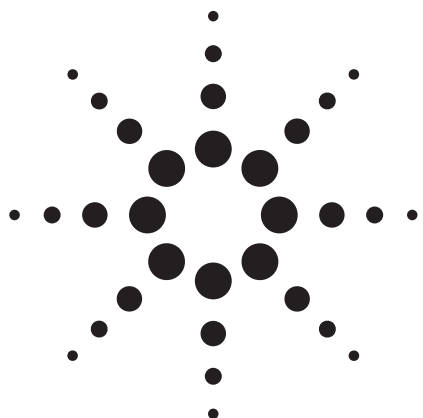




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Agilent EPM Series

437B and 438A Compatibility

Application Note



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Table of Contents

3	1. Introduction
3	2. Physical Compatibility
3	3. Sensor Compatibility
4	4. Language Compatibility
4–5	4.1 Zeroing and calibrating
6	4.2 Measurement mode selection
6	4.3 Range hold and manual ranging
7	4.4 Limits
7	4.5 Filter
7	4.6 Duty cycle, window offsets, sensor calibration tables, and frequency dependent offset tables
8	4.7 Channel offsets for the E4419A/B dual channel power meter
8	4.8 Preset
8	4.9 Measurement errors
9–10	4.10 Using the Agilent E-series power sensors
11	4.11 Recorder output
11–12	4.12 Extensions to the 437B/438A command set
12	4.13 Must calibrate/zero
13	4.14 Sources and Analyzers
13	4.15 Programming with Agilent VEE
14	5. Known Problems
15	6. Summary
16–17	Appendix A: 437B Command Summary
18–19	Appendix B: 438A Command Summary

1. Introduction

The Agilent Technologies EPM series power meters, introduced in 1997, are the successors to the 43X family of power meters.

The power meters in the Agilent EPM series are:

- E4418A/B single channel power meter
- E4419A/B dual channel power meter.

Due to the large installed base of 437B and 438A power meters, compatibility with these instruments was a high priority in the design of the EPM series. With 437B and 438A language compatibility modes, existing customers can replace their older power meters with the new EPM series power meter with minimal software rework effort. However, there are a few issues that users may encounter. The information given in this application note should help to resolve these issues.

2. Physical Compatibility

A large number of 437B and 438A power meters are used in Automated Test Equipment (ATE) environments. In order to substitute the EPM series power meters in an ATE system or rack, the EPM series has been designed to fit into the same rack space as the 437B and 438A. For this reason, the EPM series power meters are the same width (212.6 mm; 8.5 in) and height (88.5 mm; 3.5 in) as both the 437B and the 438A. Because the 437B is shorter than the 438A, it was decided that the depth of the EPM series power meters would be 348.3 mm (13.7 in), this being midway between the 437B and the 438A depth dimensions. Generally, it is the rack height and width that are the main constraining factors for instruments, so this compromise in the depth dimension should not affect the majority of ATE users. As with the 437B and 438A, there are rackmount kits available for the EPM series power meters (Options 908 and 909).

3. Sensor Compatibility

The 437B and 438A power meters operate with the Agilent 8480 series of power sensors, measuring signals from 100 kHz to 110 GHz. The EPM series also works with the entire range of 8480 series sensors and with the new Agilent E-series power sensors. The E-series sensors cannot be used with 437B or 438A power meters.

4. Language Compatibility

The Agilent E4418A/B with 437B language compatibility mode selected can systematically replace a 437B power meter in an existing application. Similarly the E4419A/B can replace the 438A power meter. Please note that the E4419A must have firmware revision A.02.02 or higher in order to have 438A language compatibility. The main advantages gained by using the language compatibility modes are:

- re-use of current system software
- increased measurement speed: the EPM series have a “x2 mode” which provides twice the measurement speed compared to the 437B/438A and 8480 series sensor combination.
- use of new E-series sensor range. These are wide dynamic range sensors with sensor calibration factors stored in EEPROM, for CW applications.

