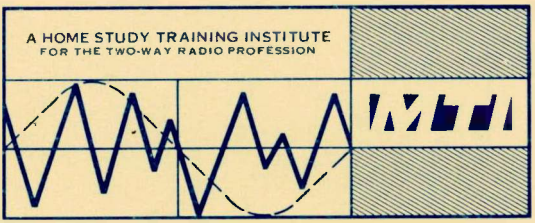
COURSE OF STUDY

MTI

Mobile Training Institute

429 S. Eighteenth Street • Box 735

Camp Hill, PA 17011 • (717) 737-9499



MTI was founded in 1960 by Motorola Communications and Electronics, Inc. – when they recognized the need for specialized training in professional FM Two-Way radio. MTI now operates independently of Motorola, but the emphasis remains the same. Prior to MTI's inception, no training program adequately covered the technical aspects of this unique communications medium. MTI has solved this problem.

There are advantages to home study electronics training beyond the technical knowledge you will receive. With a home study program, you have the ability to establish your own study schedule to coincide with other activities and work schedules. You set your own progress rate and meet your own deadlines, while at the same time, you become more self-reliant. As you learn to dig out the facts through the MTI course, the knowledge you gain will be better understood and retained – because you actually taught yourself.

Two-way radio technicians in the United States must have a valid FCC commercial license, other than third class, to service non-governmental transmitters. While the MTI course is not designed as a study program for obtaining the FCC license, it does contain information that is helpful in passing the FCC exam. Many inexpensive FCC license study guides are available.

Two-way radio has long been accepted as a proven tool for business, industry and public service institutions. Radio provides constant communication between management and personnel. Once restricted to limited use by police, fire and military personnel, today anyone who shows the need for two-way radio can use its advantages to great benefit.

These millions of radios require competent, continuing maintenance to keep them at peak performance levels. Many systems are vital to public health and safety. They must be operating at all times. This requires many two-way technicians. Perhaps the industry can use your talents.

MTI offers 34 specific lessons for professional FM two-way radio technicians. MTI has the only training program exclusively devoted to professional FM two-way radio communications, with the added bonus that circuits from two-way products are used to illustrate various principles. To keep the MTI program current, a revision of the course content has just been completed. MTI wants you to have the latest knowledge available from the ever-changing field of electronics, so that you will be up-to-date in your skills.

SEMICONDUCTORS & TWO-WAY RADIO

The Outline for Course F

FM TWO-WAY RADIO SERVICING

34 LESSONS, PLUS 13 REFERENCE TEXTS

LESSON A-1 SEMICONDUCTOR REVIEW
Semiconductor Materials. Carriers. Hole Movement. PN Junctions. Diodes. Zener Diodes. Varactors. SCR's. Special Purpose Diodes. Diode Identification. Diode Testing.

LESSON A-2 TRANSISTOR REVIEW
Bipolar Transistors. Transistor Elements. Operation. Transistor Currents. Transistor Amplifiers. Impedances. Coupling. Bias Circuits. Thermal Stabilization.

LESSON A-3 FET REVIEW
FET Construction. Operation. Junction FET. Depletion IGFET. Enhancement IGFET. Dual Gate FET. Vertical FET. Symbols. FET Amplifiers. Constant Current Diodes. FET Servicing. Handling FETS

LESSON A-4 INTEGRATED CIRCUITS
Types. Packaging. IC Symbols. Linear IC's. Differential Amplifiers. Operational Amplifiers. CMOS IC's. Handling CMOS Devices. Servicing IC's.

REFERENCE TEXT 1-S, TRANSISTORS
Transistor Theory. Operation Of The Diode. Operation Of The Transistor. Typical Operating Characteristics. Typical Transistor Ratings. Applications In Two-Way Equipment. Servicing Transistorized Equipment.

REFERENCE TEXT — TRANSISTOR FUNDAMENTALS
System Considerations. Transistor As An Active Device. Semiconductor Physics. P-N Junction. How Transistors Operate. Basic Circuit Configurations. Circuit Configurations. Characteristic Curves. Operating Limits. Power Dissipation. Transistor Amplifier Circuits. Classes Of Amplifiers. Coupling Networks. Transistor Oscillator Circuits. LC Oscillators. Crystal-Controlled Oscillators. RC Oscillators. Relaxation Oscillators. Zener Diodes. Silicon Controlled Rectifiers. Unijunction Transistors. Field-Effect Transistors.

LESSON R-1, FREQUENCY MODULATION
Amplitude Modulation. The FM Transmitter Amount Of Frequency Change. Rate Of Frequency Change. Center Frequency. Deviation. The FM Receiver and Detection. Audio Frequency. FM Is More Interference-Free. FM Transmitter Efficiency. FM Bandwidth.

LESSON R-2 RECEIVER BLOCK DIAGRAM ANALYSIS
Receiver Requirements. Simple Broadcast Receiver. Basic FM Receiver. Communications Receivers. Two-Way Bands. The Double Superhet. Triple Conversion. Single Conversion Receivers. Mulitiple Frequency Operation. Integrated Circuits.

