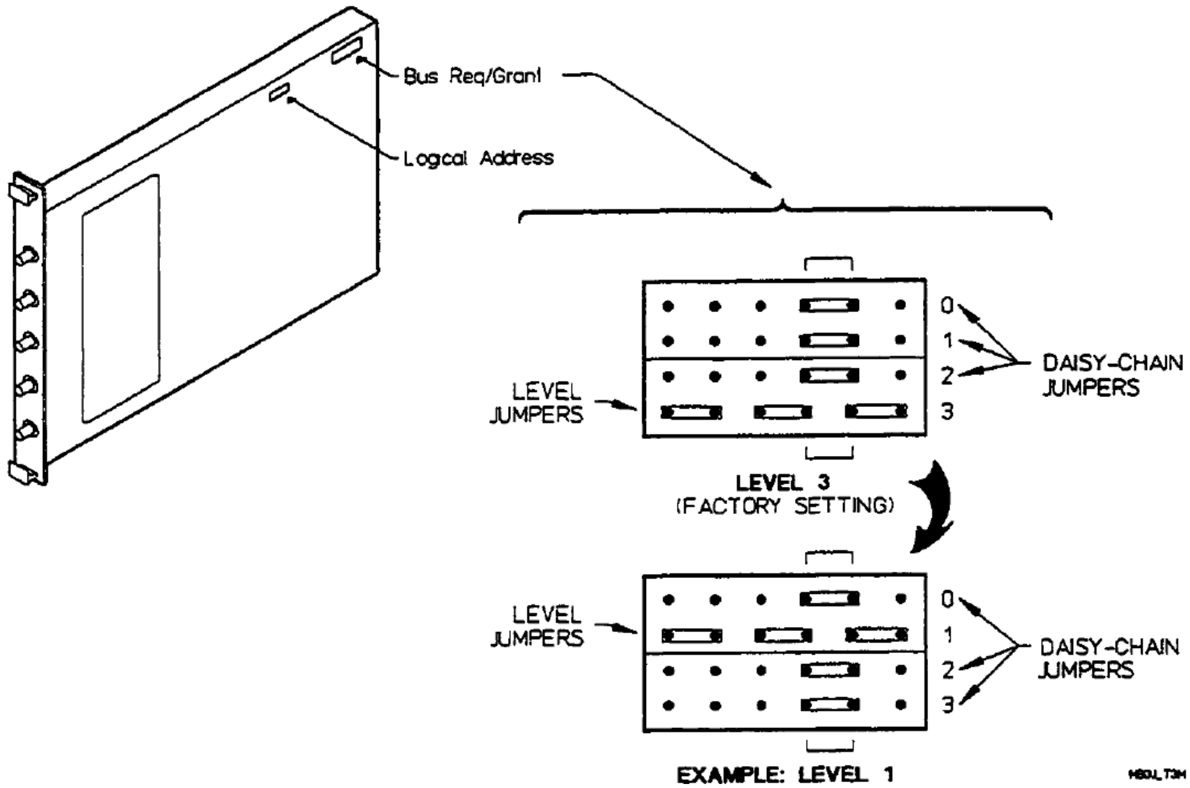


Figure A-3 Bus Grant Jumper Location and Selection

System Default Logical Addresses

The Keysight VXIbus instruments have a set of logical addresses that correspond to instrument type. These are listed in Table A-1. Keysight instrument factory switch settings will correspond with those listed in the table. If an application requires more than one of a particular instrument type, then the additional instrument(s) will require different address(es).

Table 3 Default Keysight Logical Addresses For VXIbus

Instrument Type	Switch Setting	Secondary Address
INTERFACES		
Command modules/Computers	00	00
Servant interfaces (RS-232, MS-1553)	08	01
Disk drives	16	02
ANALOG SENSORS DMMs		
(Reserved for multiplexers of scanning DMMs)	24	03
Digitizers (AIDs, Oscilloscopes)	32	04
Counters	40	05
Power Meters	48	06
Others (Spectrum analyzers)	56	07
	64	08
ANALOG SOURCES		
DC output (D/As, power supplies)	72	09
Arbitrary Waveform Generators	80	10
Function/Pulse Generators	88	11
RF/Signal Generators	96	12
Others	104	13
SWITCHES		
Multiplexers	112	14
Others (Matrix, RF, uWave, Form C, GP, Power)	120	15
Reserved for additional switches	128	16
DIGITAL		
Digital Functional Test	136	17
Digital I/O (general purpose)	144	18
Others (BERT, Bus analyzers, etc.)	152	19
ALTERNATE address for computer/resource manager	160	20
IBASIC	240	30

NOTE

The multiplexers are set up adjacent to the multimeters to allow them to operate as a scanning voltmeter system.

A gap has been left in the assigned addresses so that as many as 11 multiplexers can operate with a single voltmeter without disturbing the default switch settings of the other instruments.

Logical address 32 is available if the multiplexers are to be used independent of the multimeter.

Installation and Verification

The following paragraphs explain how to install the Keysight E1420B counter into the Series C mainframe, ensure proper ventilation, and verify initial operation.

Cooling Considerations

The Keysight E1420B counter automatically receives the correct ventilation when used with an Keysight 75000 Series C mainframe.The cooling requirements for the Keysight E1420B counter are:

1.0 Liters/second
0.15mm H20

If a different mainframe is used, you must ensure that adequate cooling is provided to the module as per the VXIbus Specification described under title B.7.3, Mainframe specifications, paragraph B.7.3.5, Mainframe cooling.

Hardware Setup

After you've set the correct logical address (if needed) and bus request/grant level (if necessary), follow the procedure below to install the counter.

1. Ensure that ac power IS NOT applied to the mainframe.
2. Ensure that the metal shields on each side of the counter are securely attached to the counter before inserting the module into the mainframe.
3. Ensure that the bus grant/request switches/jumpers on the backplane are set correctly for the slot you want to use. (If you are using the Keysight 75000 Series C Mainframe, you may not have to do anything with them.)
4. Carefully slide the counter module into the appropriate slot.
5. Ensure that the module edge connectors align and seat correctly into the backplane slot connectors.
6. Secure the top and bottom module mounting screws with a 1/8 inch flat blade screw driver.
7. Ensure that proper ventilation is provided to the module as described above.
8. Verify initial operation as described in the next paragraphs.

