# 3.4GHz 2WATT AMPLIFIER KIT



**SPECIFICATIONS: EME141-3400 KIT**

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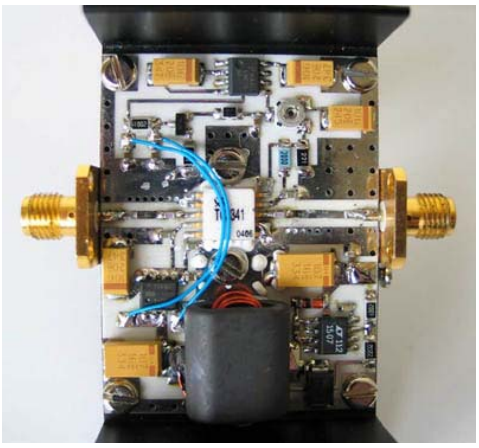
|---|---|
| Frequency Range: | 3.3 to 3.7GHz Bandwidth @ 1dB |
| RF Ouput: | 1.8 Watts ( +32.5dBm @ 1dB compression ) |
| RF Input: | 3.2mW ( +5dBm ) for 1.6Watt ( +32dBm ) Output |
| | **Maximum Input without damage 10mW +10dBm** |
| Gain: | 27dB minimum |
| OPIP3: | Output IP3 +42dBm |
| Power Supply: | 500kHz switching regulator 90% minimum efficiency |
| | +9 to +14vdc ( +12vdc 470mA ) |
| Size: | PC Board 47.5 x 37mm |
| Kit Webpage: | **www.minikits.com.au/eme141.htm** |



**DESIGN:** This High Performance 3.4GHz Power Amplifier uses a low cost Transcom TC3341 PHEMT MMIC IC. The MMIC provides a gain of 27dB and a saturated output power of more than +32dBm. The MMIC requires minimal input and output matching to 50ohms, and makes other discrete PA designs using GaAs and HFETs etc, virtually obsolete for these power levels. The PA is suitable for linear modes including SSB transverters, or non linear FM amateur television. The PA uses a high performance switching power supply to provide high efficiency over a wide input voltage range, which has very low heat dissipation compared to conventional voltage regulators. The MMIC requires a thin PC Board with large Vias, ( plated holes ) directly under the device for heat transfer. A Ceramic based PC board has been used with lots of plated Vias for grounding to keep RF losses to a minimum, guaranteeing the gain and output power of the amplifier. Much of the amplifier construction is mechanical work, requiring taping of holes in a heatsink to mount the Amplifier board, and RF connectors etc.

**DESCRIPTION:** The complete Power amplifier is built on a single 48 x 37mm size PC board. The TC3341 device internally is probably two matched PHEMT FETs in parallel, ( Refer to the circuit diagram which shows two sets of drain and gate bias supplies ). The device requires +8 volts on pins 4 and 5. A negative bias supply is required on pins 9 and 10 to set the quiescent current to 700mA without RF drive. All Drain supply power decoupling RF chokes are internal to the TC3341 device so no external chokes are required for decoupling. The TC3341 is essentially a 50ohm MMIC, and no external matching was found to be required on the prototypes. 50ohm striplines, are used on the input and output of the MMIC to connect to the RF connectors. For continuous operation, the amplifier requires good heat sinking. Methods used are 2 point mounting screws, and solder filled Via holes directly underneath the device.

