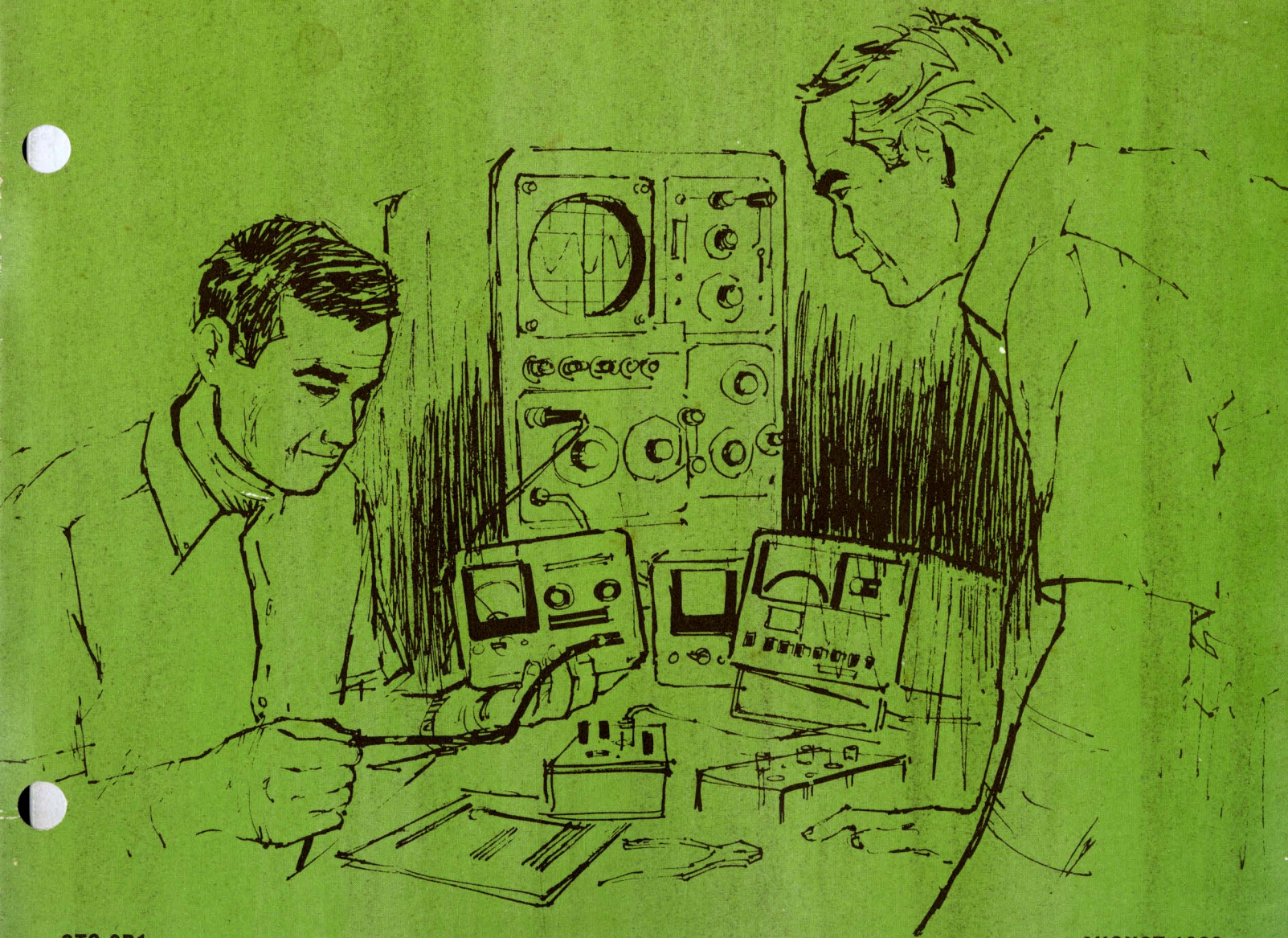


APPLICATION NOTE CATALOG



MOTOROLA *Semiconductor Products Inc.*



APPLICATION NOTE SELECTION GUIDE

The Applications Notes listed below and described in the subsequent section, have been prepared to acquaint the circuits and systems engineer with the broad line of Motorola Semiconductor Products and their applications.

To obtain copies of these notes, simply list the AN number or numbers and send your request on your company letterhead to: Technical Information Center, Motorola Semiconductor Products Inc., P.O. Box 20912, Phoenix, Arizona 85036.

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APPLICATION NOTE ABSTRACTS

AN-134 Low-Cost Power Inverter Circuits Using Off-the-Shelf Components

Design of efficient power inverters requires careful matching of transistors, transformers, and starting network. This note provides insights to this matching problem and gives a comprehensive table allowing the designer to select the proper transistor for his specific inverter requirement.

AN-139 Understanding Transistor Response Parameters

This note explains high-frequency transistor response parameters and discusses their interdependence. Useful nomograms are given for determining f_{fe} , f_T , f_{ae} , f_{max} , and many other parameters.

AN-140 Characterization of SCR's as Switches for Line Type Modulators

Although Silicon Controlled Rectifiers are highly desirable as switches in DC pulse circuits, they are usually specified and characterized for AC applications only. This article discusses the SCR characteristics desirable for DC pulse applications, and proposes simple test circuits for evaluating such devices as pulse circuit switches. A device already characterized for such applications is described.

AN-147 High-Power Varactor Diodes: Theory and Application

This article treats varactors in non-rigorous terms, discussing what they are, how they work, and how to use them in practical high-power, high-frequency, output circuits.

AN-150 Getting Transistors Into Single-Sideband Amplifiers

Silicon power transistors coupled with unique circuit design approaches make possible a 30 watt peak-power single-sideband transmitter operating at 30 MHz.

AN-151 Charge Storage Varactors for Extra UHF Power

This report describes a varactor multiplier which may be used to achieve power outputs of more than 50 Watts at 150 MHz, and 20 Watts at 450 MHz. With such high-frequency capabilities, transistor-varactor combinations can replace triodes and klystrons in many UHF and microwave applications.

AN-156 An All-Solid-State Marine Band Transmitter

This report gives all the necessary details: circuit drawings, construction techniques, etc., for a low - cost all - solid-state, crystal-controlled, marine-band transmitter. The unit operates between 2.0 and 2.85 MHz, and features low current drain (1.5 Adc), a high efficiency output stage, and direct operation from a 13 volt dc supply.

AN-159 Design Tips for Coaxial-Cavity Varactor Multipliers

Most microwave engineers picture a coaxial cavity as a bulky construction, difficult to design easily. This report demonstrates that varactor multipliers can easily be designed as small as any other. Design principles and operational data for 500 MHz - 1000 MHz doublers are given.

AN-161 High Power RF Switching Diode Can Replace Mechanical Coax Relays

This report gives a complete description of the design and capabilities of the new MV1892 RF switching diode. Characterizing parameters and various circuit recommendations are also given.

AN-163 Silicon Power Transistors Provide New Solutions to Voltage Control Problems

Three useful circuits - a short circuit proof voltage regulator, an inexpensive switching regulator and a 100 kHz dc-to-dc converter are described.

AN-166 Using Linvill Techniques for RF Amplifiers

A design procedure, derived from theory developed by J. G. Linvill, simplifies the design of single stage small-signal RF amplifiers. A 200 MHz amplifier serves as an example of the technique.

AN-169 A Low Voltage High Current Converter

The output of low-voltage sources, i.e. solar cells, etc., often must be converted to a higher voltage to be useful. Utilizing a high-performance power transistor to efficiently perform this task, this converter can switch currents as high as 50 amperes.

AN-173 Reducing (di/dt) - Effect Failures in Silicon Controlled Rectifiers

In SCR circuits with device-limited currents, severe local heating problems often develop in the SCR's. Three useful techniques are presented to eliminate this problem.

