# A CASE STUDY OF ABNORMAL SOUND FROM VFD MOTOR

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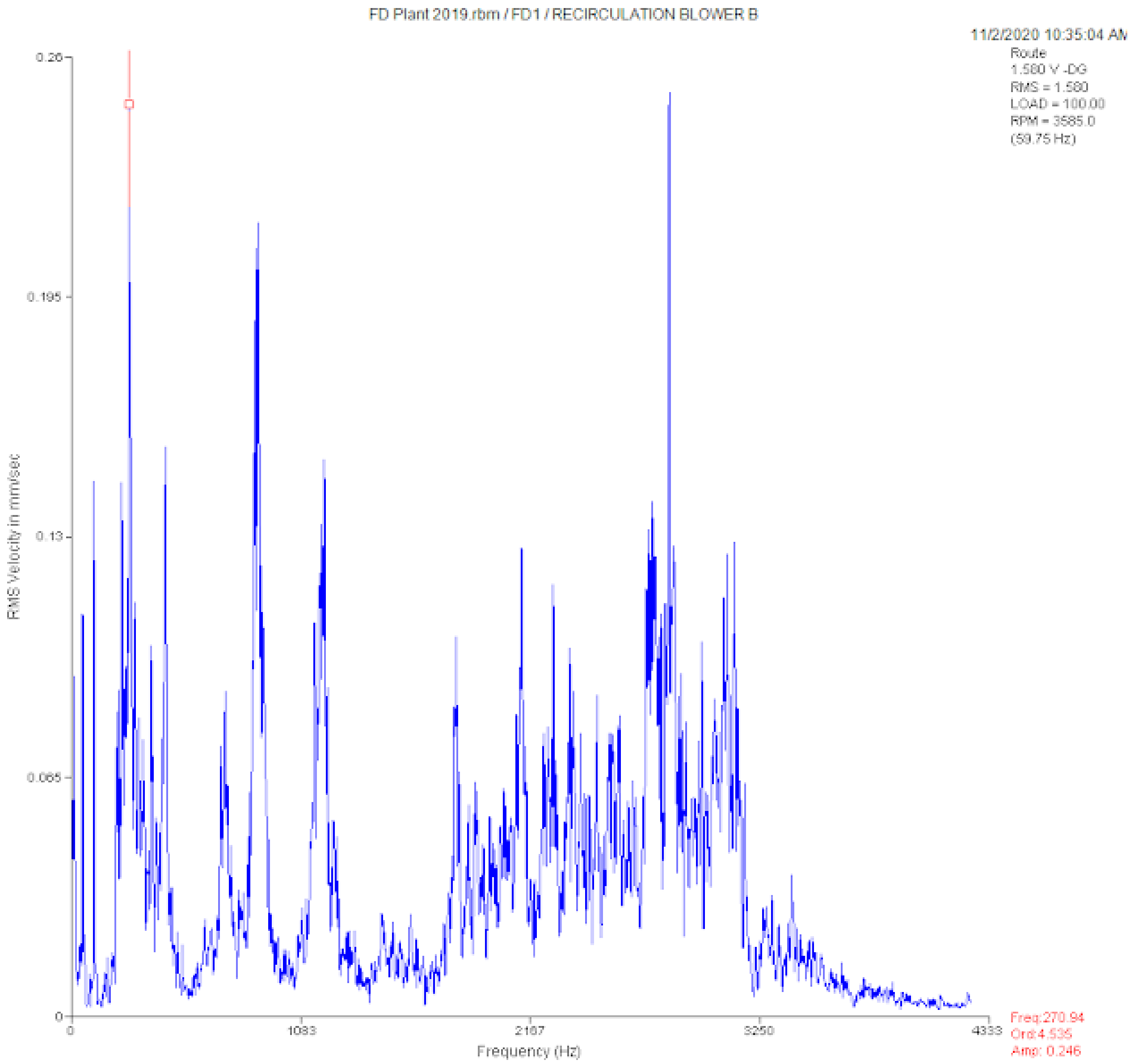
Variable speed drives have always raised challenges for the condition monitoring personnel d varying speed and load conditions and the necessity of fixing the operating parameters bef collection or use the techniques such as order tracking etc. to diagnose the faults. Here discussing an interesting case, where an abnormal sound, similar to a damaged bearing sound, arose from the motor during the commissioning run, after being a standby for mor months. Different tests were performed before concluding the results, which are explaine The motor was in continuous service until stopped a few months back due to the decline in de The subject motor drives a single stage radial flow blower.

