Computer simulation of the networks of smart ultrasonic actuators for monitoring fluid flow in geological media

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A concept of active monitoring of underground fluid flow is proposed based on injecting the fluid with a multitude of smart actuators (screamers) which are capable of organising their outputs sequentially such that the bulk of the energy is pumped into frequencies much lower than the main frequency of a separate actuator. The best results correspond to the perfect sequentialisation whereby the next screamer starts emitting the signal immediately after the previous is finished such that the system of screamers effectively emits one long pulse. Nevertheless, as computer simulations show, the portion of the energy in low frequencies is relatively insensitive to the random errors in the sequentialisation and random variations in the amplitude (from zero to twice the average amplitude). The latter is especially important since the amplitude of the signal at the receiving point suffers from attenuation which is greatly dependent upon the (random) distance to the screamer and properties of the medium (e.g., rock stratum). Furthermore, the low frequency energy content achieved by sequentialisation is considerably higher than outputs by the same number of actuators emitting in random. The sequentialisation can be achieved by each screamer monitoring the pulses emitted by other screamers without the need for an independent communication channel. This is accomplished by equipping each screamer with a listening devise and two counters, one being initially the screamers number which gets reduced with each scream heard and another used when an interruption in the sequence of screams is detected. It then determines the moment when (and if) this screamer has to step in. Computer simulations showed that this algorithm sequentialises the screamers even in the presence of initial gaps in the schedule (due to the possible loss of some screamers).