Verifying Operation

You are ready to power up and verify counter operation after completing these tasks:

- Keysight E1420B counter installation complete as described above.
- Slot 0 command module (or embedded controller) present in the correct slot properly set up and previously checked out.
- A 10-MHz reference standard is connected to the lnt/Ext Reference BNC input of the E1420B faceplate. Refer to Chapter 2, Power-up Self Test, for more information.
- VXIbus mainframe Controller (Keysight 9000 Series 200/300 or equivalent) connected to the - Slot 0 command module, properly set up and previously checked out (Not necessary when an embedded controller is present).

Verify the counter's initial operation with this procedure:

1. Power up the system controller.
2. Power up the VXIbus mainframe.
3. Observe successful completion of Self-test for both the Slot 0 command module and the Keysight E1420B counter module. (The "Failed" LED on the E1420B front panel is lit, then extinguishes after a few seconds indicating successful completion of self-test.)
4. Begin functional check-out or full performance testing as described in Chapter 2 of this manual.

B Error Messages

CODE	MESSAGE	CAUSE
-100	Command error	
-101	Invalid character	Unrecognized character in specified parameter
-102	Syntax error	Command missing space/comma between parameters
-103	Invalid separator	Command parameter separated by space not comma
-104	Data type error	Wrong data type specified in parameter
-105	GET not allowed	Group Execute Trigger was received
-108	Parameter not allowed	Parameter specified-in parameterless command
-109	Missing parameter	Parameter missing in entered command
-112	Program mnemonic too long	Header contains more than 12 characters
-113	Undefined header	Command header incorrectly specified
-121	Invalid character in number	Entered character for numeric data is incorrect
-123	Numeric overflow	Exponent larger than 32000
-124	Too many digits	More than 256 digits specified
-128	Numeric data not allowed	Number specified for parameter not letter
-131	Invalid suffiX	Parameter suffiX incorrectly specified (e.g. 50 M instead of 50 MHz)
-138	Suffix not allowed	Parameter suffiX specified when not allowed
-141	Invalid character data	Parameter type specified not allowed (e.g. "MEAS:FREQ InGH" instead of "MEAS:FREQ MAX"
-144	Character data too long	Character data element has more than 12 characters
-148	Character data not allowed	Entered character data not recognized by counter
-150	String data error	Entered string data contained a non-specific error
-151	Invalid string data	Entered string data syntax invalid

CODE	MESSAGE	CAUSE
-158	String data not allowed	String data encountered but not allowed
-160	Block data error	Entered block data contained a non-specific error
-161	Invalid block data	Entered block data syntax invalid
-168	Block data not allowed	Block data encountered but not allowed
-170	Expression error	Entered expression contained a non-specific error
-171	Invalid expression	Entered block data syntax invalid
-178	Expression data not allowed	Expression data encountered but not allowed
-180	Macro error	Entered macro command or parameter contained a non-specific error
-181	Invalid outside macro definition	Macro parameter placeholder encountered outside a macro definition
-183	Invalid inside macro definition	Program message sent with *DMC is syntactically invalid
-200	Execution error	Requested measurement is not available
-201	Invalid while in local	Command not executeable while device in local
-203	Measurement timeout	Measurement execution exceeded maximum time
-204	Channel not configured for measurement	Appropriate channel was not set up for the requested measurement
-205	Arming configuration conflict	External arm source inconsistent for start and stop within the same program message
-206	Measurement has not been initiated	Executed FETCh? without initiating measurement for new configurationtion
-207	Invalid totalize	Totalize on channel 2 (totalize on 1 or totalize 2 by 1)
-208	Value out of range	Calculated parameter outside allowed range
-209	Data clipped to limit	Entered parameter(s) outside of range - data truncated at limit
-212	ARM ignored	ARM:IMMediate set without being INITialized
-213	INIT ignored	Another measurement already in progress
-215	Arm deadlock	Attempted FETCh? while arming was in HOLD or BUS mode
-221	Setting Conflict	A valid command but not supported for the specified channel.
-222	Data out of range	Specified parameter value too large/small
-223	Too much data	Excess data for memory/device-specific process requirements

CODE	MESSAGE	CAUSE
-224	Illegal parameter value	Specified numeric value not allowed
-230	Data corrupt or stale	New measurement started but not completed since last access
-231	Data questionable	Measurement accuracy is suspect
-240	Hardware error	Execution error due to hardware fault
-241	Hardware missing	Option 010 or 030 not installed
-270	Macro error	Non-specific execution related macro error
-271	Macro syntax error	Illegal macro syntax entered
-272	Macro execution error	Macro execution error due to macro definition error
-273	Illegal macro label	Entered macro label not accepted by device
-274	Macro parameter error	Macro definition contains improperly used macro parameter
-276	Macro recursion error	Device found macro recursive
-277	Macro redefinition not allowed	Macro label already defined
-301	Exceeded shared memory	Allotted VXIbus shared memory space is full.
-310	System error	Non-specific system error has occurred
-331	Selftest failed; EPROM checksum failure	Specified hardware failed
-332	Selftest failed; RAM failure	Specified hardware failed
-333	Selftest failed; Clock 10 failed	Specified hardware failed
-334	Selftest failed; Front-end failed	Specified hardware failed
-335	Selftest failed; Calibration RAM failure	Specified hardware failed
-350	Too many errors	The error queue is full-more than 30 errors have occurred
-400	Query error	
-410	Query interrupted	Data not read from output buffer before another command was executed
-420	Query unterminated	Command generating data unable to complete due to configuration error
-430	Query deadlocked	Command cannot complete output due to controller request for input

C Keysight E1420B Command Summary

Introduction

This appendix provides summary tables for IEEE 488.2 Common and SCPI commands used with the Keysight E1420B Universal Counter. The Appendix is organized as follows:

Appendix Summary

Command Summary

This section summarizes both the IEEE 488.2 Common and Keysight E1420B SCPI (Standardized Commands for Programmable Instruments) commands in tabular format. IEEE 488.2 Common commands appear first followed by SCPI commands for the Keysight E1420B Universal Counter. The SCPI command summary also includes information about the SCPI status of the Keysight E1420B SCPI commands.

