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TEST & ALIGNMENT SPECIFICATION

FOR BDA 800 MHz 20W PA (Power Amplifier)

DCT000000004

Revision 1, May 17, 1999

TITLE	SIGNATURE	DATE
Originator		
Product Group Team Leader		
Marketing		
Administration		

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- **REVISION RECORD**

Revisions are tracked here as ...

1	May 17, 1999	Updated from SMA Documents	Alan Aslett

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- **INTRODUCTION:**

The objective is to align variable elements in Kaval 20W 800-900 MHz power amps to optimize RF performance, and verify performance against specifications. This procedure applies to amplifiers to be used together with external electronic fault monitoring modules in Kaval BDA systems. Certain internal fault detection features are not aligned in such case and these adjustments are set to positions which defeat these functions. Alignment of fault detection circuitry not necessary in BDA applications are covered in another document.

The Kaval 20W power amplifier is a single stage Class AB linear power amplifier using a high power LDMOS amplifier transistor. Compression point is about 20W, and intermod performance rivals that of similar amplifiers with 30W ratings. This design is optimized for best intermodulation and minimum heat in multicarrier repeaters, not necessarily highest output power in saturation. Due to the necessity of using microstrip matching elements at these frequencies, and the need to tune the amplifier to various application bands, microstrip element lengths must be adjusted in some cases. The PCB design includes easily cuttable "zipper links" in the microstrip stubs which allows tuning using a hobby knife. Care must be taken when cutting links that the entire link is removed. A thin knife cut may leave copper slivers that may later reconnect and detune the amp after exposure to vibration. For this reason, use the wider back edge of the hobby or putty knife, and verify, using a magnifier, that the links are properly and permanently cut. If during adjustment, it is found that one went too far, and a link needs to be restored, this can be easily done by solder bridging. At all times, do not apply power to UUT unless both input and output are properly RF terminated. Be especially careful not to connect UUT with input and output reversed since this unit has ample capability to destroy network or spectrum analyzers.

- **EQUIPMENT:**

The following equipment is needed for execution of this procedure.

- ❑ Scalar Network analyzer, 1 GHz capable. Analyzer must be normalized and calibrated per manufacturer's instructions prior to any test session and at 1 hour intervals thereafter.
- ❑ Termination calibration kit for above (type N)
- ❑ Spectrum Analyzer, 1 GHz capable, input dynamic range up to +25 dBm with input intermod < -60 dBc
- ❑ 50W 20 dB Attenuator good to 1 GHz. Type N.
- ❑ Multimeter
- ❑ 800-1000 MHz Splitter/Combiner, Isolation > 20 dB 800 MHz to 1000 MHz. (Narda 4322-2 or equivalent)
- ❑ Two 10 dB fixed attenuators
- ❑ Turret Attenuator with 1 dB resolution. 0-30 dB minimum range.
- ❑ Broadband Linear Power Amplifier, 3W, 800-100 MHz, (Mini-Circuits ZHL-1000-3W or equivalent.)
- ❑ Two synthesized signal generators capable of tuning over 800-900 MHz band with output capability of +5 dBm minimum.
- ❑ Johanson capacitor trimming tool No. 8777
- ❑ Power supply cable with male Framatome "Jupiter" connector.
- ❑ DC Power supply capable of 2A at 24 VDC with variable current limiting.
- ❑ Customized Amplifier top cover with access holes drilled for access to C19 and R5
- ❑ Toggle press or other means for temporarily securing amplifier top lid during test. (You may use 4 screws in the corners as an alternative.
- ❑ RF interconnection cables as required. Do not use between series adaptors between network analyzer and UUT RF input or between UUT RF output and high power attenuator.

Note, for accurate output level measurements, be sure to offset any cable losses or attenuator variations from the output reading. Output losses should be characterized to within 0.1 dB.