In general, the EPM series power meters should be a “drop-in” replacement for the 437B or 438A. However there are various issues that should be considered, especially with software that has assumed or made use of delays and features inherent to the 437B or 438A. The following sections offer advice for situations where using the EPM series power meter as a replacement for the 437B/438A has not been fully straightforward. For clarity, the programming examples are in BASIC. It is assumed that the user is familiar with the 437B/438A command sets.

4.1 Zeroing and calibrating

After sending the zero or calibrate commands, it is best to check either the status register or status message to determine when this process has completed. Using a fixed delay period is not recommended.

```
100 OUTPUT @Pm;"ZE"           ! Avoid this technique
110 WAIT 10
```

```
200 OUTPUT @Pm;"CL100EN"      ! Avoid this technique
210 WAIT 5
```

Instead consider :

**For E4418A/B single channel power meter
(437B language):**

```
100 OUTPUT @Pm;"CS;ZE"        ! Clear status register and
                                initiate zero
110 IF (BIT(SPOLL(@pm),1)=0)    ! Wait until zero completes
    THEN GOTO 110              (status-reg bit 1 set)

200 OUTPUT @Pm;"CS;CL100EN"    ! Clear status register
                                and calibrate
210 IF (BIT(SPOLL(@pm),1)=0)    ! Wait until cal completes
    THEN GOTO 110              (status-reg bit 1 set)
```

Or:

```

100 OUTPUT @Pm;"CS;ZE"      ! Clear status register and
                             initiate zero
110 OUTPUT @Pm;"SM"          ! Request status message
120 ENTER @pm;$Message
130 IF $Message[5,6] = "06"   ! Wait until zero completes
    THEN GOTO 110             (06 means zeroing)

200 OUTPUT @Pm;"CS;CL100EN" ! Clear status register and
                             calibrate
210 OUTPUT @Pm;"SM"          ! Request status message
220 ENTER @pm;$Message
230 IF $Message[5,6] =       ! Wait until cal completes
    "08" THEN GOTO 210       (08 means calibrating)

```

For E4419A/B dual channel power meter**(438A language):**

```

100 OUTPUT @Pm;"CS;AE;ZE"   ! Clear status register and
                             initiate channel A zero
110 IF (BIT(SPOLL(@pm),1) = 0) ! Wait until zero completes
    THEN GOTO 110             (status-reg bit 1 set)
200 OUTPUT @Pm;              ! Clear status register and
    "CS;AE;CL100EN"          calibrate ChA
210 IF (BIT(SPOLL(@pm),1)=0) ! Wait until cal completes
    THEN GOTO 110             (status-reg bit 1 set)

```

Or:

```

100 OUTPUT @Pm;"CS;AE;ZE"   ! Clear status register and
                             initiate channel A zero
110 OUTPUT @Pm;"SM"          ! Request status message
120 ENTER @pm;$Message
130 IF $Message[5,6] = "06"   ! Wait until zero completes
    THEN GOTO 110             (06 means ChA zeroing)

200 OUTPUT @Pm;              ! Clear status register and
    "CS;AE;CL100EN"          calibrate ChA
210 OUTPUT @Pm;"SM"          ! Request status message
220 ENTER @pm;$Message
230 IF $Message[5,6] = "08"   ! Wait until cal completes
    THEN GOTO 210             (08 means ChA calibrating)

```

Another method is to set the status register mask such that an SRQ will be generated when the zero or calibration is completed.

4.2 Measurement mode selection

The 437B and 438A have certain delays associated with measurement mode changes and auto ranging. Some software may have made use of this feature to allow, for example, some other instrument to settle before triggering the power meter. Such assumptions cannot be made for the Agilent EPM series power meters, as they are much faster and more responsive. A typical scenario for the E4419A/B dual channel power meter is discussed below.

