

# Power frequency website

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**Abstract** — the following paper deals with a presentation of measured frequency values in the form of a website to allow the public domain access to previously restricted information. The development of the platform is discussed with a view of structure and design. In focus, and also as the subject of this paper, the features are analysed and evaluated on content and usability.

## 1 MOTIVATION

The power frequency is the frequency of the oscillations of alternating current in an electric power grid. It is transmitted from a power plant to the end-user. In large parts of the world this is 50 Hz, especially in Continental Europe, also known as the Union for the Coordination of Transmission of Electricity (UCTE). All members of the UCTE have voltage level and frequency in common. Together, they form a huge European electrical power grid. Nevertheless changes in the frequency may occur if supply or demand exceeds its counterpart. In the case of escalated supply the frequency will increase, while in the case of escalated demand it will decrease. The main objective is to keep the frequencies of the synchronous areas balanced around the 50 hertz standard to ensure a safe power supply. Also important is the fact that the course of the frequency provides information on consumer's behavior at a particular time of day, within a particular season. Additionally, it serves as a basis for the use of control energy in the form of instantaneous reserves. At a certain degree it is even used as the base for trade in electricity exchanges. Many energy operators keep this valuable information restricted from the public domain and deny access to it for research purposes.

Consequently the objective of this project was to measure the power grid frequency in the UCTE and publish the results on a webpage providing free access to members of the public. For this purpose, the frequency is measured by a self-made device with the following contents and attributes[1]:

- *Transformer* - the voltage is transformed from 230V AC to 9V AC.
- *Circuit* - limiting voltage to 4.7V and generating square wave signal.
- *Arduino* - calculating frequency  $f=50/T$  and sending frequency to Raspberry Pi.

- *Raspberry Pi* - storing frequency with timestamp in the database.

With the frequencies now stored, they are ready to be published and displayed[2].

## 2 WEBSITE

An effective method to reach a broad audience is to provide access to findings through a website.

In order for this to occur, several conditions must be met, which have been defined below:

1. The measured values offered to users must be presented in a clear and accurate format. Subsequently, this means, the structure and the design of the website will need to be of the same extent.
2. It has to base on PHP and HTML and thus also support MySQL databases, CSS and JAVA for dynamic visualisation.
3. It must be based on a tool that is offered by the university's server to be classified as safe<sup>1</sup>[3].
4. It must be easy to manage and operate for people using it for subsequent projects.

In order to fulfill all these points, the software "WordPress" is used for creating the website.

### 2.1 Wordpress

Wordpress is freeware software to manage the content of a website such as text and pictures. It is particularly useful to build and maintain a weblog, since it can assign any post to one or more free creatable classes and automatically generate the corresponding navigation elements. In parallel, Wordpress also manages hierarchical pages and allows use of it as a content management system (CMS).

The system provides the possibility to check reader's comments prior to the content being published. Additionally, the system also provides a central link management – a management of user rights, and the possibility of external plugins. Wordpress is thus a full-fledged CMS.

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<sup>1</sup> The IT service of the university requires certain safety precautions before the domain is enabled for the internet.

Equally important, Wordpress is based on PHP and requires a MySQL database. It is licensed under the GNU General Public License, making it free for all users. According to the developers, the system attaches great importance on web standards, elegance, ease of use and adjustability[4].

The theme-technique, design and programming of Wordpress are clearly separated, making it easy to develop structures for those that are not familiar with programming. It also allows users to program various functions directly into their selected theme.

A normal Wordpress theme consists of a set of building blocks (PHP functions) and HTML code. Each theme fundamentally follows the same structure. Therefore, there are some developers of special themes that already include all the basic building blocks in order to simplify the development of their own themes[5].

For experimental purposes, web space has been claimed from www.bplaced.net, a webhost which offers a broad service package with 2GB web space, FTP, PHP6 and a MySQL Database[x]. This domain was used for the development and initial tests with Wordpress[6].

## 2.2 Design

As previously mentioned, the basic design is specified by a theme that can be customised based on user needs and requirements. For this paper, the theme "Spacious" was selected as the design template.

The following picture illustrates the basic structure of the theme:

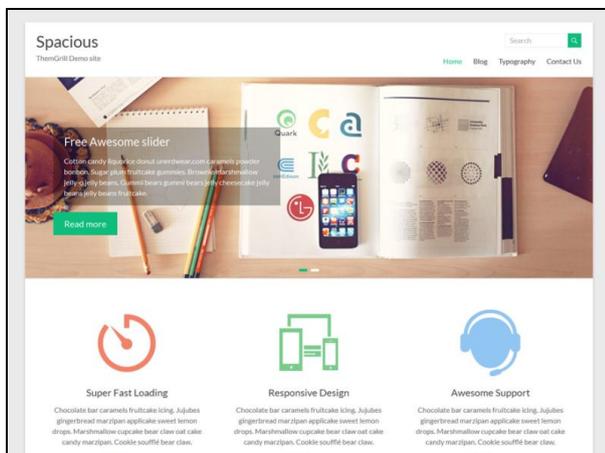


Figure 1 Theme "Spacious"[5]

This design can be used for business, portfolio, blogging or any other type of site. It has 4 page layouts, 2 page templates, 4 blog display types, 13 widgets areas, 5 custom widgets focusing on business template, a primary colour option to match the logo and website, a boxed and wide layout, and light and dark color skin[5].

