Comparison of GSM mobile the synchronous pul

by Bernhard Liesenkötter

Summary

The debate over harmful effects of mobile radio emissions focuses on alleged biological effects from pulse modulated radiofrequency of the GSM standard that are suspected to be particularly strong. The known relatively high field strengths of broadcast and television transmitters, in contrast, are thought less relevant. This contribution will compare the pulse edge steepnesses of the GSM signal to those of television signals. The result will show that most spectral components of GSM pulses are also discerned in television synchronous pulses, the latter however having a many times higher pulse edge steepness. A consideration of the prevailing mobile radio and television radiation intensities may lead to the conclusion that television technology – having been introduced worldwide more than 50 years ago – disproves the assertion that pulse edge steepnesses of digitally modulated radiofrequency would cause biological damage.

1. Claimed health damages from steep-edge pulses

Many German-language essays and opinions published on the internet stress possible health risks of mobile radio based on reports of measureable effects from mobile radio exposure e.g. on the EEG of humans, etc. The health relevance of such effects is still unclear, though; to date, no unequivocal evidence of harmful effects has been established.

This article will deal with a key assertion made in these essays: that, above all, digital pulse modulation of mobile radio transmissions poses a health threat.

An often cited hypothesis of [1] – particularly by mobile radio critics – is that it is not the intensity of unmodulated or conventional, mostly analog modulated, radiofrequency emissions (in the VHF range and above) that affect biological processes in the living organism but the steepness of pulse edges of digitally modulated signals as are applied by mobile radio devices of the GSM standard.

Quotation from [1]: “It has to be stressed that the biological system responds to the change per time,

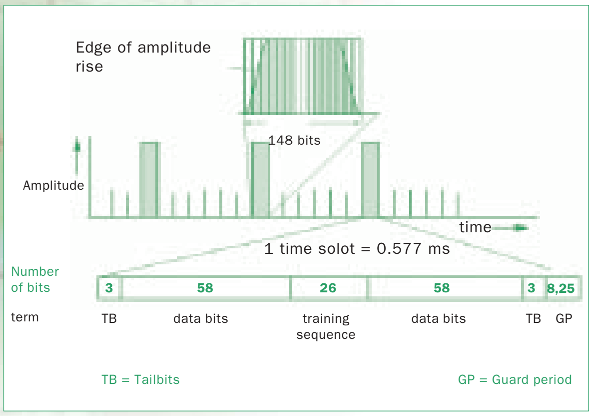

Fig. 1: Structure of a „normal burst“ with amplitude and steepness (taken from [2])

radio digital modulation and ses of TV transmitters

and that the periodicity of this signal change is biologically relevant."

The evidence included there emphasizing the comparable harmlessness of TV signals provides additional insight supporting the following observations regarding the debate over possible dangers from mobile radio applications that will perhaps be rather surprising to some.

2. Technical basics and comparison between television and mobile radio emissions

In the following, the edge steepnesses occurring in the modulation of radiofrequency signals of television transmitters and GSM mobile radio devices will be examined. The signal content of transmissions is imprinted onto radiofrequency carriers by different modulations. The modulation of TV transmitters usually called "analog" in truth is a combination of analog amplitude modulation (image content) and frequency modulation (sound content), as well as a pulse transfer for image synchronization. The digital modulation of mobile radio devices – in the following described in more detail – is a combination of a continuous phase modulation and amplitude gating (on/off switching). The synchronous pulses of the TV signal thus can be justly compared to the pulses of amplitude gated mobile radio transmission.

2.1. Analysis of mobile radio transmission

The strongest field strength resp. radiation intensity the user is exposed to – and the most critical one, due to its strictly periodic pulsation[1] – in the range of mobile radio is that of mobile stations (mobile radio end device, cell phone). Base stations, in contrast, mostly transmit several signals in different so-called time slots so that the resulting radiation has no such distinctly regular periodic pulsation; on top of that, radiation intensity is lower by several orders of magnitude in the public access area around the base stations than that of mobile stations at the phone user and his/her immediate vicinity (escort, next seat in public transport, etc.).

