When we analyse the success story of the ham Vasantha Kumar, VU2VWN, a school teacher by profession who rose to the height of Principal in Polytechnic College, with strong willpower and commitment to his duties, then it is worthwhile to analyse how he became a most successful HAM and Home brewer?

Before becoming a ham he spent most of his time by reading books and periodicals. At the age of 20, he came to know about ham radio and he was very much fascinated with it. He began studying literature on ham radio and electronics. He also started assembling various electronic gadgets and conducted various experiments this field. When he wanted to study Morse code there were no trainers who can teach wireless Morse. He approached a telegraph operator working in the Post and Telegraph Department. (This P&T Department under Government of India later renamed as BSNL. In order to study the Morse code, he spent many days near the radio receiver trying to decode it. Eventually he became an expert to send and receive the Morse code.

When he was working at Kottayam he visited the Ham Radio Station (Shack) for the first time. This shack was that of Old Man (OM) Guhan Menon (VU2TG). Vasanthakumar was very much thrilled with the mere sight of that radio station.

After many years of waiting he became the member of the Ernakulam Amateur Radio Society in the year 1980. The club arranged the venue for the A.S.O.C examination at the Chavara Cultural Centre. He appeared the examination, passed the examination and got the A.S.O.C. grade I license in the year 1982. Later he got an advanced grade license too.

When he got the license in 1982 the ham population in India was very low compared with U.S.A. and Japan. The availability of technical experts, literature on ham equipments and electronic components required for the assembly of ham station equipment was very poor. The Price of imported ham radio equipment was prohibitively high for an average Indian. The main source of technical details available to home brew Amateur radio was from the American Radio Relay League (ARRL) publications. Their sophisticated designs were beyond the reach of an average Indian ham. We had to depend on the older and cheaper versions of the designs. Availability of suitable components was also a challenge. Most Home brewers were to assemble Vacuum tube based transmitters which required high voltage R.F components salvaged from the junk traders of military surplus at Delhi. It required long travel and consumed much time to sort the components for the remote dwellers. These equipments occupied a bulk of the space. Many hams used the crystal controlled oscillators which restricted the operations to certain fixed frequency. Few hams were able to work with variable frequency Oscillators with which one can work on desired frequency.

Solid State Design technique was only peeping to the scene. Some low power (QRP) solid
state design using crystal controlled oscillator and variable frequency oscillator C.W. transmitters were appeared in the publication ‘Radio’ Magazine, but it made no considerable effect.

**VWN QRP Transmitter**

When he received his HAM radio license, Vasanthalumar realised that a cost effective, efficient, easy to build and easy to operate on C.W. and A.M. mode low power transmitters without the risk of shock was in demand. He started experimenting with readily available components in the local (Cochin) market. The experiment resulted in a 5 transistor low power QRP transmitter. It was built in two battery eliminator power supply box, one for the variable frequency oscillator (VFO) with buffer amplifier and a bigger box for the RF Power Amplifier (PA) with driver RF preamplifier. The PA box also contained the power supply for the P.A.

FET’s (BFW10) were used for the one for VFO and another one as buffer amplifier. Three transistors BC148B, BC157 and SL100 were used for the RF, preamplifier, driver and P.A. respectively. Pure DC from 6 volt battery was fed to the VFO. 24 Volt DC rectified and filtered from the 230 volt A.C. supply was delivered to the P.A.

The reception reports received from the band was very encouraging and the circuit was grand success. But the power output was enough to override the noise in the band especially at night. So he started experimenting with the popular audio power transistors available for the RF power amplifier. Finally the BD139 transistor which was widely used in Audio Power amplifiers with high cut off frequency (Ft) was chosen and made the job efficiently.

Since the design lacked a modulator, it was very difficult to communicate with unskilled hams using voice communication. This handicap was overcome by adding an amplitude modulator using the easily available audio power amplifier IC TBA 810 was added to the transmitter.

When we analyse the modus operandi of his experiments we can see that he got no high tech laboratory facilities and never used the tough mathematical approach. It was all based on trial and error basis and simple design procedures. The only sophisticated piece equipment he used was the multimeter and the assembling tools used were soldering iron and screw driver. But his approach was very scientific. He studied the working principles of several equipments. He observed and analysed the advantages and drawbacks of it and moulded the idea for the further development according to his wish. When he conducted his experiments he thoroughly studied the principles and made the records/notes of the observations and inference. When the outcome was failure he looked into the cause and improved the design.

