Contents

1

1.1.1 Introduction

The following pages describe current harmonics under different conditions.

The aim of this application note is to improve users' background knowledge to evaluate harmonic measurements.

All harmonics shown are for a 6-pulse rectifier (three phase supply). The conditions, which are covered in this application note, are:

1. Normal situation where the three phases are balanced.
2. One phase missing
3. Voltage on one phase 3% higher
4. Voltage on one phase 3% lower
5. Voltage on one phase 3% higher and 3% lower on one of the other phases
6. One diode interrupted
7. Normal situation but a very stiff main

1.1.2 Normal Situation where the Three Phases are Balanced

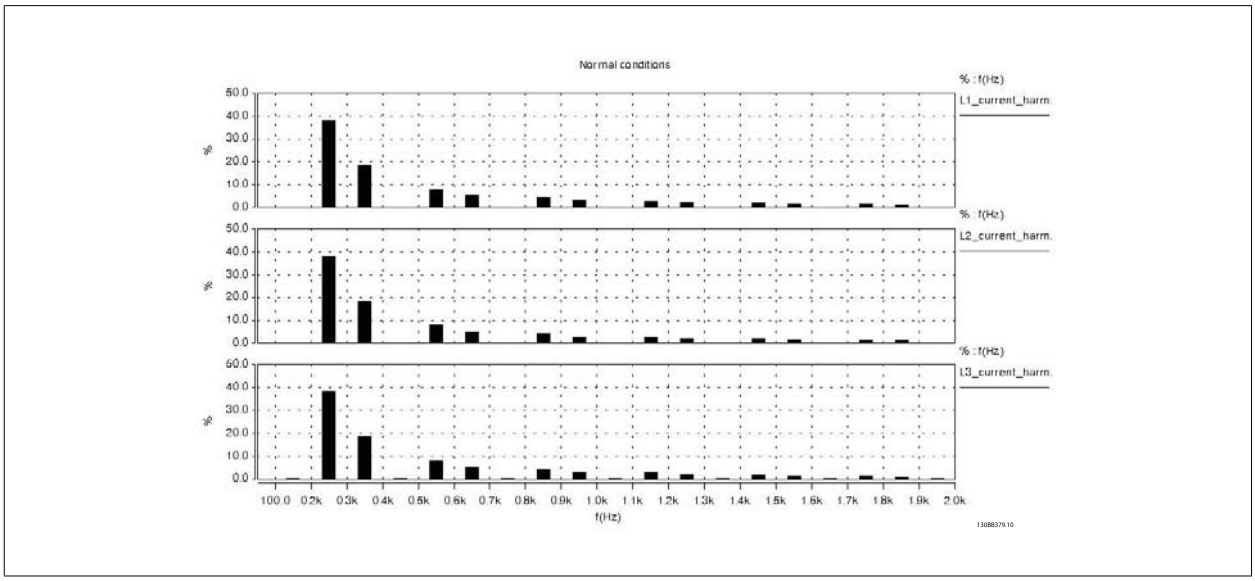
The harmonic spectrum below shows natural harmonic currents generated by a non-linear 3-phase overload (like a frequency converter).

The harmonic currents generated by non-linear load are given by the formula:

$h = p \times n \pm 1$

where **p** is the pulse number of the non-linear load (**p** = 6 for a 3-phase frequency converter), **n** are positive integer starting from 1 → ∞.

Regarding harmonic measurements only harmonics for n ≥ 50 are of interest.



The above formula shows that the natural harmonics are:
5, 7, 11, 13, 17, 19, 23, 25, 29, 31, 35, 37, 41, 43, 47, 49...∞