The SCPI (TMSL) commands used in the counter are in conformance with the SCPI Standard 1990.0. The counter's SCPI commands consist of the following:

- Applicable Common commands as defined in IEEE 488.2.
- Subsystem commands as defined (and listed) in the SCPI Standard. (These are the commands contained in Table C-2 as Std.)
- Subsystem commands designed for the counter in conformance with SCPI standards but currently not listed in the SCPI standard. (These are the commands contained in Table C-2 as New and may or may not be incorporated in future versions of SCPI.)

IEEE 488.2 Common Commands

Table C-1 lists the IEEE 488.2 Common commands implemented for the Keysight E4120A Universal Counter.

Table C-4 Common Command Summary

COMMAND	DESCRIPTION
*CLS	Clears the Status Byte Register, Standard Event Status Register, and error queue.
*DMC	Assigns a sequence of program elements to a Macro label.
*EMC	Enables/disables the execution of macros.
*EMC?	Returns the current enable/disable status of a macro.
*ESE	Enable events in Standard Event Status Register to be reported.
*ESE?	Returns the sum of all enabled bits in the Standard Event Status Register.
*ESR?	Returns the sum of all set bits in the Standard Event Status Register.
*GMC?	Returns the current definition of a macro.
*ION?	Returns identification string.
*LMC?	Returns the labels of all currently defined macros.
*OPC	Sets bit o in the Standard Event Status Register after all pending operations complete.
*OPC?	Returns ASCII "1" after all pending operations complete.
*PMC	Purges all currently defined macros.
*RCL	Recalls configuration previously stored via the *SAV command.
*RST	Resets the counter to a known power-on/reset status.
*SAV	Saves the current counter module configuration.
*SRE	Enable Status Register bits to assert SRQ.
*SRE?	Returns sum of enabled Status Byte register bits.
*STB?	Returns sum of all bits set in Status Byte Register. T
*TRG	riggers the counter.
*TST?	Executes the counter's internal self-test.
*WAI	Causes the counter to wait until all previous commands or queries complete.

SCPI Commands

Table C-2 lists the SCPI commands implemented for the Keysight E4120A Universal Counter.

Table C-5 SCPI Command Summary

KEYWORD/SYNTAX	PARAMETER FORM	CHANNEL NUMBER	SCPI STATUS
ABORt[1|2|3]		1,2,3	Std
ARM			Std
[:SEQuence[1]1:STARt!]			Std
:SEQuence21:STOP			Std
[:LAYer[1]]			Std
[:IMMediate]			Std
:LEVel	<valueiMINimumiMAXimumiDEFault>		Std
:LEVel?	[<MINimumiMAXimumiDEFault>]		Std
:SLOPe	<POSitiveiNEGative>		Std
:SLOPe?			Std
:SOURce	<EXTernal|IMMediate|BUS| HOLDIITLTrig<n»n= 0-7		Std
:SOURce?			Std
CONFigure(1|2|3]			Std
[:VOLTage]			Std
:AC	[<expected value>[,<resolution>]]	1,2	Std
:DC	[<expected value>[,<resolution>]]	1,2	Std
:FREQuency	[<expected value>[,<resolution>]]	1,2,3	Std
:RATio	[<expected value>[,<resolution>]]	1,2,3	New
:FTIMe			Std
-or-			
:FALL			
:TIME	[<lower reference>[,<upper reference> [,<expected value>[,<resolution>]]]]	1	Std
:MAXimum	[<expected value>[,<resolution>]]	1,2	Std
:MINimum	[<expected value>[,<resolution>]]	1,2	Std
:NWIDth	[<reference>[,<expected value> [,<resolution>]]]	1,2	Std
:PERiod	[<expected value>[,<resolution>]]	1,2,3	Std
:PWIDth	[<reference>[,<expected value> [,<resolution>]]]	1,2	Std
:RTIMe			Std
-or-			
:RISE			
:TIME	[<lower reference>[,<upper reference> [,<expected value>[,<resolution>]]]]	1	Std
:TINTerval	[<expected value>[.<resolution>]]	1	New
:TOTalize	[<expected value>[,<resolution>]]	1	New
CONFigure£11213]?			Std

Table C-2 SCPI Command Summary (continued)

<table>
<tr><th>KEYWORD/SYNTAX</th><th>PARAMETER FORM</th><th>CHANNEL NUMBER</th><th>SCPI STATUS</th></tr>
<tr><td>DIAGnostics</td><td></td><td></td><td>Std</td></tr>
<tr><td>:CAUbrate</td><td></td><td></td><td>New</td></tr>
<tr><td>:OFFSet?</td><td><BOTH></td><td></td><td>New</td></tr>
<tr><td>:FULLscale?</td><td><BOTH></td><td></td><td>New</td></tr>
<tr><td>:ASSembly</td><td></td><td></td><td>New</td></tr>
<tr><td>[:ALL]?</td><td></td><td></td><td></td></tr>
<tr><td>:A1?</td><td></td><td></td><td>New</td></tr>
<tr><td>:A2.?</td><td></td><td></td><td>New</td></tr>
<tr><td>:BLOCk</td><td></td><td></td><td>New</td></tr>
<tr><td>[:ALL]?</td><td></td><td></td><td>New</td></tr>
<tr><td>:CALRam?</td><td></td><td></td><td>New</td></tr>
<tr><td>:ROM?</td><td></td><td></td><td>New</td></tr>
<tr><td>:RAM?</td><td></td><td></td><td>New</td></tr>
<tr><td>:COUNtchain</td><td></td><td></td><td>New</td></tr>
<tr><td>[:ALL]?</td><td></td><td></td><td>New</td></tr>
<tr><td>:CONNector?</td><td></td><td></td><td>New</td></tr>
<tr><td>:INTerpolat?</td><td></td><td></td><td>New</td></tr>
<tr><td>:DINTerpolat?</td><td></td><td></td><td>New</td></tr>
<tr><td>:MRC?</td><td></td><td></td><td>New</td></tr>
<tr><td>:TIMebase?</td><td></td><td></td><td>New</td></tr>
<tr><td>:READ</td><td></td><td></td><td>New</td></tr>
<tr><td>:INT?</td><td><STS|SPS|STL|SPL|STARt|STOP|CAL|ALL></td><td></td><td>New</td></tr>
<tr><td>:MRC?</td><td><EREG|TREG|ALL></td><td></td><td>New</td></tr>
<tr><td>:UFAil[?]</td><td><OFF|O|ON|1> (N/A for Query)</td><td></td><td>New</td></tr>
<tr><td>FETCh[11213J</td><td></td><td></td><td>Std</td></tr>
<tr><td>[:<function>]?</td><td></td><td>1,2,31,2</td><td></td></tr>
<tr><td>INITiate[1j2j3)</td><td></td><td></td><td>Std</td></tr>
<tr><td>[:IMMediate]</td><td></td><td></td><td>Std</td></tr>
<tr><td>:CONTinuous</td><td><OFFIOIONI1></td><td></td><td>Std</td></tr>
<tr><td>:CONTinuous?</td><td></td><td></td><td>Std</td></tr>
<tr><td>INPut[1j2]</td><td></td><td></td><td>Std</td></tr>
<tr><td>:ATTenuation</td><td><value|MINimum|MAXimum|Default></td><td>1,2</td><td>Std</td></tr>
<tr><td>:ATTenuation?</td><td>[<MINimum|MAXimum|DEFault>]</td><td>1,2</td><td>Std</td></tr>
<tr><td>:COUPling</td><td><AC|DC></td><td>1,2</td><td>Std</td></tr>
<tr><td>:COUPling?</td><td></td><td>1,2</td><td>Std</td></tr>
<tr><td>:IMPedance</td><td><value|MINimum|MAXimum|DEFault></td><td>1,2</td><td>Std</td></tr>
<tr><td>:IMPedance?</td><td>[<MINimum|MAXimum|DEFault>]</td><td>1</td><td>Std</td></tr>
<tr><td>:ROUTe</td><td><COMMon|SEParate></td><td>1,2</td><td>New</td></tr>
<tr><td>:ROUTe?</td><td></td><td></td><td>New</td></tr>
</table>

