

VINPFN v.1.0 Manual

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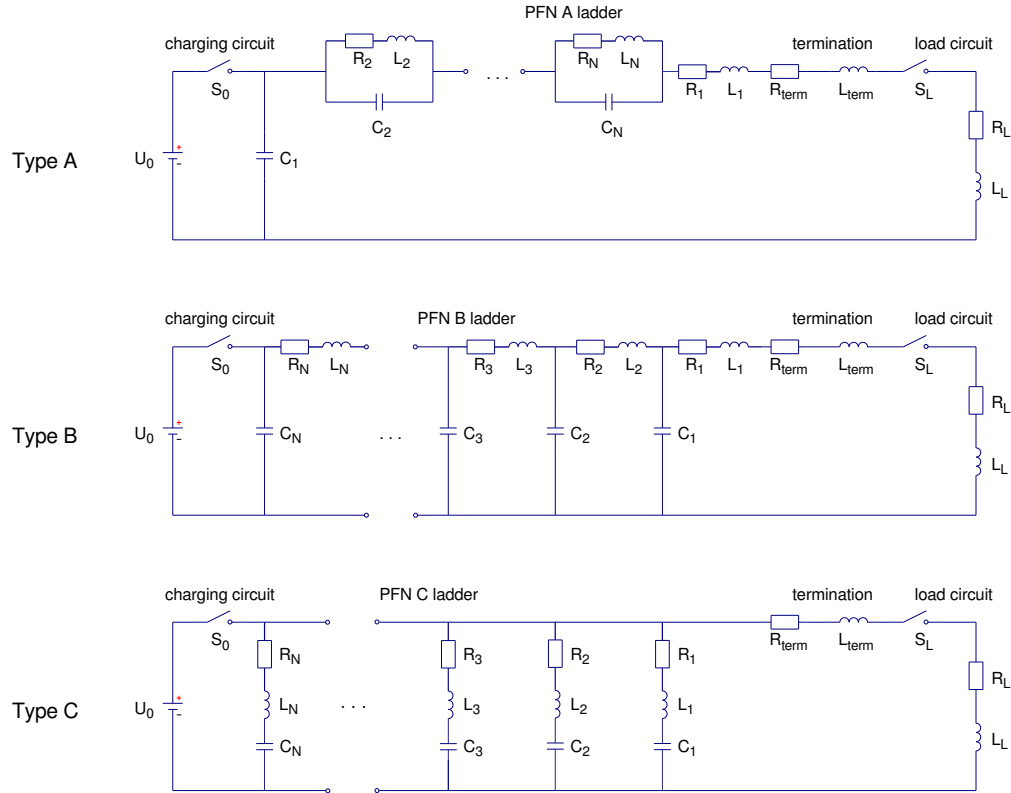
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Introduction

VINPFN is short for VINETA Pulse Forming Network Analysis and is a set of Matlab scripts developed at the Max Planck Institute for Plasma Physics to support the design of pulse-forming networks (PFNs) for plasma experiments at the VINETA facility. The program is, however, general enough to be used as a tool for modeling PFN applications wherever the loads can be considered resistive or inductive. Models of three voltage-fed network types are implemented – Type A, B, and C, which are defined in Figure 1.

Figure 1: Voltage-fed Pulse Forming Networks implemented in VINPFN. **Top:** PFN Type A – The first capacitor C_1 is charged when the load is connected. **Middle:** PFN Type B – All capacitors are initially charged. **Bottom:** PFN Type C – All capacitors are initially charged.



The VINPFN program is launched by the *vinpfn* command with no input arguments. The main window is displayed in Fig. 2. From here the selection of calculation to be performed is made.

Figure 2: Main window of VINPFN for selection of network and calculation type.

The image shows a dialog box titled 'Main window of VINPFN for selection of network and calculation type'. It contains two sections: 'Type of Network' and 'Type of Calculation'. In the 'Type of Network' section, there are three radio buttons: 'PFN A' (selected), 'PFN B', and 'PFN C'. In the 'Type of Calculation' section, there are two radio buttons: 'General' (selected) and 'Optimization'. At the bottom right, there are 'OK' and 'Cancel' buttons.

General Calculations

The General-calculation option allows for free variations of the network parameters. An example input window is shown in Figure 3 with parameters defined in Table 1. There are several data-output options available of which the most important is the load-current plot. For detailed studies of a network the currents of the individual inductors and capacitors can also be plotted as well as the capacitor voltages. The network output current pulse data can also be saved to a text file. A directory and filename must then be provided.

Figure 3: Input window for general PFN calculations.