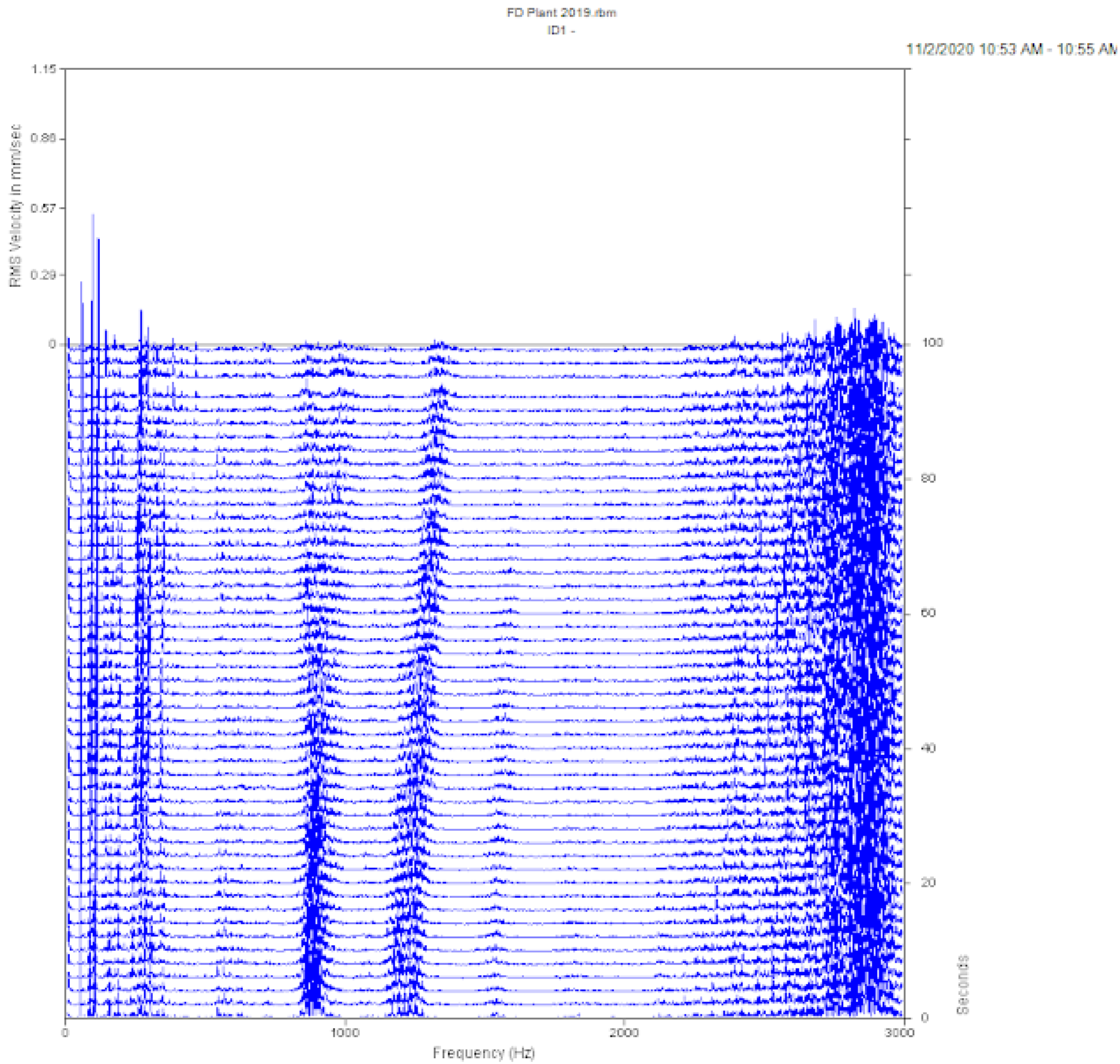
## Observations

Abnormal sound noticed from the motor when operated in the minimum speed range du load. Vibration spectrum collected from motor showed raised noise floor, around and above up to 3500 Hz, the majority of the peaks observed above 2000 Hz range.