Table C-2 SCPI Command Summary (continued)

KEYWORD/SYNTAX	PARAMETER FORM	CHANNEL NUMBER	SCPI STATUS
MEASure[1l2l3]			Std
[:VOLTage]			Std
:AC?	[<expected value>[,<resolution>]]	1,2	Std
:DC?	[<expected value>[,<resolution>]]	1,2	Std
:FREQuency?	[<expected value>[,<resolution>]]	1,2,3	Std
:RATio?	[<expected value>[,<resolution>]]	1,2,3	New
:FTIMe?			Std
-or-			
:FALL			
:TIME?	[<lower reference>[,<upper reference>	1	Std
	[,<expected value>,[<resolution>]]]]		
:MAXimum?	[<expected value>L<resolution>]]	1,2	Std
:MINimum?	[<expected value>[,<resolution>]]	1,2	Std
:NWIDth?	[<reference>[,<expected value> [,<resolution>]]]	1,2	Std
:PERiod?	[<expected value>[,<resolution>]]	1,2,3	Std
:PWIDth?	[<reference>[,<expected value> [,<resolution>]]]	1,2	Std
:RTIMe?			Std
-or-			
:RISE			
:TIME?	[<lower reference>[,<upper reference>	1	Std
	[,<expected value>[,<resolution>]]]]		
:TINTerval?	[<expected value>[,<resolution>]]	1	New
MEMory			
:VME:ADDRess	<address>		New
:VME:ADDRess?	[MINimum!MAXimum]		New
:VME:SIZE	<bytes>		New
:VME:SIZE?	[MINimum!MAXimum]		New
:VME:STATe	<OFF|O, ON|1>		New
:VME:STATe?			New
OUTPut			Std
:TTLTrg<n> n= 0-7		Backplane	Std
[:STATe)	<OFF|O|ON|1>	Trigger Lines	Std
[:STATe]?			Std
:ROSCillator		lnt/Ext	New
[:STATe]	<OFF|O|ON|1>	Reference	New
[:STATe]?			New
READ[1l213]			Std
[:<function>]?		1,2,3	

Table C-2 SCPI Command Summary (continued)

KEYWORD/SYNTAX	PARAMETER FORM	CHANNEL NUMBER	SCPI STATUS
[SENSe[11213]]			Std
:AVERage		1,2	New
[:STATe]	<0FFIOIONI1>		New
[:STATe]?			New
:COUNt?			New
:EVENt		1,2	New
:LEVel			New
[:ABSolute]	<Value|MINimum|MAXimum|DEFault>		New
[:ABSolute]?	[<MINimum|MAXimum|DEFault>]		New
:AUTO	<OFF|0|ON|1|ONCE>		New
:AUTO?			New
:RELative	<Value|MINimum|MAXimum|DEFault>		New
:RELative?	[<MINimum|MAXimum|DEFault>]		New
:SLOPe	<POSitive|NEGative>		New
:SLOPe?			New
:HYSTeresis	<MINimum|MAXimum|DEFault>		New
:HYSTeresis?			New
:FREQuency			Std
:APERture	<Value|MINimum|MAXimum|DEFault>	1,2,3	Std
:APERture?	[<MINimum|MAXimum|DEFault>]	1,2,3	Std
:RANGe		1	Std
[:UPPer]	<value|MINimum|MAXimum|DEFault>		Std
[:UPPer]?	[<MINimum|MAXimum|DEFault>]		Std
:AUTO	<OFF|0|ON|1>		Std
:AUTO?		1,2	Std
:FUNCtion	"[VOLTage:]AC"	1,2	Std
	"[VOLTage:]DC"	1,2,3	Std
	"[VOLTage:]FREQuency"	1,2,3	Std
	"[VOLTage:]FREQuency:RATio"	1	New
	"[VOLTage:]FTIMe"	1	New
	"[VOLTage:]FALL:TIME"	1,2	New
	"[VOLTage:]MAXimum"	1,2	New
	"[VOLTage:]MINimum"	1,2	New
	"[VOLTage:]NWIDth"	1,2,3	New
	"[VOLTage:]PERiod"	1,2	New
	"[VOLTage:]PWIDth"	1	New
	"[VOLTage:]RTIMe"	1	New
	"[VOLTage:]RISE:TIME"	1,2	New
	"[VOLTage:]TINTerval"	1,2	New
	"[VOLTage:]TOTalize"	1,2,3	New
:FUNCtion?			Std
:PERiod			New
:APERture	<Value|MINimum|MAXimum|DEFault>	1,2,3	New
:APERture?	[<MINimum|MAXimum|DEFault>]	1,2,3	New

