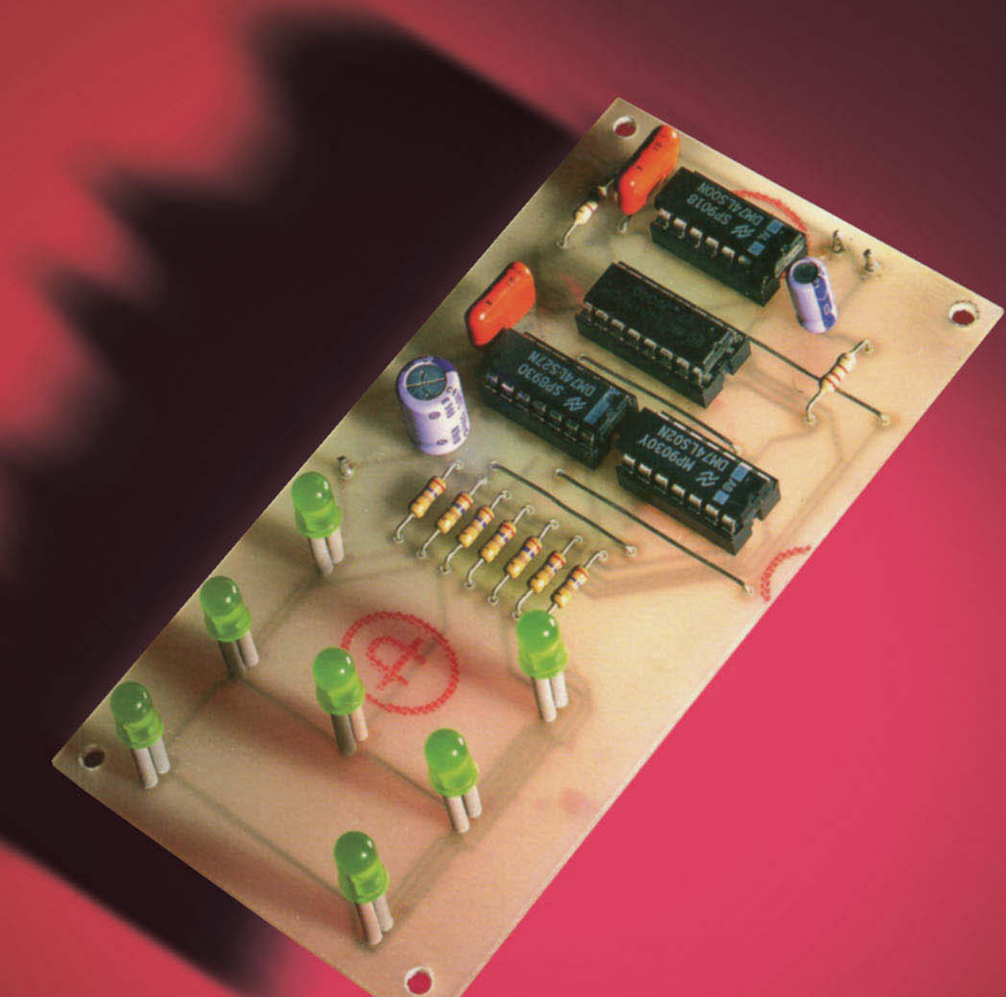
MODERN TTL CIRCUITS MANUAL



R. M. MARSTON

Modern TTL Circuits Manual

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NEWNES

To Esther, with love, and with gratitude for the endless patience and unfailing kindness that she has shown me throughout the several difficult months that it took me to evaluate and test all of the devices and circuits described in this book and to create the texts that accompany them.

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Preface

Modern high-speed digital electronics is dominated by two basic logic technologies, those of TTL (Transistor–Transistor Logic) and CMOS (Complementary MOSFET logic), both of which are now used in the world's leading high-speed general-purpose digital IC range, the '74' series. This unique 'Circuits Manual' book takes an in-depth look at the '74' series of ICs, concentrating mainly on its range of TTL devices but mentioning modern CMOS types where they offer special advantages. It presents the reader with over 360 outstandingly useful and carefully selected circuits, diagrams, graphs and tables, backed up by over 48 000 words of highly informative 'how it works' and 'how to use it' text and captions.

