VINPFN v.1.0 Manual

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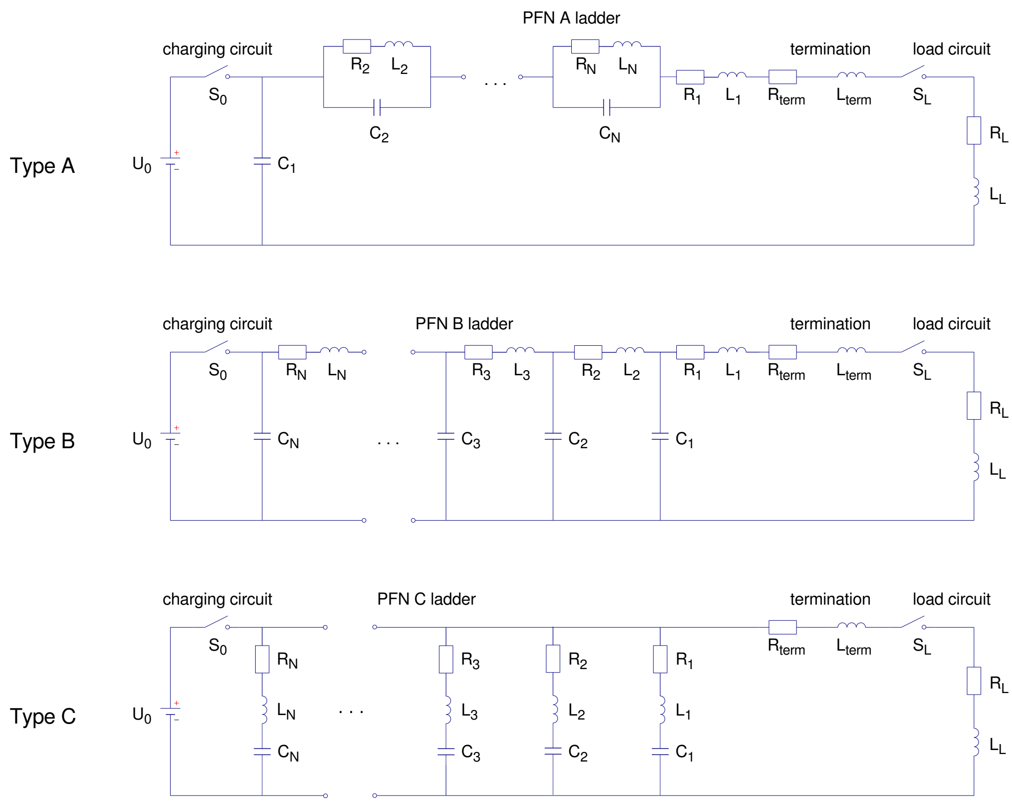
Introduction

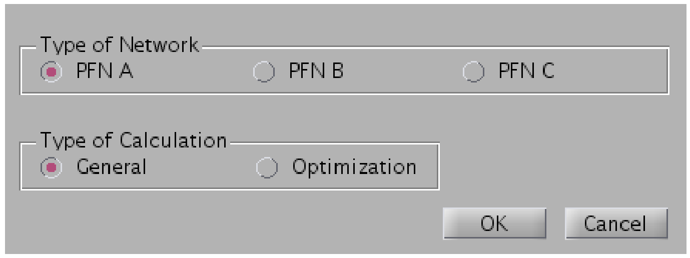
VINPFN is short for VINETA Pulse Forming Network Analysis and is a set of Matlab scripts developed at the Max Planck Institute for Plasma Physics to support the design of pulse-forming networks (PFNs) for plasma experiments at the VINETA facility. The program is, however, general enough to be used as 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.



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.