**POWERSUPPLY:** The power supply uses a high performance 500kHz LT1507 switching regulator IC providing up to 90% efficiency. The input of the LT1507, Pin 2 has filtering components consisting of a 140uH choke and 100uF Low ESR capacitor, which effectively stops switching noise from the LT1507 regulator from appearing on the main DC power input. The output of the LT1507, Pin 3 has a similar filter consisting of another 140uH choke and low ESR Tantalum capacitor to provide a regulated and filtered +8v supply for the MMIC PA. A negative voltage is required to bias the MMICs gate, and is produced with an LMC7660 –ve voltage generator IC. The LMC7660 is powered by the +8v switching regulator which allows the 7660 to produce around –7.4v output. There is a 5kohm trimpot for bias adjustment of the MMIC. A protection circuit is built in to cut off the +8v to the MMIC if the –ve bias disappears. With a bias of 0v on the gate of the MMIC, it will try and sink as much current through its drain/source until it destroys itself. **Shorting of the gate connection to Gnd causes excessive drain current that can destroy the device instantly.** Under normal operation, the –7.4v output from the LMC7660 is dropped across a 5v6 zener diode, producing a slightly –ve voltage of around –1.8v on the emitter of the BC847 transistor compared with its base voltage turning it on. The collector voltage is pulled low, which in turn pulls the gate ( pin 4 ) of the FDS9400A MosFET low, turning on the MosFET. The +8v supply is then switched through the drain to source providing a voltage to the MMIC. If the –ve bias voltage disappears, then the BC847 is turned off and the collector voltage rises to +8v turning off the MosFET which cuts the supply to the MMIC.

**CONSTRUCTION:**

**1. The first and most difficult part of the construction is fitting the TC3341 MMIC to the board.** The PCB supplied is

a Fiberglass reinforced Ceramic material with one side being used as a groundplane. The board has extensive via holes around and underneath the MMIC device for heat transfer and RF grounding. Align the MMIC device on the board and tack solder adjacent diagonal pins 5 and 10 to the boards pads. Check very carefully that you have aligned it properly before soldering all the pins to the board.

**2.** Next you will now require a 50 Watt soldering iron with a large broad tip of around 3-4mm. Turn the iron temperature flat out if adjustable. Turn the PC board upside down and either hold the board in a vice, or stand the board above the bench with some spacers so that the chip does not touch the bench top. The next stage is to heat the board Vias that are directly over the MMIC and feed solder into the Vias to fill them up. Use a 0.7mm diameter solder and heat the board up with the iron and feed the solder in. Do not built up the solder on the bottom of the board or else it won't sit flat for heat-sinking. Try and flow the excess solder into and across the surrounding board Vias, and then use solder wick to suck up the excess. **This needs to be done quickly or else the MMIC chip can heat up too much and either fall off of the board, or be damaged from heat.** After the MMIC is soldered to the board, you should see a small amount of solder around the outside of the MMIC on the top track side of the board. This is a good indication that the solder has passed through the Vias and soldered the MMIC to the board.

**3.** Follow the PCB overlay diagram and circuit carefully, by checking the components and placing them onto the board. **Do not fit the FDS9400A until the power supply voltage has been tested in the Testing section below.** Start with the SMD IC's, transistor and diodes, followed by the resistors and capacitors. To solder in the chip components, use a pair of tweezers to hold the component in place, soldering one side first then the other side. Check that you have correctly soldered all components before going any further.