The manual is split into seven chapters. The first starts off by explaining digital IC basics, goes on to describe TTL principles, then introduces the various modern sub-families within the '74'-series range of ICs, and concludes by explaining TTL basic-usage rules, etc. Chapter 2 deals with modern logic circuitry; it starts off by looking at the symbology and mathematics of digital logic, then presents a mass of practical logic circuitry and data. The next four chapters progress through waveform generator circuitry, clocked flip-flop and counter circuits, special counter/dividers, data latches, registers, comparators and code converters. The final chapter deals with specialized types of IC such as multiplexers, demultiplexers, addressable latches, decoders, full-adders, bus transceivers, priority encoders, rate multipliers, etc.

The book, though aimed specifically at all practical design engineers, technicians and experimenters, will doubtless also be of great interest to all amateurs and students of electronics. It deals with its subject in an easy-to-read, down-to-earth, mainly non-mathematical but very comprehensive and professional manner. Each chapter starts off by explaining the basic principles of its subject and then goes on to present the reader with a great mass of practical circuits and useful data, all of which have been fully evaluated and/or verified by the author.

Throughout the volume, great emphasis is placed on practical 'user' information and circuitry, and this book, like all other volumes in the *Circuits Manual* series, abounds with useful facts and data. Most of the ICs described in the book are modestly priced and readily available types.

The reader may note that I generated all of this manual's artwork (diagrams, graphs and tables, etc.) via a standard 33mHz 486DX PC and Laserjet IIIp printer, using the excellent low-cost 'Top Draw' Windows artwork/CAD package and my own 'Top Draw' – generated sets of circuit symbols. Readers interested in the basic package may obtain further details directly from its American producers (Top Software, PO Box 1141, Conifer, CO80433, USA) or from its UK distributors (Nildram Software, 82 Akeman Street, Tring, Hertfordshire, HP23 6AF (Tel: 0442 891331).

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1994

1 TTL principles and families

TTL (Transistor–Transistor Logic) devices are major members of the popular and internationally recognized '74' series of digital ICs (Integrated Circuits). This opening chapter starts off by explaining digital IC basics, goes on to describe TTL principles, outlines the major features of the '74' series of ICs, then introduces the various modern sub-groups of the '74' TTL family, and concludes by explaining basic TTL usage rules.

Digital IC basics

An IC can be simply described as a complete electronic circuit or 'electronic building block' that is integrated within one or more semiconductor slices or 'chips' and encapsulated in a small multi-pin package, and which can be made fully functional by merely wiring it to a suitable power supply and connecting various pins to appropriate external input, output and auxiliary networks.

ICs, like ordinary electronic circuits, come in two basic types: they give either a 'linear' or a 'digital' type of circuit action. Linear circuits give a basic output that is directly proportional to the magnitude (analogue value) of the input signal, which itself may have any value between zero and some prescribed maximum limit. One of the simplest types of linear circuit is the unity-gain buffer; if a large sinewave signal is connected to the input of this circuit, it produces a low-impedance output of almost identical form and amplitude, as shown in *Figure 1.1a*. Linear circuits and ICs are widely used as signal processors, pre-amplifiers, power amplifiers, oscillators, etc.