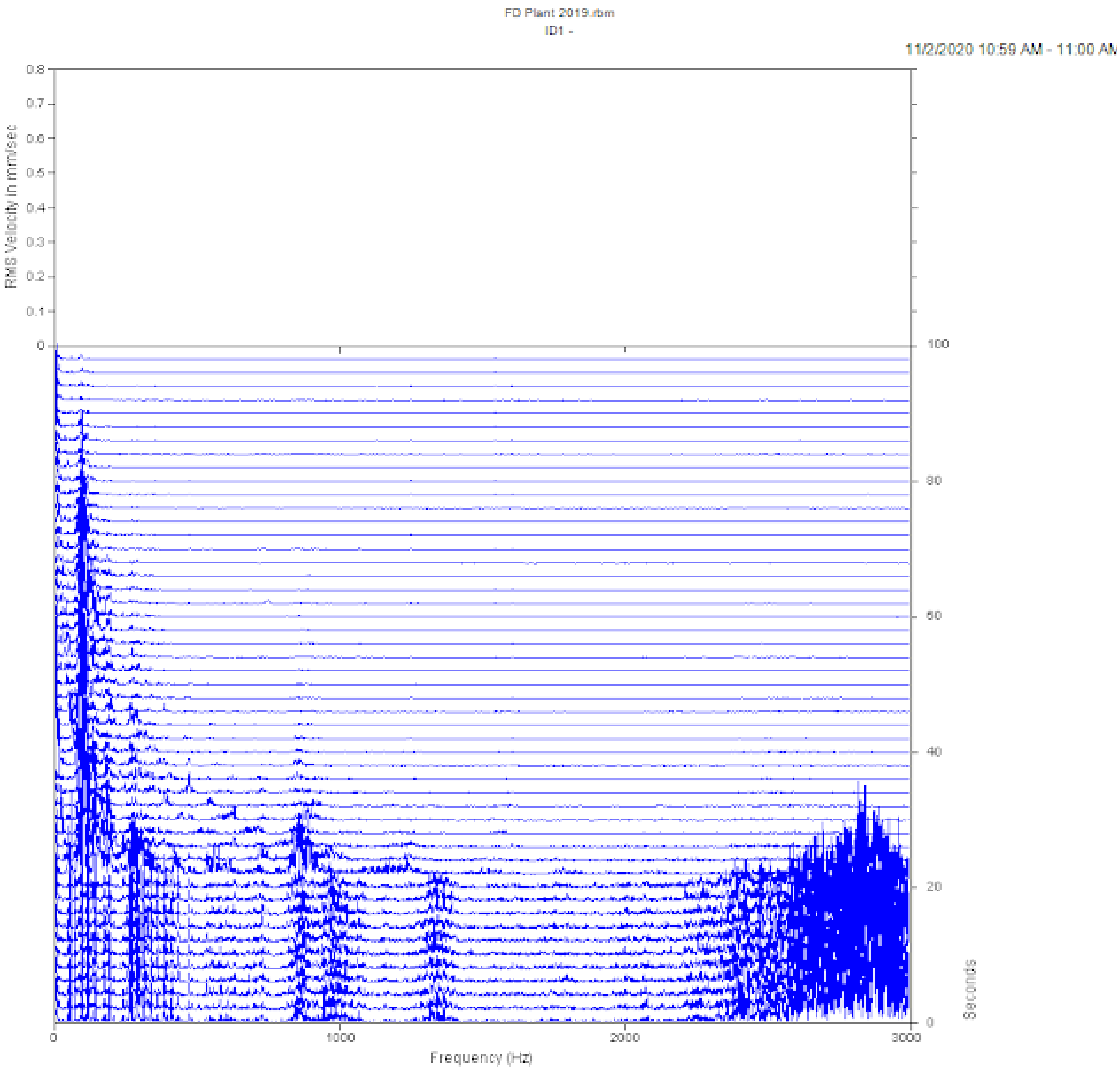

Pic.1 Vibration spectrum

Run-up test was done to identify the changes in peaks. The speed was increased from 315( 3490 rpm. It can be seen that some of the noise below 1000 Hz being reduced with increase i




Pic.2 Run-up test cascade plot

The coast-down test was performed to rule out the electrical noise from the vibrations.