100	! The power meter is currently measuring Channel A and Channel B is connected to the output of a signal generator.
110	!
120 OUTPUT @Pm;"BP"	! Select measurement Channel B
130 OUTPUT @Sg; "LEVEL -10DBM"	! Set signal generator output level to -10dBm
140 OUTPUT @Pm;"TR2"	! Trigger power meter
150 ENTER @Pm;\$POWER	! Read measured power

In this example, the response time of 438A may well have been sufficient to allow the source output level to settle before triggering the power meter. However, as the E4419A/B is much more responsive than the 438A, it is almost certain that in this situation the E4419A/B would have triggered before the source had settled. Consequently, the wrong result would be returned. This method is therefore not recommended. Instead consider a settling delay after line 130 (this, of course, will be instrument dependent) or read the status back from the source and hold until the level has settled.

4.3 Range hold and manual ranging

When using the 8480 series sensors, the EPM series power meter has effectively one range. The 437B, for example, has 5 ranges when used with the 8480 series sensors. This means that when using 437B or 438A language, both the range hold and manual range selection commands are meaningless to the EPM series power meter. These range commands are accepted but will have no effect. As the EPM series power meter is always in auto range, the status message fields for the attached sensor(s) will be set to 11 (auto range mode and in range 1) at all times. Manual ranging in the 437B and 438A is invariably used to obtain faster measurement speed as the up/down range switching associated with auto ranging is inhibited. Software using manual ranging may require modification, especially if it is making decisions based on the status message of the sensor range fields. The simplest cure is to remove all references to manual ranging, as the EPM series power meter will perform more than satisfactorily, in terms of measurement speed, in auto range.

Note: The ranging commands do have implications when the E-series of power sensors are being used. This is discussed later in section 4.10, "Using the Agilent E-series power sensors."

4.4 Limits

The over and under limits checking functions used in the 438A perform exactly the same way in the E4419A/B. The only function that the E4419A/B does not support is the “over high limit” and “under low limit.” This is because the E4419A/B does not allow the high limit threshold to be less than the lower limit threshold, which this particular function requires. Software using this feature will require a work around.

The 437B and 438A allow upper and lower limits of +/-299.99 dBm while the EPM series power meter restricts the lower limit to -150 dBm and the upper limit to +230 dBm. Entries out of this range will be accepted but truncated.

After a remote preset, the low limit will be set to -0.001 dBm and the upper limit to 0.0 dBm.

4.5 Filter

The digital averaging filter in the EPM series power meter ranges from 1 to 1024, while the maximum averaging on the 437B and 438A is 512. Using 437B/438A language mode, the maximum number of averages allowed in the EPM series power meter is 512. If 1024 averages was selected prior to entering 437B/438A language, then this will automatically be reduced to 512.

Note that in 437B/438A language mode, front panel operation will not allow 1024 averages to be selected.

With auto filter enabled, the filter setting selected may differ from that in the 437B or 438A. The setting selected by the EPM series power meters is explained in the EPM series Programming Guide under SENSE:AVERage:COUNT:AUTO.

4.6 Duty cycle, window offsets, sensor calibration tables, and frequency dependent offset tables

Window offsets and frequency dependent offset (FDO) tables are not available on the 437B or 438A but are features on the EPM series power meter. The duty cycle feature and sensor calibration tables are not available on the 438A but are on the E4419A/B. In general, the EPM series power meter's instrument state is not altered when the 437B/438A language is selected. Therefore, prior to entering 437B/438A language, should any of these features be enabled, they will then remain so until a remote preset command is issued. This is also the case with a local-to-remote transition with 437B/438A language selected. An explanation for unexpected results or behavior may well be due to having one of these features unknowingly enabled. At the start of an application program a preset command is worth considering, as this will ensure that the EPM series power meter is in a known state.

Note: A front panel preset does not disable a selected sensor cal table or FDO table.

4.7 Channel offsets for the E4419A/B dual channel power meter

Prior to entering 438A language or after a local-to-remote transition while in 438A language, the E4419A/B channel offset state and level will be altered as follows:

- If the channel offset is ON and the level is 0 dB, then the channel offset will be turned OFF.
- If the channel offset is OFF and the level is not 0 dB, then the level will be set to 0 dB.