He never has the habit of copying existing design as it is but be used to alter the design according to his ideas. When he struck with an idea he quietly implemented it. His design became very popular and many hams started using it. He enjoyed the thrill of popularity of his design. He constantly communicated with those hams who copied the design and assisted them in making and setting up the station. He also cleared their doubts and accepted their suggestions.
for betterment.

**The advantages**

1. It has fairly stable variable frequency oscillator so that one can operate on desired frequency.
2. It has adequate power to establish a communication.
3. It has the CW as well as the AM mode.
4. The design is efficient and cost effective and easy to homebrew by even an inexperienced in electronics.
5. The components used were easily available in the local market.
6. The tunable final tank circuit makes it more power efficient.
7. The collector modulation reduces the circuit complication and good quality audio transmission.
8. It is cheap and affordable for an average ham.

**Circuit Diagram Notes**

**QRP transmitter**

It has three main blocks namely the VFO, R.F. power amplifier and the modulator.

The VFO and Tuned Power Amplifier together generate the Radio Frequency carrier wave to the required power to operate in CW mode. In AM mode, the Audio amplifier amplifies the speech signal available at the output of a condenser microphone to the required strength and used to vary the amplitude of the carrier using collector modulation. A modulation transformer is used for collector modulation.

**VFO**
The VFO circuit consists of a variable frequency LC oscillator and a buffer amplifier. It is made with two BEW10 FETs. The oscillator circuit uses standard Colpitts type oscillator.

VFO

The VFO is designed for the use of 40m band and the frequency range is 7 MHz to 7.1 MHz. L1, C2, C3, C4, C5, C6, C7 and CT2 one another forms the tuned circuit. When power is applied to the transistor stage Q1, the current flowing through the Q1, makes voltage across the RFC1 and the resistor R2. This voltage excites tank circuit into oscillation to its resonant
frequency. The damped oscillations are amplified using Q1, and feedback to maintain the oscillation at constant amplitude. The output is coupled to next buffer amplifier stage through the capacitor C8. The buffer amplifier is also of the FET Q2, in the source follower configuration which makes less loading to the oscillator. The RF voltage developed across the resistor R4 is coupled to the next RF preamplifier stage through C10.

**FIG. 2.2 CIRCUIT DIAGRAM OF V.F.O.**

The D.C. power supply to the V.F.O. stage is obtained from a 6 volt battery for better stability and low noise.

**Power amplifier**

The P.A. consists of three stages with the transistors Q3, Q4 and Q5 that is BC547B, SK100B and BD139 respectively. Q3 is biased in class A mode and forms the RF preamplifier. This stage amplifies signal from the VFO. The output from this transistor is coupled to the driver stage through C10 which is class-C operated with the PNP transistor Q4. This transistor conducts during the negative peaks of the incoming signal and amplifies the signal further to drive the PA, hence the name driver amplifier. The power amplifier stage is also operated in class C mode with an NPN transistor Q5 (BD139) whose collector load is a tank circuit made of C12, CT3 and L2 which is tuned to wanted frequency. The transistor Q5 conducts during the positive peaks of the signal developed across L3. A pulsating current flows through the tank coil L2 and Q5. But due to the flyback action a continuous wave is developed across The RF output is tapped from the coil L2 to match the impedance of the coaxial cable and is fed to the dipole antenna.

DC Power to the P.A. is obtained from step-down transformer. The 24 volt step down AC
is rectified, filtered and the +ve line is connected to the P.A. through the modulation transformer secondary winding. The ground connection of the power supply is connected through the Morse key to the P.A. Ground. By tapping the key we can interrupt the power to P.A. and enable the code transmission in the CW Mode.

**Modulator**

The modulator consists of an AF preamplifier built using BEL548B and AF power amplifier using IC TBA810. The microphone picks up the audio and converts it into the corresponding electrical signal of audio frequency. This audio frequency is amplified using the preamplifier and power amplifier to the required level. The output of the modulation level can be controlled by varying potentiometer (PT).