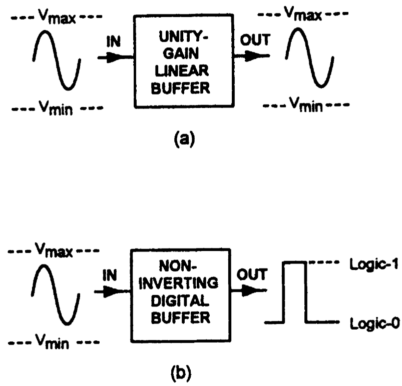
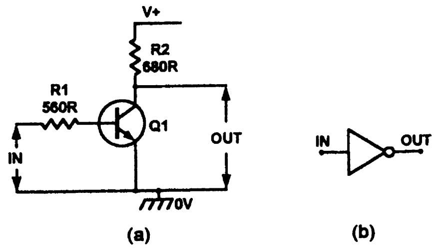


Figure 1.1 *When a large input sinewave is fed to the input of a linear buffer (a), it produces a good sinewave output, but when fed to the input of a digital buffer (b) it produces a purely digital output.*

Digital circuits, on the other hand, are effectively blind to the precise amplitudes of their input signals, and simply recognize them as being in either a 'low' or a 'high' state (usually known as 'logic-0' and 'logic-1' states respectively); their outputs similarly have only two basic states, either 'low' or 'high' (logic-0 or logic-1). One simple type of digital circuit is the non-inverting buffer; if a large sinewave signal is connected to the input of this circuit, it produces an output that (ideally) is of purely digital form, as shown in *Figure 1.1b*.

Digital circuits come in a variety of basic types, and can be built using a variety of types of discrete or integrated technologies. *Figures 1.2* to *1.7* show a selection of very simple digital buffers and 'gates' that are designed around discrete components, and which can be used in a variety of practical low- to medium-speed applications.

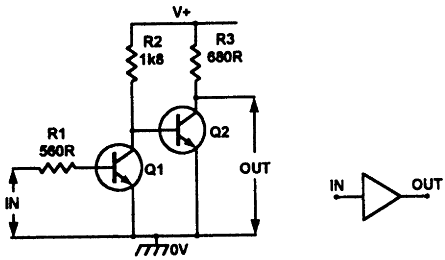
Figure 1.2a shows a simple inverting digital buffer (also known as a NOT gate), consisting of an unbiased transistor wired in the com-



IN	OUT
0	1
1	0

(c)

Figure 1.2 *Circuit (a), symbol (b), and Truth Table (c) of a simple inverting digital buffer.*



IN	OUT
0	0
1	1

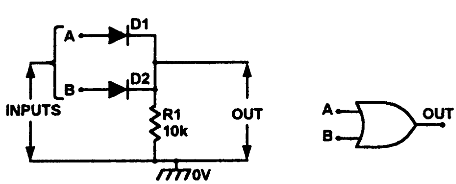
(a) (b) (c)

Figure 1.3 *Circuit (a), symbol (b), and Truth Table (c) of a non-inverting digital buffer.*

mon-emitter mode, and *Figure 1.2b* shows the international symbol that is used to represent it (the arrow-head indicates the direction of signal flow, and the small circle on the symbol's output indicates the 'inverting' action). The circuit action is such that Q1 is cut off (with its output high) when its input is in the zero state, and is driven fully on (with its output pulled low) when its input is high; this information is presented in concise form by the *'Truth Table'* of *Figure 1.2c*, which shows that the output is at logic-1 when the input is at logic-0, and vice versa.

Figure 1.3a shows a simple non-inverting digital buffer, consisting of a direct coupled pair of common-emitter (inverter) transistor stages, and *Figure 1.3b* shows the arrow-like international symbol that is used to represent it; *Figure 1.3c* shows the Truth Table that describes its action: the output is at logic-0 when the input is at logic-0, and is at logic-1 when the input is at logic-1.

In digital electronics, a 'gate' is a circuit that opens or gives an 'output' (usually defined as a 'high' or logic-1 state) only under a certain set of input conditions. *Figure 1.4a* shows a simple 2-input OR gate, made from two diodes and a resistor, and *Figure 1.4b* shown the international symbol that is used to represent it; *Figure*



A	B	OUT
0	0	0
0	1	1
1	0	1
1	1	1

(a) (b) (c)

Figure 1.4 *Circuit (a), symbol (b), and Truth Table of a simple 2-input OR gate.*