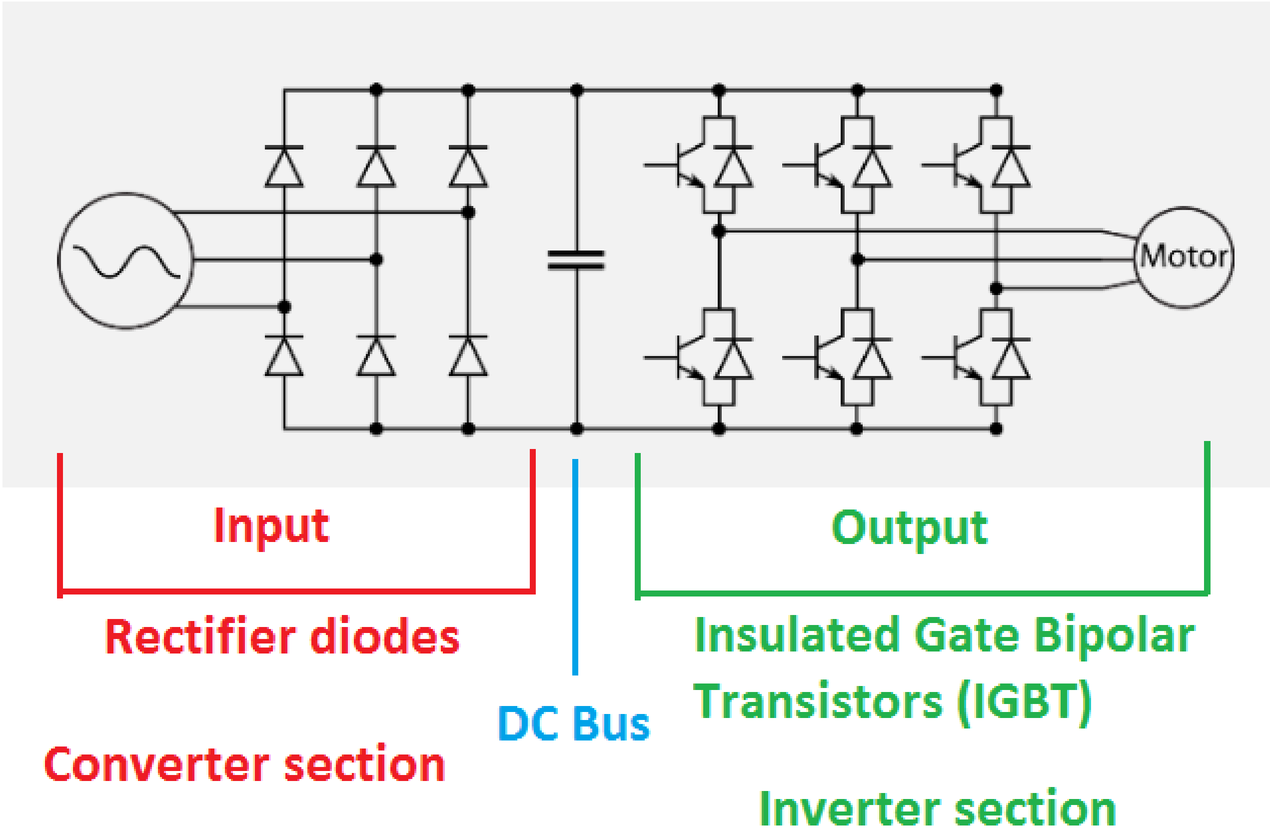

Pic.3 Coast-down cascade plot

During the coast-down or ramp down, it was observed that the peaks above 2000 Hz imm vanished. A detailed study was done to identify the cause of these peaks. For understanding working of VFD is briefly described below.