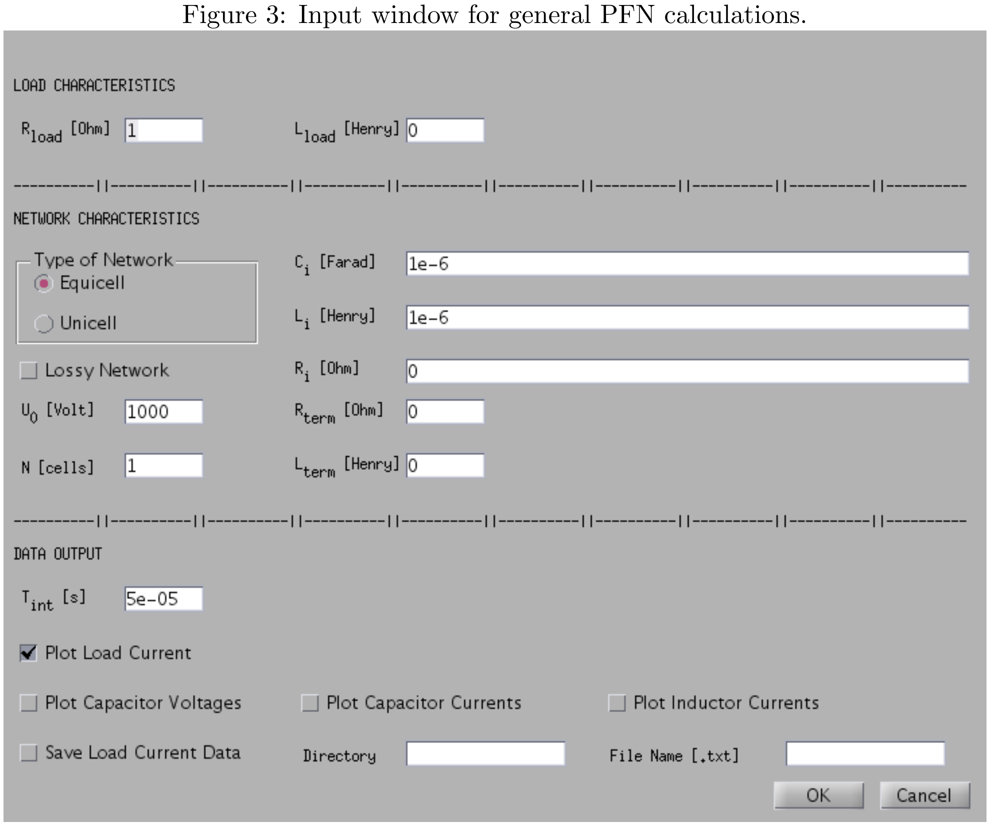


Table 1: General-calculation parameters

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 berepeated 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 seperated 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.

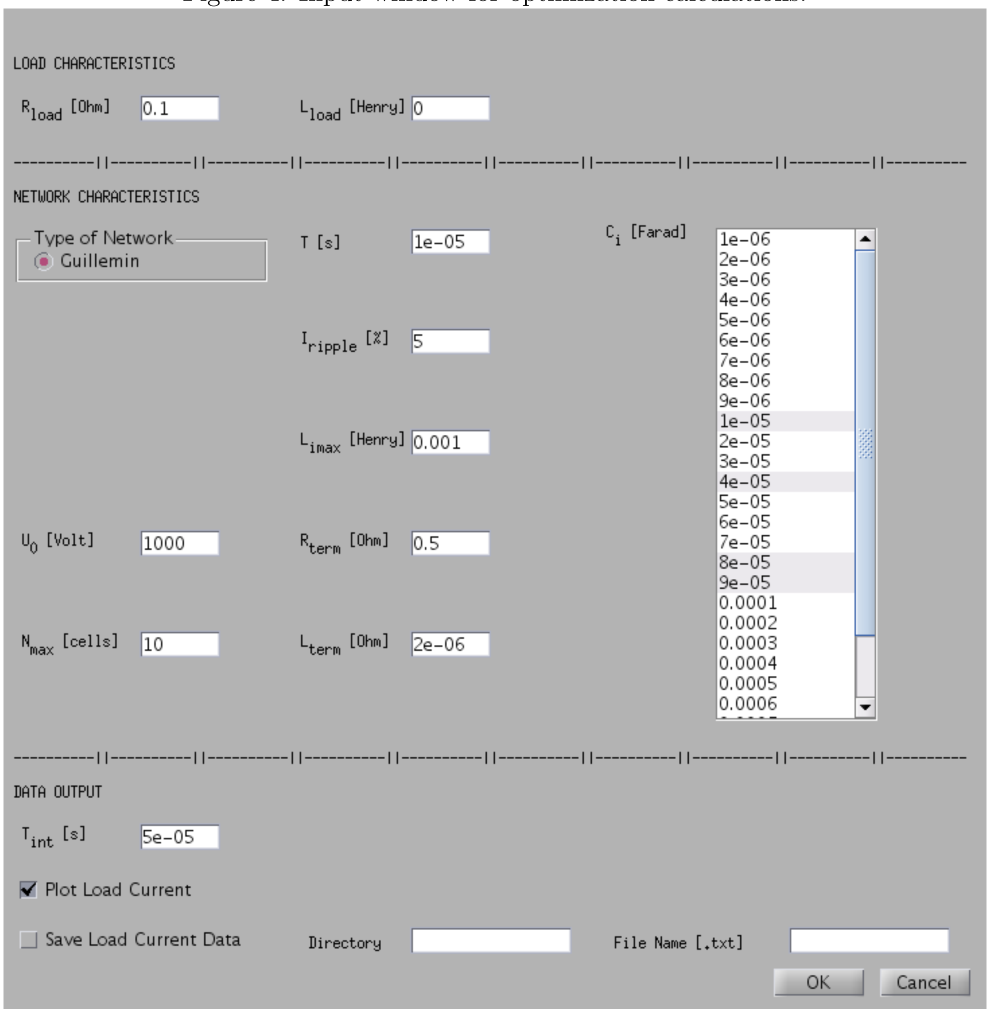


Table 2: Optimization parameters

Parameter	Definition	Description
$\mathbf{R}_{load}$	load resistance in Ω	
$\mathbf{L}_{load}$	load inductance in H	
Type of Network	network model	**Type A Equicell**: All cells are identical. **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. **Type B Rayleigh**: All cells are identical. **Type C Guillemin**: Each cell capacitor is chosen to be near the ideal Guillemin value.
$\mathbf{U}_0$	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 *caplist.txt*.
$\mathbf{L}_{imax}$	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.