Sādhanā (2022)47:184
https://doi.org/10.1007/s12046-022-01957-5


# Note on a new bridged-T null network

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MS received 11 July 2022; revised 8 August 2022; accepted 8 August 2022

**Abstract.** A new bridged-T null network is presented in this note, together with its detailed analysis.

**Keywords.** New bridged-T null network; Null conditions; Transfer function.

## 1. Introduction

Bridged-T null networks (BTNN) are well known and have been applied for various purposes [1, 2]. In the latter reference, the author discussed in details, the conventional BTNN, shown in figure 1 ($N_1$), and its less known variation in which the series connection of L and r in the bridge is replaced by a parallel connection, as shown in figure 2 ($N_2$). Another variation is possible in which, the parallel connection is put in shunt with the ladder, as shown in figure 3 ($N_3$). The parallel connection of L and r is rather unnatural, as the losses of an inductor are most naturally represented in a series connection of L and r.

In the present note, we present yet another variation of $N_1$, to be called $N_4$, as shown in figure 4, which is believed to be new, because a reasonably extensive search by the author failed to reveal its existence in the literature. $N_4$ is attractive beacuse it appears that tuning is possible by a grounded resistor. Later, it will be shown that in tuning, L also needs to be adjusted.

The network $N_4$, in common with the other three, can be most conveniently analyzed by the dual input technique [1, 3], followed by a single node equation. After some algebraic calculations, followed by simplifications, we get the transfer function (TF) as

$$T(s) = P(s)/Q(s), \quad (1)$$

where

$$P(s) = LC^2Rs^3 + \left(2LC + aC^2R^2\right)s^2 + (1 + 2a)sCR + 3, \quad (2)$$

$$Q(s) = P(s) + sCR, \quad (3)$$

and, we have assumed that

$$r = aR. \quad (4)$$

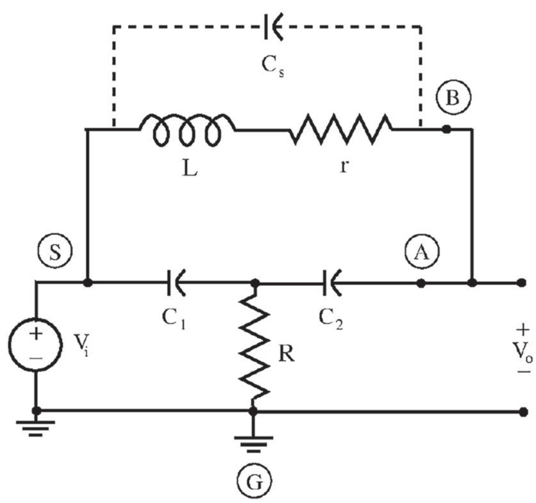


**Figure 1.** The conventional BTNN ($N_1$). $C_s$ represents the stray capacitance of the inductor, and its effect has been considered in [1].