Table C-2 SCPI Command Summary (continued)

<table>
<tr><th>KEYWORD/SYNTAX</th><th>PARAMETER FORM</th><th>CHANNEL NUMBER</th><th>SCPI STATUS</th></tr>
<tr><td>[SENSe[1|2|3]] (continued)</td><td></td><td></td><td></td></tr>
<tr><td>:RATio</td><td></td><td></td><td>New</td></tr>
<tr><td>:APERture</td><td><Value|MINimum|MAXimum|DEFault></td><td>1,2,3</td><td>New</td></tr>
<tr><td>:APERture?</td><td>[<MINimum|MAXimum|DEFault>]</td><td>1,2,3</td><td>New</td></tr>
<tr><td>:ROSCillator</td><td></td><td></td><td>Std</td></tr>
<tr><td>:SOURce</td><td><INTernal|EXTernal|CLK10></td><td>Int/Ext</td><td>New</td></tr>
<tr><td>:SOURce?</td><td></td><td>Reference</td><td>New</td></tr>
<tr><td>:TINTerval</td><td></td><td></td><td>New</td></tr>
<tr><td>:DELay</td><td></td><td></td><td>New</td></tr>
<tr><td>[:STATe]</td><td><OFF|0|ON|1></td><td></td><td>New</td></tr>
<tr><td>[:STATe]?</td><td></td><td></td><td>New</td></tr>
<tr><td>:TIME</td><td><value|MINimum|MAXimum|DEFault></td><td></td><td>New</td></tr>
<tr><td>: TIME?</td><td>[<MINimum|MAXimum|DEFault>]</td><td></td><td>New</td></tr>
<tr><td>:TOTalize</td><td></td><td></td><td>New</td></tr>
<tr><td>:GATE</td><td></td><td></td><td>New</td></tr>
<tr><td>[:STATe]</td><td><OFF|0|ON|1></td><td></td><td>New</td></tr>
<tr><td>[:STATe]?</td><td></td><td></td><td>New</td></tr>
<tr><td>:POLarity</td><td><NORMal|INVerted></td><td></td><td>New</td></tr>
<tr><td>:POLarity?</td><td></td><td></td><td>New</td></tr>
<tr><td>:SOURce?</td><td></td><td></td><td>New</td></tr>
<tr><td>STATus</td><td></td><td></td><td>Std</td></tr>
<tr><td>:OPERation</td><td></td><td></td><td>Std</td></tr>
<tr><td>:CONDition?</td><td></td><td></td><td>Std</td></tr>
<tr><td>:ENABle</td><td><value>|<non-decimal numeric></td><td></td><td>Std</td></tr>
<tr><td>:ENABle?</td><td></td><td></td><td>Std</td></tr>
<tr><td>[:EVENt]?</td><td></td><td></td><td>Std</td></tr>
<tr><td>:QUEStionable</td><td></td><td></td><td>Std</td></tr>
<tr><td>:CONDition?</td><td></td><td></td><td>Std</td></tr>
<tr><td>:ENABle</td><td><value>|<non-decimal numeric></td><td></td><td>Std</td></tr>
<tr><td>:ENABle?</td><td></td><td></td><td>Std</td></tr>
<tr><td>[:EVENt]?</td><td></td><td></td><td>Std</td></tr>
<tr><td>:PRESet</td><td></td><td></td><td>Std</td></tr>
<tr><td>SYSTem</td><td></td><td></td><td>Std</td></tr>
<tr><td>:ERRor?</td><td></td><td></td><td>Std</td></tr>
<tr><td>:PIMacro</td><td><string></td><td></td><td>New</td></tr>
<tr><td>:VERSion?</td><td><string></td><td></td><td>Std</td></tr>
</table>

D Using Option 040-High Throughput/Shared RAM

Introduction

This appendix provides information for using Option 040, High Throughput/Shared RAM. The option is briefly explained followed by an example program (Keysight BASIC) for Frequency measurements. Specific information for the memory subsystem commands is contained in the MEMory Subsystem command reference in chapter 5. The topics covered are:

Appendix Summary

Keysight E1420B Shared Ram Description

These paragraphs briefly describe how Option 040 works with the counter and any available VXIbus Shared RAM. The discussion mentions the SCPI commands that are used to configure the RAM and control its access. These commands are described in greater detail in chapter 5 as the MEMory Subsystem.

Figure D-1 illustrates the VXIbus shared RAM model for the Keysight E1420B. The VXIbus shared RAM is the portion of memory labeled VME A24. During normal operation MEMory:VME:STATE is set OFF. The counter acquires measurements that are stored locally in the VME A16 address space.

When shared RAM is enabled (MEMory:VME:STATe ON), a copy of each measurement result is stored in two places: the VME A24 space (every new measurement result incrementing to a new address) and in the counter's local memory as well. This VME A24 memory area is 12 megabytes wide and is accessible to all VMENXIbus instruments.

Because shared RAM is not specifically supported by the VME/VXIbus standards, each application program that uses it must also contain correct memory configuration statements and optimal parameters. These will ensure that proper memory management occurs with no instances of memory contention.

When these conditions are met and memory management has been optimized, the Keysight E1420B operates identically as when shared RAM is absent. Measurements can still be FETCh-ed with shared RAM enabled and a current value will be retained. There is one exption: the behavior of *OPC in CONTinuous mode.

During CONTinuous mode, the operation complete flag is set when the allocated shared RAM runs out (determined by MEM:VME:SIZE). The total number of measurements captured in shared RAM is equal to the set size (MEMory:VME:SIZE <Value>) divided by 8. During CONTinuous mode, the E1420B will loop back to the starting address location in shared RAM when the entire available memory space (#HC00000) has been allocated to the E1420B and is completely filled with measurement data.

Maximum throughput for a given gate time can be obtained at the expense of some accuracy by calibrating the counter only once before the block measurement begins. You can do this by configuring the counter for the frequency or time interval measurements with "MIN'' as a resolution parameter; for example,

"CONF:FREQ DEF,MIN"

Selecting any other resolution will cause the counter to behave normally -calibrating the interpolators before every measurement in the block. Throughput reduces from 140 meas/sec (1 msec gate time) to 110 meas/sec (1 msec gate time) for frequency measurements.