APPLICATION NOTE ABSTRACTS (continued)

- AN-174 High-Efficiency, Low-Voltage Inverters**
Two low-voltage inverter circuits, employing a new fast-switching power transistor, operate at approximately 80% efficiency, reducing heat dissipation to a minimum.
- AN-176 Power Varactor Gives 5 Watts Output at 3 GHz**
A discussion of the design and performance of the high power MV1808 varactor, including design details of a 1 GHz frequency doubler and a 1 GHz to 3 GHz tripler.
- AN-177 Two Stage Varactor Multiplier Provides High Power at 400 MHz**
This "times-eight" frequency multiplier can provide a nominal 40 watts of CW power at an output frequency of 400 MHz with a conversion efficiency of 30 percent.
- AN-178 Epicap Tuning Diode Theory and Applications**
General electronic-tuning considerations are discussed, including important parameters such as Q, tuning range, and temperature stability.
- AN-181 A Regulated Power Supply Using a Reference Amplifier**
This useful industrial circuit, specially designed to provide highly stable output, uses a reference amplifier semiconductor device to minimize voltage fluctuations and temperature variations.
- AN-182 A Method of Predicting Thermal Stability**
Variations in DC bias current with temperature is an important consideration in the design of reliable transistor audio amplifiers. This note gives a useful method of predicting the thermal stability of biasing circuits.
- AN-186 A Single Stage Video Amplifier**
High-performance germanium transistors allow the design of this simple, low-cost, single-stage video amplifier, suitable for small-screen television receivers.
- AN-187 MECL Integrated Circuit Line Driver**
Specially designed for high fan-out capabilities, this integrated circuit line driver can supply a signal to 150 logic gates without deterioration.
- AN-189 Solid-State Pulse Width Modulation DC Motor Control**
Pulse-width modulation, an effective method of dc voltage control, provides motor speed regulation under varying torque conditions - ideal for traction drive vehicles.
- AN-191 Varactor Diodes and Circuits for High Power Output and Linear Response**
Three new varactors are described, and varactor multiplier circuits - a 50 MHz to 100 MHz push-push doubler, a 500 MHz to 1000 MHz harmonic doubler, and a 200 MHz to 600 MHz harmonic tripler - - are presented in detail.
- AN-193 Using Negative Bias to Improve SCR Performance**
The circuit designer can take advantage of a fundamental SCR property - turn-off gain at low anode current - - to reduce turn-off time and increase holding current.
- AN-194 Designing Integrated Serial Counters**
MECL monolithic integrated J-K flip-flops serve as building blocks for ultra-high-speed ripple counters. General design techniques for designing counters of any arbitrary count.
- AN-196 Epicap Tuning of Resonant Circuits**
Designers may now extend reliability and circuit performance by replacing mechanical tuning parts with new high Q Epicap voltage-variable capacitor tuning diodes. A design procedure leads to the selection of the optimum Epicap for any circuit.
- AN-199 A Solid-State 15 kHz Power Inverter**
Fast-switching power transistors allows the design of a high-frequency power converter featuring minimum size and weight of reactive components.
- AN-202 Noise Margins of MECL Integrated Circuits**
A knowledge of ground line and signal line dc and pulse noise margins is essential to the logic designers. Many curves illustrate the variations of input and ground line noise margins with temperature and fan-out.
- AN-203 Tuned Amplifier Design with an Emitter-Coupled Integrated RF Amplifier**
This note describes the design of a tuned amplifier utilizing the MC1110 integrated circuit as a basic building block. DC considerations, characterization in terms of y-parameters, and amplifier design using Linvill's method are discussed.
- AN-204 High Performance Integrated Operational Amplifiers**
Two new high performance monolithic operational amplifiers feature exceptionally high input impedance and high open loop gain. This note describes

the function of each stage in the circuit, methods of frequency compensating and dc biasing. Four applications are discussed: a summing circuit, an integrator, a dc comparator, and transfer function simulation.

AN-208 A Unique, Ultra-High-Speed, Switching-Time Test Device

Ultra-high-speed test fixture allows accurate measurement of switching times for a wide variety of transistors.

AN-210 FM Modulation Capabilities of Epicap VVC's

The author shows by empirical methods that the frequency vs. voltage curve for Epicap voltage variable capacitors is linear for small (sufficient for most FM modulator applications) voltage variations.

A rigorous mathematical explanation of this linear interdependence follows the empirical demonstration.

AN-211 Field Effect Transistors in Theory and Practice

The basic theory, construction, and application information for field effect transistors (junction and MOS types) are given. Also included are some typical test circuits for checking FET parameters.

AN-213 Varactor Multipliers Provide High Output Power Above 6 GHz

The author employs a high performance varactor diode in the design of several multiplier circuits which feature exceptionally high output power versus frequency capabilities. Among the circuits discussed are a 2 to 5 GHz doubler, a 2 to 6 GHz tripler, a 2.83 to 8.5 GHz tripler, and a 500 MHz to 4 GHz one-step multiplier.

A physical and electrical characterization of the 1N5154, 1N5155 varactors, sufficient for design purposes, precedes the actual design discussion.

AN-214 A 160 MHz-15 Watt Solid-State Power Amplifier

High performance RF power transistors make possible the design of a three stage 160 MHz amplifier with 15 Watts power output. The amplifier operates on 28 Vdc supply voltage with an overall efficiency of 62%, and features 30.5 dB overall power gain

The author employs large-signal transistor input-output admittance data in the network designs for this amplifier.

AN-215 RF Small Signal Design Using Admittance Parameters

The author shows that the power gain and stability of high frequency transistors may be com-

pletely described by two-port parameters.

This paper presents a summary of the overall design solution for the small signal RF amplifier using admittance parameters. Design considerations and relationships for both stable and the potentially unstable transistor are presented together with a discussion of the neutralized, unneutralized, matched, and mis-matched amplifiers.

AN-216 UHF Transmission-Line Oscillator-Design Using the Smith Chart

Two high performance UHF oscillators; a 500 MHz, 1 Watt oscillator; and a 1 GHz, 0.5 Watt oscillator employ transmission lines for linear elements. The author illustrates that the use of transmission lines simplifies the breadboard design of many UHF circuits. An important feature is the use of the Smith Chart to simplify the network synthesis.

AN-217 UHF Transmission Line Power Amplifier Designed with Smith Chart Techniques

A UHF power amplifier capable of 2 Watts power output at 450 MHz employs transmission lines for linear elements. The author illustrates that the use of transmission lines simplifies the design of many UHF circuits. An important feature is the use of the Smith Chart to simplify the network synthesis.

AN-219 The Field Effect Transistor in Digital Applications

Field effect transistors have definite advantages over junction transistors in many digital applications; high fan-out, direct coupled circuitry (lower component count), extremely low power dissipation, and low temperature coefficient circuits are among the most important.

This paper provides the designer with an up-to-date discussion of JFET and IGFET switching characteristics and how they are used in the design of basic digital circuits. The final portion of this paper discusses a family of JFET logic circuits, a family of IGFET, and future prospects.

AN-220 FET's in Chopper and Analog Switching Circuits

The author's discussion begins with elementary chopper and analog switch characteristics -- explores fully the considerations required for conventional and FET chopper and analog switch design -- and finishes with specific FET circuit examples.

AN-221 4-Layer and Current-Limiter Diodes Reduce Circuit Cost and Complexity

The authors present four simple circuits in which 4-layer diodes and current-limiter diodes are

used to provide increased circuit performance: A Saw-tooth generator (two variations), a staircase generator and a ring counter.

A brief discussion of the electrical characteristics of 4-layer and field effect diodes precedes the circuit examples.