4.8 Preset

While in 437B/438A language mode, a front panel preset will set the meter as detailed in the EPM series User's Guide, while a remote preset will set the meter as detailed in the 437B or 438A manual.

4.9 Measurement errors

Measurement errors can occur for a variety of reasons, but it is worth being aware of the error reporting methods used by the 437B and 438A. The status message will report measurement errors and entry errors. Also, the data output message may return an error rather than the measurement result. The format for this method is +9.00xxE+40 where xx is the measurement error code as listed in the 437B and 438A manuals (pages A2–3 for 437B manual; pages 3–57 for 438A manual). Some errors not mentioned in these manuals are detailed below.

For E4418A/B:

+9.0000E+40	E4418A/B in standby mode and not triggered (send TR1/TR2 before requesting result)
+9.0035E+40	E-Series sensor error (sensor data suspect)
+9.0036E+40	Must calibrate/zero (see section 4.14)

For E4419A/B:

+9.0000E+40	E4419A/B in standby mode and not triggered (send TR1/TR2 before requesting result)
+9.0035E+40	E-Series sensor error on channel A (sensor data suspect)
+9.0036E+40	E-Series sensor error on channel B (sensor data suspect) OR must cal/zero channel A
+9.0037E+40	Must calibrate/zero channel B (see section 4.14)

Note: When a measurement/device error occurs, the 438A always returns +9.0000E+40.

4.10 Using the Agilent E-series power sensors

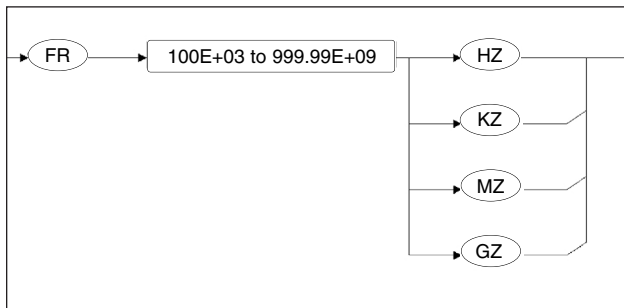
The E-series power sensors (E4412A and E4413A) can only be used with EPM series power meters and cannot be used with the 437B or 438A power meters. However, the E-series sensors can be used with the EPM series power meters in 437B and 438A language mode. Due to the fact that the E-series sensors have calibration factors stored in sensor EEPROM, the sensor calibration factor and reference calibration factor commands are no longer valid. Sending these commands will cause a syntax error as detailed below.

- Status register bit 2 will be set (entry error)
- Status message entry error field will be set to 50 (calibration factor out of range/ignored)
- Status message entry error field will be set to 91 (invalid GPIB code)

It is possible to use an E-series sensor in place of an 8480 series sensor. However, it is worth being aware of the functional differences between the two families, particularly regarding calibration factors. Two common methods for holding 8480 series sensor calibration data are described below.

- In 437B language mode only, the sensor calibration data can be held within one of the power meter's sensor calibration tables. In this case the data has previously been entered into a specific table and the calibration table selected using the SE command. Prior to making a measurement, the frequency at which the measurement is being made is sent to the power meter using the FR command. The power meter interpolates the cal factor from the sensor cal table. In applications of this nature, the E-series sensor can be directly substituted in place of the 8480 series sensor as the calibration data held within the E-series sensor EEPROM effectively becomes the selected table. The SE command is now redundant and will cause an entry error.
- The 8480 sensor calibration data can be held on a host computer. Prior to making a measurement, the frequency at which the measurement is to be made is used by the host software to derive the correct calibration factor. This calibration factor is sent to the power meter using the KB command. In this application, the host software will require modifications if an 8480 sensor is to be replaced with an E-series sensor. Provided no system corrections are included in the calibration factor, then these modifications should be straightforward. For example, send the frequency to the power meter rather than the calibration factor. If system corrections need to be included, then the section on Frequency Dependent Offsets (FDO) in the Agilent EPM series power meter's Programming Guide should be referred to (for EPM series power meter firmware revision 1.02 and 2.02 onwards).