In paragraph 3.3, the worst case regarding the pulsation at a base station of only one active time slot is assumed; the signal form then is equivalent to the emission of a mobile station.

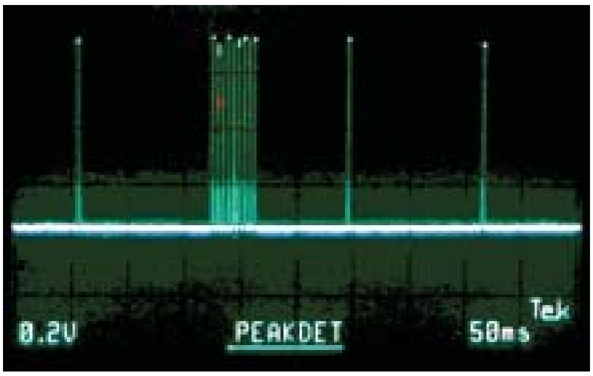

Fig. 2: Measured pulse form of the mobile phone radiation in listening mode (DTX mode, 12 bursts over a total period of 480 ms)

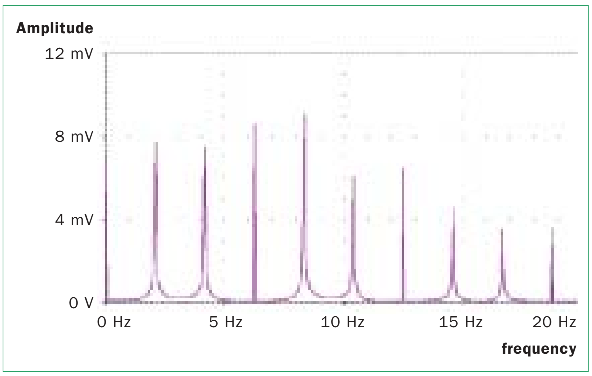

Fig. 3: Signal spectrum of mobile phone transmission according to fig. 2 (demodulated LF range, lowest frequencies)

2.1.1 Structure of signals transmitted in a time slot

In the GSM standard, a mobile station transmits both the voice content and additional information on the connection build-up and operation as a digitally modulated carrier frequency, e.g. at about 900 MHz. Modulation occurs in a 4.615 ms rate as pulse sequences (also called bursts) with a pulse length of 0.577 ms each. During the break of 4.038 ms between bursts, seven other mobile stations may communicate on the same carrier frequency with the same base station so that the total period is subdivided into 8 time slots. Fig. 1 shows the bursts of a mobile station and the build-up of a typical burst. Common to all – partially differently built – bursts are the three tailbits at the beginning and at the end determining part of the burst edge steepness.

The structure of a typical burst is characterized by GMSK[2] modulation during the bit sequence and by a continuous amplitude change from 0 to maximum at the beginning resp. from maximum to 0 at the end of the bit sequence. This amplitude change (according to [2]) can occur in the time frame of the mentioned 3 tailbits (about 11 µs). Official specifications propose a time mask of maximally 28 µs; the industry uses an average of about 18 µs.

2.1.2 Resulting signal spectrum of the mobile station

The spectral distribution of the signal transmitted via the carrier wave can be determined from the pulse modulation with a 4.6 ms rate and a duty ratio of 1:8 (Fourier analysis). The result shows, of course, that there is not only the often cited 217 Hz oscillation but also – almost just as strong – oscillations at 434 Hz and 651 Hz, and other spectral lines as well; their amplitudes decrease only above 1 kHz to well below 50 % of the 217 Hz amplitude.

