VERY IMPORTANT FACTS ABOUT MMM CONCEPT & MULTIFREQUENCY ULTRASONIC TECHNOLOGIES

1. Typical multifrequency and frequency-wideband, ***high power ultrasonic*** *sources*, transducers, sonotrodes, ultrasonic generators and processors do not exist in a literal meaning that somebody could freely (and arbitrarily) select, fix and/or change frequency, amplitude and power from certain low frequency until MHz range. Asking to have something like that is against physics, acoustics and nature of resonant systems. Ultrasonic sources are solid-body, specific-geometry, mechanical structures. Different mechanical structures have different natural resonant frequencies, and different oscillating and resonant modes, but not at all flat, uniform, linear and typically frequency-wideband amplitude, impedance and phase characteristics.

2. Solid, compact, robust, heavy and thick-walls mechanical structures usually have very limited number of discrete resonant frequency modes (including harmonics). Such structures (or ultrasonic resonators and sources) ***can never operate high-power***, in a wideband or multi-frequency range (since this is against physics and nature). MMM technology is not applicable or not efficient when driving such mechanical systems.

3. Solid and mechanically flexible structures with complex geometry, relatively thin-walls, internal holes and channels, with number of distinctive compartments... usually have big number of natural resonant frequencies and harmonics. Such mechanical structures are usually convenient to be driven high-power, with signals-modulated MMM ultrasonic generators. Produced acoustic emission and associated frequency, amplitude and phase distributions and spectrum could be considered as being wideband, as much as mechanical and spatial or geometric complexity will allow (but not more). Of course, ***different ultrasonic-carrier-signal modulations will (mathematically) tend to produce number of harmonics (like known in Fourier Signal Analysis), but specific mechanical system will really accept and resonate high-power only where resonant properties of mechanical system will accept (or allow to happen) mentioned mathematically created, wideband spectrum***.

4. Really-wideband, linear, flat and stable characteristics ultrasonic sources and resonators ***could be realized only when producing very low oscillating amplitudes and power***. Everything else are unreasonable and imaginative expectations.

5. Many producers of ultrasonic cleaning and multifrequency technology are creating ultrasonic sources (fixed to the same tank or ultrasonic reactor) with 2, 3 or several different groups of transducers (each group operating on its single and discrete resonant frequency). Later, they need to apply either 2 or 3 or several ultrasonic generators and operate each group of transducers separately, or to have the same generator with different output (inductive matching) circuits and to operate (sequentially) each group of transducers during certain limited period. Since many ultrasonic transducers could operate on 2 or 3 different frequencies, some producers are creating ultrasonic generators that are able to change operating frequency with certain time intervals sequencing. This is like having 2 or 3 or several ultrasonic generators, each of them operating on its fixed (discrete) frequency, driving its group of transducers. In fact, this is not a real multifrequency and wideband ultrasonic technology. This is just standard, old fashion ultrasonic technology, hardware and software extended to operate on few different, fixed frequencies. Here, under MMM technology, we do not address such false multifrequency sources.

6. Good, industrially and technologically applicable, efficient high power and wideband or ***MMM ultrasonic sources can be realized only by applying proper ultrasonic generator to a properly designed mechanical system***. Mechanical system, or ultrasonic load, should naturally have many resonant frequencies (different oscillating modes and harmonics) in order to be efficiently driven by MMM ultrasonic generators. We cannot realize something what is against Physics, acoustics or mechanics. MMM generators are operating on a selectable carrier (or dominant) ultrasonic frequency, which is additionally modulated on different ways (by

amplitude, frequency, phase, PWM, repetition rate, randomly etc.), and within bands-limited, mathematically defined, operating and signals-processing frequency interval (realized by software settings of MMM generators). ***Only combination of specific and targeted mechanical design situation and specific MMM ultrasonic generator settings will produce efficient and relatively wideband ultrasonic processing***. MMM and wideband multifrequency effects are consequences and products of carrier signal modulations (but in the same time, MMM ultrasonic generator will still operate on a relatively fixed or band-limited carrier frequency; -only acoustic products of such driving will have extended-frequency spectral complexity, as much mechanical system can accept or follow).

7. In cases when we do not have very rich spectral complexity of certain ultrasonic load, we can still achieve MMM effects by proper carrier-signal modulations-settings, creating periodical trains of spatially, time and/or phase shifted repetitions, reflections and echoes of the same single frequency wave-group. ***Such effects are effectively destroying standing-waves structure and significantly contributing to spatially uniform and high efficiency ultrasonic processing. Mentioned effects are creating acoustically equivalent state to very high frequency and wideband-frequency sonic and ultrasonic sources*** (while carrier frequency is still in a relatively low frequency domain).

See more here:

Vibrations, oscillations, resonant states and united theory of macro and microcosmic matter-waves phenomenology is here (e-book for download):
http://mastersonics.com/documents/revision_of_the_particle-wave_dualism.pdf

http://bookstore.mpi-ultrasonics.com/index.php?main_page=product_info&cPath=48&products_id=165

European Patent Application (related to MMM technology): EP 1 238 715 A1
Multifrequency ultrasonic structural actuator
Applicant: Prokic Miodrag, MP Interconsulting, 5.03.2001 – 11.09.2002

Miodrag Prokic, Piezoelectric Transducers Modeling and Characterization. 240 pages, January 2004, MPI, Le Locle, Switzerland, www.mpi-ultrasonics.com

H. Feng et al. (eds.), Ultrasound Technologies for Food and Bioprocessing, Food Engineering Series, DOI 10.1007/978-1-4419-7472-3_5. *Chapter 5 Wideband Multi-frequency, Multimode, and Modulated (MMM) Ultrasonic Technology (author M. Prokic).* Springer Science+Business Media, LLC 2011

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www.MPI-Ultrasonics.com
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