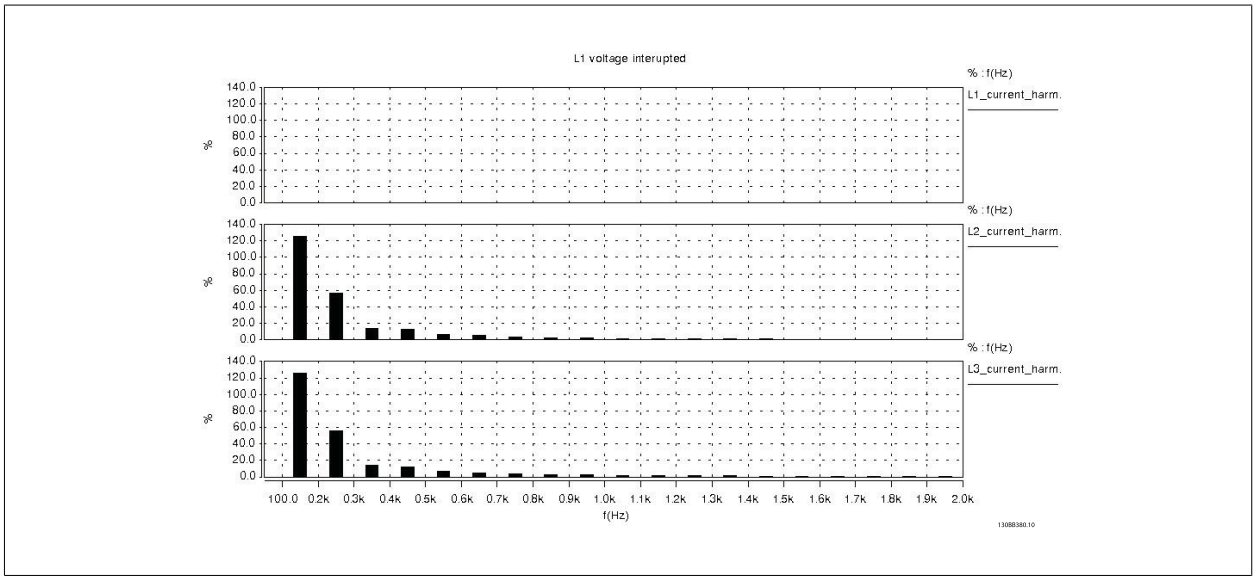
Measurements on a real application will often show a minor content of other harmonics as well due to the fact that the mains never is 100% balanced.

The magnitude of the individual harmonic depends on the load and on the impedance of the system (cable, transformer, etc.)

1.1.3 One Phase Missing

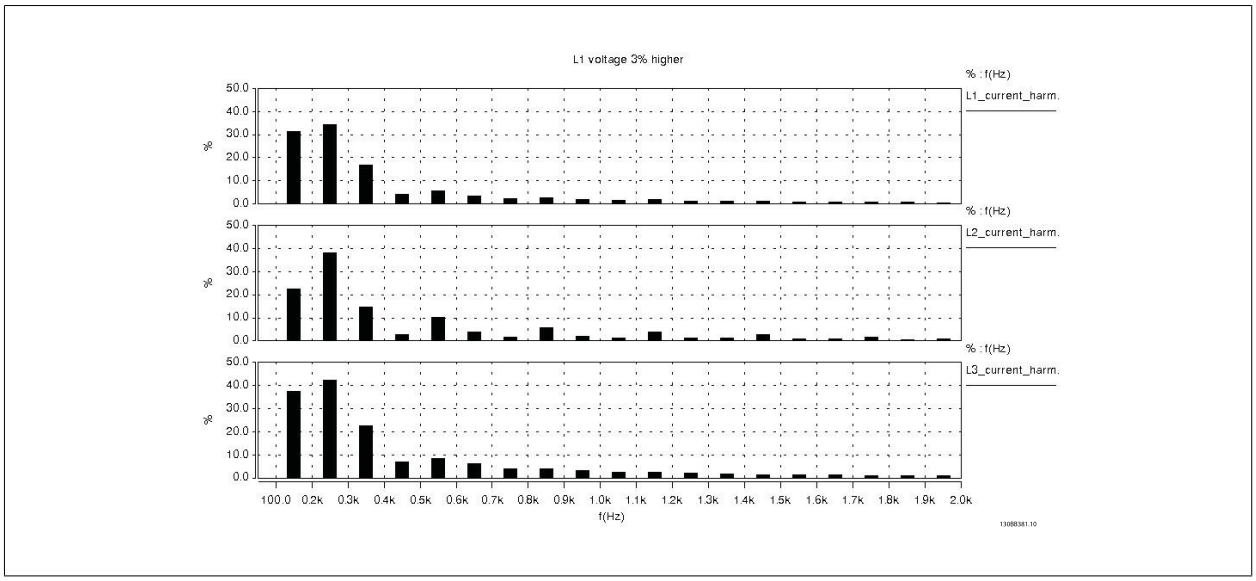
The graph shows the harmonic spectrum if one of the phases is missing. Beside the natural harmonic content, there is a high content of 3rd harmonic (150 Hz).