LESSON R-3, RF SECTION
Single-To-Noise Ratio. Man-Made Noise. Natural Noise. Receiver Noise. Transistor And Tube Noise. Selectivity. Desensitization. Intermodulation. Preventing Desensitization And IM.

LESSON R-4, OSCILLATOR MIXER AND IF
High Frequency Oscillator. Crystals. Vibrational Modes. Crystal Aging. Temperature Considerations. Crystal Warping. Frequency Multipliers. Tube Mixer. Bipolar Transistor Mixer. FET Mixer. Deviation. The First IF Amplifier. Crystal Filters.

LESSON R-5, SECOND MIXER AND IF SECTION
The Second Oscillator. Tube Oscillator. Transistor Oscillators. The Second Mixer. Tube Mixer. Solid State Mixers. Selectivity. IF Stage. Single Conversion Receiver. Mixer. "Pulsar" IF Board. The "MICOR" IF.

LESSON R-6, THE LIMITER
Limiter Action. The Saturated Limiter. The Tube Limiter. Transistor Limiter. Automatic Bias Operation. Saturation And Noise Reduction. The Limiter Output. Flywheel Effect. Receiver Quieting.

LESSON R-7, THE DISCRIMINATOR
Plain Vector Talk. Basic Discriminator Action. Deviation Vs. Output Phase Relationships. Modified Phase Detector. Crystal Discriminator. Deemphasis. Discriminator Response Curve.

LESSON R-8, SQUELCH AND AUDIO CIRCUITS
Tube Squelch. Transistor Squelch. Speakers. Tube Audio Section. Transistor Audio Circuits. "MOTRAC" Audio. "MOCOM 35" Audio. "Pulsar" Audio. "MICOR" Audio.

LESSON R-9, THE METER IN THE RECEIVER
Metering Methods. The Test Set. Metering Functions. Oscillator Metering. IF Metering. Discriminator Metering. Audio Metering. Voltage Readings. Troubleshooting. Decibels.

LESSON R-10, RECEIVER SPECIFICATIONS
General Specifications. Sensitivity. Desensitization. Selectivity. Measurement Methods. Modulation Acceptance. Intermodulation. Discriminator Stability. Oscillator Stability. Spurious Responses. Audio Output And Response.

REFERENCE TEXT 1-R, PRACTICAL GROUNDING
Grounding Principles. Grounding Practices. Resistance Measurements. Methods Of Improving Resistance. Driving Methods. Deep Grounding. Computed And Actual Resistances. Operating Results And Test Grounds. Copperweld Ground Rods.

REFERENCE TEXT 2-R, RF INTERFERENCE
Interference Noise. Desensitizing. Spurious Responses. Intermodulation. Cavity Resonators. RFI Analysis Charts. Intermodulation Interference Frequencies Of IM Products. IM In Transmitters. IM In Receivers. Diagnosis And Treatment. Sideband Noise. Receiver Desensitization. Transmitter Noise. Receiver Problems.

REFERENCE TEXT 3-R IGNITION NOISE
Suppression Fundamentals. Preliminary Procedures. Locating The Sources Of Interference. Interference Suppression Techniques. Marine Radio Suppression. Shielded Ignition.

REFERENCE TEXT, LIGHTNING
Exposure Factors. Lightning Stroke Current. Incidence Of Thunderstorms. Cycle Of A Lightning Stroke. Introduction To Grounding. Grounding Philosophy. Equalization Of Potentials. Antennas And Supporting Structures. Two-Way Antennas. Microwave Antennas. Two-Way Antenna Structures. Microwave Antenna Structures.

LESSON T-1, FM TRANSMITTER BLOCK DIAGRAM:
Types Of Modulation. The Oscillator. The Audio Amplifier. Deviation Con-

trol. The Phase Modulator. Frequency Multiplication. Power Amplifier. Antenna Circuit.

LESSON T-2, THE TRANSMITTER OSCILLATOR:
Frequency Stability. Power Requirements. The Oscillator Load. Operating Frequency. High Band Oscillator. Low Band Oscillator. Offset Oscillator. Transmitter VCO.

LESSON T-3, THE PHASE MODULATOR
PM Versus FM. Vectors, Rate Of Change. Phase Modulator. Preemphasis. Serrasoid Modulator. Direct FM. Sidebands And Bandwidth.

LESSON T-4, AUDIO CIRCUIT
Deviation Control. Microphones. Preemphasis. Audio Preparation. Clippers. Integration. Splatter. Deviation Control Circuits. Direct FM Audio Circuits.

LESSON T-5. FREQUENCY MULTIPLICATION
Class C Multipliers. Multiplier Operation. Flywheel Effect. Tank Circuit Impedance. Driving Power. Tube Mulipliers. Deviatiun Multiplication. Transistor Multipliers. Varactor Circuit.