AN-222 The ABCs of Solid-State DC to AC Inverters

The author provides a comprehensive examination of the entire field of dc to ac inverters. Among the topics discussed are: the proper inverter for a specific application; operation principles of different types of inverters; the problem of proper device selection in the design of inverters; an inverter design example.

AN-223 Cascade Noise Figure for Integrated Circuit Transistors

In vacuum tube circuitry, the combination of the grounded-cathode and the grounded-grid cascade has superior noise properties to all other two-stage amplifiers. In transistor circuitry the noise performance of a single-stage amplifier is well known, but little information has been published about the best performance obtainable from two-stage transistor amplifiers. This paper evaluates the noise performance of all possible two-stage transistor amplifiers. Also, since the noise contribution of stages beyond the second is normally small, this analysis will be valid for amplifiers with any number of stages.

AN-225 High Performance All Solid-State Servo Amplifiers

The design of 7.5 Watt transformer-coupled solid-state servo amplifier and a 10 Watt complementary transistor servo amplifier are fully discussed. The transformer coupled amplifier, requiring only three transistors, provides a stable voltage gain of 100. The complementary amplifier, though more complex, is direct coupled throughout thus eliminating the transformer and its accompanying phase shift problems.

AN-226 Thermal Measurements on Semiconductors

This note describes the techniques used by Motorola to obtain the thermal resistance of transistors, rectifiers, and thyristors.

AN-227 Thyristor Trigger Circuits for Power-Control Applications

Variations of the basic triggering circuit using the MPT20 to control thyristors are shown. AC control circuits are detailed for both triacs and SCRs as well as an SCR DC control.

AN-228 20 Watts at 1 GHz with Step Recovery Varactors

Varactor harmonic multiplier circuit power handling capabilities have now been extended to 20 Watts at 1 GHz and 10 Watts at 2 GHz by two new varactors, the 1N5149 and 1N5150. This note provides a complete discussion of the design and performance of these two varactors. Several high performance multiplier circuits: a 0.5 GHz to 1 GHz doubler; a 0.4 GHz to 1.2 GHz tripler; and a 0.46 GHz to 1.84 GHz quadrupler are also discussed.

AN-229 High Speed Complementary Flip-Flop Features Extremely Low Power Dissipation

New complementary micro-power transistors permit the design of an ultra-high speed flip-flop featuring extremely low power dissipation. The complementary character of the 2N3493 and 2N2409 "0-pF" transistors allow the engineer to design flip-flops with high operating frequency, high circuit efficiency, and high gain.

AN-231 FET Differential Amplifier

The field effect transistor is often a better choice than the bipolar transistor in many differential amplifier applications, particularly when high input impedance is required. This report discusses drift compensation of field effect transistors for differential amplifier applications.

AN-232 1.5 GHz 10 Watt Two-Stage Cascade Multiplier

Two high-performance varactors -- the 1N5149 and 1N5150 -- are employed in a cascade multiplier which features over 10 watts power output at 1.5 GHz.

AN-233 Design of Monostable Multivibrators Using MECL Integrated Circuits

This application note describes an integrated monostable multivibrator composed of a MECL R-S or J-K flip-flop plus a few discrete components. A main feature of the multivibrators is their complete compatibility with the MECL family of current mode integrated circuits. These multivibrators can provide a timed output ranging from 60 ns to the millisecond range. The note discusses special circuits which have even faster recovery times. Pulsed recovery (recovery during any point during the delay time) is possible with both types of multivibrators.

AN-234 MRTL Family of Integrated Circuits

The purpose of this note is to familiarize the logic designer with the Motorola Resistor Transistor

Logic (MRTL) family. Logic diagrams, pin layouts, and loading data are given for each device. Three illustrative applications of MRTL; an asynchronous 4-bit comparator, an asynchronous 5-bit adder, and a shift register, serve as design examples. This family is noted for its economy and variety of logical elements.

AN-235 Using the Motorola MDTL Line of Integrated Circuits

The MDTL line of integrated circuits is briefly characterized with important capabilities of the MDTL series, such as noise immunity, discussed. MDTL applications are presented, including shift registers, ripple counters, clocked counters, and decade shift counters.

AN-238 Transistor Mixer Design Using Admittance Parameters

Mixer circuit design may be simplified by the use of small-signal admittance parameters. This note describes in detail the effective application of this design technique and the corresponding results. Several design examples are discussed.

AN-239 MECL Integrated Circuit Schmitt Triggers

The Schmitt Trigger, a regenerative circuit which changes state abruptly when the input signal crosses specified dc trigger levels, can be fabricated from MECL integrated logic gates. This note describes the modifications necessary to convert standard MECL logic gates to Schmitt Triggers, and also the performance to be expected from such units. Examples of the MECL Schmitt Trigger used for wave shaping and pulse generator applications are also included.

AN-240 SCR Power Control Fundamentals

Relationships of control angle to peak voltage, average voltage, RMS voltage and power are presented in chart form. Time constant for relaxation oscillators are discussed for both DC and AC supplies. These basics form the heart of SCR control.

AN-241 Low-Cost High-Voltage Servo Amplifier

The availability of low-cost high-voltage power transistors make possible the design of a practical high voltage servo amplifier without transformers and with greatly reduced phase shift problems.

AN-242 A Modulated SCR Zero-Point Switching Circuit

By employing SCR devices in a zero-point switching mode, the circuit designer can greatly reduce RFI generation. This note describes the zero-

point switching concept, and provides a circuit design example (AC controller - - DC half-wave controller).

AN-243 Transistor-Varactor-Multiplier Versus Transistor-Multiplier

Several watts of power in the upper portion of the L band may be obtained with either the transistor amplifier driving a varactor multiplier (TAVM), or the transistor amplifier-multiplier (TAM). This report presents a careful evaluation of both types of circuits.

AN-244 The MECL Line of Digital Integrated Circuits

This note familiarizes the digital integrated circuit user with Motorola MECL integrated circuits; pin layouts, and logical diagrams. Pertinent characteristics for each device in the MECL integrated circuit line are given. The note includes applications of various circuits illustrating the versatility of the MECL family. High speed operation, high input impedance, high fan-out, and very low internally generated noise characterize the line of integrated circuits.

AN-245 An Integrated Core Memory Sense Amplifier

This application note discusses core memories and related design considerations for a sense amplifier. Performance and environmental specifications for the amplifier design are carefully established so that the circuit will work with any computer using core memories. The final circuit design is then analyzed and measured performance is discussed. The amplifier features a small uncertainty region (6 mV max), adjustable voltage gain, and fast cycle time (0.5 μ s).

AN-246 A 50 Watt 50 MHz Solid-State Transmitter

This three-stage, three-transistor transmitter can provide 50 watts continuous power output at 50 MHz with 62% overall efficiency. The author employs a straightforward design approach based on large-signal transistor input/output admittances.

AN-247 An Integrated Circuit RF-IF Amplifier

A new, versatile integrated circuit for RF-IF applications is introduced which offers high gain, extremely low internal feedback and wide AGC range. The circuit is a common-emitter, common-base pair (the cascade connection) with an AGC transistor and associated biasing circuitry. The amplifier is built on a very small die and is economically comparable to a single transistor, yet it offers performance advantages unobtainable with a single device. This application note describes the AC and DC operation of the circuit, a discussion of Y-parameters for calculating optimum power and voltage gain, and a variety of applica-

APPLICATION NOTE ABSTRACTS (continued)

tions as an IF single-tuned amplifier, IF stagger-tuned amplifier, oscillator, video-audio amplifier and modulator. A discussion of noise figure is also included.

AN-248 A High Voltage Monolithic Operational Amplifier

This note introduces a high voltage monolithic operational amplifier featuring high open loop gain, large common mode input signal, and low drift. The function of each stage in the circuit is analyzed, and methods for frequency compensating the amplifier are discussed. DC biasing parameters are also examined. Four applications using the amplifier are discussed: a source follower, a twin tee filter and oscillator, a voltage regulator, and a high input impedance voltmeter.