When using an E-series sensor in 438A language, the FR (frequency) command will be accepted. The syntax for this command is shown below.



Note: Sending this command when the active entry channel is connected to an 8480 series sensor will cause a syntax error.

The Agilent E-Series sensors have an upper and lower range and are affected by the ranging commands as detailed below.

- **RA (auto range):** The EPM series power meter selects the most suitable range and this will be reported in the status message range fields for the attached sensor(s) (11 = lower range and 12 = upper range).
- **RH (range hold):** The EPM series power meter will hold on the current range irrespective of input level and the status message range fields for the attached sensor(s) will reflect this (01 = lower range and 02 = upper range). The front panel display will indicate that range hold is in effect.
- **RM (manual range selection):** The EPM series power meter will select the lower range for RM1EN and the upper range for RM2EN (RM3EN, RM4EN and RM5EN are accepted and also select the upper range). The status message range fields for attached sensor(s) will reflect the range selected (01 = lower range and 02 = upper range). The front panel display will indicate that range hold is in effect.

When calibrating an Agilent 8480 series sensor using the power meter's reference oscillator, an error is returned if the sensor is not connected to the power reference. This connection test does not apply to E-series sensors.

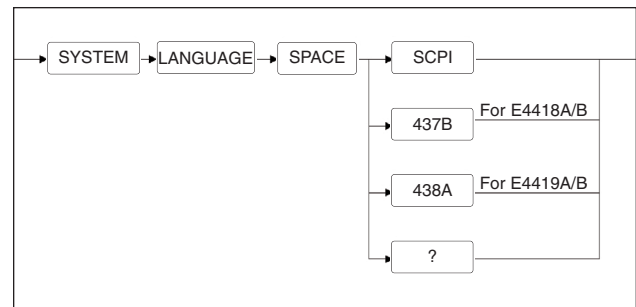
4.11 Recorder output

The recorder output on the 437B or 438A would normally be used with manual ranging and produces an analog output level (0 to +1 volts) that is proportional to the power level being measured. This voltage level is scaled relative to the minimum and maximum power levels for the current range. The EPM series power meter has one continuous range. Therefore, in order to be compatible with the 437B or 438A, it is necessary to manually set the EPM series power meter recorder minimum and maximum power levels to suit the power being measured (see the EPM series User's Guide, Chapter 2, "Recorder Output" section). It should also be noted that the recorder output on the 437B and 438A is permanently enabled, while on the EPM series power meter it can be turned off. The recorder output on the E4419A is also channel selectable. The E4419B has two recorder outputs, dedicated to each measurement channel.

4.12 Extensions to the 437B/438A command set

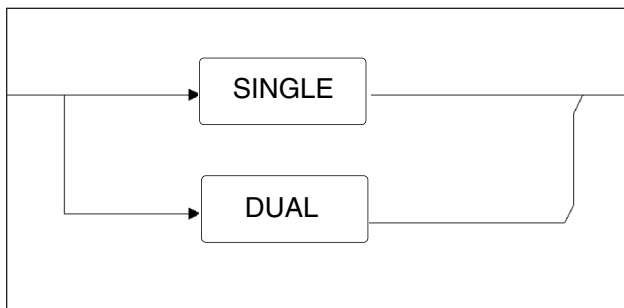
In addition to the 437B/438A command set, the EPM series power meter in 437B/438A language mode also accepts some extra commands, as described below.

- **Language selection:** allows either SCPI or 437B/438A language to be selected. This command is accepted by both language modes and can also be queried, whereby it will return either SCPI, 437B, or 438A.

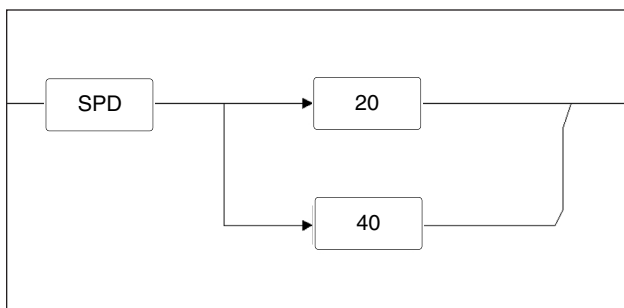


Note: When changing language remotely, allow a one-second delay before sending further remote commands.