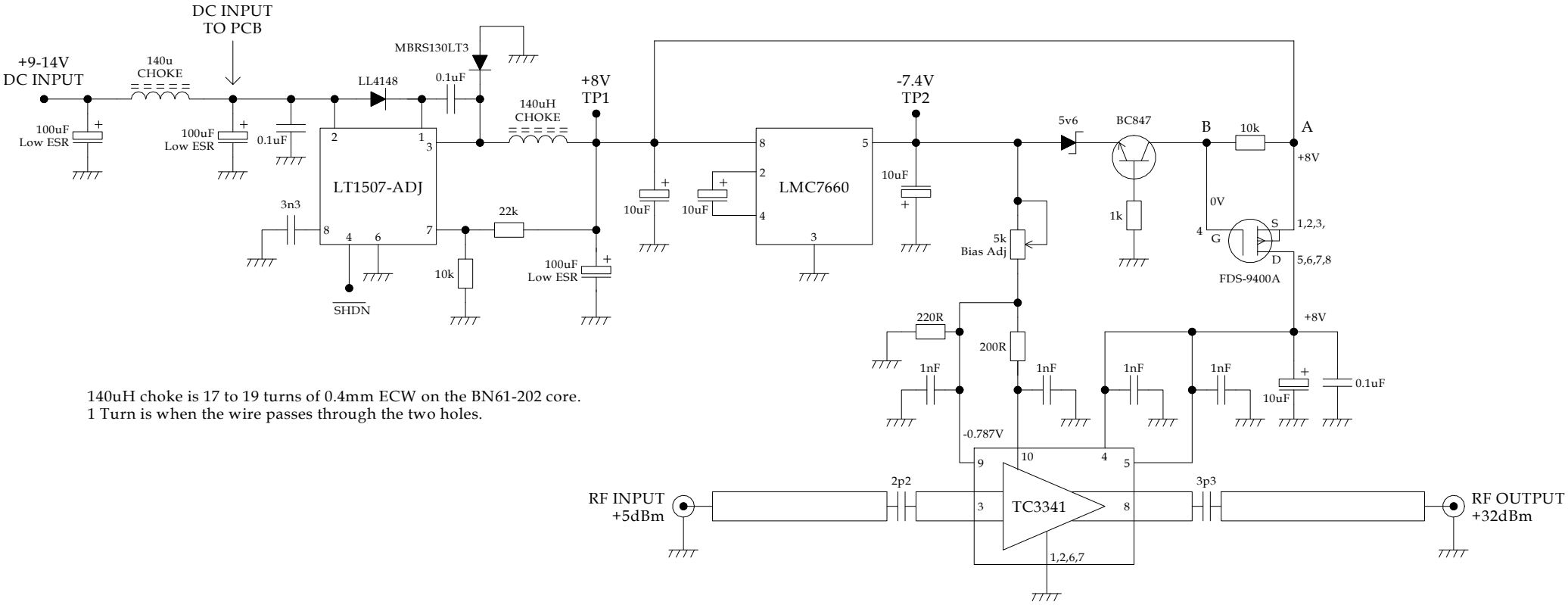
**4.** Next the two 140uH chokes need to be wound using the supplied 0.4mm ECW and two BN61-202 binocular cores. Each core requires at least 17 to 19 turns of the wire to be an effective choke at 500kHz. One turn on a binocular core is when the wire passes through one hole, then around and through the other hole. Cut the 140cm length of 0.4mm wire in half and start winding one of the chokes making sure to leave at least a 3cm length at the end of the wire, so that it will be long enough to tinned and connected to the PC board. When winding the chokes, take your time to neatly wind the turns side by side so that at least 60cm of the 0.4mm ECW wire will fit the core. If you crisscross the windings too much, then you might not get enough turns onto the core. Next place one of the chokes onto the board, and measure and trim the wires to suit the pads on the board. Scrape and tin the wire ends, and solder to the board. A small amount of non acidic silicon sealer or super glue can be put under the choke to hold it onto the board. The other choke is fitted externally to the PC board and can be fitted later inline with the DC power connection to the board.

**5.** The Kit is supplied with a length of wire wrap wire to connect points A to A, and B to B on the PC board. Refer to the Kits webpage, www.minikits.com.au/eme141.htm for a picture of the PC board to see how the wires are arranged to sit across the top of the MMIC device. **Make sure that you connect these correctly as damage could occur to the PA circuitry.** Some non acidic silicon can be used to hole the wires in place.

**6.** The PCB was originally designed to fit an off the shelf 38mm long finned heat-sink to allow 4 hole flange mount SMA connectors to be bolted onto each end. These heat sinks are no longer available, so it is suggested that to make it easier to mount the PA inside a enclosure, and with different types of heat sinks, that the PC board be mounted onto a 38mm long aluminium plate. The plate can be cut from standard 50mm wide aluminium flat bar which is at least 6mm thick to allow 4 hole mount SMA flange connectors to be easily fitted. Depending on the size of the enclosure or if it is mounted to a chassis will depend on the heat sinking requirements of the amplifier. The power supply is very efficient, so most heat generated comes from the MMIC. The MMIC draws 700mA at +8V which is 5.6Watts to produce around 2 Watts of RF output, so around 30% efficient. To keep the amplifier around room temperature, the heat sinking needs to be at least 4.5 degrees C per Watt or better.