For some time now, people concerned also point to the 8.33 pulsation which occurs when the mobile station is in listening mode (in the DTX mode). This effect is due to the fact that no own voice informa-

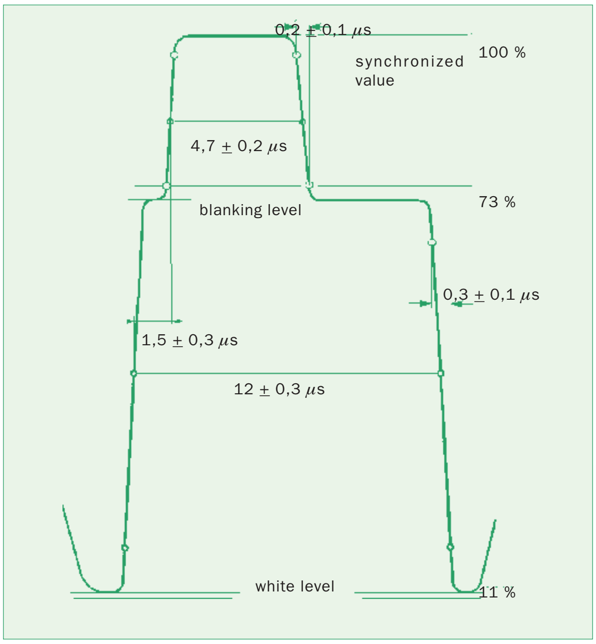

Fig. 4: Specified shape of synchronized pulses (73 % to 100 %) at the transmitting end of a TV transmitter (Pflichtenheft no. 5/2.1)

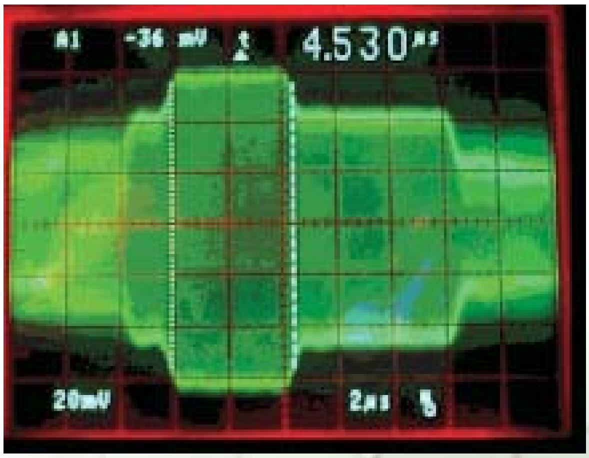

Fig. 5: TV signal measured at the reception antenna of the user. Depiction of the area around the synchronous pulse (middle axis is equivalent to 0 % in fig. 4)

tion has to be transmitted and that the mobile station transmits some measurements every 120 ms. This so-called SACCH channel of the mobile station appears only once in the so-called „26 multi-frame“ with a total length of 120 ms. The modulation based on it therefore consists only of one burst per 120 ms. The regular rhythm however is strongly changed by the transmission of further information (one burst each in 8 subsequent TDMA frames, repeated every 480 ms). Figure 2 shows such typical transmission of a mobile phone measured in listening mode.
The duty ratio of 1:240 of the SACCH creates an extreme broadband spectrum where the 8.33 MHz oscillation, just as its multiples, appears in practically the same (very low) height up to the kilohertz range. This theoretically regular spectrum however is structurally changed by the transmission of the burst group in a 480 ms rate so that even a 2.08 Hz oscillation occurs with its multiples (4.17 Hz, 6.25 Hz, etc.) in very weak and alternating intensities.
Fig. 3 shows the lowest frequencies of the spectral components calculated from the signal in fig. 2 (based on a signal content remaining unchanged over 20 seconds). One must not forget that the pulse height was assumed to be 1 V; the different harmonic oscillations existing in the signal mixture show only an amplitude of approx. 0.8 % each (also the maximum spectral line – the 217 Hz oscillation – appears only with 1.15 %).
A possible frequency selective excitable medium at these lowest signal frequencies thus can only be excitated with $6.4 \cdot 10^{-5}$ (i.e. 0.064 per cent) of pulse peak power.
When considering whether some of these oscillations could potentially have a disturbing influence on living organisms – all living creatures are accustomed to the inherent frequencies of the resonator earth sphere + ionosphere (7.5 Hz and its first multiple of this) –, one should therefore pay attention to the minimum power percentage of these frequencies contained in the information signal of the mobile device, and to the fact that this low-frequency information signal of the radiofrequency carrier oscillation would have to be gained first by demodulation via a nonlinear function of body cells. This nonlinearity, however, has yet to be proven without a doubt for the higher frequencies (see e.g. [3]).