Multiple of the 3rd harmonic (6., 9., etc.) are also present.



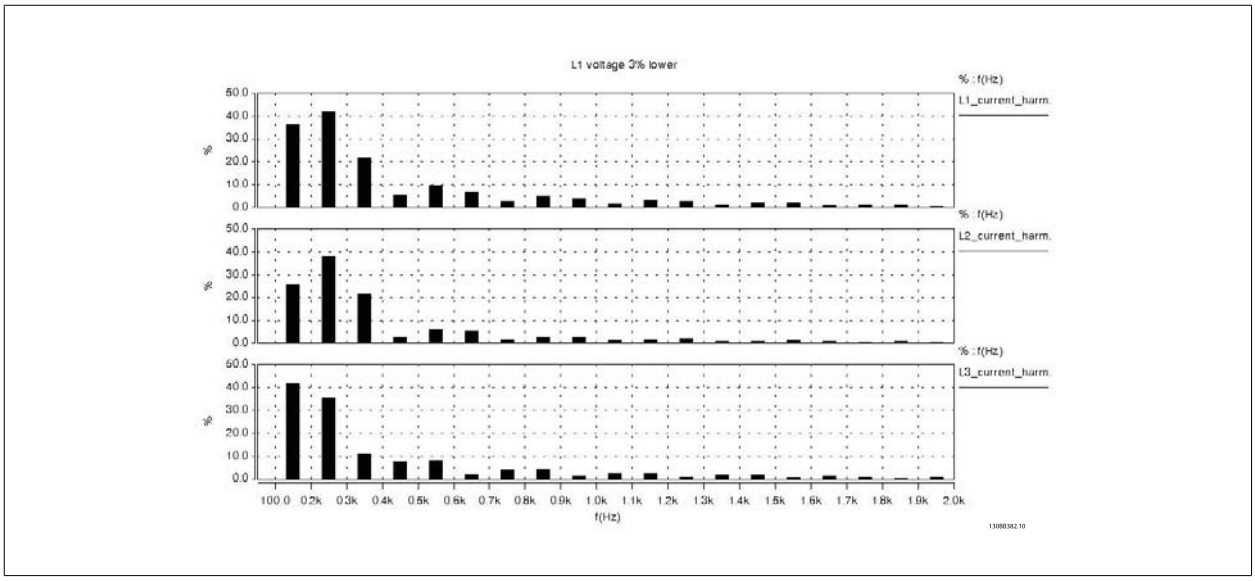
1.1.4 Voltage on one Phase 3 % Higher

If the voltage of one of the phases is higher than the voltage on the other two phases, the harmonic content is the same as if one phase is missing, but the magnitude of the harmonics are not equal at the three phases.



