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A new approach for analyzing the effect of non-ideal power supply on a constant current underwater cabled system

Key words: Non-ideal power supply; Constant current input; Ocean observation system

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Motivation

1. The effect of a constant current (CC) power supply on the CC ocean observation system is a problem that once was neglected.

2. The dynamic characteristics of the CC power supply may have great influence on the whole system, especially the voltage behavior in the event of load change. This needs to be examined.

3. We studied an effective model of the non-ideal power supply, which would be convenient to check the dynamic behavior of the system in a practical design.

Main idea

1. A method is introduced to check whether the CC power supply can satisfy the dynamic requirements of the CC ocean observation system.

2. An equivalent model to describe the non-ideal CC power supply is presented, through which the dynamic characteristics can be standardized.

3. Focusing on the power failure problem, the output voltage responses are performed and the models are validated.

Method

1. When a load resistor is connected directly to a power supply and the load resistance steps to a new value, there is an inertial delay in the output voltage response curve. To describe this phenomenon, we assume that the non-ideal CC power supply consists of an ideal CC source in parallel with an equivalent admittance *g* in the form of $g = A_n \frac{\mathrm{d}^n}{\mathrm{d}t^n} + A_{n-1} \frac{\mathrm{d}^{n-1}}{\mathrm{d}t^{n-1}} + \cdots + A_0$.

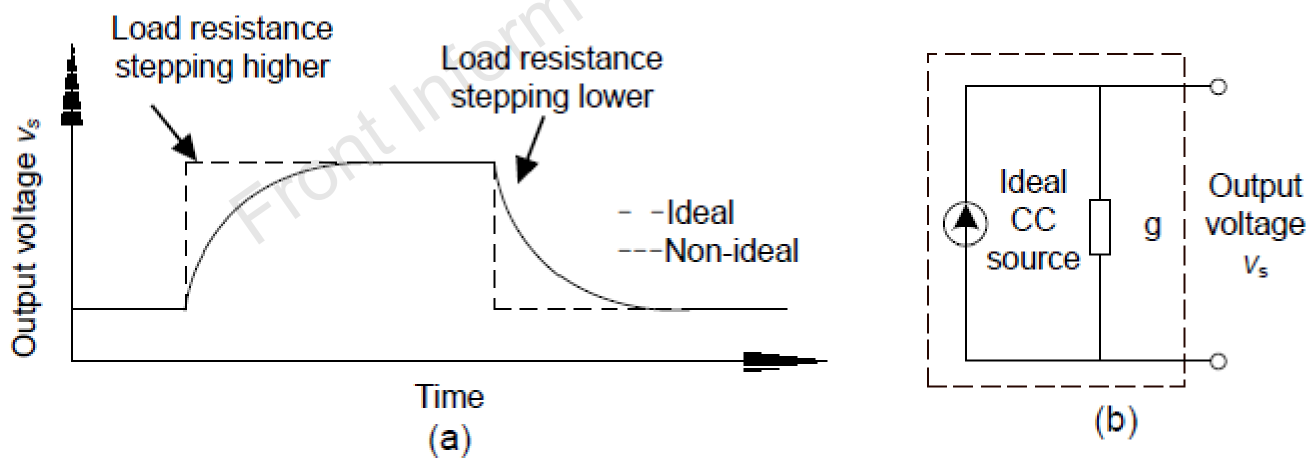

Fig. 1 Voltage response curve of the non-ideal and ideal constant current (CC) power supply with a step of load resistance (a) and a simplified model of the non-ideal CC power supply (b)

Method (Cont'd)

2. We can give the specific *g* by means of system identification. Since the non-ideal CC supply may be a nonlinear system, we need to identify it at the working point where it is as near the required working point as possible. Without a specialized system-identification apparatus, it is quite difficult to obtain *g* directly.

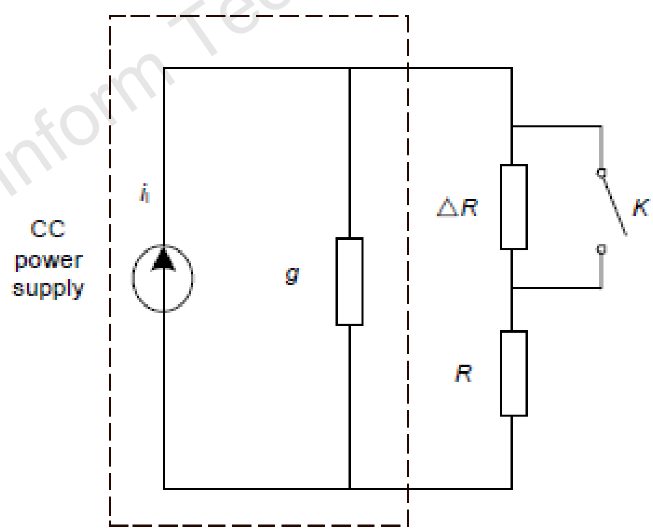

Fig. 2 Diagram for system identification of power supply (CC: constant current)

Method (Cont'd)

3. To verify the model of the non-ideal CC power supply, a minimum system of a single node in the ocean observation system must be modeled. The small signal is also obtained.