- **PROCEDURE**

  - **Initial Conditions**
    R5 fully counterclockwise
    R19 fully clockwise
    R29 fully clockwise
    C19 turned out so slug is flush with top of cylinder.
    All stub zippers intact.
    RF input connected to network analyzer reflection port.
    Output terminated by direct connection of 50W 20 dB attenuator. Attenuator output connected to network analyzer transmission port.
    See Fig. 1

  - **DC Regulator**
    Apply 24VDC, current limited to 2A at DC input.
    Verify current draw is less than 100 mA
    Measure voltage at U3 pin 1. Verify this to be 8.0VDC +/- 0.25V

  - **Overcurrent Trip Point**
    Not adjusted in this procedure

  - **Preliminary Gate Bias**
    Adjust R5 clockwise until supply current is 1.4 A +/- 0.05A

  - **Temperature Shutdown Point**
    Not adjusted in this procedure

  - **Input Match**
    Observe input return loss on a logarithmic 5 dB/division scale. Note position of maximum return loss (dip in curve).
    If dip is below desired midband frequency, then stub lengths at input locations A,B,C,D must be reduced to bring match to higher frequencies. If dip is above desired band, then stub length must be increased. If insufficient stub length is available, then additional copper tape can be added in increments similar to stub segment sizes on PCB.
    Adjust C19 occasionally during tuning, at beginning and after any stub has been cut, to maximize return loss dip depth. This adjustment may slightly impact dip frequency as well. Do not bottom out C19.
    When tuning, remove one segment from stub A first, then C, Then B, and then D. If you still need to remove more, then start again at A and follow the sequence repeatedly. Do not remove an additional stub segment from any of the 4 input stubs until all others already have an equal number removed.
    If you have removed all input stub segments and appear close to moving dip to desired point, then cut off additional copper from the input wide trace, maintaining a center conductor width close to the width between the cuttable stubs.
    You are done when input return loss dip is centered at about midband, and return loss at band edges is about equal and better than 10 dB.
    Also verify that gain is flat within 1 dB over the band, and that gain peak is not outside the band. Optimal gain tuning should correspond roughly with optimum return loss tuning. If this is not the case, then check for missing matching components and improper soldering at power device.

  - **Output Match**
    Set up apparatus as in Fig. 2. At beginning of each test session, verify that intermod levels of combined generator setup are less than –60 dBc at an output level of +17 dBm/carrier.
    Set first generator to 500 kHz below midband frequency. Set second generator to 500 kHz above midband frequency. Ensure generator levels are within 0.2 dB of each other at all times.
    Energize UUT and adjust input signal level to achieve +30 dBm per carrier at UUT output.
    Adjust C19 for lowest third order intermodulation to carrier ratio. Note that gain may vary a small amount with this adjustment so do not look at intermod alone..
    Adjust bias for lowest intermodulation to carrier ratio. If prior adjustments are nominal, you will notice a peak in intermod rejection, at some bias current between 1.25 and 1.6A Do not try to adjust much higher than 1.6A. Intermod should get worse both above and below this “sweet spot”. You may also find a null at lower currents, but this is generally a false optimization point that will disappear with higher input levels.
    While adjusting bias voltage, it may be better to observe output main carrier level alone on a fine dB scale. The best optimization point generally yields peak gain. Higher bias currents may actually reduce gain as the device conduction cycle passes 180 degrees.

You may wish to alternate between C19 and R5 adjustments as you approach the final optimal point.
Temporarily note intermodulation rejection level.
Start cutting output stubs in locations E, G, F, H (in that order) in a similar manner to the input tuning scheme. After any cut. Readjust C19 and R5 to find the lowest intermod. If intermod rejection level has gotten worse as a result of the stub cut, then reattach the stub using solder and adjustment is complete.
If intermod improves as a result of a stub cut, then record the new intermod rejection level and cut the next stub in the rotation. Repeat the C19 and R5 optimization.
As you gain experience, you will determine certain head start staring positions for each band. The table below provides some examples for guidance.
As you improve the output match, you may need to readjust input levels to get the desired +30 dBm per carrier output operating level. If you wish to adjust in sub dB steps, fine adjustment of supply voltage may help achieve the target.
Record final best intermod rejection and record IP3. Measure the difference between the lowest main carrier and the highest intermod product. Divide this dB ratio by two. Add this to the main carrier level. This is the third order intercept point.

- **Review Input Return Loss (Optional once process capability proven)**
  If drastic tuning occurred at the output and you are not using first attempt guideline stub settings, then input match may need further fine tuning. Return to setup of Fig. 1 and verify that input return loss is roughly centered at the operating band and remains within minimum spec. You may need to repeat the procedure of 4.6. If input match requires readjustment, then IP3 measurement must be re-verified, and C19 and R5 may require additional tweaks.

