Analytical Review of the Roomcap Antenna

The RoomCap Antenna (RCA) is a new short wave antenna construction that reaches the efficiency of large antennas.
The RCA consists of a short radiator, which has a large surface area, and hereby forms a capacity. This capacity shall be small to ground, but shall be as large as possible into the free space, therefore the name Roomcap.
The capacity is formed between such a radiator and a counterplane, which is oriented perpendicular to the radiator, such that the direct capacity between them is minimal, while each surface has a large capacity into free space.
If you apply a voltage to this capacity, an electric field is generated, hence the RCA antenna is an E-field antenna.
The RCA works as a resonant circuit, and the capacity is formed by the capacity of the radiator and the counter plane. They are oriented such, that they have minimal direct capacity, while each one has a large capacity into space.
Many different antenna types have been developed and published which work also with the E-field, but they are based on wrong ideas like e.g. the EH antenna (Ted Hart, W5QJR), Isotron and others.
Last example: “Antenne à champ électrique” in HB Radio No 2 – 2013, pages 23-24.
There, two planes are parallel to each other, therefore the main electric field is between them, and only at the border there is some free field that radiates. This explains why the author had to write that he was not heared with this antenna …

Here follows the calculation of the efficiency of the RCA, based on the values measured on the installed antenna, as seen in the following picture (= **Picture 1**).

<u>A word about the room capacity</u>:

The capacity formed between the radiator and the counterplane is called room capacity Cr.

As for each capacitor, also this one has an imaginary resistance and a real resistance. The relation between the imaginary resistance Xc = 1 / (2 x Pi x f x C), and the real resistance define the quality factor Q of the capacitor. This real resistance is called loss resistance Rloss of a capacitor.

The quality factor Q is calculated as follows:

Qc = Xc / Rloss-serial or

Qc = Rloss-parallel / Xc

For the imaginary resistance Xc current and voltage will have 90 degrees phase difference, therefore the power (U x I) is reactive power and not real power.

For the loss resistance Rloss of a capacitor, current and voltage are in phase, and the power (U x I) is real power.

An ideal capacitor has an infinite parallel loss resistance and produces only reactive power.

However, with an antenna we want to radiate real power. Power is calculated as P = (U x U) / R, therefore, **decreasing the parallel R radiates more Power P**.

A “normal“ capacitor is made by two parallel planes which are separated by the dielectric. The capacity increases when the size of the planes increases, and when the distance between the plates decreases. The field between the plates is shielded by the plates themselves and practically cannot reach the outside, correspondingly this capacitor has a high parallel Rloss and practically no radiation.

In the case of the room capacity we use a completely “open“ construction, where the two planes of the capacitor are in perpendicular position, therefore the direct capacity is nearly zero. But each plane has a large capacity into free space. Therefore, the measured capacity is an indirect capacity. In a such formed capacitor the radiation resistance of the room becomes the loss resistance of this capacitor. In our case, I call the loss resistance of this capacitor Rs (parallel radiation resistance).