AN-249 Designing Around the Tuning Diode Inductance

The effect of varactor inductance is described, and equations and graphs are presented in order to predict the inductance value and to determine when its effects on performance is significant.

In addition a design example of a varactor-tuned capacity-loaded half-wave cavity from 470 MHz to 890 MHz, and derivations of design equations for varactor tuned quarter wave and half-wave cavities as well as for lumped series tuned circuits are shown.

AN-251 Decade Counters Using MRTL Integrated Circuits

This application note discusses the design and implementation of decade counters using the MRTL family of integrated logic. Ripple counters, shift counters, and parallel clocked counters are developed using BCD, 2⁴21, and excess 3 digital codes. Up and down counting techniques are discussed. Output decoding, problem areas and circuit limitations are covered for all counter types.

AN-252 Choosing MRTL Integrated Logic Circuits

This article discusses resistor-transistor logic, MRTL, integrated circuits, and the considerations a user should make prior to using this integrated circuit family. Full consideration is given to the advantages as well as the limitations one encounters with this logic form. The discussion is general in nature and applies to all popular versions of resistor-transistor logic.

AN-253 An Analysis of MRTL Integrated Logic Circuits

Special emphasis is given to noise margin specifications, large circuit fan-out, operating speeds, and interfacing with saturated logic in this analysis of Motorola MRTL integrated logic circuits. The J-K

flip-flop circuit is reviewed and basic counting and shifting circuits are presented to illustrate typical J-K applications.

AN-254 Using MRTL Integrated Circuit Flip-Flops

Circuit operation of MRTL J-K flip-flops is explained fully. The R-S flip-flop is also briefly discussed. Pulse input requirements and loading considerations are discussed and some applications of the J-K flip-flop shown in the form of minimum-logic small-count counters.

AN-257 Decade Counters Using MECL J-K Flip-Flops

This note discusses the use of MECL integrated circuits in four types of decade counters. The logic and circuit design of an excess three up-down counter, a 2⁴21 up-down counter, a Gray code counter, and a switch-tail ring counter with ten line output are illustrated.

AN-258 Monostable Multivibrator Design Using An Integrated Circuit Operational Amplifier

This application note discusses the use of integrated operational amplifiers connected as monostable multivibrators. The classical monostable circuit including some limitations with respect to the conventional component and integrated device designs are briefly reviewed. The basic circuit theory and qualifications of the operational amplifier connected as a monostable device are then discussed and the timing equation derived. Alternate monostable configurations and their ultimate design limitations are briefly reviewed with respect to utilization of the MC1430/1530 and MC1431/1531 family of devices. Finally a design example is used to illustrate the principles and limitations outlined.

AN-259 Using Integrated Circuits in a Stagger Tuned IF Strip

Integrated Circuits are quickly becoming "the way to go" in the electronic industry, and justifiably so. Their small size and high reliability, coupled with low cost make them an ideal component for radio, television, communication gear, computers, and an infinite number of other uses. This application note describes the use of an Integrated Circuit High Frequency Amplifier, the MC1550, in a stagger tuned I-F strip. The design frequency is 45 MHz; however, the procedure is similar for designs covering its full range of operation (DC to 300 MHz).

AN-260 Selecting Varactor Diodes

High output power in the UHF region can be achieved with varactors. A device selection procedure

APPLICATION NOTE ABSTRACTS (continued)

based on experience, theory and common sense is offered.

AN-261 Transistor Logarithmic Conversion Using an Operational Amplifier

The design of a log amplifier using a common base transistor configuration as the feedback element of an integrated circuit operational amplifier circuit is discussed in this application note. Six decades of logarithmic conversion are obtained with less than 1% error of output voltage. The possible causes of error are discussed followed by two applications: direct multiplication of two numbers, and solution of the equation $Z = X^n$.

AN-262A Decade Counters Using MDTL Integrated Circuits

Decade counting is a basic digital operation and may be performed by a wide variety of counting circuits. This note illustrates how some of the commonly used $\div 10$ counting techniques can be accomplished with Motorola Diode-Transistor Logic (MDTL) integrated circuits. Ripple, clocked, and shift decade counters using a variety of coding methods are discussed.

AN-263 Choosing DTL Integrated Logic Circuits

This article discusses diode-transistor logic, DTL, integrated circuits, and the considerations a user should make in choosing this integrated circuit family. Consideration is given to the advantages and limitations one encounters with this logic form. Three versions of DTL are considered in this report; conventional DTL, modified DTL, and high noise immunity DTL.

AN-264 MRTL Integrated Circuit Shift Registers

This note discusses the design considerations for the implementation of a 16-bit shift register using J-K flip-flops. The shift register described has the capability, upon command, to shift left or shift right and to enter information serially or in parallel. All problems encountered in the implementation and operation of the register are discussed.

AN-266 MECL Integrated Circuit Flip-Flops

Current Mode bi-stable elements are discussed along with pertinent characteristics and specifications. The R-S, J-K, and Master-Slave types of flip-flops are evaluated according to performance. Methods of reducing overshoot when driving a large number of flip-flops and flip-flop fan-in, fan-out capabilities are also given.

AN-267 Matching Network Designs with Computer Solutions

Computer solutions for four networks commonly used in solid-state high frequency amplifiers have been tabulated.

AN-268 Pulse Triggering of Radar Modulator SCR's

Factors involved in dynamic gate triggering are examined and relations of gate triggering characteristics to variations of total current amplifications with gate current are shown.

AN-270 Nanosecond Pulse Handling Techniques

The rapid advancement in the field of high speed digital integrated circuits has brought into focus many problem areas in the methods of pulse measurement techniques and new concepts dealing with these problems. This paper is intended to discuss the more common, yet perhaps not well known, pitfalls of measurement systems, a method of detecting them and possible solutions.

AN-271 Breadboard Techniques For Low Frequency Integrated Circuit Feedback Amplifiers

Certain considerations, unnecessary for discrete devices, are of critical importance in the breadboarding of integrated circuit systems. This paper provides the engineer or technician with some wiring tips and important precautions for integrated circuit breadboarding.

AN-273 More Value out of Integrated Operational Amplifier Data Sheets

The operational amplifier is rapidly becoming a basic building block in present day solid state electronic systems. The purpose of this application note is to provide a better understanding of the open loop characteristics of the amplifier and their significance to overall circuit operation. Also, each parameter is defined and reviewed with respect to closed loop considerations. The importance of loop gain stability and bandwidth is discussed at length. Input offset circuits are also reviewed with respect to closed loop operation.

AN-274 MECL Integrated Circuit Shift Registers

A generic shift-right, shift-left register with parallel entry, end-around-shift, and complementation capabilities is discussed. Maximum practical operating speed, delay times and timing considerations of the logic gating signals are determined. The basic register as developed may be used for data handling,

APPLICATION NOTE ABSTRACTS (continued)

for number scaling, or in the arithmetic portion of a digital computer.

AN-276 Useful Frequency Range Extension for MC1530 Operational Amplifiers

This application note explains various frequency compensating techniques designed to extend operating frequency of the MC1530. In addition circuit configurations and frequency response curves are shown for various compensation techniques. Examination shows this amplifier can be used at frequencies up to 14 MHz.

AN-277 Overshoot and Ringing in High-Speed Digital Systems

The amount of overshoot and ringing that may be expected in a system is determined as a function of driving source impedance, rise-time, wiring length, and loading. Determination of allowed overshoot and methods of reducing overshoot are discussed for conventional point to point wiring methods. Capacitive loading effects of MECL devices and circuit hardware are also discussed.