## Working of a VFD

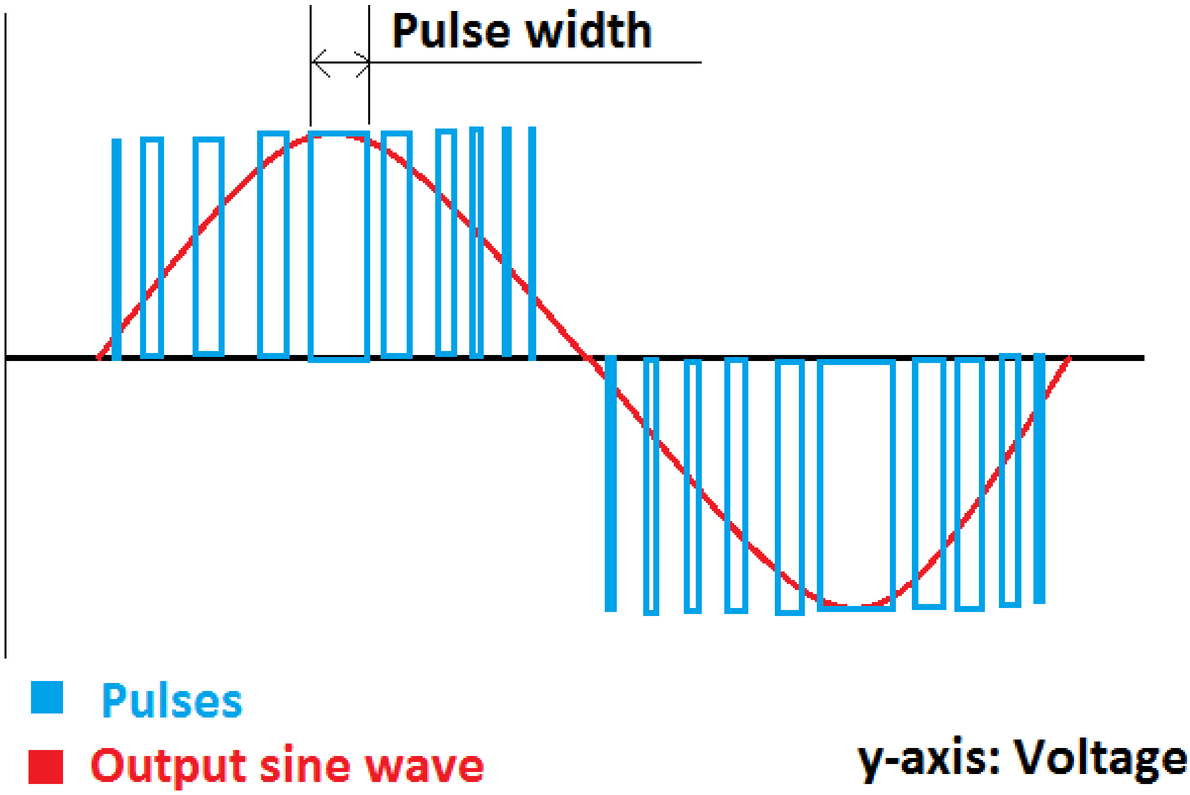
VFD module consists of input diode rectifiers, DC bus and IGBT inverter. The AC current su the VFD module is converted into DC current by diodes, which is smoothened out by the cap DC bus. The smoothened DC current is converted into the AC current of required frequency width modulation, achieved by using the IGBT.

Here, I am not going to discuss in detail about the working of input and DC bus sectio concern is regarding the output current and what component of this current could be leadi vibrations in the motor. To understand this, let us discuss how IGBT works.




Pic.4 VFD module

As mentioned, IGBT or Insulated Gate Bipolar Transistors varies the frequency by puls modulation. The pulses are developed by simply "opening" and "closing" the circuit, just like switches. Similar to normal switch operation, when the switch is closed, the current flows, v switch is open, the current flow stops. Now, to control the width of the pulse, the timing of ea have to be varied. When the pulse width is more, the voltage output is more and vice versa. F obtain a sine wave output, the pulse width at the centre of each half-cycle will be more tha the ends. The timing of each pulse is varied by controlling the opening and closing of transist If you remember the basics of the transistor, which consists of collector, emitter and gate te where the main current passes through the collector and emitter (which is built as normally normally closed) and the gate signal triggers the connection between the two (collector and e it will be much easier to understand (If you do not have the basic idea, I strongly recommend some articles on transistor working). The chip, which provides the control timings based program, activates or deactivates the current flow through the transistor. Thus, we get output

