24 GHz World Record EME QSO

Following the up-grading of VK7MO's dish to 1.14 metres (3 foot 8 inches) VK7MO completed his first 24 GHz EME QSO with OK1KIR using JT4F for a new World record distance of 16383 km. The increase in dish size to 1.14 metres remains within practical limits for portable operation. However, the evidence to date is that QSOs will only be possible under very good conditions -- low Doppler spreading, low degradation and low Precipitable Water at both ends.

Equipment

OK1KIR was running 20 watts to a 4.5 metre dish and VK7MO around 8 to 9 watts to a 1.14 metre dish. VK7MO did full Doppler correction for both the TX and RX paths.

Conditions

Precipitable Water was 14.8 mm at OK1KIR and 12.2 mm at VK7MO. At the median elevation of 15 degrees for this QSO this represents losses of 3.4 dB when OK1KIR is receiving and 3.3 dB when VK7MO is receiving. Predicted full Doppler Spreading was around 103 Hz which reduces to 40 Hz with the narrow beamwidth of OK1KIR's antenna. This represents a relatively low spreading loss of about 2 dB (cf a 10 Hz reference). Degradation was low at 0.9 dB.

1270 Hz Single Tone

1270 Hz single tones were used to start the QSO and it was quickly evident signals were at decodable levels. Fig 1 shows the 1270 Hz tone received by VK7MO.

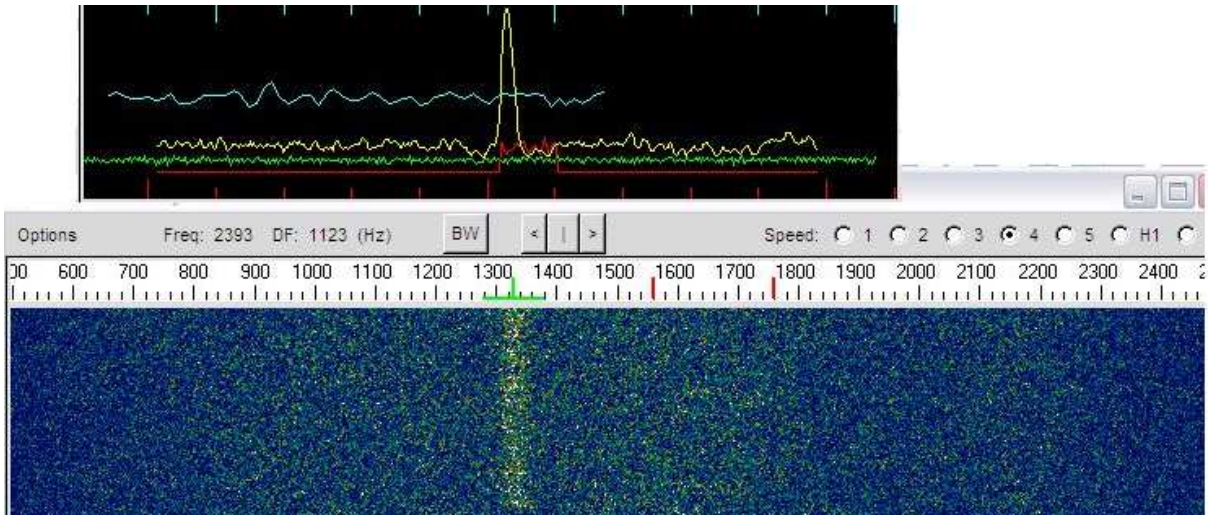
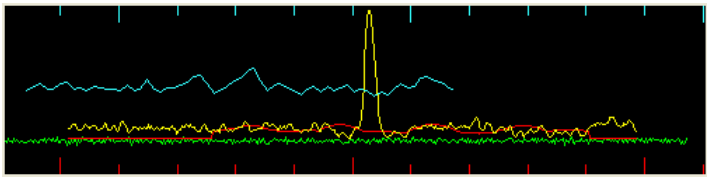


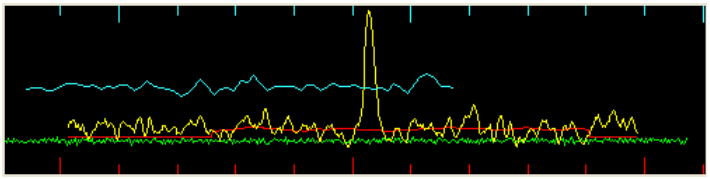
Fig 1: 1270 Hz single tone on Yellow Graph and Waterfall as RXed by VK7MO

As shown on the waterfall the spreading is slightly above the predicted 40 Hz, probably around 45 Hz.