AN-278 Using Shift Registers as Pulse Delay Networks

This note discusses high speed clocked shift registers using J-K flip-flops and employed as a digital incremental delay. The register may be clocked with a frequency division counter to accomplish any desired delay with increments as small as 20 ns. The circuit as developed may be used for timing basic computer decisions or as an adjustable delay line for pulse.

AN-279 Setup and Release Times in the MRTL J-K Flip-Flop

This application note discusses the setup and release times for J-K flip-flops. The method used to measure setup and release time is discussed. A few simple decade counters are analyzed for worst case release times.

AN-280 MECL 85 MHz J-K Flip-Flop

A new high-speed J-K flip-flop is discussed. Capabilities, performance, and applications are explained along with typical and worst case operating data. This flip-flop with four J inputs and four K inputs more than doubles the operating speed of registers and counters as employed in a system.

AN-282 Systemizing RF Power Amplifier Design

The design of high-power, Class C, RF transistor amplifiers can be greatly simplified through the use of large-signal device characterization. This note

explains design procedures and furnishes large-signal impedance data for thirteen Motorola RF power transistors.

AN-283 Using MDTL IC Flip-Flops

To properly implement a logic system with integrated circuits, it is important that the logic designer be familiar with the devices he uses. One of the more complex of integrated circuits is the clocked flip-flop. The purpose of this report is to acquaint the reader with the operation of the MDTL flip-flop, to discuss the different modes of operation, and to show some typical uses for this flip-flop.

AN-284 MDTL IC Shift Registers

This report shows some frequently encountered shift register designs implemented with MDTL logic devices. Various operating characteristics are discussed as well as some of the important design considerations.

AN-285 Loading Factors and Paralleling Rules for MRTL Integrated Circuits

The need for loading factors in Motorola Resistor Transistor Logic (MRTL) is discussed and proper usage is illustrated. Modification of loading factors is covered for the case when circuit outputs are paralleled. Illustrations are provided by using the MC700P Series of integrated circuits.

AN-286 Binary Addition Using MRTL IC's

This note discusses the principles of binary addition with positive numbers and considers the implementation of binary adders with MRTL. The full adder function is illustrated using MRTL half adders, NOR gates arranged to simulate half adders, and with NOR gates in a two level logic scheme.

The full adder and associated logic is developed for a four-bit parallel (asynchronous) adder and for serial (synchronous) adder.

AN-287 Color IF Amplifier and AGC Circuit

A non-neutralized, three-stage IF video amplifier is described. Included is the associated keyed AGC circuitry. The circuits were used in a transistorized color set built in the Applications Laboratory at Motorola.

AN-288 Color TV Solid State Horizontal Deflection

This report describes a horizontal deflection system for a large screen (23 inch) color television receiver capable of delivering an ultor power in excess of 40 Watts at 24 kV. The system includes a horizontal phase detector, AFC amplifier, horizontal oscillator, pre-driver, driver, and two horizontal output devices operating in a parallel mode.

APPLICATION NOTE ABSTRACTS (continued)

- AN-290 Mounting Procedure and Thermal Aspects of Motorola Plastic Power Transistors**
Heat sink mounting methods are described and illustrated and thermal resistance characteristics are shown.
- AN-291 External Direct Setting of MRTL Dual J-K Flip-Flops**
A method is described to obtain full functional capability from MRTL dual flip-flops by connecting external circuitry to the proper terminals. Applications are provided that illustrate a reduction in package count by using this configuration as compared to the employment of single unit, full capability flip-flop circuits.
- AN-292 Thermal Response of Semiconductors**
This note explains a workable method — using the concept of transient thermal resistance — of predicting junction temperature at any point in time regardless of the power waveform.
- AN-293 Theory and Characteristics of the Unijunction Transistor**
The unijunction transistor is examined as to theory of operation, design structures, static and transient characteristics.
- AN-294 Unijunction Transistor Timers and Oscillators**
Twelve different unijunction transistor circuits, complete with parts lists are given. Temperature stabilization of the peak-point voltage is examined and dynamic operation paths are discussed.
- AN-295 Suppressing RFI in Thyristor Circuits**
Measures taken to suppress RFI are shown. Design considerations and examples are explored as well as some solutions to the RFI problem.
- AN-296 Construction of A Master-Slave Flip-Flop from MRTL Gates**
Information is provided on the construction of a master-slave flip-flop circuit from standard MRTL gates. Characteristics of the resulting circuit are given and an application of the configuration illustrates the advantage of this type of flip-flop.
- AN-297 Integrated Circuits for High Frequency to Voltage Conversion**
This application note concerns the technique of using integrated circuits in a linear frequency to voltage converter from 1 MHz to 30 MHz. A theoretical analysis is given as well as a working design.
- AN-298 Noise Immunity With High Threshold Logic**
A comparison of noise immunity characteristics is made between MHTL devices and standard saturated logic devices.
- AN-299 An IC Wideband Video Amplifier With AGC**
This application describes the use of the MC1550 as a wideband video amplifier with AGC. The analysis of a single stage amplifier with 28 dB of gain and 22 MHz bandwidth is given with the results extended to a 78 dB video amplifier with 10 MHz bandwidth.
- AN-400 An Operational Amplifier Tester**
A simple and inexpensive tester for Motorola's line of operational amplifiers is described which will measure the open loop voltage gain, the equivalent input offset voltage, the maximum positive and negative output voltage swing, and a view of the transfer function which shows the linearity of the device.
Included is an elementary discussion of the parameters measured and their relationship to closed loop performance.
- AN-401 The MC1554 One-Watt Monolithic Integrated Circuit Power Amplifier**
This application note discusses four different applications for the MC1554, along with a circuit description including dc characteristics, frequency response, and distortion. A section of the note is also devoted to package power dissipation calculations including the use of the curves on the power amplifier data sheet.
- AN-402 Insulated Gate FET's Used in IC's**
The note acquaints the circuit designer with the integrated FET. A brief description of the operation of the Insulated-Gate Field Effect transistor is presented. This discussion is followed by a description of the FET in integrated form and finally, the basic advantages of FET IC's are explored.
- AN-403 Single Power Supply Operation of IC Op Amps**
A split zener biasing technique that permits use of the MC1530/1531, MC1533, and MC1709 operational amplifiers and their restricted temperature counterparts MC1430/1431, MC1433 and MC1709C from a single power supply voltage is discussed in detail. General circuit considerations as well as specific ac and dc device considerations are outlined to minimize operating and design problems.
- AN-404 A Wideband Monolithic Video Amplifier**
This note describes the basic principles of ac and dc operation of the MC1552G and MC1553G,

APPLICATION NOTE ABSTRACTS (continued)

characteristics obtained as a function of the device operating modes, and typical circuit applications.

AN-405 DC Comparator Operations Utilizing Monolithic IC Amplifiers

The use of the MC1533 operational amplifier and the MC1710 differential comparator are discussed. The capabilities and performance are given along with typical operating curves for both devices.

AN-406 UHF Broadband Amplifier Design

A design technique is given for a wideband amplifier operating at UHF frequencies. A shunt-shunt feed-back network and Y-parameters at sampled frequencies are used.

AN-407 A General Purpose IC Differential Output Operational Amplifier

This application note discusses four different applications for the MC1520 and a complete description of the device itself. The final sections of the note discuss such topics as operation from single and split power supplies, frequency compensation, and various feedback schemes.

AN-408 Problems and Solutions With MDTL and MRTL

Problems which may be encountered in using MRTL or MDTL integrated circuits in low or medium speed systems are examined in this report. Methods of shaping clock waveforms, restrictions on input and output terminals when interfacing with discrete components, and techniques for extending temperature range are discussed.

