ELECTRONICS — ET '99
Sozopol (BG)

MODIFICATION OF AN OPEN COLLECTOR DRIVER FOR LINE DRIVING WITH AN AC TERMINATION

Assoc. Professor Georgy Mihov, Ph.D.
(tel. +359 2 965 32 81, E-mail: gsm@vmei.acad.bg)
Ass. Professor Mityo Mitev, Ms. Sc.
(tel. +359 2 965 20 56, E-mail: mitev@ecad4sun.vmei.acad.bg)
Department of Electronics, Technical University of Sofia, Bulgaria

Summary: This paper presents a case of AC terminated line driving. Analysis of open collector driver has been made. It has some advantages in comparison to the traditional push-pull driving technique but it cannot be applied, when the line is AC terminated. A modified version of an open collector driver is offered. It consists of open switch driver and additional switch which turns off when the line is discharged. Appropriate experiments have been made using CMOS devices and bipolar transistors as the switch to emulate properties of drivers in practical use. Analysis of the received waveform has been made. A small overshoot exists when recessive level is turned off depending on the current discharged. It can be controlled by a current sensor.

I. INTRODUCTION

In many applications a driver of open collector (or open drain), is used for line driving (fig. 1). That is because the open collector driving technique has some advantages in comparison to the traditional push-pull driving technique. First, the conflict situations in line transmission are easily supported when more than one driver is connected to the same line. Second, the open collector driver does not need an additional controlled signal DRIVER ENABLE in multi-driver transmit mode.

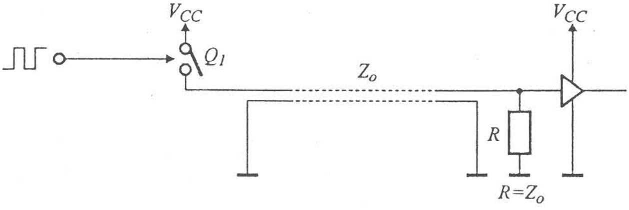

Fig. 1. Open collector driver technique.

In many applications (especially in CMOS or BiCMOS) the continuous current in the termination resistor of the line is not desired. This continuous current increases the power dissipation. It can be eliminated by using AC termination of the line. The most common solution to block the continuous current is to place a capacitor C in series to the termination resistor R. When the time constant $C \times R$ is about 4 times the propagation time t of the signal, the line is properly terminated.

However, the common open collector driver is not able to drive lines with AC termination. It is able to send a dominant level but it is not able to discharge the line and send the recessive level.

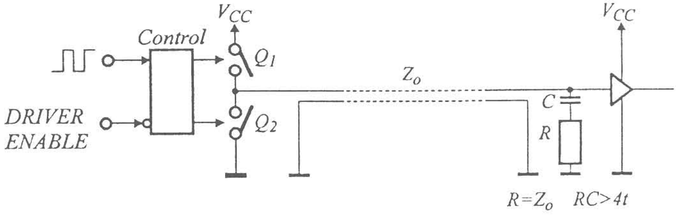

Fig. 2. Push-pull driver for line with AC termination.

In that case of AC termination a traditional push-pull driver is used. It has to be controlled by additional signal DRIVER ENABLE, if more than one driver is connected to the same line (fig. 2).

II. MODIFICATION OF AN OPEN COLLECTOR DRIVER

A modification of the open collector driver is offered for line driving with an AC termination. The driver consists of traditional open collector switch Q_1 and additional circuit that discharges the line. The additional circuit contains second switch Q_2 (complementary to the Q_1), current sensor R_s and SR-latch Tr. When a dominant level is driving the switch Q_1 is closed and Q_2 is open, that is the driver is in work mode as a usual open collector driver.

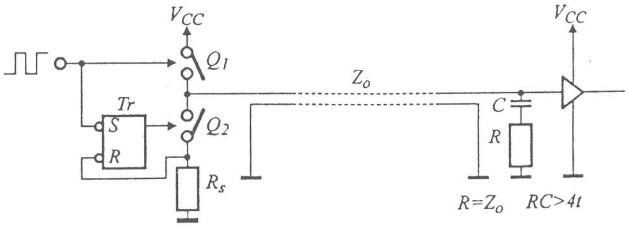

Fig. 3. Modification of an open collector driver for line with AC termination.

When a recessive level is driving the switch Q_1 is open. The switch Q_2 is closed for a short time as far as the discharged current from the line comes under some limit determined by a current sensor.

III. EXPERIMENTS

Experiments on the topic of line driving have been made. They have been made using CMOS devices and bipolar transistors as switches to emulate properly drivers in practical use. A coaxial cable with length of about 12 *m* and characteristic impedance of 60 Ω has been used.