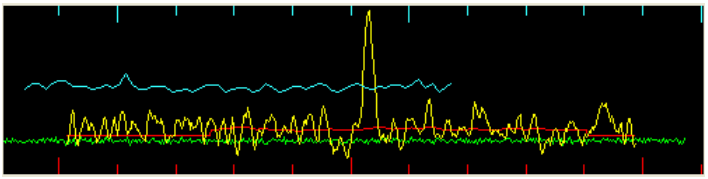
Fig 2 shows a group of graphs with the same tone as for Fig 1 degraded in 2 dB levels using the WSJT's facility to add specified amounts of noise.



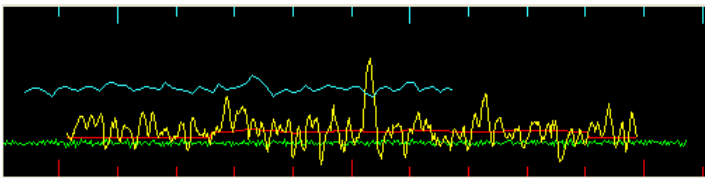
0 dB



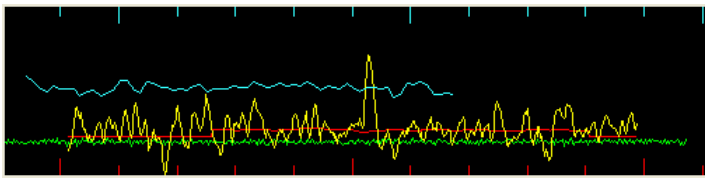
- 2 dB



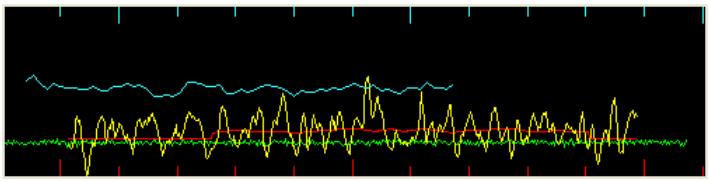
-4 dB



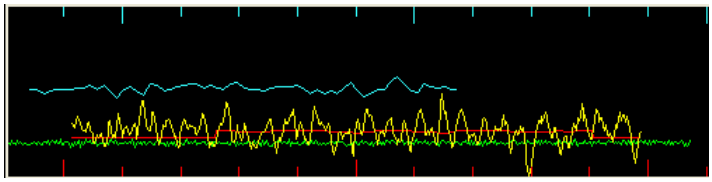
-6 dB



-8 dB



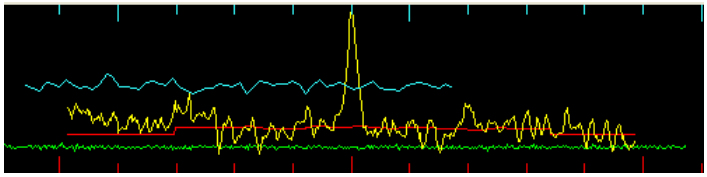
-10 dB



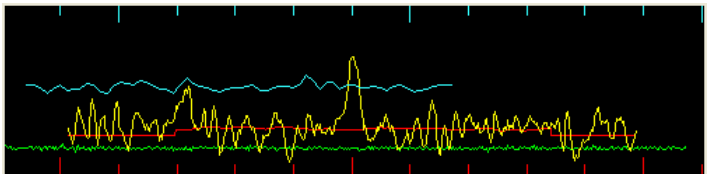
-12 dB

Fig 2: 1270 Hz tone as RXed by VK7MO degraded in 2 dB steps

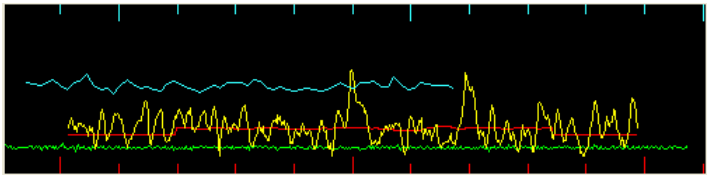
As is seen in Fig 2 the 1270 Hz tone was clearly evident with 8 dB degradation and still the strongest peak with 10 dB degradation suggesting that in terms of identifying a tone there was at least 8 dB in reserve.