The A.F. from modulator is coupled to the P.A. using the modulation transformer. The B+ current flowing through the secondary winding of the P.A. get varied according to the A.F. current variation of the modulating signal. Hence the A.F. is superimposed on the R.F. carrier wave enabling the A.M. mode of operation.

**Construction of VFO**

The construction of the VFO is straightforward and it does not require any explanation. Circuit diagram is given in Fig. 1.2. One can make use of the PCB design given in Fig.1.3. PCB construction methods are explained in appendix. However you have to take note of the following points:

1. Battery operation is preferred. For battery operation of VFO, remove the Zener diode Z. If Zener diode is omitted, the total current drain from battery to the V.F.O. will be about 8 mA only.
2. Use RF grade disc capacitors, else the circuit will fail to oscillate.
3. If silver mica capacitors are available, use that instead of styroflex capacitors.
4. VFO on/off switch is optional. It is good practise to keep the VFO on at all times during operation.
5. Always keep VFO away from 50 Hz mains transformer to avoid hum pick-up. A distance of 2 feet will be sufficient.
6. Use homemade PCB or readymade vero board for assembling the circuit.
7. VFO should be enclosed in a metal box. Simple one is to use a 6 volt battery eliminator box.
8. Use rigid copper wiring in the VFO assembly to avoid frequency shift. Never let it loose.

**Components list for VFO**
<table>
<thead>
<tr>
<th>Sl. No</th>
<th>Ref. designator</th>
<th>Description</th>
<th>Sl. No</th>
<th>Ref. designator</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>R1, R3</td>
<td>100 ohms</td>
<td>6</td>
<td>C1</td>
<td>47 PF Styroflex</td>
</tr>
<tr>
<td>2</td>
<td>R2</td>
<td>220 ohms</td>
<td>7</td>
<td>C2</td>
<td>180 PF</td>
</tr>
<tr>
<td>3</td>
<td>R4</td>
<td>1 k ohms</td>
<td>8</td>
<td>C3, C4, C5, C8</td>
<td>100 PF</td>
</tr>
<tr>
<td>4</td>
<td>R5</td>
<td>47 ohms</td>
<td>8</td>
<td>C6</td>
<td>01 MF Phillips red or striped polyester</td>
</tr>
<tr>
<td>5</td>
<td>R6</td>
<td>220 K/1 watt (for RFC)</td>
<td>10</td>
<td>C7</td>
<td>10 PF Philips gray disk or styroflex</td>
</tr>
</tbody>
</table>

### Semiconductors
1. Q1 BFW 10 (BEL) make preferred
2. Q2 BFW 10
3. Z1: 5 V / 400 mW

### Inductors
- L1
- CT1
- CT2

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Fig. PCB design For VFO

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Inductors

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1. **L1**: 2 micro Henry (Tank Coil) It can be made by winding 11 turns of 24 S.W.G. enamelled copper wire on a piece of PVC pipe of 1/2 inch inner dia. at a length of 1 cm.

2. **RFC**: It can be made by winding 150 turns of 36 S.W.G. enamelled copper wire on a 220 K ohms 1 watt resistor in a random mode or in two sections as shown in the figure.

```
[Diagram showing RFC and a coil with dimensions 1/2 inch inner dia. and 1 cm length]
```

**Miscellaneous components:**

1. Switch - Miniature toggle
2. Dial Drum - 2 inch plastic
3. Printed Circuit Board (PCB) size 2"x3"
4. Box (Iron metal) 6 volts Battery eliminator type or of that dimension
5. Spaces - 4 nos.
6. Nuts & Bolts for fixing the box.
7. Hookup wire.

**Power Supply**

Even though the recommended source of power supply to the VFO is from the battery, it is not so practical due to the running expenses of the battery. So a practical circuit that can be used to derive the power from AC mains is given in appendix. In order to avoid hum pick-up, keep the VFO. power supply away from the VFO box.