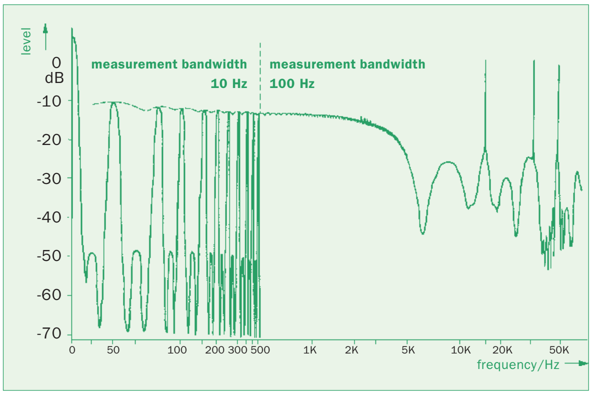

Fig. 6: Spectrum of the television synchronous pulse (taken from [4])

2.2 Analysis of television signals

The relatively complex signals of television transmitters for the most part are analog modulated (image content and sound content), but receiver synchronization ensuring accurate image reproduction is made possible by a synchronization pulse which therefore can be compared to the digital modulation of mobile radio.
Regarding the approx. 4.7 µs synchronization pulse, TV signals show the edge configuration specified in fig. 4, with a rise of 75% to almost 100% of the signal amplitude within 0.2 +/- 0.1 µs. To confirm this specified signal form, a TV transmission that can be received everywhere by an antenna can be amplified and depicted on an oscilloscope; see fig. 5 where the shape of the synchronization pulse can be easily recognized.
This pulse is applied for both line synchronization (15.625 kHz) and image synchronization (50 Hz). Its spectrum is very wide, as one can see in fig. 6.
It can be seen that numerous signal frequencies in the range between 50 Hz and 1000 Hz – that are seen by some researchers as critical in relation with mobile radio – are contained in this TV signal as well.

3. Comparison of public exposure from television and mobile radio

3.1 Intensities measured in television and mobile radio transmissions

As part of the investigations done into diseases resp. behavioral anomalies of cattle, dependent on the intensity of electromagnetic radiation, in Bavaria [5] – known as "cattle study" –, the field strengths of mobile radio base stations and of other RF sources (e.g. TV transmitters) were measured at selected farms. The total exposure intensities compared to the legal limit are shown in fig. 7. What strikes the eye is that even maximum total exposure was only 5.2 per cent of the legally permitted limit; the average value was approx. 0.3 %.

This – not optimally designed – study was disappointing for the public and experts alike since no clear results were found. Nevertheless, the conducted detailed field strength measurements of TV and mobile radio transmissions can be used for the following comparision of the (purportedly biologically effective) pulse edge steepnesses.

3.2 Comparison of exposure strengths under consideration of pulse rise steepnesses

More than half of the farms selected in [5] was located – according to the owners resp. the selecting institutions – in an area of increased exposure, above all from mobile radio. But at almost half of all measurement points shown in fig. 7 there were higher values for TV and broadcasting signals.

The calculation of pulse edge steepnesses for an arbitrarily selected farm at exposure to approx. 1 % of limits (farm no. 32 in fig. 5, on the meadow) leads to the comparison demonstrated in table 1 (measurement values taken from [6]).

3.3 Result and evaluation of comparison

The pulse edge steepness examplarily calculated for farm no. 32 in table 1 is more than 60 times higher for the received TV pulses than for mobile radio pulses.