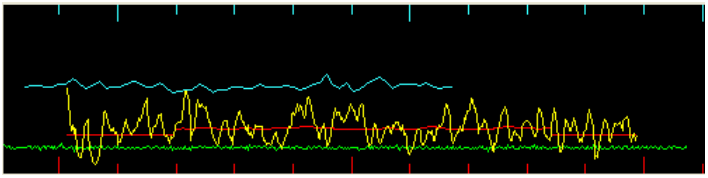
0 dB



-2 dB



-4 dB



-6 dB

Fig 3: 1270 Hz tone as RXed by OK1KIR degraded in 2 dB steps

It is seen that the 1270 Hz tone as received by OK1KIR was only clearly identifiable to -2 dB. Thus there is about 6 dB difference compared to that RXed by VK7MO. In part this is explained by the power difference of 3 dB plus an extra 2 dB of Moon noise on OK1KIRs larger dish but also because this test was conducted at Moonrise for OK1KIR, around 11 degrees elevation, when they had additional absorption noise compared to VK7MO where the elevation was around 20 degrees.

Results

VK7MO's ALL.TXT file is below:

```
164400  Transmitting: JT4F    @1270
164700  2  -18  2.4   72  37 *     VK7MO OK1KIR JN79   ?    0    1 E
164800  Transmitting: JT4F    OK1KIR VK7MO -18
164900  7  -14  2.4   74  44 *     VK7MO OK1KIR JN79        1   26 D
165100  7  -14  2.4   77  28 *     VK7MO OK1KIR JN79        1   27 D
165300  5  -15  2.2   74  44 #     VK7MO OK1KIR R-17        1   26 D
165400  Transmitting: JT4F    OK1KIR VK7MO RRR
165422  Transmitting: JT4F    @1500 (RRR)
165500  6  -15  1.9   77  44 #     VK7MO OK1KIR 73 OOO      1   31 D
165600  Transmitting: JT4F    @1700 (73)
165700  6  -15  2.4   72  46 #     VK7MO OK1KIR 73 OOO      1    8 D
165800  Transmitting: JT4F    OK1KIR VK7MO -14
165900  5  -15  2.2   74  44 #     VK7MO OK1KIR 73 OOO      1   16 D
170100  6  -15  1.8   77  42 #     VK7MO OK1KIR -17         0    4 D
```

```
170210  Transmitting: JT4F    OK1KIR VK7MO R-14
170300  7  -14  2.1   77  42 #     VK7MO OK1KIR R-17       1   16 D
170408  Transmitting: JT4F    OK1KIR VK7MO RRR
170500  5  -15  2.1   74  44 #     VK7MO OK1KIR R-17       1   22 D
170700  6  -15  2.0   79  44 #     VK7MO OK1KIR RRR OOO    1   23 D
170800  Transmitting: JT4F    OK1KIR VK7MO 73
170900  6  -14  2.6   77  44 #     VK7MO OK1KIR RRR OOO    1   18 D
171100  6  -14  2.5   74  42 #     VK7MO OK1KIR 73 OOO     1   13 D
171209  Transmitting: JT4F    @2000
```
(Note: Two QSOs were completed)

It is seen that the DTs did bounce around from 1.8 seconds up to 2.6 seconds. This is a much wider variation than seen on W5LUA and might be an indication of a slow computer working too close to its capacity. The median DF was slightly high in frequency at 77 Hz, which is typical between OK1KIR and VK7MO. The variation in DF of +/-5 Hz is extraordinarily good given that the spreading is around 50 Hz and shows that even at 24 GHz there must be some peaking of the signal.

It is further noted that not only were decodes achieved in every line but 11 of the 13 were achieved with the convolutional decoder as indicated by the “1 in the third last column.

For this test MinW was set at “D” or 39 Hz consistent with an expected spreading of around 40 Hz. In practice all except the one of the decodes were achieved with the D binwidth as shown by the last column.