- **Window selection:** The highlighted window on the E4419A/B display is equivalent to what would be shown on the 438A. Sometimes it may be beneficial to have just the highlighted window shown. This command allows either a single or dual window display.



- **Measurement speed:** In normal speed, up to 20 readings per second can be made. In fast mode, up to 40 readings per second are obtainable. This command allows either 20 or 40 readings per second to be selected. Note that number of readings per second achieved is controller dependent.



4.13 Must calibrate/zero

The E4418B and E4419B power meters have a “Must cal/zero” feature. This feature can be enabled to prevent measurements being made until the connected sensor is zeroed and calibrated. With this feature enabled and when making a measurement, the following will be reported if a zero or cal is required:

- **437B language:**
+9.0036+40 will be returned.
The status message will report measurement error 30. The OD command will return “MUST ZERO/CAL”
- **438A language:**
+9.0036+40 will be returned for Channel A.
+9.0037+40 will be returned for Channel B.
The status message will report measurement error 36 for Channel A and measurement error 37 for Channel B.

4.14 Sources and analyzers

Some Agilent signal generators and network analyzers use a 437B power meter for flatness and leveling. The EPM series power meter can be used in place of a 437B/438A with the following products:

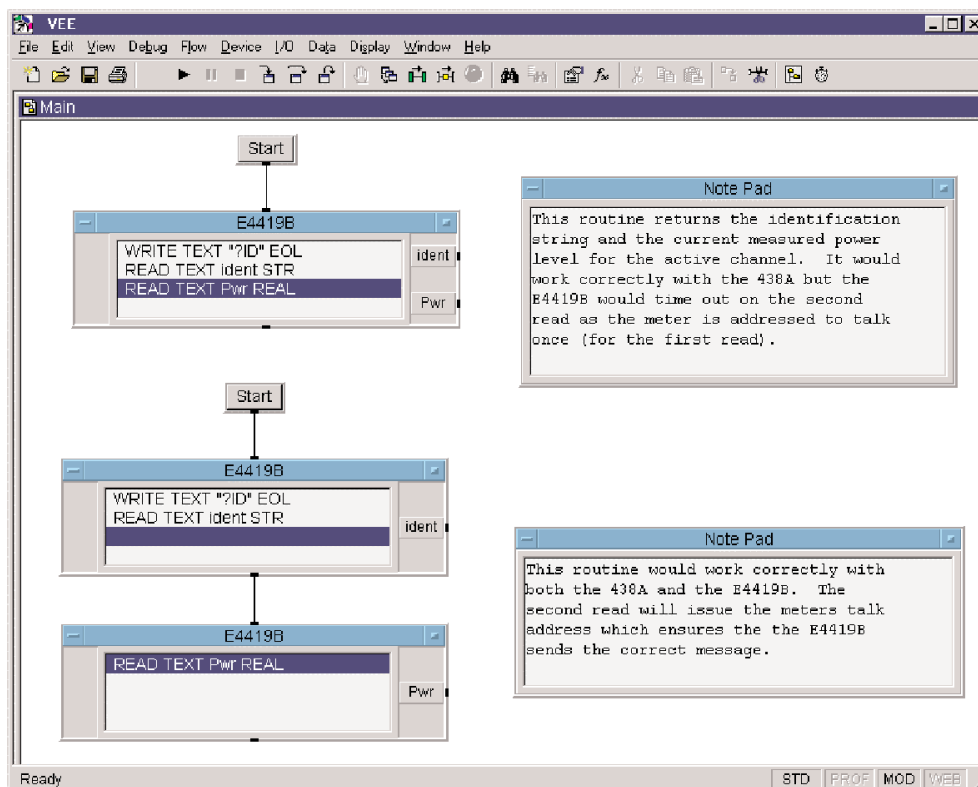
- **Signal generators:** 83732A, 83752A, 83600 series
- **Network analyzers:** 8753, 8710, 8510 series