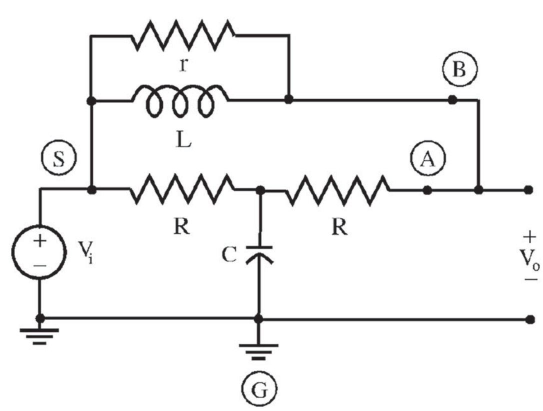


**Figure 2.** A variation of $N_1$ ($N_2$) .

Published online: 06 September 2022

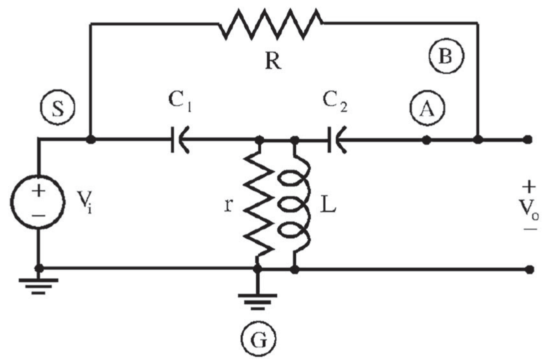


**Figure 3.** Another variation of $N_1$ ($N_3$).

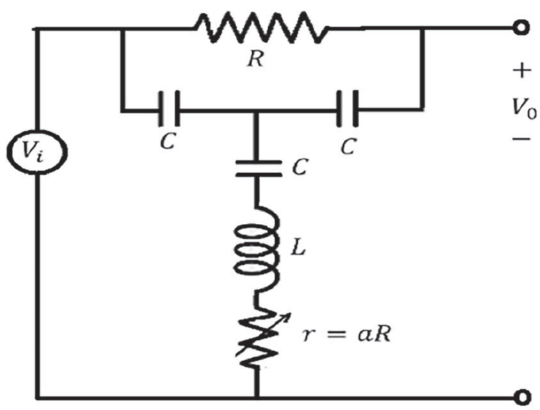


**Figure 4.** The new BTNN, $N_4$.

As expected, T(s) is a bicubic. For sinusoidal excitation, as we are interested in, putting s=jω, and separating the real and imaginary parts, we get

$$P(j\omega) = \left[3 - \left(2LC + aC^2R^2\right)\omega^2 + j\omega\left[(1+2a)CR - LC^2R\omega^2\right], \tag{5}$$

and

$$Q(j\omega) = \left[3 - \left(2LC + aC^2R^2\right)\omega^2 + j\omega\left[2(1+a)CR - LC^2R\omega^2\right]. \tag{6}$$

For null, both real and imaginary parts of P(jω) should vanish. This gives the null frequency and the the value of L required for null as

$$\omega_0^2 = 3/\left(2LC + aC^2R^2\right) \text{ and } L = aR^2C(1+2a)/(1-4a). \tag{7}$$

Clearly, as $\omega_0$ is varied by varying a, L also varies. Hence tuning has to be done by adjusting a as well as L.

Combining equations (5), (6) and (7), and assuming $x=\omega/\omega_0$, it is not difficult to show that T can be put in a normalized form as given below:

$$T = \left(1-x^2\right)\{3 + jx(1+2a)\sqrt{[(1-4a)/a]}\}\{3\left(1-x^2\right) + jx\sqrt{[(1-4a)/a]}\left[2 - x^2(1+2a)\right]\}. \tag{8}$$

This expression was simulated, and the results are shown in figure 5 for a = 0.1 and 0.2.

## 2. Conclusions

A new BTNN has been presented in this note, and has been investigated in detail. Its performance has been analyzed and its perfromance has been compared with the other two

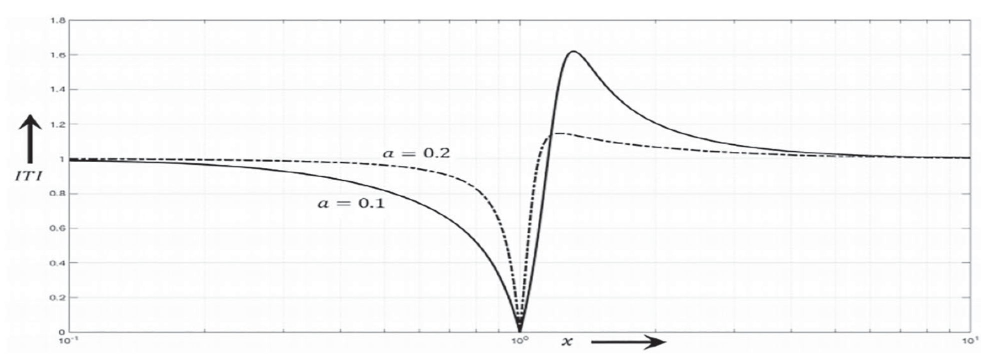


**Figure 5.** Simulation results for equation (8).

forms, given in [1], and a relatively less known variation of the conventional BTNN, along with its advantage.

## Acknowledgements

The author is thankful to Sumantra Dutta Roy and Yashwant Joshi for their help in the preparation of this manuscript.

**Funding** No funding was received from any source.

**Declarations**

**Conflict of interest** The author declares that he has no conflict of interest.

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