OKIKIR’s ALL.TEXT is below:

```
164600  0  -21  4.9   74  13 #                                    nice yellow spike
164700  Transmitting: JT4F    VK7MO OK1KIR JN79
164800  1  -19  3.0  -28  44 #                                    msgs no decode
165000  0  -21  2.9  -79  15 #                                    strange display
165200  4  -17  2.8  -28  26 #     OK1KIR VK7MO -18        0    7 E      single line decode
165300  Transmitting: JT4F    VK7MO OK1KIR -17
165305  Transmitting: JT4F    VK7MO OK1KIR R-17
165400  0  -21 -1.6  -22   7 *                                    „R“ 1500 Hz
165507  Transmitting: JT4F    VK7MO OK1KIR 73
165600  0  -21  1.0   -7  22 *                                    „73“ 1700 Hz
165800  1  -19  3.0  -15  55 #                                    no decode
170000  3  -17  3.0  -26  46 #     OK1KIR VK7MO -14        0    5 E
170106  Transmitting: JT4F    VK7MO OK1KIR -17
170200  4  -17  3.1  -24  46 #     OK1KIR VK7MO R-14       0    8 E
170310  Transmitting: JT4F    VK7MO OK1KIR R-17
170400  3  -18  2.8  -24  24 #                                    no decode
170600  3  -17  2.5  -31  26 #     OK1KIR VK7MO RRR OOO    0   21 F
170706  Transmitting: JT4F    VK7MO OK1KIR RRR
170800  2  -18  2.9  -22  37 #     OK1KIR VK7MO 73 O ?     0    2 E
171000  3  -18  2.8  -24  26 #                                    no decode
171100  Transmitting: JT4F    VK7MO OK1KIR 73
171200  0  -21 -0.9  -44  15 *                                    2000 Hz ?
```

Given the OK1KIR has 3 dB more power and most cope with around 2 dB more moon noise the fact that they did achieve 5 single line decodes indicates there is a little in reserve.

OK1KIR Echo Test

Appendix A shows the results of OK1KIR echo testing after the QSO. In part these echoes are spread due to the fact that OK1KIR does not correct for Doppler variation.

OK1KIR Sky Noise

Appendix B shows measurements of sky noise at OK1KIR which would be largely due to absorption noise.

Degradation Test on VK7MO files

Test as above with no degradation gave 100 % decodes

1 dB degradation

```
164900  6  -15  2.4   70  39 *    VK7MO OK1KIR JN79       0   18 E
165100  6  -14  2.4   70  42 *    VK7MO OK1KIR JN79       1   17 D
165300  4  -16  2.2   70  39 #    VK7MO OK1KIR R-17       0   10 D
165500  4  -16  1.9   70  39 #    VK7MO OK1KIR 73 OOO     0   23 D
165700  5  -16  2.4   70  39 #    VK7MO OK1KIR 73 OOO     0   10 E
165900  4  -17  2.2   70  39 #    VK7MO OK1KIR 73 OOO     1   12 D
170100  5  -16  1.8   70  37 #
170300  7  -14  2.1   79  31 #    VK7MO OK1KIR R-17       1   11 D
170500  5  -15  2.1   74  31 #    VK7MO OK1KIR R-17       1    7 D
170700  4  -17  2.0   77  28 #    VK7MO OK1KIR RRR OOO    0   14 E
170900  5  -16  2.6   77  33 #    VK7MO OK1KIR RRR OOO    1    6 D
171100  5  -15  2.5   77  28 #    VK7MO OK1KIR 73 OOO     1   14 E
171300  4  -16  2.3   70  42 #    VK7MO OK1KIR 73 OOO     0   16 E
171500  5  -15  2.3   74  28 #    VK7MO OK1KIR 73 OOO     1   21 D
```