4.15 Programming with Agilent VEE

When the 437B or 438A is addressed to talk, it will send the message appropriate to its current mode and if the receiver is prepared to listen indefinitely, then this message will repeatedly be transmitted. In the same situation the EPM series power meter in 437B/438A language mode will, when addressed to talk, send the appropriate message just once. To receive the message a second

or subsequent time, the EPM series power meter has to be readdressed or a “time out” situation will arise. Some programming languages, Agilent VEE in particular, easily (and legally) allow such scenarios to arise. The example below illustrates more fully the criteria being discussed along with the simple solution.

It is also worth noting that the EPM series power meter requires an end-of-line terminator before it executes a command line. In the example, the command WRITE TEXT “?ID” EOL will work with both the 438A and the E4419A/B in 438A language. With the EOL omitted, the instruction will work only with the 438A, as the EPM series power meter would not execute the instruction until either the EOI line on the GPIB interface was set or a line feed was received.



5. Known Problems

The following cases are known problems when using the E4419A or E4419B dual channel power meter in 438A language compatibility mode.

1. With the E4419A dual channel power meter in 438A language mode, the data ready bit in the status register will not be set when in measurement mode B (measurement mode A is not affected).

Symptom:

```
10 OUTPUT @Pm; "BE;BP;CS" !Measurement mode B
20 OUTPUT @Pm; "TR1"      ! Or TR2
30 IF (BIT (SPOLL(@Pm), 0) ! Wait for data ready
    THEN GOTO 30
40 ENTER @Pm;Pwr
```

Possible work-around:

```
10 OUTPUT @Pm; "BE;BP;CS"
20 OUTPUT @Pm; "TR1"
30 ENTER @Pm;Pwr
```

Having triggered the meter, the same effect can be obtained by addressing the meter to talk and waiting for the response. The result will not be returned until the measurement cycle has completed.

The data ready bit is intended to allow the controller to do other tasks, while periodically checking the state of this bit. In TR2 mode with 512 averages, it could take 30 seconds before the result is available.

This bug is corrected on the E4419B dual channel power meter (firmware revision A.02.03 or higher).

2. With the E4419B dual channel power meter in 438A language mode, measurement error code 36 could be returned for either of the following reasons:

- E-series sensor error on channel A (sensor data suspect)
- The "must cal/zero" feature is enabled and channel B requires calibrating or zeroing.

6. Summary

Replacing the 437B and 438A with the new Agilent Technologies EPM series of power meters should be a simple process. However, as this application note has highlighted, there are some issues that users may encounter. The information given here should help to resolve these issues.

For more details on the EPM series power meters, please contact your local Agilent sales office for EPM series power meter literature.

Appendix A: 437B Command Summary

This table details all the 437B commands that the Agilent E4418A and E4418B support and the command function. For a detailed description of these commands please refer to the 437B Power Meter Operating Manual.

Command	Description
CL	Calibrate
*CLS	Clear all status registers
CS	Clear the status byte
CT	Clear sensor type
DA'	All display segments on
DC0	Duty cycle off
DC1	Duty cycle on
DD	Display disable
DE	Display enable
DF	Display enable
DN'	Down arrow key
DU'	Display user message
DY	Enter duty cycle
EN	Enter
ERR?	Device error query
*ESR?	Event status register query
*ESE	Set event status register mask
*ESE?	Event status register mask query
ET	Edit sensor table

Command	Description
EX	Exit
FA	Automatic filter selection
FH	Filter hold
FM	Manual filter selection
FR	Enter measurement frequency
GT0	Ignore GET bus command
GT1	Trigger immediate response to GET
GT2	Trigger with delay response to GET
GZ	Gigahertz
HZ	Hertz
ID	Identification query
IDN?	Identification query
KB	Enter measurement cal factor
KZ	Kilohertz
LG	Log units (dBm/dB)
LH	Enter high (upper) limit
LL	Enter low (lower) limit
LM0	Disable limits checking
LM1	Enable limits checking