**Construction of RF Power Amplifier**

Construction of the RF power amplifier is straightforward and it does not requires any explanation. You can make use of the PCB design given in figure. PCB construction methods are explained in appendix. However you have to take note of the following points:

Specifications of RF amplifier:

1. DC input is about 7W measured at 35 volts when the current to the BD 139 final was about 200 mA. to 250 mA.
2. RF output is 4 to 5 watts into 75 ohm load.
COMPONENT LAYOUT

FIG. 2.5 FRONT PANEL OF THE BOX
Precautions to be taken:

1. Use 75 ohm coaxial cable for connecting V.F.O to P.A., L2 to CT3, L2 to Antenna etc.
2. If possible, avoid switches, connector etc., to save money as well as frequent repairs.
3. L2 should be mounted vertically while L3 horizontally and away from L2 as far as possible. The space between L2 and L3 should be more than 1.5 inches
4. If any unwanted self oscillation is noticed, move collector tap upwards turn by turn, until the self oscillation stops.
5. Enclose the Radio Frequency Power Amplifier in a large battery eliminator or amplifier box. V.F.O. can be placed in this box.
6. Special precaution should be taken while soldering the styroflex capacitors. Hold its legs using a nose plier to avoid overheating.
7. Always use 0.1/100 volt capacitors across all rectifier diodes to eliminate hum in RF signal
8. 100 pF capacitor connected in the base of Q3 can be omitted.
9. Voltage at the collector of BEL547B (Q3) should be more than 2.5V: If not, increase the value of bias resistor 470 K to 560K.
10. When AM operation is required remove the jumper between the points in the B+ line and connect the modulation transformer secondary there.
Components List: Power Amplifier
Resistors

1. R7  470 k ohms 1/4 watt
2. R8  1 k ohms 1/4 watt
3. R9  1 k ohms 1/4 watt
4. R10 220 ohms 1/2 watt
5. R11 10 ohms 1 watt
6. R12 220 ohms 1/2 watt
7. R13 47 k ohms 1 watt
8. R14 1 k ohms 1 watt (For making L3)
9. VR 10 k ohms 1 W (wire wound potentiometer). It is used to control power.

Capacitors

1. C15 1000 PF Styroflex only.
2. C16 100 PF Philips grey disk or styroflex
3. C17 0.01 MF Philips redorstripedipoly.box type.
4. C18 0.01 “
5. C19 0.01 “
6. C20 0.1 MF “
7. C21 0.1 MF “
8. C22 1000 MF/47V - Electrolytic
9. CT3 330 PF - PVC2J gang condenser XYCON make preferred

Inductors

1. L2 - 4.4.microhenry: It can be made by winding 24 turns of 20 SWG enamelled copper wire on a piece of polythene pipe of inner dia. 1.7 cm. and length 3 cm. Tap out the coil at 13th 15th and 16th turns. 13th tap can be used for connecting 50 ohms coax when using the inverted “V” antenna. 15th tap can be used for matching 75 ohms coax when using the dipole antenna.
2. L3- RFC. It can made by winding 150 turns (75+74) (as in the figure) of 36 S.W.G. enamelled copper wire on a 1 k ohms 1 watt resistor Horizontal mounting is essential. Open circuit of 1 k resistor causes Self oscillation of BD 139

Diodes:

1. Z2  72 volt/400 mw Zener (If not available use three 24 V/0.4 watt in series)
2. D4  LED (clear LED used as tuning indicator. Tune CT3 for minimum brightness)
3. D5  IN4001
4. D6  IN 4007

Transistors:

1. Q3 RF Preamp. - BEL547B, SL100 B, BELL 100 N etc.
2. Q4 RF Driver - SK 100 B (SMC or CDIL make)
3. Q5 BD 139 preferred (BU 407,UD 856, D 882, D 886, C 2562 can be used)
Miscellaneous:

1. T1  Step down mains transformer - 24 volt - 0 -24 volt 1 Amp.
2. F  Fuse holder with 500 mA fuse.(Note 1)
3. P.C.B.  Size 3" x 4" (vero board also can be used)  Ref Fig. 2.7
4. Aluminium heat sink with mica washer. A sizes of 2" x 2" mm is adequate. Place it on the transistor Q5 BD 139.
5. Headphone jack and pin to connect key to the transmitter.
6. Dial Drum for the tuning capacitor CT3.
7. RF connector for antenna connection via coaxial cable (male & female).
8. Use required length of hook-up wire.
9. Key click filter using 0.01 and 100.ohms can be use as shown in fig. X .Not essential.
10. Metal box and fittings of suitable size. See fig of System layout
11. Feeder-75 ohms coax 14 metre long, with dipole antenna of length 66'6"50 ohms coax 14 metre long, with inverted 'V' antenna of 66'6"

Note 1: For measuring collector current of BD139, remove fuse (F) and insert multi-meter probes. After setting current insert F into holder.