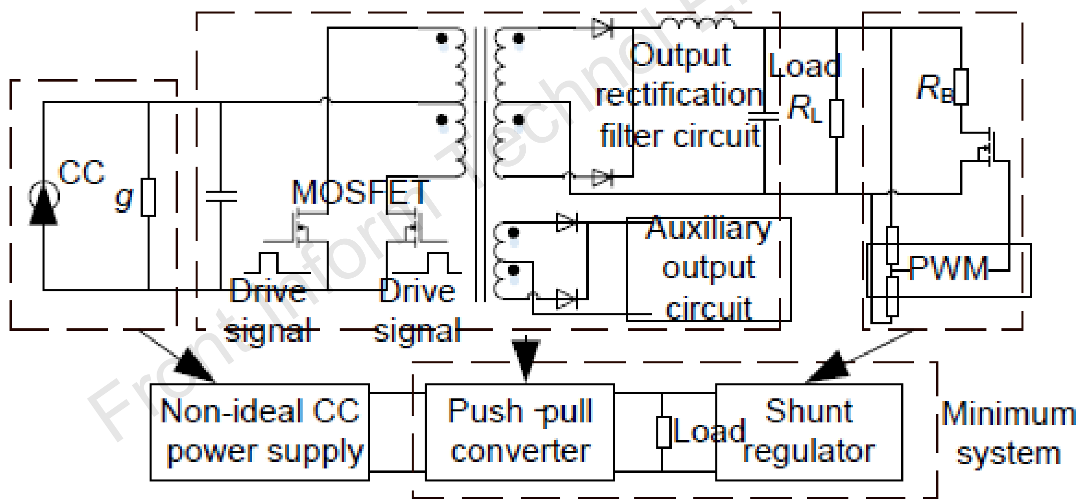

Fig. 3 Circuit diagram of the push–pull DC–DC converter with a non-ideal CC power supply and the shunt regulator (CC: constant current; DC: direct current; PWM: pulse width modulation)

Major results

To obtain *g*

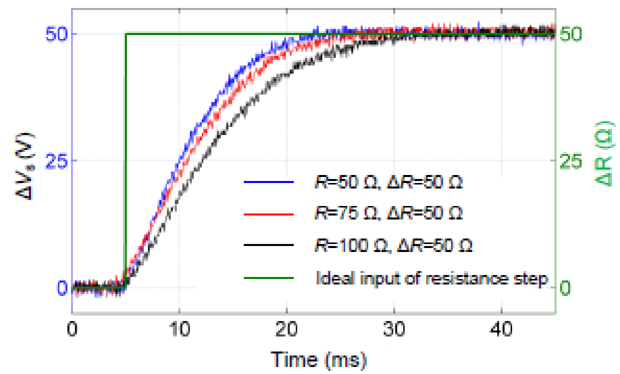

Fig. 5 The measured waveforms of the output signal (output voltage increment of the power supply ΔV_s) and the ideal input signal (increment of the load resistance ΔR) (References to color refer to the online version of this figure)

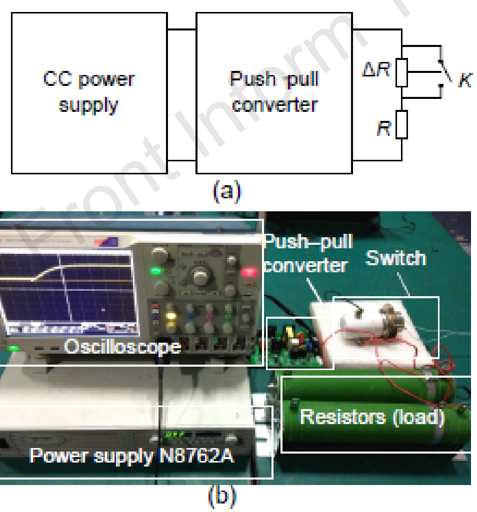

Fig. 7 The experimental schematic for *α* adjustment (a) and the corresponding setup of the experiment (b) (CC: constant current)