**7.** Next accurately align the PC board onto the aluminium plate, and mark the mounting hole locations with a very fine felt tip pen. Next centre punch the centre of the markings for drilling. Drill the holes in the heatsink with a 2.1mm drill bit. Tap the holes with a M2.5 metric Tap using CRC or similar lubricant, and countersink the holes. Clean the swarf from the surface of the heatsink thoroughly, and check that the board sits flat. **Refer to the Connections section below and mark and drill the holes for the two SMA connectors before fully mounting the board using heat sink compound to the plate.** Apply liberal heatsink compound under the PC board where the MMIC sits and mounts to the heat sink, and use the supplied M2.5 screws to mount the board. The mounting screws must provide good contact with the top of the board each side of the MMIC to help with heat dissipation. **Be careful when tightening the screws, as over tightening could cause stress to the board and crack chip components.**

**8.** RF amplifiers should always be mounted inside a shielded enclosure to reduce any exposure to stray RF radiation. As mentioned earlier in these construction notes, the recom-




140uH choke is 17 to 19 turns of 0.4mm ECW on the BN61-202 core.
1 Turn is when the wire passes through the two holes.



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| DRAWN | MINI-KITS |
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| FILE | EME141-3400-VER2.SKF |

mended mounting of the PC board onto an aluminium plate makes it much easier to mount inside an enclosure. The enclosure could be larger to mount a complete Transverter, and does not have to be a separate enclosure as long as the RF from the output of the PA is shielded from lower level RF transmit circuitry.

**CONNECTIONS:**

**1.** If you are using the recommended aluminium plate for this Kit, then it is recommended that you use 4 hole flange mount SMA connectors, **( SMA06, SMA13 )** as they can be mounted to the plate using M2.5 x 6mm screws. Solder the centre pin of an SMA connector to one end of the board and mark the hole locations with a fine felt tip pen. Do the same with the other end of the board, and then remove the connectors from the board. **Be very careful here as any alignment mistakes when marking and drilling the holes for the connectors may mean starting with a new aluminium plate from scratch.** Centre punch and drill the holes with a 2.1mm drill bit. Tap the holes with a M2.5 metric Tap using CRC or similar lubricant. Clean the swarf from the surface of the heatsink and mount the SMA connectors, soldering the centre pin afterwards.

**TESTING:**

**1.** Connect a suitable 3400MHz antenna or 50ohm ( >3W ) dummy load to the output of the amplifier, and a suitable 50ohm load on the input. Connect a suitable ammeter inline with the amplifiers +12vdc supply.

**2.** First the switching power supply should be tested to make sure that it is producing close to +7 volts on the output of the 140uH choke, **( TP1 )**. Using a current regulated bench power supply, apply +9 volts to the DC Input to the amplifier and check that the voltage at TP1 is close to +8 volts. Then increase the bench power supply voltage slowly up to +14 volts to check that the output is still a constant +8 volts. **Do not exceed +15 volts maximum input rating or damage may occur to the LT1507.**

**3.** Next measure the negative voltage on pin 5 of the LMC7660, **( TP2 )** with a multi-meter to confirm that it is close to – 7.4 volts. If all is OK then disconnect the bench power supply from the amplifier and solder the FDS9400A to the board.