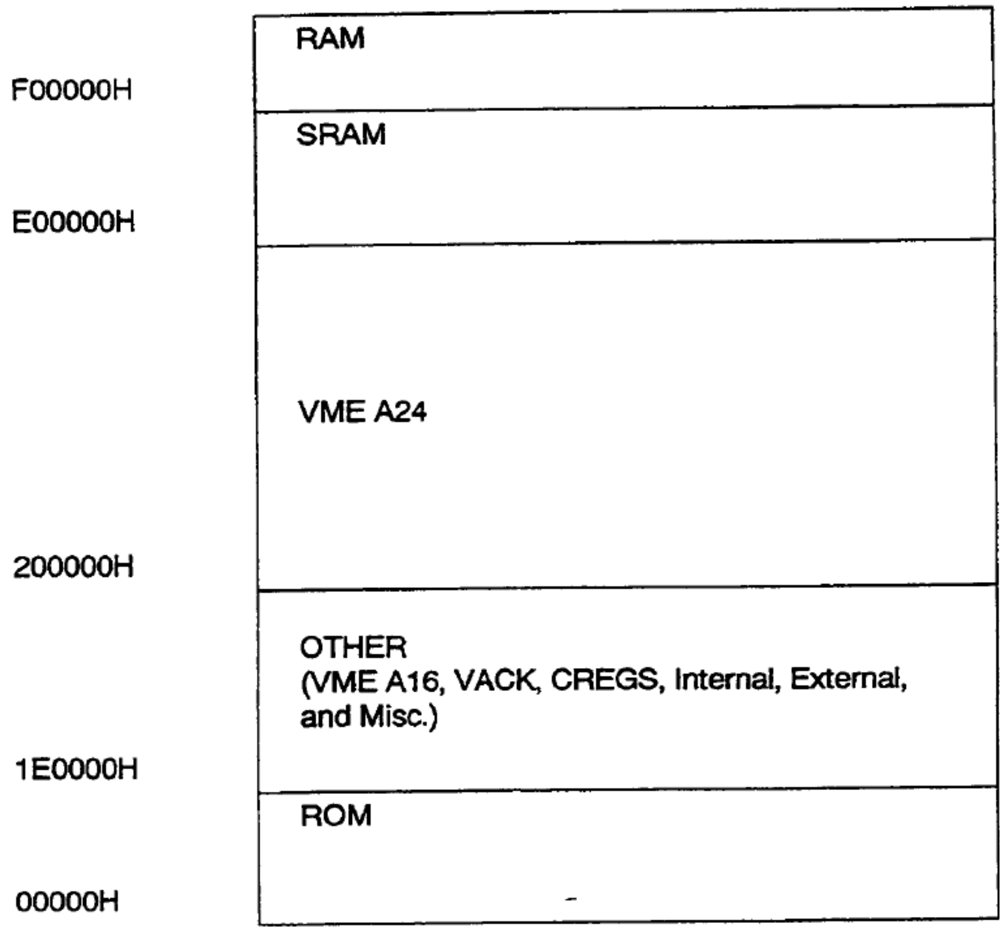


Figure D-4 VXIbus Shared Memory Model Address Space

NOTE

The programs included at the end of this section are provided "as is". These programs are intended for example only on the use of Shared Memory. Support of these programs is limited (see WARRANTY, paragraph 3, on the inside front cover). Some library files needed to actually run the "C" program example may not be shown here, and are not available.

Shared Memory Programming

The procedure and programs listed here will make frequency high-throughput burst measurements that utilize shared memory. The programs are in Keysight BASIC and ''C", requiring the same hardware and software described in previous chapters. The Shared memory Set-up procedure prepares your hardware for the example program and can also be used to set up your counter for programs that you create.

Shared Memory Set-up Procedure

PREPARATION

1. Set all I/0 paths and data variables

2. Reset the counter: "*RST''

3. Obtain the current shared memory address and available size:

   "MEM:VME:ADDR?"
   enter variable

   "MEM:VME:SIZE?"
   enter variable

4. Enable external VME memory: "MEM:VME:STAT ON'

INITIATE MEASUREMENTS

1. Check that #Measurements does not exceed available memory size divided by 8 to avoid memory contention.

2. Configure the counter to make a measurement:

   "CONF:FREQ DEF,MIN"

3. Initiate continuous measurements:

   ''INIT:CONT ON"

4.Check for an Operation Complete indication:

   "*OPC?"

RETRIEVE DATA

1. If desired, the data can be read from shared memory to the controller, or can reside in shared memory to be accessed by other instruments on the bus.

2. For command descriptions and sample program examples, refer to the User's Manual for the Command Module being used, for example, the Keysight E1405B.

NOTE The Keysight 1405B command functionality is required tor the example programs shown. The Keysight 1405A command module will not support shared RAM.