AN-409 MDTL Multivibrator Circuits

This note describes methods of using MDTL gates to form astable and monostable multivibrators. The operation of the MC951/MC851 monostable multivibrator is also covered as well as a simple pulse-shaping circuit.

AN-410 A Unified Approach to Optimum FET Mixer Design

The optimization of conversion gain, noise figure, and cross modulation are treated in relation to the basic mixer analysis and meaningful device parameters.

AN-411 The MC1535 Monolithic Dual Op Amp

This note discusses two dual operational amplifier applications and an input compensation scheme for fast slew rate for the MC1535. A complete ac and dc circuit analysis is presented in addition to many of the pertinent electrical characteristics and how they might affect the system performance.

AN-412 Duplexing With Step Recovery Varactors

The switching function in a duplexer circuit can be performed automatically by a step recovery varactor, eliminating the need for an external bias circuit. In this note, two CW duplexers are described: a 133 MHz lumped constant component duplexer and a 450 MHz microstrip transmission line duplexer.

AN-413 Unijunction Trigger Circuits for Gated Thyristors

This note describes the methods of supplying controlled pulse widths in synchronization with the ac power line to gated thyristors. The unijunction transistor provides a simple and convenient means of obtaining such pulses as well as including feedback with very little additional circuitry.

● Denotes Application Notes appearing for the first time in this index.

● AN-414 Operation and Application of MHTL I/C Flip-Flops

A master-slave R-S and a dual J-K are the initial flip-flop elements available in the Motorola High Threshold Logic (MHTL) family. This note describes operation and characteristics of each unit and illustrates several applications of these devices.

● AN-415 Avoiding Second Breakdown

The use of safe-area data, the physical mechanism of second breakdown and applications to various circuits are presented. Also included is a short discussion of test procedures and a typical test circuit used to establish safe area curves.

● AN-416 One-Step High Order Frequency Multipliers

The circuits described in this report include the use of lumped constants, coaxial cavities, and waveguides. The design of lumped constant, low order multipliers is discussed in Application Notes AN-147 and AN-151 and coaxial cavity multiplier design is treated in Note AN-159. Therefore, only a brief outline of the X2 and X3 multiplier circuits will be given.

● AN-417 IC Crystal Controlled Oscillators

Crystal controlled square wave oscillators can be used as clock drivers, harmonic sources for frequency markers, in frequency synthesizers, frequency comparators, etc. It is difficult to obtain high frequency square waves due to the long propagation delays of the most integrated circuits. The MECL II clock driver with 2 ns propagation delay eliminates this problem. This note describes square wave oscillator circuits with crystal control that are capable of output frequencies, inverted and non-inverted, up to 150 MHz.

● AN-418 High Speed Monostable Multivibrator Design with MECL Integrated Circuits

This note describes two configurations of monostable multivibrators using the MC1023 clock driver and a delay element. Operating frequencies in excess of 70 MHz and pulse widths of 4 nanoseconds are possible. Methods of obtaining the predetermined delay are also discussed.

● AN-419 UHF Amplifier Design Using Data Sheet Design Curves

This note describes the design of UHF narrow-band amplifiers using the device loading admittances taken directly from the device data sheet. A design example is given in the form of a 1 GHz microstrip amplifier. Predicted results are compared to actual measured values. Also included is a short discussion on practical microstrip construction techniques.

● AN-420 An Integrated Circuit Stereo Preamplifier

This note describes the use of the MC1303P dual preamplifier integrated circuit in a high quality stereo preamplifier circuit. It shows the designer how to adapt or modify the circuit to meet particular needs. The resultant preamplifier is suitable for use in systems having the most critical requirements.

● AN-421 Semiconductor Noise Figure Considerations

A summary of many of the important noise figure considerations related with the design of low noise amplifiers is presented. The basic fundamentals involving noise, noise figure, and noise figure-frequency characteristics are then discussed with the emphasis on characteristics common to all semiconductors. A brief introduction is made to various methods of data sheet presentation of noise figure and a summary is given for the various methods of measurement. A discussion of low noise circuit design, utilizing many of the previously discussed considerations, is included.

● AN-422 Testers for Thyristors and Trigger Diodes

This paper describes inexpensive go-no-go testers for thyristors and trigger diodes. Each is very simple to use and is well adapted to incoming inspection and other applications requiring fast testing of major parameters.

● AN-423 Field-Effect Transistor RF Amplifier Design Techniques

Amplifier design theory utilizing the two port network model for an active device has been well developed and used extensively in bipolar transistor high frequency amplifier design.

This paper discusses some of the theoretical and practical considerations for using this popular method to design field effect transistor amplifiers.

● AN-424 Designing a Digital Organ Tone Generator

A digital organ tone generator is described here to familiarize the reader with the capabilities of Motorola in-stock integrated circuits in novel electronic organ designs. An organ using this kind of tone generator has several advantages over the conventional 12-master oscillator divider organ.

● AN-425 Transistor Inverter—40 Watts, 400 Hz, Square Wave Output

A two-transistor, two-transformer circuit is described that uses a novel UJT starting circuit and a zener diode for maintaining frequency control.

● AN-426A Low-Power Audio Amplifiers Using Complementary Plastic Transistors

The use of complementary-symmetry output transistors in low-power audio amplifiers enables the circuit designer to achieve maximum circuit performance at minimum component cost. This note describes several audio amplifier circuits suitable for power outputs of up to 2 watts with 8-, 16- and 40-ohm loads. Also described is a line-operated single-ended audio amplifier suitable for table-radio or television applications.

● AN-430 An Integrated-Circuit Chroma Demodulator for Solid-State Color Television Receivers

This note describes an integrated-circuit chroma demodulator for solid-state television receivers, using the Motorola XC-1325P. The demodulator requires only the chroma signal and two reference phases from the 3.58 MHz color oscillator for providing low-impedance color difference signals to drive the chroma output stages directly.

● AN-432A A Monolithic Integrated FM Stereo Decoder System

This application note discusses the circuit approach that has been taken in the realization of the first monolithic integrated stereo multiplex decoder built for consumer usage, as well as some of the details concerning its incorporation in an FM stereo receiver.

● AN-434 The Motorola Autobass and Percussion System

A new musical feature that could readily be incorporated in any electronic organ is described in this note. This feature provides an attractive selling point to beginner organists, as it substantially reduces the number of techniques they must learn to perform a satisfactory accompaniment. The implementation of the system with integrated circuits is straightforward and quite simple.

APPLICATION NOTE ABSTRACTS (continued)

- **AN-435 The Electronic "Strobotuner", An Accurate Digital Musical Instrument Tuning Aid**

This report presents the electrical design of an accurate digital tool for tuning musical instruments. The concepts basic to the design and the principles of operation are discussed with a step-by-step procedure for using the tuner. A method of checking the accuracy after a tuning procedure is also included.
- **AN-436 Conventional and Soft-Start Dimming of Incandescent Lights**

This note describes two dimmers that provide wide-range control of incandescent light intensity by adjusting the angle of conduction in a series triac. One dimmer features simplicity for small size and low cost, while the other offers soft-start operation to limit inrush current and lengthen lamp life.
- **AN-437 Design Considerations and Performance of Motorola Temperature-Compensated Zener Reference Diodes**

This application note defines Motorola temperature-compensated zener (reference) diodes, explains the device characteristics, describes electrical testing, discusses the advanced concepts of device reliability and quality assurance, and outlines device construction.
- **AN-438 Analysis and Design of Active Filters Using Op Amps**

Excellent filters for frequencies below 100 kHz can be economically realized with operational amplifiers. Increased Q, design flexibility, reduced weight and cost also add to the attractiveness of operational amplifier active filters. Rigorous design theory and practical circuit examples are given in this note.
- **AN-439 MC1539 Op Amp and its Applications**

This application note discusses the MC1539, a second generation operational amplifier. The general use and operation of the amplifier is discussed with special mention made of improved operation over that of its first generation predecessor—the 709 type amplifier.