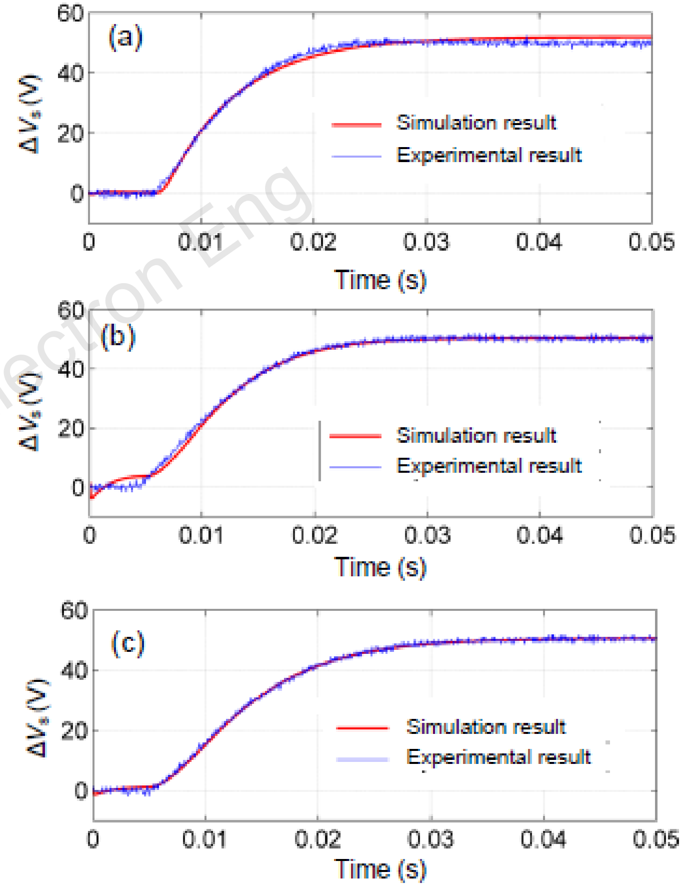

Fig. 6 The simulated responses under the input signal of the ideal resistance step and the measurement results when *R*=50 Ω (a), 75 Ω (b), and 100 Ω (c) (References to color refer to the online version of this figure)

Major results (Cont'd)

Adjustment of the model

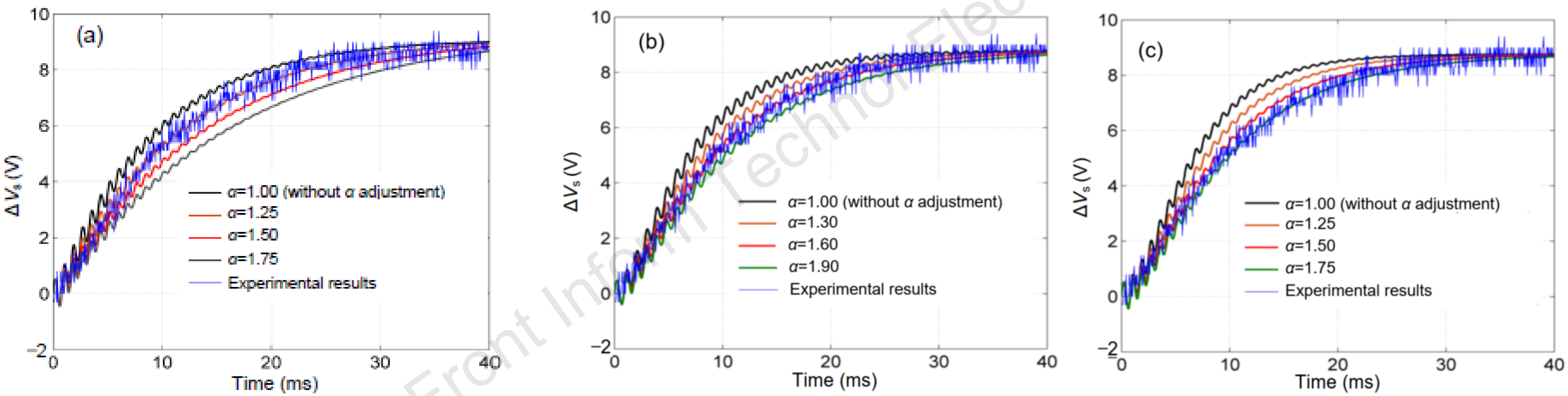

Fig. 8 The experimental and simulation results with different α's when R=50 Ω (a), 5 Ω (b), and 100 Ω (c) (References to color refer to the online version of this figure)

Major results (Cont'd)