Keysight BASIC Example Program

```
10 ! Program Example : Enabling Shared RAM for Option 040
20 ! AI 10/3/91 BP BASIC 5.13
30 !
40 ! The purpose of this example program is to demonstrate the
50 ! E1420B's use of the shared memory of an E1405B slot-0 controller.
60 !
70 ! 100 Frequency measurements are taken continuously and stored
80 ! in the A24 Shared memory space of the E1405B. The size of memory allocation
90 ! is specified to be 800 bytes. When all measurements have been stored,
100 ! the *OPC? query will return a '1', indicating operation complete status.
110 !
120 ! Although this example was created using an external controller,
130 ! the real advantages of shared memory are maximized when used in
140 ! conjunction with an embedded controller, such as the BP V/360.
150 !
160 ASSIGN @E1405b TO 70900;EOL CBR$(10) END   ! Open a path @E1405B between the
165                                           ! computer and the Command Module,
170                                           ! specifying the Line Feed (LF) and EOI
175                                           ! as the EOL sequence
180 ASSIGN @Speed TO 70900;FORMAT OFF         ! Open a data transfer path
190 ASSIGN @E1420b TO 70906;EOL CBR$(10) END   ! Open a path @E1420B between the
195                                           ! computer and the counter
200 OUTPUT @E1405b;''*RST"                    ! Reset the command module to its
default
205                                           ! state
210 OUTPUT @E1420b;"*RST"                     ! Reset the counter to its default
state.
220                                        ! Default setting is MEM:VME:ADDR #8200000
230 OUTPUT @E1420b;"MEM:VME:ADDR?"            ! Query counter to return the first
235                                           ! available shared memory address
240 ENTER @E1420b;Addr                        ! Return memory address
250 PRINT "The first available Shared VME A24 Memory Address Location is : ",Addr
260 OUTPUT @E1420b;"MEM:VME:SIZE 800"         ! sets the shared memory size to 800
```

```
265                                            ! bytes, or 100 measurements
270 OUTPUT @E1420b;"MEM:VME:STAT ON"      ! Enable use of external VME memory
275                                            ! from the starting address
280 OUTPUT @E1420b;"CONF:FREQ DEF,MIN"         ! set up the counter for a frequency
285                                            ! measurement with "MIN" resolution
290                                            ! selects a minimum gate time
300 Starttime=TIMEDATE
310 OUTPUT @E1420b;"INIT:CONT ON"           ! Initiate the counter to make continuous
315                                            ! measurements
320 OUTPUT @E1420b;"*OPC?"                     ! Query the counter for an operation
325                                            ! Complete indication
330 ENTER @E1420b;Complete                     ! A '1' is returned if the measurements
335                                            ! are completed
340 Stoptime=TIMEDATE
350 Deltat=Stoptime-Starttime                  ! Timestamp the measurement throughput
360 PRINT "Time elasped = ",Deltat
370 PRINT "OPC COMPLETE STATUS = ",Complete
380 PRINT ""
390 PRINT "Measurements from Shared RAM:"
400 Start read:                                ! Read back data from the E1405B
410 DIM lfdig$[1],Count$[9],Data(1:100)
420 OUTPUT @E1405b;"DIAG:UPL?";Addr,800     ! Request the data + header from the
425                                         ! shared RAM
430 ENTER @Speed USING "#,X,K,K";Ndig$;Count$[1;VAL(Ndig$)]
440 ! Extract the data header from the
445 ! measurement block
450 ENTER @Speed;Data(*)                  ! Transfer measurements to Data array
460 PRINT Data(*)                         ! Print each measurement from Shared RAM
470 OUTPUT @E1420b;"INIT:CONT OFF"        ! Turn off continuous measurements
480 END
```

"C" Example Program

```
#include "shared mem.h"/* constant definitions and other */
/* include files. */
/***************************************************************
* int open_vxi()
*
* This routine requires a logical address (integer) as an input.
* It returns the file descriptor of the device at logical address
* lad.
* The Master vxi device is first opened for reading and writing
* and a servant is subsequently selected at logical address lad.
* The vxi structures that are represented here are required to
* be used with the VIXEN drivers.
****************************************************************
*/
int open vxi(lad)
int lad;-
{
int g fd;
int ret;
vxi_ctl_status vxi_control;
g_fdopen("/dev/vxilprimary",O_RDWR);
if (g_fd == -1)
{
/* open vxi backplane interface */
perror("open: ldevlvxilprimary failed\n");/* report error */
exit(-1);
}

vxi_control.type = VXI_TIMEOUT;
vxi_control.arg[O] = 0;
ret= ioctl(g fd,VXI CONTROL,&vxi control);
if (ret == -1)---
{
perror(•ioctl: open_vxi: a\n");
exit(-1);
}vxi_control.type = VXI_ABET;
vxi_control.arg[O] = 7;
```

```
ret= ioctl(g fd,VXI CONTROL,&vxi control);
if (ret == -1)---
{
perror(•ioctl: open_vxi: b\n");
exit(-1);
}vxi_control.type = VXI_END;
vxi_control.arg[O] = 1;
ret = ioctl(g_fd,VXI_CONTROL,&vxi_control);
if (ret == -1)
{
perror("ioctl: open_vxi: c\n");
exit(-1);
}vxi_control.type = VXI_SELECT_SERVANT;
vxi_control.arg[O] = lad;

/* set an infinite timeout for */ /* VXI transaction */
/* report error *//* set the access bus error */ /* timer to 1.1 sees */
/* report error */
/* Set the END bit in the last */
/* byte available word serial */
/* command sent to the servant */
/* using the write() command*/
/* report error */
/* Specify that all future */
/* read() and write() system */
ret = ioctl(g_fd,VXI_CONTROL,&vxi_control); /* calls should talk to the */
if (ret == -1)
{
perror("ioctl: open_vxi: d\n");
exit(-1);
}
/* servant specified by lad *//* report error */

vxi_control.type

VXI MAP SHARED;

/* map address 200000h to the*/
vxi_control.arg[O] = o:X2ooooo;
```

```
vxi_control.arg[1] = 0;
/* current users memory space */
/* No offset */
vxi_control.arg[2]1;
/* size to be mapped = 64k */

D-6 Using Option 040-High Throughput/Shared RAM
ret ioctl(g_fd,VXI_CONTROL,&vxi_control);
if (ret -1)
{
perror ("ioctl: open_vxi: f\n");
exit (-1);
}
/* report error *//* report the starting address*/
/* for shared memory */
printf ("Actual content memory mapped %d\n",vxi_control.arg[O]);return g_fd;/* return
file descriptor */
}/*
*****************************************************************
* main()
* This is the main routine that gets invoked. It calls open_vxi
* and takes two input arguments: logical address and number of
* iterations. Once the device driver is successfully opened it
* proceeds to make <iterations> number of regular frequency
* measurements and 100 shared memory measurements. The number of
* shared memory measurements can be modified by changing the size
* parameter in the command mem:vme:size <size> in shared mem.h
*****************************************************************
*/main(argc, argv)
int argc;
char ** argv;
{
char input_str[1000][100];
char in_input[l];int num meas,num meas store;
int g_fd;/* Eli20 file discriptor */
int lad;/* logical address */
int ret;vxi ctl status vxi_control;
double *p;
p  ox200000;/* set a pointer to the starting */ /* address in shared memory */
```

```
if (argc < 2)
{
/* Check for input arguments */
printf("%s: usage\n%s <logical address> <iterations>\n",argv[OJ, argv[O]);
exit(l);
}ladatoi(argv[l]);/* convert argument 1 to integer */

g_fd open_vxi(lad);
if (g_fd == -1)
{

/* open the vxi device at logical */ /* address lad */
exit(l);/* exit if error */
}

if ( argc < 3 )
{
printf("enter number of measurements retgets(input_str );
if ( ret NULL)

/* Check if less than 3 input arguments */
/* print message */
desired ( 100 maximum)\n");
/* get the input string */
{
perror("No measurements requested'\n");/* report error */
}
}
else
{
retstrcpy(input_str, argv[2]);/* If not record the third argument */
}Using Option 040 - High Throughput/Shared RAM D-7

num_meas = atoi( input_str );
num_meas_storenum_meas;
/* convert it to integer */

write(g_fd,RST,strlen(RST)); write(g_fd,CLS,strlen(CLS));
write(g_fd,ROSC,strlen(ROSC));write(g_fd,OUTP,strlen(OUTP));
```

```
/* send a '*rst' to the card */ /* send a '*cls' to the card */
/* configure oscillator for TCXO */
/* 'rosc:sour int' */
/* configure card to source the */
/* oscillator out. 'outp:rosc on' */

write(g_fd,CONF,strlen(CONF));write(g_fd,APER,strlen(APER));write
(g_fd,ABORT,strlen(ABORT));
write(g_fd,ON_INIT,strlen(ON_INIT));
/* configure card for a frequency */ /* measurement. •conf:freq def,def */ /* set
aperture to min gate time */
/* 'freq:aper min */
/* 'abort' any previous measurement */ /* set continuous measurements on */
/* init:cont on */

/* configure the shared memory size for 100 readings */
write(g_fd,VME_MEM_SIZE,strlen(VME_MEM_SIZE)); /* 'mem:vme:size 800' */
/* Set shared memory on: 'mem:vme:state on' */
write(g_fd,VME_MEM_STATE_ON,strlen(VME_MEM_STATE_ON)};
num_meas = num_meas_store;

while (num_meas- >0)
{
/* Clear out memory */
*p = 0.0;
p++;
}
write(g_fd,CONF,strlen(CONF)); write(q_fd,APER,strlen(APER});
write(g_fd,ABORT,strlen(ABORT));
write(g_fd,ON_INIT,strlen(ON_INIT));write(g_fd,OPC_Q,strlen(OPC_Q));read(g_fd,in_input
,l);
printf("%s\n", in_input);write(g_fd,OFF_INIT,strlen(OFF_INIT));

/* send a *ope? to the card */
/* read returned value */
/* All 100   readings are done */
/* turn init:cont off */
}
```