2 db degradation

```
164900  4  -17  2.4   70  35 *    VK7MO OK1KIR JN79       0   17 E
165100  5  -15  2.4   70  42 *    VK7MO OK1KIR JN79       0   18 F
165300  4  -16  2.2   77  28 #
165500  4  -17  2.0   70  37 #    VK7MO OK1KIR 73 OOO     0    9 D
165700  2  -18  2.4   70  37 #
165900  4  -17  2.2   70  42 #    VK7MO OK1KIR 73 OOO     0   15 F
170100  2  -18  1.9   72  31 #
170300  5  -15  2.1   79  31 #    VK7MO OK1KIR R-17       0   13 E
170500  5  -16  2.1   70  42 #    VK7MO OK1KIR R-17       0    6 D
170700  3  -17  2.0   79  26 #    VK7MO OK1KIR RRR OOO    0   14 E
170900  4  -16  2.7   77  28 #    VK7MO OK1KIR RRR OOO    1   12 D
171100  3  -17  2.5   74  28 #    VK7MO OK1KIR 73 O ?     0    3 D
171300  2  -18  2.3   79  26 #    VK7MO OK1KIR 73 OOO     0   13 D
171500  4  -16  2.3   70  37 #    VK7MO OK1KIR 73 OOO     0   17 D
```

3 dB degradation

```
164900  1  -19  2.4   81  28 *    VK7MO OK1KIR JN79   ?   0    4 D
165100  4  -16  2.4   79  28 *    VK7MO OK1KIR JN79       0   14 E
165300  0  -20  2.2   70  24 #    VK7MO OK1KIR R-17       0   13 D
165500  2  -18  2.0   70  37 #    VK7MO OK1KIR 73 OOO     0   18 E
165700  3  -17  2.4   74  26 #
165900  2  -19  2.3   70  33 #    VK7MO OK1KIR 73 OOO     0    6 D
170100  1  -20  1.8   72  20 #
170300  5  -16  2.1   79  28 #    VK7MO OK1KIR R-17       0    5 D
170500  3  -18  2.1   79  26 #    VK7MO OK1KIR R-17       0    9 D
170700  3  -18  2.0   79  28 #    VK7MO OK1KIR RRR O ?    0    5 D
170900  2  -18  2.7   79  28 #
171100  3  -18  2.5   79  28 #
171300  2  -19  2.3   74  28 #    VK7MO OK1KIR 73 OOO     0    7 D
171500  3  -18  2.3   74  26 #
```

4 dB degradation – 10 missed decodes

```
164900  3  -17  2.4   70  37 *     VK7MO OK1KIR JN79       0   12 D
165100  3  -18  2.4   79  24 *
165300  1  -20  2.2   70  31 #
165500  0  -20  2.0   83  26 #     VK7MO OK1KIR 73 OOO     0    7 D
165700  1  -19  2.4   63  15 #
165900  2  -19  2.2   70  24 #
170100  1  -19  1.9   68  28 #
170300  3  -17  2.1   77  28 #     VK7MO OK1KIR R-17       0    3 D
170500  2  -18  2.1   81  26 #
170700  0  -20  2.1   90  18 #
170900  2  -18  2.6   79  31 #
171100  1  -19  2.4   77  28 #
171300  0  -21  2.3   77  13 #
171500  0  -20  2.3   70  33 #     VK7MO OK1KIR 73 OOO     0    7 D
```

5 dB degradation --

```
164900  3  -18  2.4   70  42 *
165100  1  -19  2.4   77  24 *     VK7MO OK1KIR JN79   ?   0    5 D
165300  1  -19  2.2   70  26 #
165500  0  -20  1.9   81  26 #
165700  0  -21  2.4   68  18 #
165900  2  -19  2.2   70  35 #
170100  1  -20  1.9   79  20 #
170300  3  -18  2.1   70  33 #
170500  0  -21  5.0   77   9 *
170700  0  -21  2.0   68  22 #
170900  2  -19  2.7   70  33 #
171100  1  -20  2.5   81  20 #
171300  0  -21 -0.2   50  18 *
171500  1  -20  2.3   70  26 #     VK7MO OK1KIR 73 O ?     0    4 E
```

6 dB degradation

```
164900  0  -21  2.4   72  11 *
165100  1  -20  2.4   68  20 *
165300  0  -20 -0.6   85  11 #
165500  0  -21  1.0   85   7 *
165700  1  -20  2.4   55  26 #
165900  0  -20  3.5   57   9 *
170100  1  -20  1.8   70  33 #
170300  2  -19  2.1   70  33 #
170500  0  -21  2.0   77  24 #
170700  1  -20  2.1   83   9 #
170900  1  -19  2.7   59  33 #
171100  1  -20  2.4   72  18 #
171300  0  -21  5.7   66  15 *
171500  1  -20  0.5   28   9 #
```

Summary

Degradation (dB)	% Decodes	% Correct DTs
0	100	100
1	93	100
2	79	100
3	64	100
4	29	100
5	14	86
6	0	64

From the summary it is seen that 86% correct DTs were achieved with 5 dB degradation which would allow averaging and also two single line decodes achieved at this level. Thus in terms of achieving a QSO there was around 5 dB in reserve at the VK7MO end.