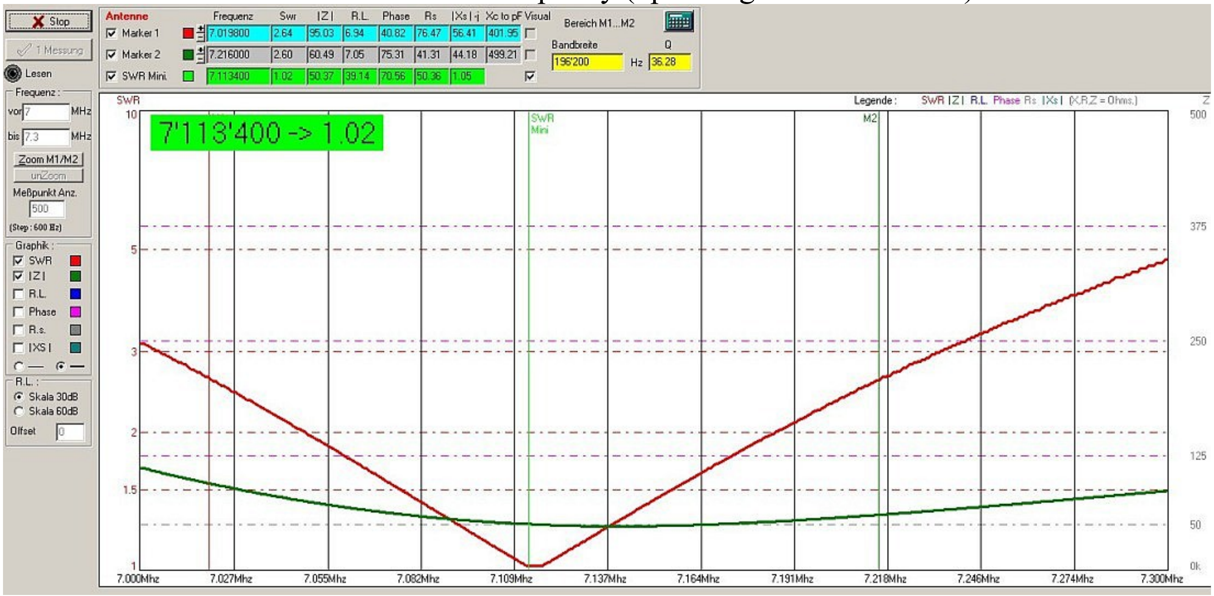
If you form an antenna by two parallel planes, then a “normal“ capacitor is built, where the (parallel) loss resistor Rs increases, when the two planes become closer together, which means that a bad radiation results from this construction.
To construct an antenna, one has to use a construction which does NOT correspond to a “normal“ capacitor, but one has to use a construction which forms an open capacitor, or with other words:
The more open a capacitor is, the more is radiated by this capacitor.

We want to produce a maximum of real power, and at the same time a minimum of reactive power. Then we reach the highest efficiency.

The present construction of the Roomcap antenna was developed, based on these ideas.

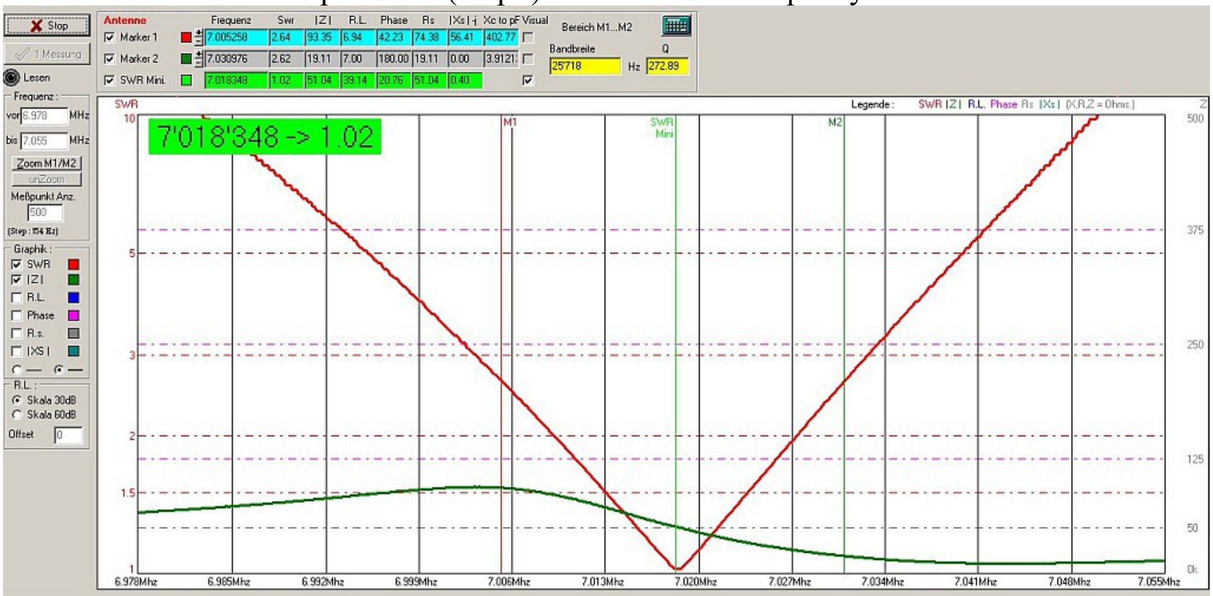
Picture 2 and 3 show the values measured by the antenna analyzer at the connector TX as seen in the equivalent circuit diagram on next pag

Measured values of antenna with room capacity (operating state of antenna) = **Picture 2** :



Here: Bandwidth = 196 KHz and Q = 36

Measured values with capacitor C (63 pF) instead of room capacity Cr: = **Picture 3**