![Fig. X Circuit of Key Click Filter](image-url)
Construction of Modulator

The construction of the modulator is straightforward and it does not require any explanation. You can make use of the PCB design given in fig.9. PCB construction methods are explained in appendix, However you have to take note of the following points:

1. Use coaxial mic cable (2 plus shield) or use ordinary shielded wire for mic connection.
2. If 3 pin mic is not available, use 2 pin condenser mic.
3. Adjust R17/Rx to get 6V at the collector of Q6.
4. TBA 810 Audio amplifier is suitable for the Modulator audio amplifier.
5. For maximum modulation, TBA810 should operate with 16 -18 V.
Components List for Modulator

Resistors: (all resistors are ¼ watts)

1. R15 1 k ohms
2. R16 470 k
3. R17 Rx- Test select to get 6V at the collector of Q6
4. R18 1 k
5. R19 47 ohms
6. R20 1 k
7. R21 100 k
8. R22 150 ohms
9. R23 100 ohms
10. PT1 100 ohms Log potmeter
Capacitors:

1. C23  47uF 16V
2. C24  1000 PF
3. C25  100 uF/16V - Electrolytic
4. C26  0.1 uF
5. C27  0.01 uF-
6. C28  0.1 uF
7. C29  1000 PF\ 
8. C30  100 uF/16V - Electrolytic
9. C31  1000 uF/25V - Electrolytic
10. C32  100 uF/16V - Electrolytic
11. C33  6K 8 PF
12. C34  100 uF/16V
13. C35  1K PF
14. C36  0.1uF
15. C37  1000 uF/25V - Electrolytic
16. C38  0.1 uF
17. C39  0.1 uF
18. C40  0.1 uF
19. C41  1000 uF/25V - Electrolytic

Semiconductors:

1. IC   TBA 810
2. Q6   BC548 B or C
3. D7   1N 4002
4. D8   1N 4002

Transformers:

1. T2 Step down mains transformer 230/ 12V-O-12V 1 Amp.
2. T3 Modulation transformer: It can be made by winding on an iron core of size 3/4" x 3/4", which is approximately equal to the size of a 6V-0-6V/600 mA AC mains transformer. For Primary side of 35 V use 200 T of secondary (3 to 6); 24V “150 T “(3 to 5); 12V “100 T “(3 to 4). Slight adjustment can be made for optimum modulation.
Miscellaneous:

a. Use a suitable box with all fittings
b. PCB with suitable dimension
c. ON/OFF switch
d. Mains cord and required length of wire
ALIGNMENT AND TUNING UP

As we have already seen the construction methods of the transmitter, now let us go for the final part i.e., the alignment and tuning up. Accessories required for alignment and tuning up are:

1. Analog/Digital Multimeter,
2. Dummy Load (a 12 volt/0.4A bulb Miller cycle bulb will do) Solder wires to the bulb as shown in the fig. Below.

![Figure Dummy Load](image)

3. RF Probe for measuring, RF voltages:

Construction method of a simple RF probe is explained in appendix.

The alignment procedures have to start from the VFO. Tuning of the VFO is nothing but the setting up of voltages at the test point to the wanted level. The following chart gives the voltages at various test points of the VFO. Refer circuit diagram of the VFO for locating the exact test points

<table>
<thead>
<tr>
<th>Test Points</th>
<th>Test D.M.M. in 20 volt range (DC)</th>
<th>Analog meter in 10 volt range (DC)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>4.9 V</td>
<td>Oscillation stops</td>
</tr>
<tr>
<td>B</td>
<td>4.6 V</td>
<td>2.7 V</td>
</tr>
<tr>
<td>C</td>
<td>3.0 V</td>
<td>1.9 V</td>
</tr>
<tr>
<td>D</td>
<td>10V</td>
<td>0.8 V</td>
</tr>
<tr>
<td>E</td>
<td>0.9 V without load/ 0.7 V with load</td>
<td>0.6 V without load/ 0.5 V with load</td>
</tr>
<tr>
<td>F</td>
<td>0.63 V without load/ 0.3 V with load</td>
<td>0.4 V without load/ 0.2 with load</td>
</tr>
</tbody>
</table>