Degradation Test on OK1KIR files

This test was limited to the 5 files that did give single line decodes and gave the following results:

No degradation

```
165200  4  -17  2.8  -28  26 #    OK1KIR VK7MO -18       0   8 D
170000  3  -17  3.0  -26  33 #    OK1KIR VK7MO -14       0   9 D
170200  4  -17  3.1  -24  31 #    OK1KIR VK7MO R-14      0  12 D
170600  3  -17  2.5  -31  28 #    OK1KIR VK7MO RRR OOO   0  21 F
170800  2  -18  2.9  -22  28 #    OK1KIR VK7MO 73 O ?    0   4 D
```

-1 dB degradation

```
165200  3  -17  2.8  -26  24 #    OK1KIR VK7MO -18       0   5 E
170000  2  -18  3.0  -26  28 #
170200  3  -17  3.1  -22  31 #
170600  2  -18  2.5  -31  24 #    OK1KIR VK7MO RRR OOO   0   8 F
170800  2  -19  2.9  -24  33 #
```

-2 dB degradation

```
165200  0  -21  2.1  -24   7 #
170000  2  -18  3.0  -24  28 #
170200  2  -19  3.1  -26  26 #    OK1KIR VK7MO R-14      0   6 F
170600  1  -20  2.5  -33  33 #    OK1KIR VK7MO RRR O ?   0   3 E
170800  1  -19  2.9  -22  24 #
```

-3 dB degradation

```
165200  1  -19  2.7  -24  20 #
170000  0  -20  3.0  -26  24 #
170200  0  -20  3.1  -33  28 #
170600  0  -21  4.7  -39  28 *
170800  0  -21  2.9  -18   9 #
```

While this test is limited to the files that did decode it does show that it would have been possible to achieve a QSO with 1 or 2 dB degradation if OK1KIR focussed only on receiving the second decode line with the signal report. This means this station only has to receive one difficult decode. This station then has only to receive RRR which can more readily be done with single tones.

CONCLUSIONS

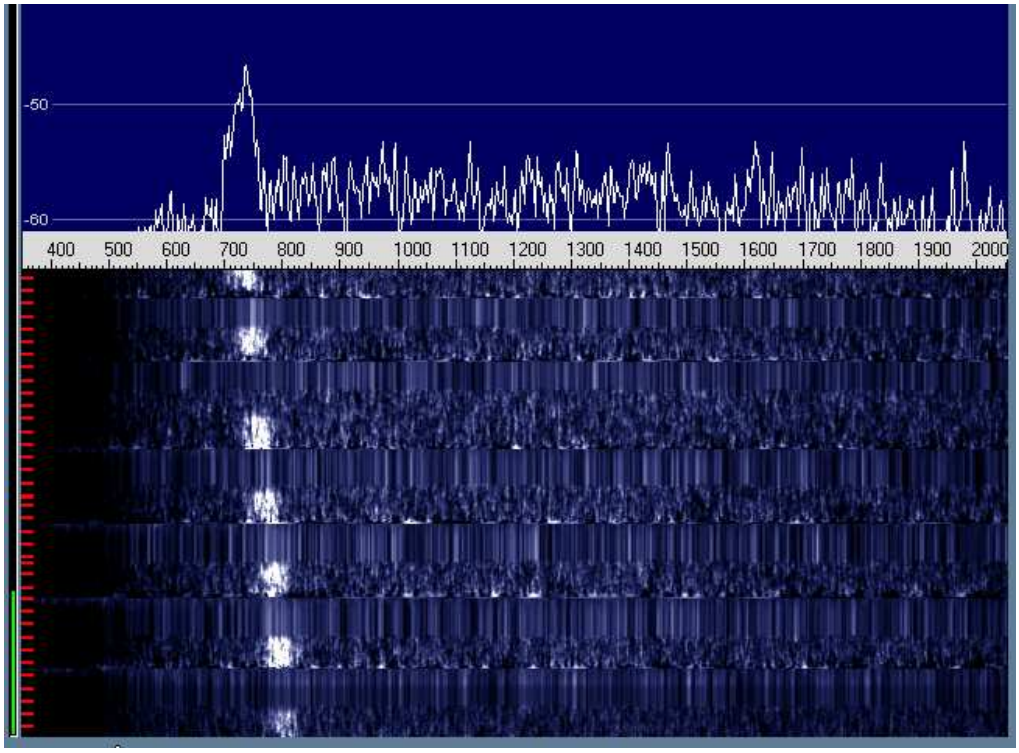
It has been demonstrated that under good conditions it is possible to complete a QSO with OK1KIR with a small portable station based on a 10 watt DB6NT PA and a 1.14 metre dish. There was probably 5 dB in reserve at the VK7MO end but only 1 to 2 dB at the OK1KIR end. Another 3 dB power increase at the VK7MO end is desirable to allow portable operation over a wider range of conditions.