Model validation

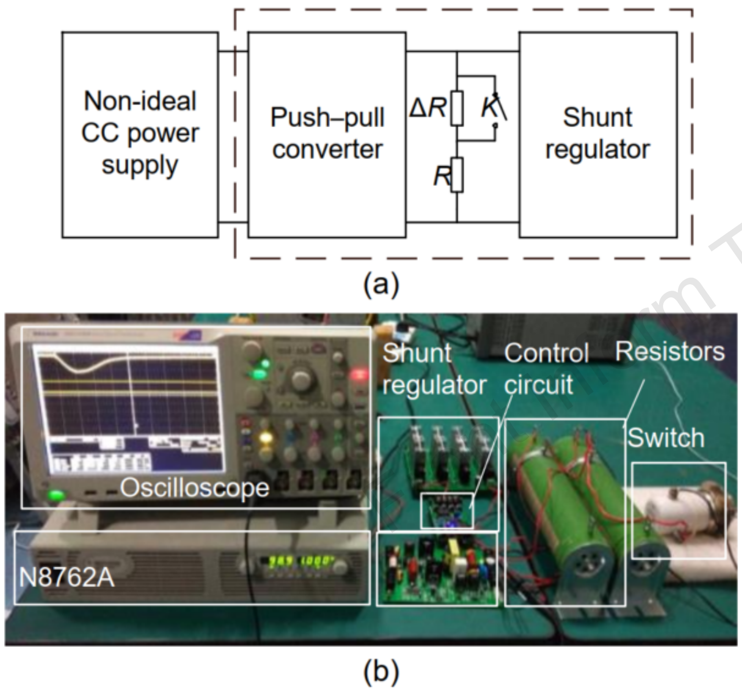

Fig. 9 Schematic for experimental verification (a) and the corresponding setup of the experiment (b) (CC: constant current)

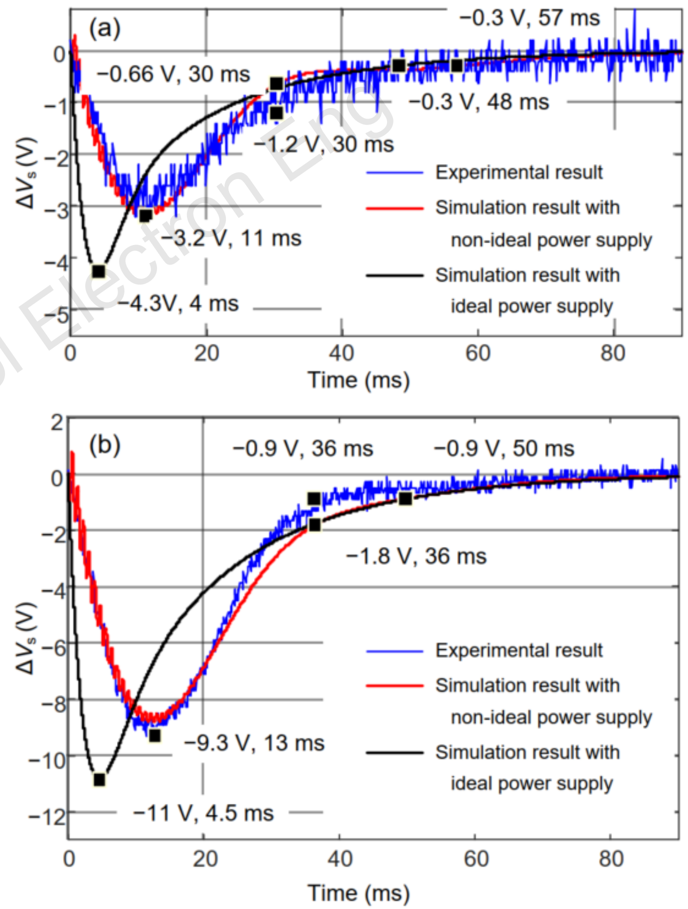

Fig. 10 Experimental and simulation results of the output voltage increment ΔV_o with load resistance stepping from 75 Ω (31% full-load power) to 50 Ω (46% full-load power) (a) and to 30 Ω (77% full-load power) (b)

Conclusions

1. In this paper, an equivalent dynamic model of a non-ideal CC power supply was introduced. The corresponding procedure in practical design for checking the CC power supply was presented. Focusing on the power failure problem when the external load cuts in, a CC power supply checked by the model above was applied in the circumstance of one node running.

2. When working on the CC ocean observation system, by applying the proposed model, the voltage response in the system to the effect of the non-ideal CC power supply can be obtained. Thus, we can determine whether the CC power supply meets the requirements of system response.