RF Voltage readings obtained at various test points of Tx PA

<table>
<thead>
<tr>
<th>Test Points</th>
<th>Test D.M.M. in 20 volt range (DC)</th>
<th>Analog meter in 10 volt range (DC)</th>
</tr>
</thead>
<tbody>
<tr>
<td>G</td>
<td>0.3 V</td>
<td>0.2 V</td>
</tr>
<tr>
<td>H</td>
<td>0.8 V</td>
<td>0.45 V</td>
</tr>
<tr>
<td>I</td>
<td>0.9 V</td>
<td>0.45 V</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>J</td>
<td>1 V</td>
<td>0.8 V to 0.75 V</td>
</tr>
<tr>
<td>K</td>
<td>24 V (200 V range)</td>
<td>20 V</td>
</tr>
<tr>
<td>L</td>
<td>14.3 V (20 V range)</td>
<td>12.5 V</td>
</tr>
<tr>
<td>M</td>
<td>13.4 V &quot;</td>
<td>12.5 V 50 V range</td>
</tr>
<tr>
<td>N</td>
<td>13.4 V &quot;</td>
<td>12.5 V &quot;</td>
</tr>
</tbody>
</table>

Alignment and Tuning of Power Amplifier.

To align our transmitter follow the steps explained below:

1. Check thoroughly for any wiring mistake and correct if found.
2. Connect the battery to the V.F.O. Measure RF output voltage at the VFO output terminal through the RF Probe. It should be around 0-4 volts
3. Bring the V.F.O. frequency to the 7 MHz ham band using the 22 PF (CT2) button trimmer. The frequency coverage using CTI will be around 150 kHz. Bring the ham band in the centre of the dial as shown in the figure

![V.F.O Dial]

4. If the VFO frequency is not within the ham band, the capacitor values are not correct. Try some other capacitors of different values so as to bring the frequency to the required band. It is better to adjust the capacitor C2 (180 pF) value. Now connect VFO to the PA section.
5. Set the power control Potentiometer (VR) to its maximum value of 5 K ohms or 10K ohms.
6. Connect dummy load to the antenna terminal A 12 V 0.4A Miller cycle bulb is OK. Use short leads.
7. Remove 0.5 Amp, fuse and connect the multimeter in 250 mA DC range across it.
8. Apply Power to the PA.
9. The TX should be in CW mode.
10. Press key and adjust power control so as to get 100 mA reading in the multimeter.
11. Tune CT3 so that this current decreases slightly and shows a dip at some setting of CT3. Now the tank is in tune.
12. Gradually increase the power using the 10K pot so that the bulb begins to light. Again tune the capacitor CT3 for maximum brightness of the bulb.
13. Adjust the power control to get 200-250 mA of collector current.
14. Now connect the antenna instead of the bulb and repeat the procedure.
15. The LED will only light up at the collector current of about 150 m.A. When the tank is in tune the LED will become slightly dim. It shows that the tank is in tune.
16. More than 250 mA of collector current is not recommended for safe operation.
17. Coaxial cable as feeder is compulsory. Not other feeder can be used. If any mismatch/mistune occurs, the final BD 139 transistor Q5 may burn off.
18. Always start adjusting at low current. i.e. less than 150 mA and only after getting a dip, increase to the maximum power.
19. Tune the final only in CW mode. Adjustment of collector current on A.M. mode will cause PA transistor burn off.
20. For AM adjustment, gradually increase modulation to a level at which the collector current meter shows a flicker or a wavering. Stop the modulation gain from further increasing.
21. Always use minimum turns tap for the modulation transformer secondary to attain 100% modulation. Over ruin the P.A. (BD 139-Q5)
22. Normal range of this TX in C.W. mode is found to be around 500 km. slightly lesser range in AM mode is expected. Many contacts with stations as far as 7000 kms were also established under better band conditions. To achieve long range communication, you should be a patient and an expert operator.

Note:
The original article was published in the year 1992, written by VU2PCM and most of the figures were handwritten by OM Vasanthakumar. This is the edited version of the original article, edited by Dr. T.K. Mani (VU2ITI) and OM Niras (VU3CNS)