Obviously, this fact is not acknowledged in public debate; it is often omitted by focusing on the full amplitude gating of the mobile radio signal. The logarithmic measure of amplitude change expressis verbis mentioned in [1] in this context for emphasizing the 100 % gating of mobile radio is completely irrelevant since this ratio, at disappearingly small minimum levels, naturally must point towards the infinite.

Due to the selection of many measurement points made in [5] focusing on a suspected mobile radio threat, we must assume that, in average, exposure to the pulse content of TV signals is considerably higher (or at least of the same order of magnitude) across Germany than it is from mobile radio base stations or other services.

	TV signal (at 511 MHz)	**mobile radio signal** (base station in the vicinity)
pulse edge steepnesses	1.1 V/m (mean value of several measurement points)	0.16 V/m (maximum value)
Measured electric field strength	0.297 V/m (= 100 % - 73 %)	0.16 V/m (= 100 %)
Pulse rise time	0.3 μs (from 73 % to 100 %)	minimum 11 μs (normal: approx. 18 μs)
Resulting pulse **edge steepness**	**1 V/m** per 1 μs	**0.015 V/m** per 1 μs

Table 1: Comparison of TV signal and mobile radio signal

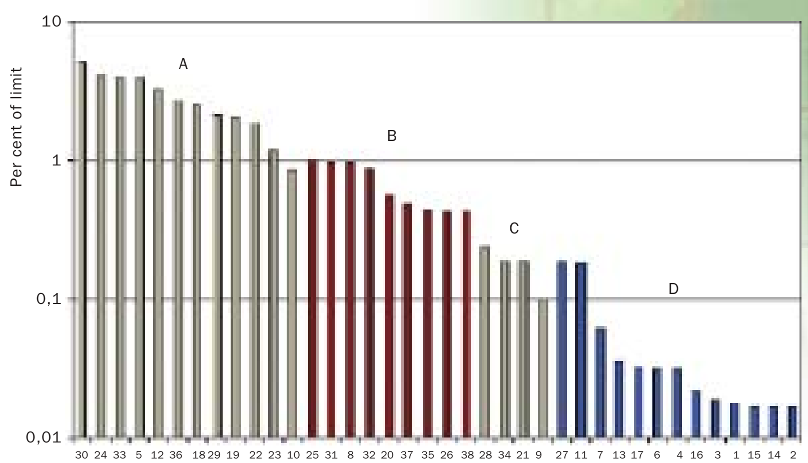

Fig. 7: Total field strengths (TV and mobile radio) at the selected farms (taken from [5]); the groups A, B, C, and D differ regarding TV resp. mobile radio percentages).

4. Conclusion

The assertion made in [1] "that the biological system responds to the change per time, and that the periodicity of this signal change is biologically relevant" may principally seem to be logical and understandable.

Apart from the fact that obviously no demodulating function has been established that would be effective in the living organism at high frequencies, those who support this view have failed to analyse the electromagnetic environment existing for some decades. The analysis presented here regarding the purported special danger from pulse modulated radiofrequency indicates the biological harmlessness of presently discussed exposure to mobile radio antenna masts (base stations) that may be seen as being sufficiently confirmed by the use of television technology that has been worldwide introduced as early as in the middle of the last century: In all countries with TV supply, the population is exposed to the periodic steep pulse edges described in 2.2. After two human and even more animal generations, harmful effects from the applied pulse modulated radiofrequency with its considerably steeper pulse edges and, at the same time, mostly considerably higher field strengths than those of mobile radio stations should have long ago been established. The ongoing long-term studies investigating the area of mobile radio thus possibly could lead to the same results regarding their harmlessness as experimental studies [7] that, a decade after the dying of the forest was claimed to be the result of electromagnetic radiation emitted by directional radio and radar, disproved these theories.

Acknowledgements

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Footnotes

1 pulsation is a synonym for periodic amplitude modulation (= a digital form of modulation)
2 Gauss minimum shift keying, a specific type of phase modulation where the amplitude remains constant