First, an common open collector driver has been emulated with the experimental line. In fact the output transistor Q_1 is in open emitter mode but that is not important except of some decreasing of dominant level due to the V_{BE} of the Q_1.

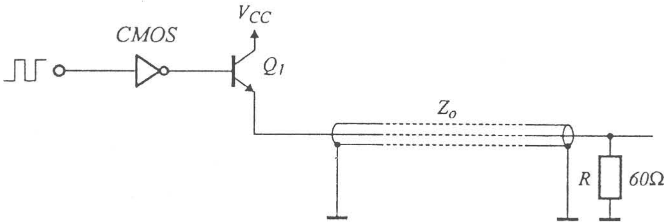

Fig. 4. Experiment of open collector (open emitter) driver.

Waveforms with this transmission line are shown on fig. 5. The waveform at the driver is above and the waveform at the end of the line is below. The line is properly terminated. Some small overshoots and undershoots at the fronts of the signal can be found due to the parasite elements in prototype and scope probes.

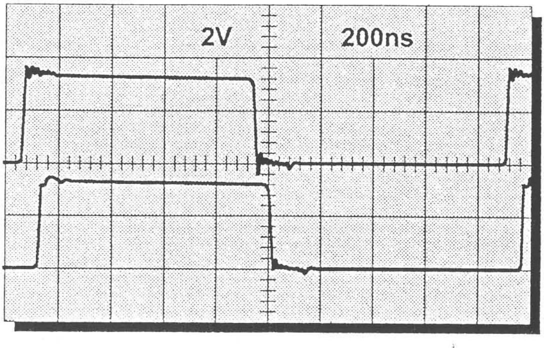

Fig. 5. Waveforms with line transmission by an open collector driver.

The second experiment has been made with a push-pull driver (fig. 5). The second switch Q_2 has been emulated with transistor working in open emitter mode.

The line is AC terminated. As far as the propagation time of the line is about 60 *ns* the used time constant for AC termination has to be more than 240 *ns*. A capacitor with value of 4.7 nF has been placed in series of the termination resistor. That forms a time constant of 282 ns.

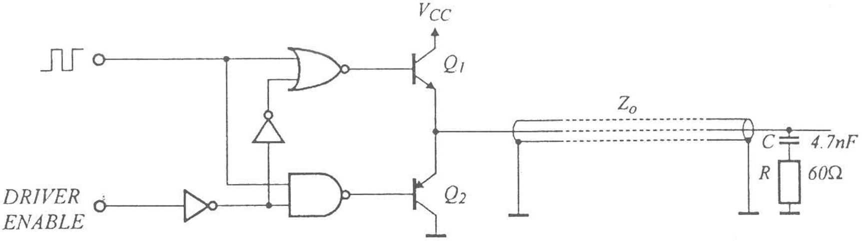

Fig. 6. Experiment of push-pull driver.

Waveforms with the push-pull driver are shown on fig. 7. An increasing of recessive level can be found due to the V_{BE} of the Q_2.

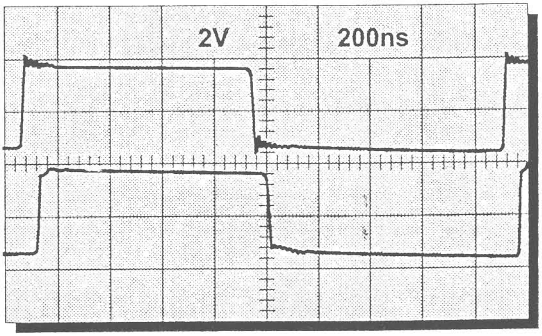

Fig. 7. Waveforms with line transmission by an push-pull driver.

The experiment above has been carried out to calibrate the experimental situation. The last experiment has been made with the offered modification of the open collector driver. The experimented device is shown on fig. 8. Output transistors Q_1 and Q_2 also are in open emitter mode. The switch Q_2 is closed for a time as far as the discharged current from the line comes under some limit. The current sensor R_S limits the level of discharged current from the line. The voltage V_{BE} of the transistor Q_3 is used as a threshold for limited current. The value of the line current I_S when the switch Q_2 turns off is determined by equation $I_S = V_{BE}/R_S$.

Waveforms with offered driver are shown on fig. 9, 10 with two R_S. The voltage of the line signal V_{pp} is about 3.5 V. The full current I_o in the line is $I_o = V_{pp}/R_o$, that is approximately 60 *mA*.