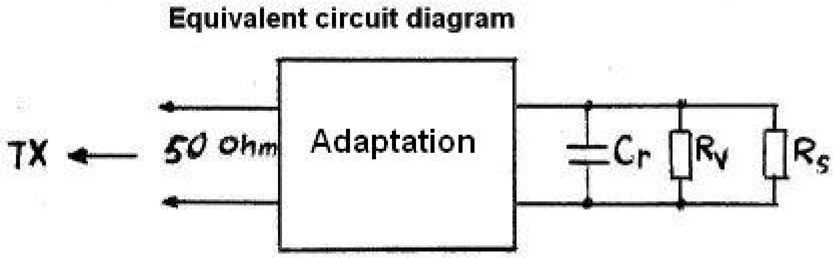


Here: Bandwidth = 25.7 KHz and Q = 272.9

In picture 3 the room capacity is replaced by a physically small air capacitor.

By comparing the two measurements you note, that the bandwidth of the antenna with the room capacity is 196 KHz, while the antenna with the air capacity shows only abt. 26 KHz. The large bandwidth in picture 2 is the consequence of the (parallel) real radiation resistance. The air capacitor in picture 3 has nearly infinite parallel resistance and results in small bandwidth of the antenna.

The radiated power goes fully into the real radiation resistance Rs.



The following calculation is based on the parallel equivalent circuit diagram for operation in the 40m band (7.1 MHz band):
TX = Coax connector 50 ohms to transmitter or antenna analyzer

Explanation of symbols
Cr = Capacity of antenna = room capacity = capacity between radiator and counterplane
f0 = Resonance frequency of antenna (X of antenna = 0)
Rv = Parallel loss resistance (total antenna loss)
Rs = Parallel radiation resistance , real resistance at f0
Rtot = Total parallel resistance (Rv and Rs in parallel)
Eta = radiation efficiency of antenna (in percent)
Ps = radiated power (real power)
Pe = Input power (RF power fed into the antenna)
BW = Bandwidth (at frequencies F1 and F2, SWR = 2.62)
Q (general) = Quality factor Q, where Q = f0 / BW (see Eq-A4 in [1])
Qant = Quality factor of antenna = Q of antenna in operation
Ql = no-load Q = Q of antenna while room capacity is replaced by a small air capacitor. The room capacity was measured as 63 pF, correspondingly an air capacitor of 63 pF was inserted instead of the radiator.
Xl = Inductive reactance of the adaptation output (= 353 Ohm at 7.1 MHz)
TX = Transmitter

Calculation of the radiation efficiency Eta of the antenna (in percent):

Eta = radiated RF power / RF power fed into antenna = (Ps / Pe) x 100

P = U x U / R, inserted into equation above:

Eta = ((U x U / Rs) / (U x U / Rtot)) x 100, reduced follows:

Eta = (Rtot / Rs) x 100

Then :

From Eq 1 in [1] follows rearranged:

Rp = Xp x Qu

Therefore, in the above circuit diagram:

Rtot = Xl x Qant = 353 x 36 = 12.7 K Ohm (Q from picture 2)

Rv = Xl x Ql = 353 x 272 = 96 K Ohm (Q from picture 3)

Rs is calculated from Ohm's law for parallel resistors:

Rs = (Rv x Rtot) / (Rv – Rtot) = 14.6 K Ohm

Now, the efficiency can be calculated from Rtot and Rs as follows:

Eta = (Rtot / Rs) x 100 = (12.7 / 14.63) x 100 = 87 %

Accordingly, the **antenna has on 40m an** **<u>efficiency of 87 %</u>**

The same calculation on 20m (14 MHz) shows an efficiency over 93 %, and on 80m (3.5 MHz) over 80 %, always using the same radiator.

PS:
Calculation using the series equivalent circuit diagram instead of the parallel equivalent circuit diagram will show the same result.

Note:
Measuring of picture 3 was done by using a small air capacitor (63 pF). The measured Q in picture 3 includes the loss of this capacitor. If this one would be totally loss less, then this measured Q would be a little larger, and hereby the calculated efficiency somewhat higher.

Reference:
[1] = Q Factor Measurement, Jaques Audet, QEX Jan/Feb 2012
http://hb9abx.no-ip.biz/ant27april13e
and http://hb9abx.no-ip.biz/VE2AZX-Q-factor.pdf