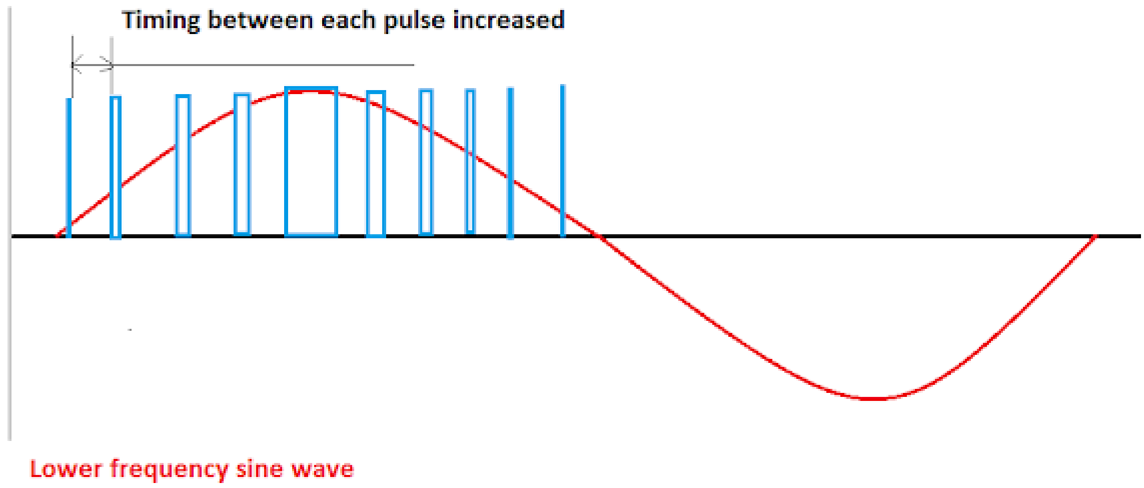



Pic.5 Pulse width modulation and generation of the voltage wave

**We have an idea now on how the voltage is varied (i.e. by varying the pulse However, the frequency is varied by increasing or decreasing the time i between each pulse. As the time between the pulses is increased, the fre decreases as time decreases, frequency increases. (Marking this as importa explains how our abnormal sound is appearing)**

Now, getting back to the output current, as discussed before, the output sine wave is not a sine wave but contains many pulses, which varies in width. The harmonic distortion in t depends on the number of pulses per cycle and the gap between each pulse, as described in t below. Note that the same 20 pulses per cycle are used here and only the timing is v comparison to pic. 5. (Excuse me for the rough hand sketches)

As the number of pulses is increased, the harmonic distortion decreases and vice versa.




Pic.6 Varying frequency by controlling the timing between each pulse

The number of pulses per second of the IGBT output (the carrier wave) can be any of the foll kHz, 4 kHz, 8 kHz or up to 16 kHz. The more number of pulses, the better the output. Hov the number of pulses are increased, the heat developed in VFD will be high and sophisticated cooling and thus the requirement of a larger size VFD module.

Coming back to the motor sound, in our case, the switching frequency was identified to b which is observed in the spectrum. The raised noise floor was an indication of excited frequencies, probably the stator lamination or winding resonance at the carrier frequency recommendations were provided to check and increase the switching frequency to 4 kHz done only in limited models) or to change the speed control from scalar mode to Direct Control (DTC) mode (which was available in our ABB ACS880 model). DTC mode has advantages over the conventional V-HZ (scalar) control, due to the absence of separate vol frequency controlled PWM. Approximate sinusoidal flux and current can be achieved throu The recommendations were implemented and the audible sound vanished. Note that we changing the exciting frequency and shifting it away from the natural frequency of lamina our case, we reduced the distortions and thus the resonance amplitude. In case we incr frequency, the generated tone is shifting above our audible range and may still be observe frequency spectrum. Even before, during the test, when the speed was increased (increa frequency of current), the audible sound slightly decreased, thus confirming the doubt.

So, when you hear an abnormal sound from VFD motor next time, do not rush into conclusio your time, do the tests and confirm the actual problem. The same switching frequency was to similar motors in the plant, but only this particular motor produced the abnormal sound noticed that only this motor utilized scalar control mode where other motors operated in DT Hence, our second recommendation was implemented, which reduced the sound