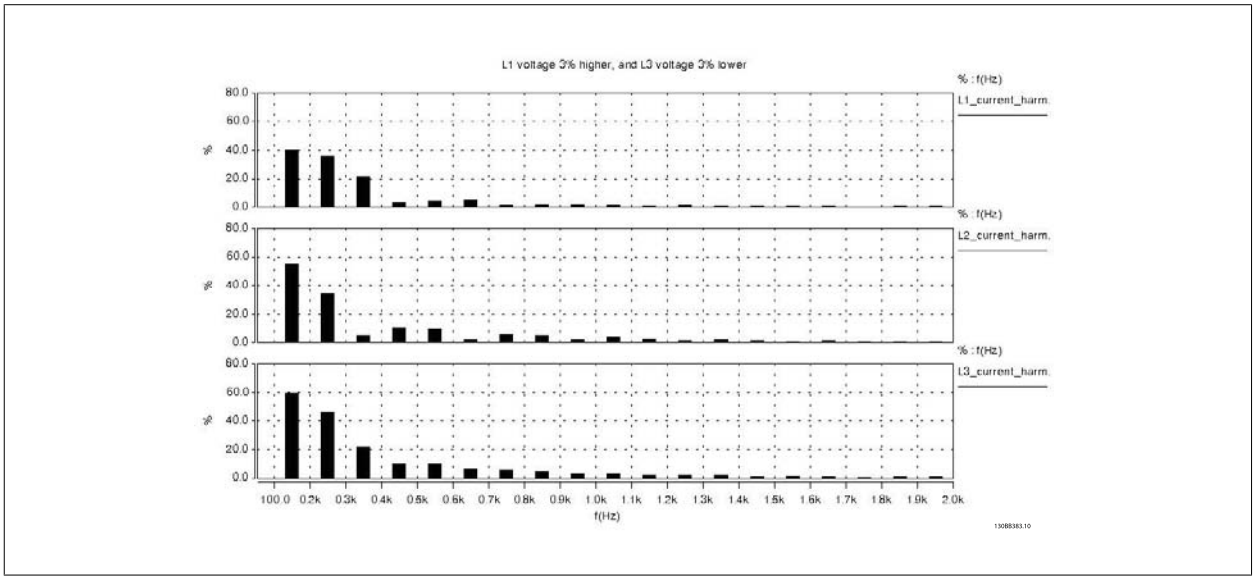
1.1.5 Voltage on one Phase 3% Lower

If the voltage on one phase is lower than the voltage on the other two phases, the harmonic content is the same as if the voltage is higher on one phase.



1.1.6 Voltage on one Phase 3% Higher and 3% Lower on one of the Other Phases

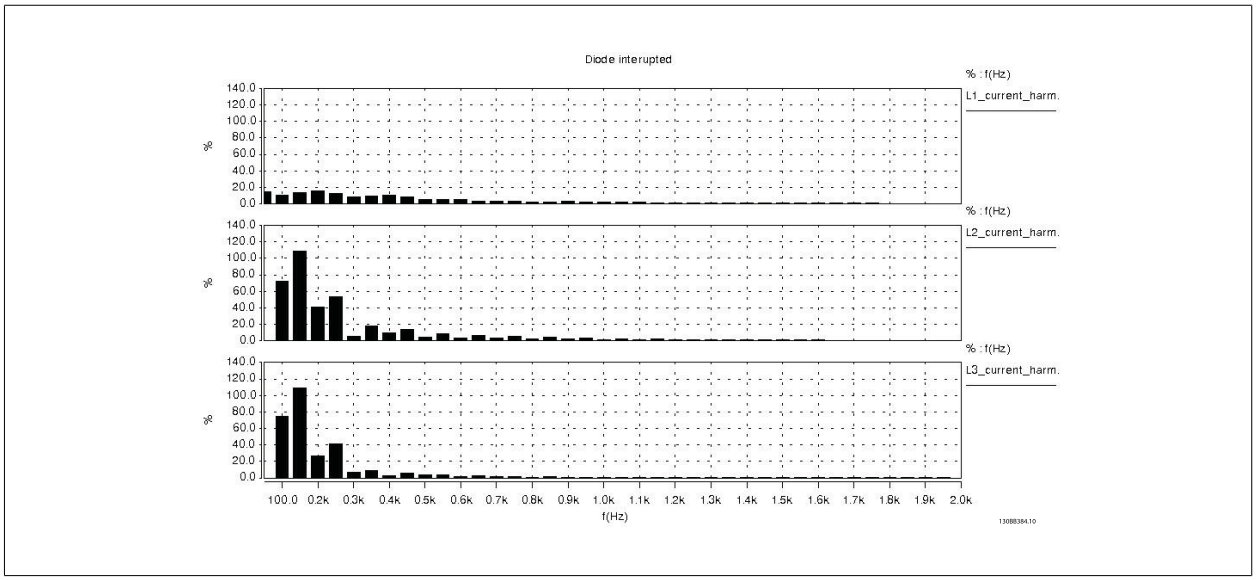
Also under these conditions the harmonic content is the same as for 3rd and 4th.



1.1.7 One Diode Interrupted

1

If one of the diodes in the rectifier is interrupted, the spectrum shows that all harmonic are present - also even harmonics like 2nd, 4th, etc. are present.



1.1.8 Normal Situation but a very Stiff Main

If the supply is very stiff (= low supply impedance) the content of the higher harmonics are increasing.