The logo is located on top left corner of the page, and the index is located on the top right. A key highlight in selecting this particular theme is the slide function. This

function allows images to dynamically change every five seconds, strategically marking fundamental topics visually through the use of small pictures and a short introduction. Below the slide function, is the Footer Side bar. This area allows for other searches and quick access to contact information.

## 2.3 Build And Maintain

With the basic framework using "Spacious" now complete, work can begin on building the website from inside. With this in mind, there is a "dashboard" that will open with the wp-login.php data. Once logged in, the administrator will get access to the admin area, and can operate using the navigation tool bar, as it is shown in Figure2 below:

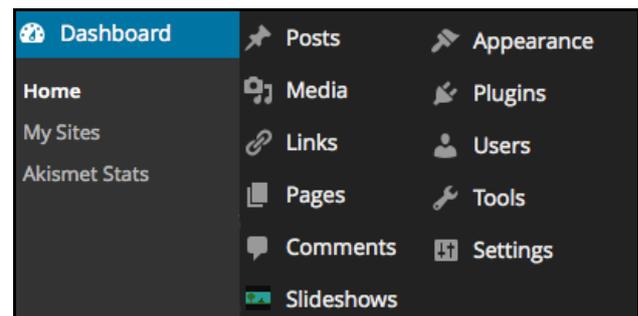


Figure 2 Dashboard

These "dashboard" tools offer the administrator control over a wide range of features to influence and improve the website and its structure.

The first column gives you general information about new features and updates.

The second column contains tools in regards to reader posts, comments and a media library. When the webpage is used as a blog, there is the opportunity to create new articles in "Posts". Under "Media", the administrator can store self-created images and photos. Wordpress even allows an interactive dialogue with users through the activation of the "Comments" function. This function allows the administrator to restrict comments for review before they are published on the website.

The third column refers to the functionality of the page and focuses on two key functions.

The first key function, located under the menu item "Appearance", is titled "Widget". Widgets add content and features to your Sidebars. Examples are the default widgets that come with Wordpress for post categories, tag clouds, navigation, searches, etc. They provide a simple and easy-to-use way of giving the administrator design and structure control of the Wordpress Theme, extending to include the header, footer, and elsewhere on the webpage. Furthermore, the widgets can be added, removed, and rearranged. The order and placement is set in the functions.php file. Some Wordpress widgets offer customisation and options such as forms to fill out

inclusion or exclusion of data and information, optional images, and other customisable features[7].

The second key function is "Plugins". – bits of software that can be uploaded to extend and expand the functionality of the Wordpress site[8].

These two functions will be responsible for the visualisation of the frequency as a graph and as a dynamic presentation. This will be discussed in more detail in section of this paper.

### 3 POWER FREQUENCY

The content and the service of the website are divided into 5 pages:

- Home
- Power frequency
- Story of 50Hz
- About project
- Contact

The last three points provide users with background information.

In "Story of 50hz" users can read about the history and development of 50Hz level. Additionally, the "About project" provides a summarised overview the entire project including its purpose and the more technical elements involved. The section "Contact" gives the user the opportunity to make comments and suggestions on the content and feed back on the overall usability of the website.

The heart of the project is located in the section "Power frequency". This section explores current frequency, last hour, past frequencies and a section to download content. In order to provide a bride offer on the website, the user has four ways to call the current power frequency data:

- Current frequency
- Last hour
- Past frequencies
- Download

This involves various forms of representation the user can quickly invoke.

#### 3.1 Current frequency

To represent the current power frequency, a dynamic graph is required to update every second and display the latest frequency value in the database. In order to visually display this real-time data, the service Highcharts is used. Highcharts offers a charting library written in JavaScript which can quickly and easily be added to the website. It supports line, spline, area, areaspline, column, bar and pie chart types. The remarkable feature of this tool is that it does not require client side plugins such as Flash or Java. Highcharts only requires one of two JavaScript files to

run: either the highcharts.js core or the jQuery. In combination, these data scripts and Prototype's Ajax API, allows the creation of live charts that can be directly updated with values from the server[9].

In order to display the values from the database using Highcharts, a php file needs to be created. In this example it is called read-last-value.php. This file consists of mostly MySQL commands and instructions. First, the connection to the server(Raspberry Pi) needs to be established by the command mysql\_connect.