Command	Description
LN	Linear units (watts/%)
LP2	Learn mode
LT ¹	Left arrow key
MZ	Megahertz
OC0	Reference oscillator off
OC1	Reference oscillator on
OD	Output display
OF0	Offset off
OF1	Offset on
OS	Enter offset value
PCT	Percent
PR	Preset
RA	Auto range
RC	Recall instrument configuration
RE	Set display resolution
RF	Enter sensor table reference alibration factor
RH	Range hold
RL0	Exit from relative mode
RL1	Enter relative mode (take new reference)
RL2	Enter relative mode (use last reference)
RM	Set measurement range
*RST	Reset

Command	Description
RT ¹	Right arrow key
RV	Read service request mask
SE	Select sensor calibration table
SM	Status message
SN	Enter sensor identification/serial number
SP ¹	Special
SPD 20 40 ²	
*SRE	Set the service request mask
*SRE?	Service request mask query
ST	Store (save) power meter configuration
*STB?	Read status byte
SYST:LANG SCPI ³	Selects SCPI language
TR0	Trigger hold
TR1	Trigger immediate
TR2	Trigger with delay
TR3	Trigger free run
*TST? ⁴	Self test query
UP	Up arrow key
ZE	Zero
@1	Prefix for status mask
@2	Learn mode prefix
%	Percent

1. This command is accepted but has no active function.
2. This command is not an original 437B command. However, it can be used to set the measurement speed to 20 or 40 readings/sec in 437B mode.
3. This command is not an original 437B command. However, it can be used to terminate the 437B language and select the SCPI language. Note that it is recommended that the instrument is preset following a language switch.
4. Always returns 0000 in 437B language.

Appendix B: 438A Command Summary

This table details all the 438A commands that the Agilent E4419A and E4419B support and the command function. For a detailed description of these commands please refer to the 438A Operating and Service Manual.

Command	Description
AD	Sensor A minus Sensor B measurement
AE	SET A
AP	Sensor A measurement
AR	A/B ratio measurement
BD	Sensor B minus Sensor A measurement
BE	SET B
BP	Sensor B measurement
BR	B/A ratio measurement
CL	Calibrate
CS	Clear the status byte
CT	Clear sensor type
DA'	All display segments on
DD	Display disable
DE	Display enable
DO	Display offset
EN	Enter
FA	Automatic filter selection
FH	Filter hold
FM	Manual filter selection
FR	Enter measurement frequency

Command	Description
GT0	Ignore GET bus command
GT1	Trigger immediate response to GET
GT2	Trigger with delay response to GET
KB	Enter measurement cal factor
LG	Log units (dBm/dB)
LH	Enter high (upper) limit
LL	Enter low (lower) limit
LM0	Disable limits checking
LM1	Enable limits checking
LN	Linear units (watts/%)
LP1	Learn mode #1
LP2	Learn mode #2
OC0	Reference oscillator off
OC1	Reference oscillator on
OS	Enter offset value
PR	Preset
RA	Auto range
RC	Recall instrument configuration
RH	Range hold
RL0	Exit from relative mode
RL1	Enter relative mode (take new reference)

Command	Description
RM	Set measurement range
RV	Read service request mask
SM	Status message
SPD 20 40 ²	
ST	Store (save) power meter configuration
SYST:LANG SCPI ³	Selects SCPI language
TR0	Trigger hold
TR1	Trigger immediate
TR2	Trigger with delay
TR3	Trigger free run
ZE	Zero
@1	Prefix for status mask
?ID	Identification query

1. This command is accepted but has no active function.
2. This command is not an original 438A command. However, it can be used to set the measurement speed to 20 or 40 readings/sec in 438A mode.
3. This command is not an original 438A command. However, it can be used to terminate the 438A language and select the SCPI language. Note that it is recommended that the instrument is preset following a language switch.

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