The image shows a complex input window for general PFN calculations. It is divided into three main sections: 'LOAD CHARACTERISTICS', 'NETWORK CHARACTERISTICS', and 'DATA OUTPUT'.
 - 'LOAD CHARACTERISTICS': Contains input fields for R_{load} [Ohm] (value: 1) and L_{load} [Henry] (value: 0).
 - 'NETWORK CHARACTERISTICS': Contains a 'Type of Network' section with 'Equicell' (selected) and 'Unicell' radio buttons. Below this is a 'Lossy Network' checkbox (unchecked). To the right are input fields for C_i [Farad] (value: 1e-6), L_i [Henry] (value: 1e-6), R_i [Ohm] (value: 0), R_{term} [Ohm] (value: 0), U_0 [Volt] (value: 1000), N [cells] (value: 1), and L_{term} [Henry] (value: 0).
 - 'DATA OUTPUT': Contains an input field for T_{int} [s] (value: 5e-05). Below this are checkboxes for 'Plot Load Current' (checked), 'Plot Capacitor Voltages' (unchecked), 'Plot Capacitor Currents' (unchecked), and 'Plot Inductor Currents' (unchecked). At the bottom, there are checkboxes for 'Save Load Current Data' (unchecked), a 'Directory' input field, and a 'File Name [.txt]' input field. 'OK' and 'Cancel' buttons are at the bottom right.

Table 1: General-calculation parameters

Parameter	Definition	Description
\mathbf{R}_{load}	load resistance in Ω	
\mathbf{L}_{load}	load inductance in H	
Equi-/Unicell	type of network	In an equicell network all cells are identical. One C_i value and one L_i value need to be specified and these will then be repeated N times to build a network. In a unicell network each cell can have a unique capacitor and inductor. All cell elements must be specified starting with cell 1 (nearest the load).
Lossy Network	type of network	In a lossy network cell resistors R_i in series with the cell inductors are used to model internal losses.
\mathbf{C}_i	cell capacitor in F	Capacitance of each cell capacitor. For an equicell network only one C_i value is required. For a unicell network all capacitances must be listed separated by commas. If the Equicell box is marked an equicell network will be modeled using the first capacitance in the list.
\mathbf{L}_i	cell inductor in H	Inductance of each cell inductor. For an equicell network only one L_i value is required. For a unicell network all inductances must be listed separated by commas. If the Equicell box is marked an equicell network will be modeled using the first inductance in the list.
\mathbf{R}_i	cell resistor in Ω	Resistance of each PFN segment. If the Lossy Network box is unmarked R_i will be set to zero. For an equicell network only one R_i value is required. For a unicell network all resistances must be listed separated by commas. If the Equicell box is marked an equicell network will be modeled using the first resistance in the list.
\mathbf{U}_0	source voltage in V	Initial PFN voltage. For Type A this is the voltage over capacitor C_1 . For Type B and C this is the voltage on all cell capacitors.
\mathbf{N}	number of network cells	$N \geq 1$. For a unicell network N must equal the number of listed capacitors and inductors.
\mathbf{R}_{term}	termination resistor in Ω	Resistor for load matching or power dump.
\mathbf{L}_{term}	termination inductor in H	Inductor for load matching.
\mathbf{T}_{sim}	temporal interval in s	Simulation time from load connection.

Optimization Calculations

The VINPFN program has some simple optimization routines to support PFN designs. Capacitors to be considered need to be provided in a sorted list in a file called *caplist.txt*.

The optimization routines are different depending on the type of network, although the input parameters are the same. Figure 4 displays the input window for Type C networks as an example. The parameters are defined and explained in Table 2.

Figure 4: Input window for optimization calculations.

LOAD CHARACTERISTICS

R_{load} [Ohm] L_{load} [Henry]

NETWORK CHARACTERISTICS

Type of Network ☐ Guillemin

T [s] C_i [Farad]

I_{ripple} [%]

L_{imax} [Henry]

U_0 [Volt] R_{term} [Ohm]

N_{max} [cells] L_{term} [Ohm]

DATA OUTPUT

T_{int} [s]

☒ Plot Load Current

☐ Save Load Current Data

Directory File Name [.txt]

Table 2: Optimization parameters

Parameter	Definition	Description
\mathbf{R}_{load}	load resistance in Ω	
\mathbf{L}_{load}	load inductance in H	
Type of Network	network model	<p>Type A Equicell: All cells are identical.</p> <p>Type A Duplex: The active (first) cell may have different C_1 and L_1 than the equicell PFN A chain. The largest capacitor selected from the C_i list will be modeled as primary.</p> <p>Type B Rayleigh: All cells are identical.</p> <p>Type C Guillemin: Each cell capacitor is chosen to be near the ideal Guillemin value.</p>
\mathbf{U}_0	source voltage in V	Initial PFN voltage. For Type A this is the voltage over capacitor C_1 . For Type B and C this is the voltage on all cell capacitors.
\mathbf{N}_{max}	max number of network cells	$\mathbf{N}_{max} \geq 1$
τ	pulse duration in s	Desired current pulse length.
I_{ripple}	current ripple in %	Tolerance of current around the nominal value.
\mathbf{C}_i	cell capacitor in F	Capacitances to be investigated from the sorted list in file <i>caplist.txt</i> .
\mathbf{L}_{imax}	max cell inductance in H	If calculated cell inductors exceed \mathbf{L}_{imax} they will be modeled with the \mathbf{L}_{imax} value.
\mathbf{R}_{term}	termination resistance in Ω	Resistor for load matching or load power reducer, or for modeling of load switch.
\mathbf{L}_{term}	termination inductance in H	Inductor for load matching or modeling of load switch.
\mathbf{T}_{sim}	simulation length in s	Simulation time from load connection.