In addition to the detailed discussion on the dc and ac operation of the device, considerable emphasis is placed on operational performance. Many applications are offered to demonstrate the device capability, including a high frequency feed-forward scheme, and a source follower application.
- **AN-440 Theory and Characteristics of Photo Transistors**

A brief history of the photo-electric effect is discussed, followed by a comprehensive analysis of the effect in bulk semiconductors, pn junctions and phototransistors. A model is presented for the photo-transistor. Static and transient data for the MRD300 provide typical phototransistor characteristics. Appendices provide a discussion of the relationship of irradiation and illumination and define terms specifically related to phototransistors.
- **AN-441 SCR Slaving Circuits**

This circuit makes use of a low-cost transistor to overcome the limitations of a conventional R-C discharge circuit in slave firing of an SCR. It is especially useful where zero-point switching techniques are employed to control large electrical loads.
- **AN-442 Designing DC-DC Converters for Capacitor Charging with Batteries**

This paper outlines design considerations for converters used for charging energy-storage capacitors with low-voltage batteries. The ratio of capacitor voltage to battery voltage is chosen to be greater than 100. A discussion of converter characteristics is presented here from the standpoint of efficiency, frequency of oscillation, rate of energy transfer from battery to capacitor, and peak battery current drain.

A complete circuit is included that is tolerant of semiconductor parameter variations and is thus suitable for economical mass production.
- **AN-443 Directional and Speed Control for Series, Universal and Shunt Motors**

A simple circuit containing few components allows control of both speed and direction of rotation of dc motors. The use of thyristors provides continuous driver control through the speed range without compromising the torque characteristics of the motors.
- **AN-444 Triac Prevents High Current Relay Arcing**

A triac in shunt with the contacts of a relay that switches large currents drastically reduces the size of contacts required. Since the triac is subjected to current surges for only a short time and at a low duty cycle, it can conduct currents many times its steady-state rated value.
- **AN-445 Pulse-Width Modulation for DC-Motor Speed Control**

Feedback derived from a motor's armature and dependent on its speed can be used to counteract the reduction in speed that accompanies loading. This note describes two speed-control circuits which use different methods to obtain the feedback signal. One method uses voltage sensing, and the other an optical pickup.
- **AN-446 128-Bit Read Only Memory**

Read Only Memories can now be fabricated as integrated circuit arrays and hence will have a great

impact upon digital system design. Applications of the Motorola 16-word, 8-bit Read Only Memory (ROM) are discussed. The applications are grouped into two classifications according to the type of memory addressing utilized — (1) Random Accessing (2) Sequential Addressing.

● AN-447 **Fast Charging Systems for Ni-Cd Batteries**

This note discusses the requirements and problems encountered in designing fast charging systems for nickel-cadmium (Ni-Cd) cells, including some cell characteristics affected by high-rate charging.

● AN-449 **AC and DC Relay Drivers**

Though semiconductor devices are replacing electro-mechanical relays in many uses, some applications require the switching of a signal which is isolated from power and other sources. This can be done only with a relay. This application note describes three different circuits that can be used for electronic control of these relays.

● AN-450 **Induction Motor Speed Control**

A method of providing speed control above and below design speed for an induction motor is shown in this note. Such speed control increases the versatility of an induction motor and permits it to be used in fulfilling requirements formerly satisfied only by dc motors.

● AN-451 **A Frequency Counter Using Motorola RTL Integrated Circuits**

A frequency-period counter with a total hardware cost under \$200.00, based on unit quantity prices, is described. The instrument measures the periods and frequencies of periodic waveforms, ranging in frequency from 10 Hz to 20 MHz, and counts random occurrences for selected gate times of one millisecond to 10 seconds. A four digit decimal readout is provided. The low cost is achieved by utilizing plastic MRTL devices in unique versions of a crystal controlled oscillator, a period selector, a one shot multivibrator, a pulse shaper, and a switch contact bounce eliminator circuit.

● AN-452 **An Op Amp RC Bandpass Filter**

The design of audio range active filters using operational amplifiers and RC frequency elements is discussed. A computer program in BASIC is given for general design. The design example, a filter with a center frequency of about 1600 Hz and adjustable Q from 10–200, is provided.

● AN-453 **Zero Point Switching Techniques**

This note discusses two unique pulse-type thyristor triggering circuits which meet the exact timing

requirements of zero-point switching. They dissipate very little power and can be used with either sensitive or “shorted” gate devices.

● AN-454 **AC Overcurrent Protective Circuit with Automatic Reset**

A unique circuit that will protect ac resistive loads from both overvoltage and overcurrent is shown. One feature of this circuit is that the sensing element is not in series with the load when the load is turned on.

● AN-455 **Using the FET Designers Data Sheet for Worst Case Amplifier Circuit Design**

Basic information for the use of field effect transistors is provided, and is an aid to complete understanding of the Designers* Data Sheet. This report discusses the advantages, disadvantages, types and modes of operation of FETs and presents a definitive discussion of key parameters with their relationship to circuit design, when applicable.

● AN-456 **A 50 MHz Programmable Counter Designed with MECL II Integrated Circuits**

A high speed programmable counter using the MECL II family of logic is discussed. The counter is designed to accept an input frequency up to 50 MHz and divide it by any number from 2 to 999. This number is programmed into three decades of synchronous down counters. These decades with additional decoding and control logic comprise a complete high speed divide-by-N counter system.

● AN-457 **Switching Voltage Regulator Uses Discrete and Integrated-Circuit Approaches**

A switching voltage regulator can be considerably more efficient than the conventional series-pass continuously conducting regulator. This note discusses the operation of switching regulators including design information. It also describes practical regulators using discrete and integrated-circuit driver circuits.

● AN-459 **A Simple Technique for Extending Op Amp Power Bandwidth**

The design of fast response amplifiers is presented without the use of “tricky” compensation procedures or calculations using data sheet information. Circuit analysis for compensation procedure is given.

● AN-460 **Using Transient Response to Determine Operational Amplifier Stability**

This application note describes a technique for evaluating the stability of any particular feedback amplifier configuration by analyzing its response to a step-function input. A theoretical analysis is given along with an example.

APPLICATION NOTE ABSTRACTS (continued)

- **AN-461 Transient Suppression with a Power Zener Diode**

Voltage transients are a major cause of component failure in semiconductor circuits. A design engineer must consider this problem carefully if he is to insure maximum circuit reliability. This note discusses the sources of transients and their detection, and describes transient suppression using power zener diodes designed for this purpose.
- **AN-462 FET Current Regulators—Circuits and Diodes**

Included are numerous FET current sourcing circuits, along with an extensive treatment of the current regulating diode and its uses as a valuable component in circuit design.
- **AN-463 An Integrated Circuit Phase-Locked Loop Digital Frequency Synthesizer**

A digital frequency synthesizer design is detailed which incorporates digital channel selection and exhibits excellent frequency stability through the use of a phase-locked loop. The system design takes advantage of state of the art in both linear and digital monolithic integrated circuits, plus some ideas new to the synthesizer field.
- **AN-464 MTTL Designer's Note – The MC4004/MC4005, A 16-Bit Random Access Memory**

High speed, non-destructive readout (NDRO) memory systems can be constructed with the MTTL 16-bit memory chip. Information concerning the chip that is pertinent to the design of a complete memory system is herein presented. The topics discussed are: (1) operation of the 16-bit memory including typical read and write sequences, (2) typical dc and switching characteristics as a function of temperature, power supply, and output load, and (3) examples of memory system organization utilizing the 16-bit memory as the basic cell.
- **AN-465 MTTL Designer's Note – The MC4006/MC4007 Decoders**