**4. Set the 5kohm Bias trim-pot fully counter clockwise.** Connect a suitable ammeter inline with the DC Input to the amplifier board. Apply precisely +12v from the bench power supply to the amplifier and adjust the bias trim-pot for precisely 470mA, **( with No RF drive ). This corresponds to the bias to the MMIC being set for 700mA at +8V.**

**5.** If you have got access to a RF power meter or Spectrum Analyzer, then the gain and RF output spectrum of the amplifier can be tested. please refer to the data sheet for the TC3341 for the maximum input RF drive level, and other data before applying any RF to the input of the amplifier. The TC3341 MMIC amplifier has a minimum gain of around 27dB, so only requires around +5dBm, ( 3.2mW ) input for an output of +32dBm, ( 1.6 Watts ). The input RF drive level should be set so that the maximum RF output for linear operation is kept under +32.5dBm, and for non linear modes under +33dBm. **Excess RF drive over +10dBm can damage the TC3341 MMIC, and will just drive the amplifier into non linear saturation.**

**6.** Apply 0dBm ( 1mW ) drive to the input of the amplifier and confirm that the output is around +27dBm ( 500mW ). Driving the amplifier with around +5dBm ( 3.2mW ) should take the output to around +32dBm ( 1.6 Watts ).

**NOTES:**

**1.** When using small diecast enclosures it can be difficult to mount the amplifier into the enclosure due to the requirement to use low loss connectors at high microwave frequencies. There are a couple of suggestions that include using extended SMA adaptors like the Mini-Kits SMA18 and SMA42, or alternatively short connection cables using Quick form 0.085 cable and the Mini-Kits SMA22 and SMA41 connectors. **Under no circumstances should coaxial cable be directly connected to the board as it will place too much stress on the PC board tracks.**

**2.** Chip components crack easily so if you have problems getting the amplifier going properly, then check that you have not cracked the input and output chip capacitors on the striplines to the connectors.

**3.** The PC board should only be mounted onto a flat aluminium heat sink or plate for maximum heat transfer, and to ensure that the board is mechanically stable.

**PARTS LIST:**

**RESISTORS**

| | |
|---|---|
| 1 x 200R | SMD 1206 Resistor |
| 1 x 220R | SMD 1206 Resistor |
| 1 x 1K | SMD 1206 Resistor |
| 2 x 10K | SMD 1206 Resistor |
| 1 x 22K | SMD 1206 Resistor |
| 1 x ST-4EA-5K | SMD 4mm Trimpot |

**CAPACITORS**

| | |
|---|---|
| **2 x 2p2** | **SMD 0603 NPO Chip Capacitor** |
| **2 x 3p3** | **SMD 0603 NPO Chip Capacitor** |
| 5 x 1nF | SMD 0603 X7R Chip Capacitor |
| 1 x 3n3 | SMD 0603 X7R Chip Capacitor |
| 7 x 0.1uF | SMD 0603 X7R Chip Capacitor |
| 4 x 10uF | SMD 20-25v Case C Capacitor |
| 2 x 100uF | SMD 16v LOW ESR D Capacitor |
| 1 x 100uF | Radial 25v LOW ESR Capacitor |

**Bold Writing denotes standard Tuning Capacitor values.**

**SEMICONDUCTORS**

| | |
|---|---|
| 1 x TC3341 | PHEMT MMIC Transcom |
| 1 x LT1507CS8 | Switching Regulator SMD |
| 1 x FDS9400A | MosFET SMD |
| 1 x LMC7660 | -ve Generator Switching IC SMD |
| 1 x BC847 | PNP Transistor SMD |
| 1 x LL4148 | Diode small signal SMD |
| 1 x MBRS130LT3 | Diode Schottky Switching SMD |
| 1 x BZX284C5v6 | 5.6v Zener Diode SMD |

**MISCELLANEOUS**

| | |
|---|---|
| 1 x PC Board | EME141 |
| 1 x Instructions | EME141-3400 KIT |
| 2 x BN-61-202 | Fair-rite Binocular Core |
| 1 x 140cm length | 0.4mm ECW **( Cut in half )** |
| 1 x 10cm length | wire wrap wire |
| 10 x PS-M2.5x6-ZS | Screw M2.5 x 6mm |

**OPTIONAL**

| | |
|---|---|
| 1 x Aluminium Plate | 47.5 x 37 x 10mm |
| 1 x SMA06 | SMA Female 4 hole mount connector |
| 1 x SMA13 | SMA male 4 hole mount connector |

 

# TOP PC BOARD OVERLAY EME141_3400

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