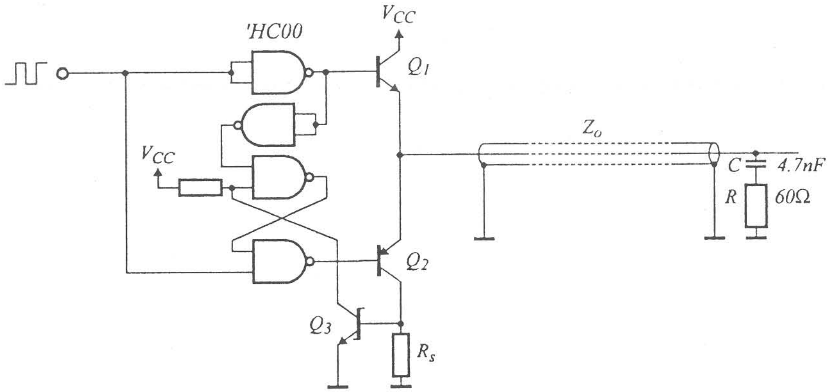

Fig. 8. Experiment of offered modified open switch driver.

First value of the R_S is 56 Ω that is the discharged current is limited to 12 *mA* (20 % from the full current or 80 % discharging). An overshoot is monitored when the switch Q_2 turns off due to the offset current of the line. This overshoot is 20 % from the voltage of the signal.

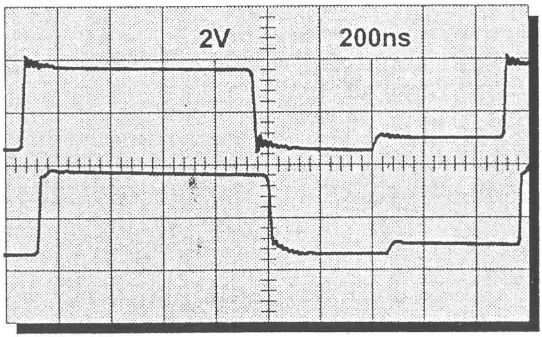

Fig. 9. Waveforms with offered driver using 80% discharging of the line.

Second applied value of the R_S is 220 Ω that is the discharged current is limited to 3 *mA* (5 % from the full current or 95 % discharging). A small overshoot is monitored with 5 % voltage from the signal.

Experiments have been carried out using oscilloscope TESLA model BM564 and scope probe TEKTRONICS model P6105.

It is recommended that such kind of open collector driver and AC termination is used with a receiver having so called 'bus hold sell' in its input.

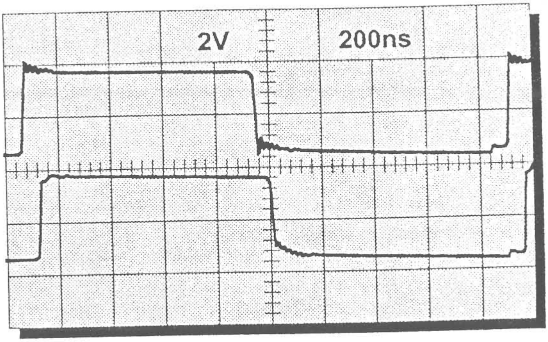

Fig. 10. Waveforms with offered driver using 95% discharging of the line.

IV. CONCLUSIONS

Analysis of open collector driver used for line driving has been made in this paper. It has some advantages in comparison to the traditional push-pull driving technique. First, the conflict situations in line transmission are easily supported when more than one driver is connected to the same line. Second, open collector driver does not need an additional controlled signal DRIVER ENABLE in multi-driver transmit mode. However, the open collector driver cannot be applied when the line is AC terminated.

A modification of the open collector driver is offered that can be used with an AC termination of the line. Experiments over the topic of line driving have been made using CMOS devices and bipolar transistors as switch to emulate property drivers in practical use.

Analysis of the received waveform shows the offered solution is working properly. Small overshoot exists when recessive level is turned off depending on the current discharged. It can be controlled by a current sensor.

V. REFERENCES

[1]. Culp, S., E. Haseloff. LVC Designer's Guide. Texas Instruments Inc. 1997.

[2]. Data Transmission Seminar '97. Texas Instruments Inc. 1998.

[3]. Katz, L. Bus-Interface Devices With Output-Damping Resistors or Reduced-Drive Output. Texas Instruments Inc. 1998.

[4]. Marinov, J., I. Kurtev, R. Ivanov, A. Seisov. Chanel for visual diagnostic control and analysis in a system for automation of experiments. 15th international conference BIAS-78. Milan, 1978.

[5]. Mihov, G. Digital Electronics — for Bachelors of Electronics. Technical University, Sofia, Bulgaria, 1998.

[6]. Perna S. ABT enables optimal system design. Dallas, Texas Instruments, 1993.