Two MTTL complex functions, the MC4006 Binary to One-of-Eight Decoder and the MC4007 Dual Binary to One-of-Four Decoder are discussed. Their basic modes of operation and expansion capabilities are described. Examples of the use of the decoders in various systems are presented.
- **AN-466 Circuit Applications for the Triac**

This note discusses the basic theory of operation of the triac with control methods and circuit applications. Among the applications included are basic switches, lamp dimmers, motor controls, a heater control, a flasher, a regulator, protective circuits and zero-point switching.
- **AN-467 Using Motorola High Threshold Logic**

This application note explains operation of the Motorola High Threshold Logic (MHTL) family of integrated circuits. It briefly describes the members of the family and provides many of the characteristics of the units. Several examples are provided to aid the reader in the application of this unique logic family.
- **AN-469 Line Operated 15-kHz Inverter**

The circuit shown in this note is a line-operated inverter. It makes use of high-voltage, high-frequency silicon power transistors to provide 120 volts and 200 watts at 15 kilohertz. Because of the high frequency of operation, the components used can be small in size, resulting in a very compact inverter.
- **AN-470 Bipolar Chopper Transistors and Circuits**

Bipolar transistor chopper circuits are used in many applications for low-drift amplification of dc and low-frequency ac signals. This note discusses the characteristics of transistors used as choppers and the circuits in which they can be used.
- **AN-471 Analog-To-Digital Conversion Techniques**

The subject of analog-to-digital conversion and many of the techniques that can be used to accomplish it are discussed. The paper is written in general terms from a system point of view and is intended to assist the reader in determining which conversion technique is best suited for a given application.
- **AN-472 Mounting and Heat Sinking Uniwatt Plastic Transistors**

The Uniwatt* plastic package is now being used for several medium-power transistor types. This note describes several methods for mounting such devices, with emphasis on proper heat sinking for best thermal characteristics.
- **AN-473 A Monolithic High-Power Series Voltage Regulator**

This note discusses MC1560/MC1561 voltage regulator in terms of internal operation, development of these circuits, and how they are advantageously used in supply fabrication.
- **AN-474 The MC1541 – A Gated Dual-Channel Sense Amplifier for Core Memories**

The MC1541 sense amplifier can provide many magnetic core memory systems with lower system cycle times and a lower package count than with previous sense amplifiers. Circuit operation, design considerations, interface problems and typical applications are discussed.

APPLICATION NOTE ABSTRACTS (continued)

- **AN-475 Using the MC1545 – A Monolithic, Gated-Video Amplifier**

Because of the unique design of the MC1545, this amplifier can be used as a gated video amplifier, sense amplifier, amplitude modulator, frequency shift keyer, balanced modulator, pulse amplifier, and many other applications. This note describes the ac and dc operation of the circuit and presents applications of the device as a video switch, amplitude modulator, balanced modulator, pulse amplifier, and others.

- **AN-476 MTTL Designer's Note – The MC4000 Data Selector and the MC4002 Data Distributor**

Two MTTL complex functions, the MC4002 four and two-channel data distributor, and the MC4000 dual four-channel data selector are discussed. Their basic modes of operation and expansion capabilities are described. Examples of the use of the data distributor and the data selector in various systems are presented.

- **AN-477 A 30-Watt 175 MHz Power Amplifier Using PNP Transistors**

This note describes a three-stage power amplifier that delivers 30 watts output at 175 MHz. It utilizes the first commercially available VHF PNP high-power transistors to provide 29 dB gain, 50% overall efficiency, and low spurious output.

- **AN-478 Small Signal RF Design with Dual-Gate MOSFETS**

The dual-gate MOSFET offers low noise, high gain, and excellent AGC, cross-modulation and overload characteristics in RF applications. Recent devices also feature silicon nitride passivation for ease of handling and reliability. This note discusses the characteristics of dual-gate MOSFETs, with emphasis on designing circuits, noise figure, AGC, bandwidth and detuning, cross-modulation and mixer operation.

- **AN-479 MTTL Designer's Note – The Operation of the MTTL J-K Flip-Flops**

The purpose of this note is to familiarize the reader with the principles of operation of the MC515/MC2109 AND-input J-K and the MC516/MC2110 OR-input J-K flip-flops. The design rules for using these flip-flops are presented and analyzed. In addition, several examples of typical applications are included.

- **AN-480 Regulators Using Operational Amplifiers**

The theory of op amp voltage regulator design is discussed. The problem areas associated with such designs are also detailed. The MC1560 is used as a OTC voltage reference in the op amp regulator designs that are shown. It is shown that regulation from 0.01% to 0.001% is possible.

- **AN-481 A Broadband 4-Watt Aircraft Transmitter**

This report describes a 4-W wideband AM aircraft transmitter intended for light aircraft. The frequency range is 118 to 136 MHz and no tuning is required when changing frequency. The RF circuitry can be operated from 12.5 V, or can be used with a series modulator described in the note from 26 V.

- **AN-482 Electronic Speed Control of Appliance Motors**

This application note discusses the possibilities of controlling several types of induction motors, universal motors, and permanent-magnet motors, and includes circuit designs for each. By matching the motor to its electronic control, the designer can obtain a simple and efficient system.

- **AN-483 20 and 30 Watt Power Amplifiers Using Darlington Output Transistors**

Use of monolithic power Darlington output transistors can greatly simplify the design of high-fidelity amplifiers. Described herein is a 20-W amplifier which uses only three transistors, and a 30-W amplifier which uses four.

- **AN-484 Medium-Power Audio Amplifiers Using Complementary Plastic Transistors**

This note describes complementary-symmetry power amplifiers of 3- to 35-watt capability designed for 8-ohm loads. The circuits use inexpensive plastic-encapsulated silicon transistors in both low-level and output stages. Information is provided for specifying the transistors, power supplies and heat sinking.

- **AN-485 High-Power Audio Amplifiers with Short-Circuit Protection**

This application note describes a recommended circuit approach for high-performance audio amplifiers in the 35-W to 100-W RMS power range. Circuitry is included which enables the amplifier to operate safely continuously under any load condition including a short.

- **AN-486 A Monolithic Circuit for Television Sound Systems**

This application note describes the MC1351P monolithic integrated circuit designed for television sound systems. The circuit consists of a limiting 4.5 MHz IF amplifier and a full wave quadrature detector; in addition, it has an audio preamplifier and an audio driver on the same chip, capable of delivering 3 V_{rms} to the audio output stage.

- **AN-487 A High-Speed Ripple-Through Arithmetic Processor**

A simple, systematic building block approach for designing a high-speed, ripple-through arithmetic

APPLICATION NOTE ABSTRACTS (continued)

processor is described. Using only gates and full adders, ultra-high speed multiplication, division, square root extraction, addition, and subtraction may be performed. Several variations of an arithmetic processor design are detailed and comparisons of speed and package count using the MECL and MDTL logic in 14-pin, 16-pin, 24-pin, 32-pin, and 64-pin packages are given.

- **AN-488 High-Speed Addition Using Lookahead Carry Techniques**

The use of the lookahead carry principle to increase the operating speed of adder systems is described. Several adders of different sizes using variations of lookahead carry are developed and the logical implementation of these using the MTTL III and MECL II and-III logic families is given.

- **AN-489 Analysis and Basic Operation of the MC1595**

The MC1595 monolithic linear four-quadrant multiplier is discussed. The equations for the analysis are given along with performance that is characteristic of the device. A few basic applications are given to assist the designer in system design.

- **AN-490 Using the MC1595 Multiplier in Arithmetic Operations**

This application note discusses the use of the MC1595 linear four quadrant multiplier in arithmetic operations. Included is a discussion of the MC1595 used in the multiply, divide, square and square root modes of operation. Actual circuits for these functions are shown with measured data and a discussion of the errors occurring in each mode.



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