D-11. Include File listing:

```
#include "/usr/include/sys/vxi.h"
#include <time.h>
#include <math.h>
#include <stdio.h>
#include <string.h>
#include <stdlib.h>
#include <sysltimes.h>
#include <sysltypes.h>
#include <syslstat.h>
#include <fcntl.h>
#include <syslparam.h>

#define ABORT "abort"
#define CLS "*cls"
#define RST "*rst"
#define TERM STR "end"
#define QUESTION "?"
#define QUOTE "\"
#define SPACE " "
#define RETURN "\n"
#define ROSC "rosc:sour int"
#define OUTP "outp:rosc on"
#define CONF •conf:freq def,def"
#define APER "freq:apern"
#define ON INIT "init:cont on"
#define OFF INIT "init:cont off"
#define FETCH_Q "fetch?"
#define OPC_Q "*Opc?"
#define IDN_Q "*idn?"

#define ARM_EXT "arm:sour ext"
#define ARM IMM "arm:sour imm"
#define VME-MEM STATE ON •mem:vme:state on"
#define VME-MEM-SIZE Q "mem:vme:size?"
#define VME-MEM-SIZE-"mem:vme:size 800"
#define VXISEND-"/usr/vxi/bin/vxisend "
#define VXIRCV "/usrlvxi/bin/vxircv "
```

E Backdating

Introduction

This appendix contains information necessary to adapt this manual to apply to older instruments.

Manual Changes

This manual applies directly to Keysight E1420B's with serial prefix 3401A and above.As engineering changes are made, newer instruments may have serial prefix numbers higher than the one shown on the title page of this manual. The manuals for these instruments will be supplied with a "Manual Updating Changes" package containing the required information. Replace the affected pages or modify existing manual information as directed in the pages of the Manual Updating Changes package. Contact the nearest Hewlett-Packard Sales and Support Office.

Older Instruments

All E1420B Universal Counters have the same hardware configuration. Firmware B3.00 and B3.40 shipped before the present firmware (3401) has a few programming errors and anomalies. Revision 3401corrects the programming errors and anomalies. It also adds new features not found in earlier versions. Modification kits are available for upgrading earlier units while in warranty (See table below for part numbers).

Table E-1 E1420B Part Changes

PART DESCRIPTION	INSTRUMENT SERIAL NUMBER			
		3142A00171 & up	3142A00456 & up	3401A00746 & up
Disc, Basic 3.5"	E142Q-13501	E142Q-13501	E142Q-13503	E142Q-13505
Disc, Basic 5.25"	E142Q-13502	E142Q-13502	E1420-13504	E1420-13506
A1 Motherboard, Std	E1420-60008	E142Q-60012	E1420-60016	E142Q-60020
A1 Exchange	E142Q-69008	E142Q-69012	E1420-69016	E142Q-69020
A1TCXO	E142Q-60009	E142Q-60013	E142Q-60017	E142Q-60021
A1 TXCO Exchange	E142Q-69009	E1420-69013	E1420-69017	E142Q-69021
A1 Motherboard, Opt 040	E142Q-60010	E142Q-60014	E1420-60018	E142Q-60022
A1 Opt 040 Exchange	E142Q-69010	E142Q-69014	E1420-69018	E142Q-69022
EPROM,A1U2	E142Q-80007	E142Q-80015	E142Q-80023	E142Q-80031
EPROM, A1U13	E142Q-80008	E1420-80016	E1420-80024	E1420-80032
EPROM, A1U12, Opt040	E142Q-80009	E1420-80017	E142Q-80025	E142Q-80033
EPROM, A1U13, Opt 040	E142Q-80010	E142Q-80018	E142Q-80026	E1420-80034
Upgrade Kit, Standard				E142Q-67004
Upgrade Kit, Option 040				E142Q-67005

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