- **Measure 1 dB Compression Point.**
  Set up a single signal generator at mid-band frequency and apply its signal to the UUT input. Adjust for output power of +34 dBm.
  Set up signal generator to use 10 dB amplitude increments. Toggle level between current setting and a setting 10 dB higher and observe output level change. Fine adjust the generator level while keeping increment at 10 dB until the difference in output level for a 10 dB step at input is 9 dB. Typically, the output will alternate between levels of + 34 and +42 dBm. In this example, +42 dBm would be the 1 dB output compression point.
  During compression tests, some LDMOS amplifiers may “run away”. If supply current goes above 2.25 A, then do not proceed with higher input levels.

- **Temperature Limit Setting**
  Ensure R19 & R29 are fully counter-clockwise. Temporarily connect an 11K resistor in parallel with R28, a Thermistor. Measure voltage at pin 8 of U1D. It should be approximately 6.7 VDC. An allowable range can be determined after a quantity of units have been built, but a 10% variation should be tolerable. Adjust R29 clockwise until the voltage at pin 8 of U1D drops to 0 VDC. Remove the 11K resistor.

- **Over-current Back-down and Under-current Fault Detect**
  Apply an input carrier of sufficient strength at mid-band to obtain an output power of +45 dBm. Use the Figure #2 setup with one generator off. Turn R19 clockwise until power drops to +44 dBm.

- **Record Results**
  Record desired operating band.
  Record gain at mid-band and band edges.
  Record input return loss mid-band and at edges.
  Record Third order intercept point at mid-band.
  Record mid-band 1 dB compression.
  Record quiescent current.

- **SAMPLE RESULTS**

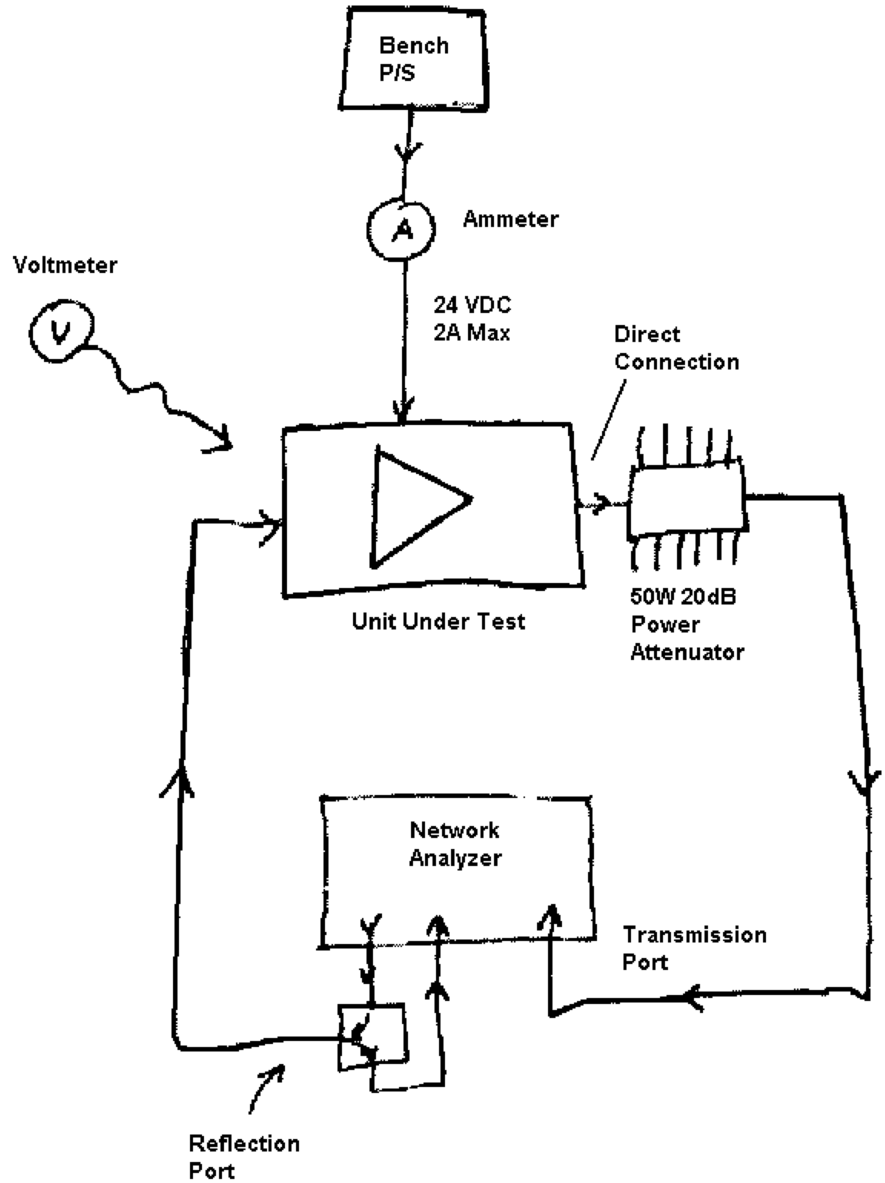
  A sample first-article unit was tuned to various popular frequencies within the 800-900 MHz band. The table below shows performance achieved and indicates the number of stub segments connected at each stub location per the attached drawing.