The database then displays the information in table format:

ID	Datum_Zeit	Millisekunden	Frequenz
1	2015-02-11 11:09:32	12	49.997
2	2015-02-11 11:09:33	79	49.998
3	2015-02-11 11:09:34	79	49.998
4	2015-02-11 11:09:35	79	49.999
5	2015-02-11 11:09:36	79	49.999
6	2015-02-11 11:09:37	79	49.997
7	2015-02-11 11:09:38	78	50
8	2015-02-11 11:09:39	79	50
9	2015-02-11 11:09:40	79	49.999

Figure 3 Database

The values are packed in an array. After encoding it into the json format, the data will be passed on to dyn.php. At this stage, it is integrated into the Java script of Highcharts for final presentation of the results. The dynamic display will be integrated with the previously mentioned Widget function into the website using a Wordpress widget called "IFrame". This simple widget can display any external HTML page inside of HTML IFrame component[10]. This means that content can displayed on an external page of your website. In this case, "http://netzfreq-bplaced.net/dyn.php" will be displayed as "http://netzfreq-bplaced.net/?page\_id=142" as current frequency. If you open "Current frequency", the dynamic representation will open automatically.

#### 3.2 Last hour

Under the heading "Last hour", the frequency response of the last hour is shown.

When the page is opened, it also generates the display at the same time. A course of the frequency will appear in blue, against a white background, which greatly increases the contrast. The X-axis represents the date and time, while the Y-axis represents the frequency value. To realise this, the Time Series Highcharts Line type is used[11]. As mentioned in the previous example, the values of the last hour will be selected in the database and passed through to the aforementioned Java-Script file.

The latest hour will be illustrated as long as the frequency measurement runs. A special feature of this chart is the ability for users to zoom in order to examine any part of the data set more closely. Users can also download the information as picture or as PDF file.

### 3.3 Past frequencies

Under the section “Past frequencies” the user can compile data and display a three-hour frequency response of the past. A condition of this feature is that the users are restricted to a particular date and time, whereby the input is permitted in a pre-defined date and time format. This guarantees the integrity of the data and the overall appearance of a calendar. The calendar is a pre-generated Java-Script file and uses a plugin called Datetimepicker[12]. Once the user enters the required date and time, all frequencies three hours ahead from that date will be selected and described as the “Last hour”, displayed by the same Highcharts line type. At this stage users can download this data in the form of an image or a PDF file.

### 3.4 Download

Finally, the webpage allows users the opportunity to download the frequencies as freeware. Elsewhere, this service comes with an additional cost or is not available at all.

Users can display all frequencies of a certain period in tabular in form off a CSV file using the pre-defined date and time format, with the Datetimepicker calendar providing the correct input. Once the data has been entered, a selection using the unix\_timestamp format is written in a CSV tabular by looping in the corresponding column, as presented in Figure 4 below:

Id	DateTime	Millisecond	Frequency
313096	27.02.2015 13:00:00	98	50.001
313097	27.02.2015 13:00:01	94	50
313098	27.02.2015 13:00:02	95	50.001
313099	27.02.2015 13:00:03	96	50
313100	27.02.2015 13:00:04	0	50
313101	27.02.2015 13:00:05	96	50.003
313102	27.02.2015 13:00:06	95	50.002
313103	27.02.2015 13:00:07	94	50.002
313104	27.02.2015 13:00:08	94	50.004
313105	27.02.2015 13:00:09	94	50.003
313106	27.02.2015 13:00:10	94	50.001
313107	27.02.2015 13:00:11	94	50.003
313108	27.02.2015 13:00:12	94	50.001
313109	27.02.2015 13:00:13	94	50.002
313110	27.02.2015 13:00:14	94	50.002
313111	27.02.2015 13:00:15	94	50.001
313112	27.02.2015 13:00:16	94	50.001
313113	27.02.2015 13:00:17	94	49.999

Figure 4 Data table

Users can use this data for their personal information and research purposes. They have the option to capture these results and create their own visual representations.

### 3.5 Move of website

Once all the design and testing is complete, the website is ready to move from its “development stage” to its “live stage”. To achieve this, all content is transferred from the development environment to the official, published webpage domain. The current URL of the website is now: <http://netzfrequenz.web.fh-koeln.de>[13].

## 4 SUMMARY

In the UCTE grid the power frequency of 50Hz is an indicator of the power supply stability in Europe.

The frequency is recorded by means of a self-made measurement device at the Cologne University of Applied Science. The values are stored on the server, which is located on the Raspberry Pi device. The university’s IT service provides a safe and secured server to host this website. The website is based on Wordpress. It is a free and open-source blogging tool and a content management system based on PHP and MySQL. Features include a plugin architecture and a template system. The frequency values are generated by specific plugins and represented in various forms as a dynamic chart, as a curve or as a table sheet. The result is an archive of frequencies available for the public to be used for their own purposes.

## 5 REFERENCES

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