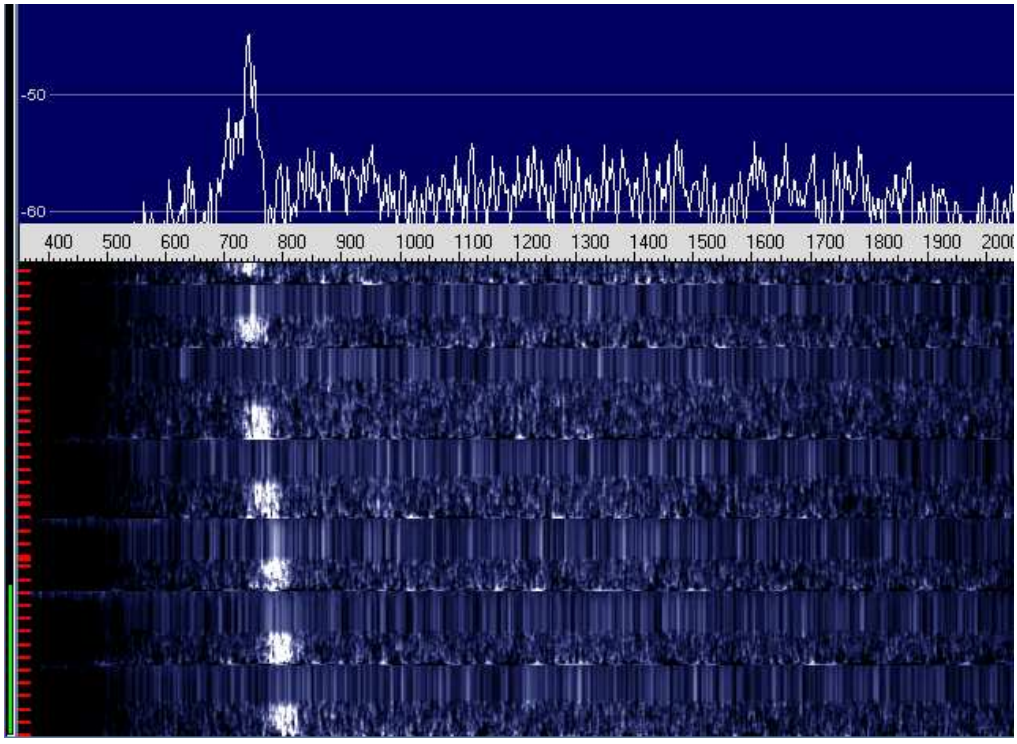
APPENDIX A

OK1KIR 24GHz 2013Apr23 at 17:20UT

Own Echoes after 24G WR with VK7MO (JT4F)

Spectran, resolution 5,4Hz (average 4). Note the frequency shape of particular echoes.





APPENDIX B

OK1KIR 24GHz EME Sky Noise Background Increase vs Dish Elevation

Date	Mar25 15:20 UT	Mar26 18:50 UT	Apr8 03:40 UT	Apr9 morning	Apr21 12:00 UT	Apr23 17:20 UT
PW[mm]	9,5	7,5	5	10	12,5	15