  All match and gain specifications are worst case over a band +/-12 MHz from nominal center frequency. Intermod and compression were measured midband only.

  It is advisable to record all these parameters for each unit tested and maintain records of what typical stub segment counts are, to assist in determining initial conditions. Input stubs should display greatest variation.

Band Center (MHz)	815	836	860	881
1 dB Compression Point (dBm)	+43.0	+43.4	+43.7	+43.2
Third Order Intercept Point (dBm) (1W/carrier)	+54.0	+54.0	+54.8	+54.0
Minimum Gain (dB)	16.6	15.7	15.0	13.2
Input Return Loss (dB)	14.7	13.4	12.5	10.3
Quiescent Current	1.35	1.35	1.55	1.55
Stub A (Segments)	3	1	0	0
Stub B (Segments)	3	1	0	0
Stub C (Segments)	5	2	1	0
Stub D (Segments)	5	3	1	0
Stub E (Segments)	5	3	2	1
Stub F (Segments)	5	3	2	1
Stub G (Segments)	5	3	2	2
Stub H (Segments)	5	4	3	2

- **FIGURE #1: 20W PA GAIN & RETURN LOSS MEASUREMENT SETUP**



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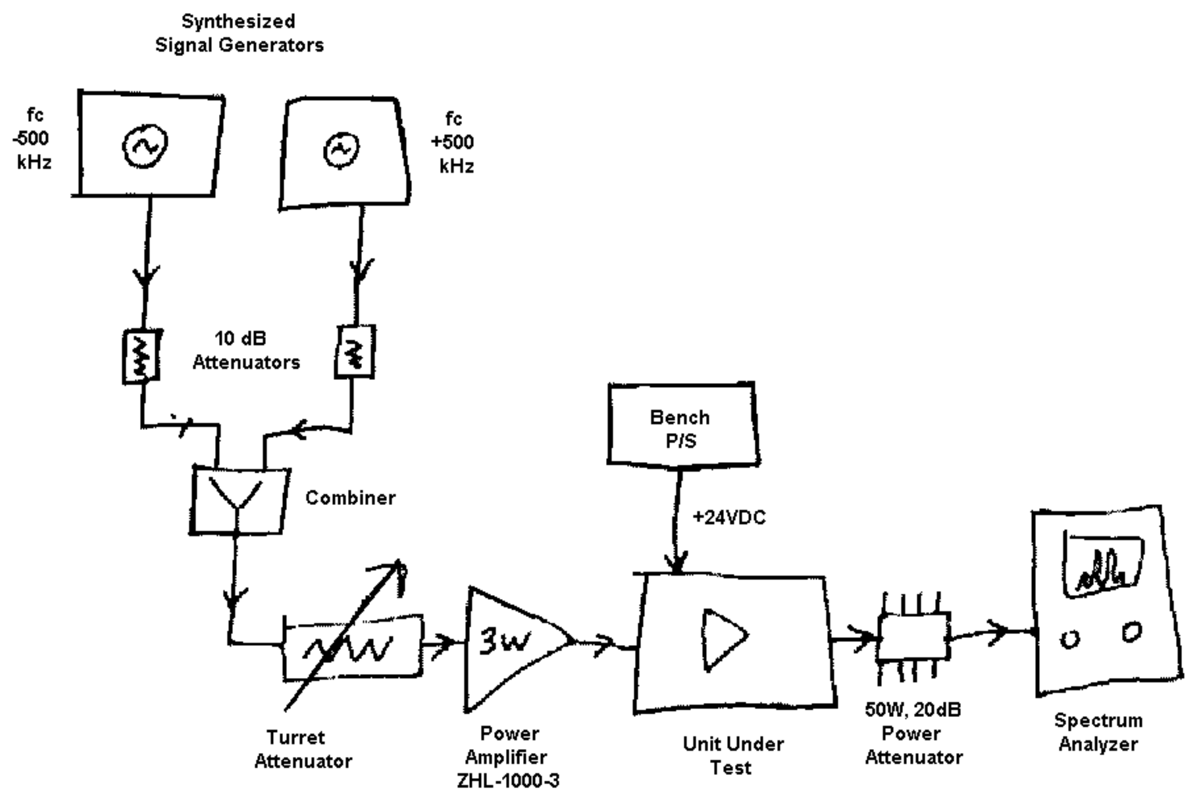
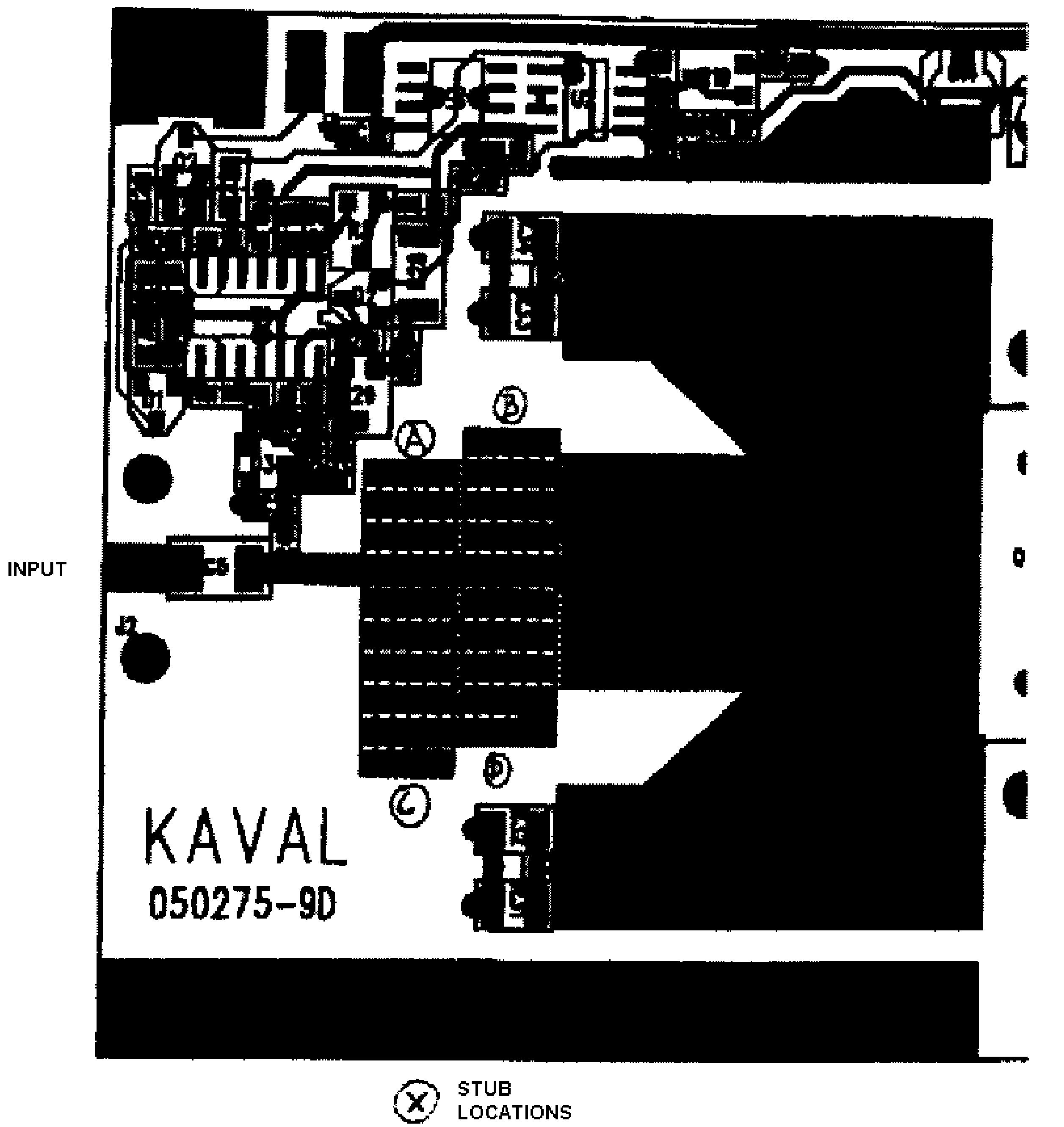
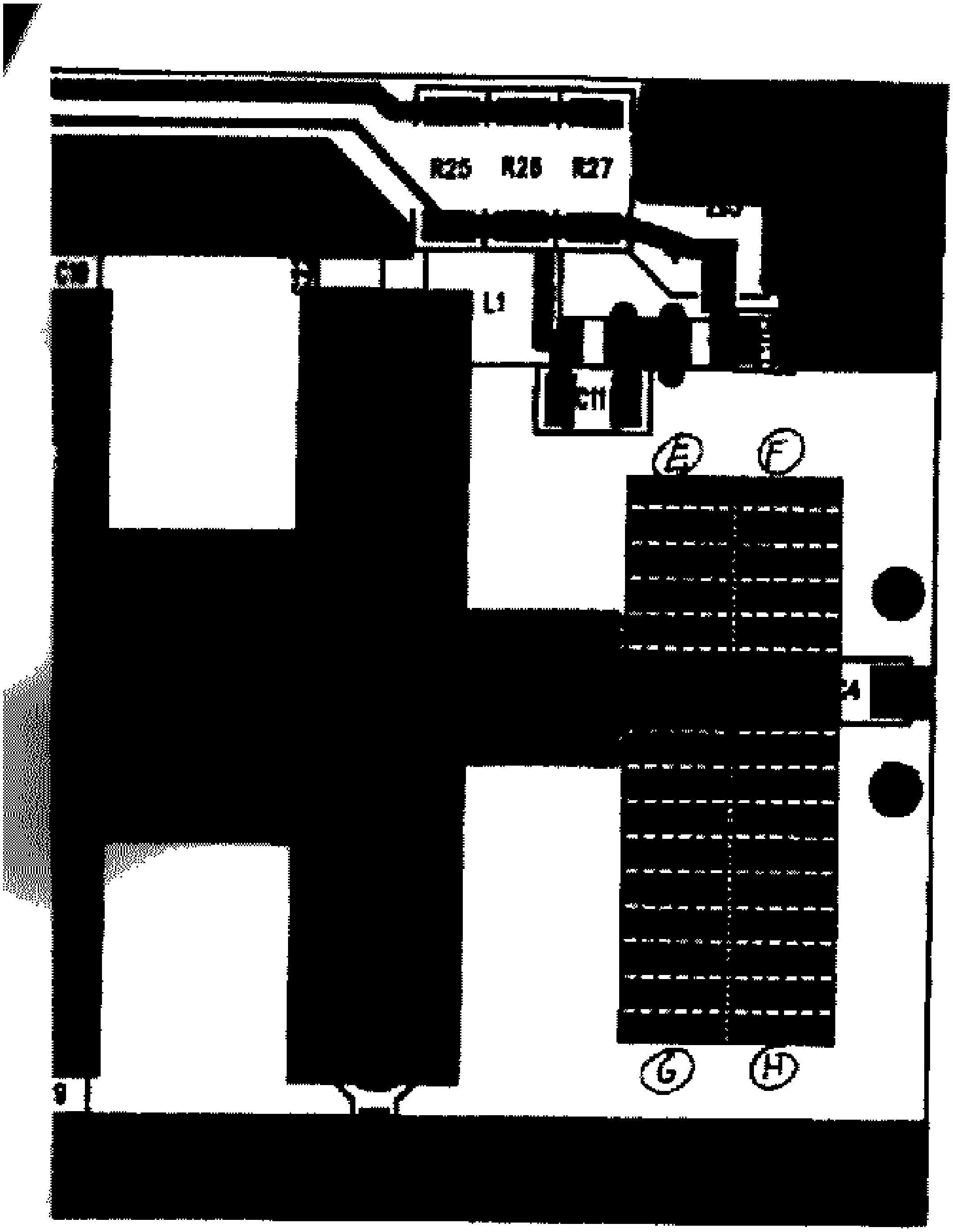
- **<u>FIGURE #2: 20W PA INTERMOD & COMPRESSION MEASUREMENT SETUP</u>**



- **FIGURE #3: INPUT ADJUSTMENT**



- **FIGURE #4: OUTPUT ADJUSTMENT**



OUTPUT

- **FIGURE #5: ASSEMBLY DRAWING**