LESSON T-6. THE POWER AMPLIFIER
FM Power Amplifiers. Drive and Bias. PA Input Circuits. The Output Tank. Antenna Coupling Circuits. Impedance And Power Transfer. Spurious Emissions And Harmonics. Feedback And Neutralization. Ferrite Devices. PA Circuits. Protective Circuits.

LESSON T-7. METERING THE TRANSMITTER
Transistor Transmitters. PA Position. Loading The Antenna. Neutrallzation. Frequency Adjustment. Deviation Adjustment. Troubleshooting.

LESSON T-8, TRANSMITTER SPECIFICATIONS
Frequency Range And Separation. Frequency Stability. Power Requirements RF Power. Spurious Outputs. Sideband Noise. Audio Impedance. Audio Sensitivity And Response. Environmental.

LESSON T-9. PORTABLE POWER SUPPLIES
Batteries and Battery Life. Nickel-Cadmium Battery. Charging Ni-Cads. AC Power Supplies. Battery Chargers. Voltage Regulation. Zener Regulators. Current Regulator Sensors. Temperature Sensors.

LESSON T-10, MOBILE POWER SUPPLIES
The Vibrator. The Dynamotor. Transistor Power Supplies. DC Distribution And Logic. Ground Reversing Converters. Protection Circuits.

LESSON T-11. AC POWER SUPPLIES
Series-Pass Regulators. Switching Regulators. Hybrid Power Supply. Phase-Controlled Power Supply. Pulse-Width Regulated Power Supply.

LESSON T-12, ANTENNAS AND TRANSMISSION LINES
Radio Waves. Wave Motion And Polarization. Wavelength. Radiation Pattern. Ground Waves and Sky Waves. Basic Antenna Action. Antenna Impedance. Gain And Directivity. Patterns And Coverage. Antenna Types. Transmission Lines. Standing Waves.

REFERENCE TEXT 3-T, LOGIC FUNDAMENTALS
Transistor Switch Characleristics. Fundamentals Of Logic. Transistor Switches. Transistor Multivibrator Circuits. Logic, Inhibitor & Gating Functions. Logic Representations. Servicing Of Logic Circuits. Symbolic Logic. Logic - What Is It? Logic Levels. Logic Symbols And Circuits. Logic Support Functions. Input/Output Languages.

REFERENCE TEXT, BASIC THEORY & APPLICATION OF TRANSISTORS
Structure Of Matter. Crystals, Acceptors And Holes, PN Junctions. Transistors. Transistor Amplifier Fundamentals. Parameters, Equivalent Circuits. Bias Stabilization. Characteristics Curves And Charts. Audio Amplifiers. Phase Inverters. Power Amplifiers. Complementary Symmetry. Compound-Connected Transistors. Tuned Amplifiers. Coupling Networks. Neutralization And Unilateralization. Wide-Band Amplifiers. Oscillators. Pulse And Switching Circuits. Modulation, Mixing And Demodulation.

REFERENCE TEXT, SELECTIVE CAVITIES
What It Is. Selectivity. How To Get Selectivity. Power. Coupling Loops. Stability. Installation And Tuning.

LESSON M-1, TONE SQUELCH
Frequency-Sensitive Elements. Reed Operation. Bandwidth And Drive. Operating Principles. Encoder Circuits. Decoder Circuits. Dual Purpose Units. Multi-Tone Systems. Switching By Tone.

LESSON M-2, SELECTIVE SIGNALING
Signaling Methods. One-Tone Systems. Two Sequential Tones. Two Simultaneous Tones. Three Tones. Four Tones. Five Tones. Maintenance.

LESSON M-3, THE TEST SET
Test Set Functions. Controls. Meter Scales. AC Voltmeter. Crystal Oscillator. Peaking Generator. Deviation Meter. Simplified Circuits. "MICOR" Metering.

LESSON M-4, GENERAL TROUBLESHOOTING
Isolating Defective Units. Check Of Individual Units. Locating The Defective Part. Techniques. The Voltmeter. Voltmeter Tips. Voltmeter Characteristics. Resistance Testing.

LESSON M-5, RECEIVER SERVICING
Techniques. Troubleshooting Charts. Signal Substitution. Alignment. Sensitivity Check. Stage Gain Measurements.

LESSON M-6, TRANSMITTER SERVICING
Preliminary Considerations. Metering. Symptom Analysis. Audio Section. Troubleshooting Chart. Trouble Isolation. Parts Replacement.

LESSON M-7, TEST EQUIPMENT
Accuracy. Time Base Accuracy. Frequency Resolution. Techniques. Frequency Meters. Heterodyning. Counters. Comparison Receivers. Deviation Monitors. Signal Generators. Wattmeters.

LESSON M-8, INSTALLATIONS AND PREVENTIVE MAINTENANCE
Preinstallation Checks. Mobile Installations. Base Station Installations. Noise Suppression. Preventive Maintenance. Power Sources. Antennas. Towers. Receivers. Transmitters.

REFERENCE TEXT, DUPLEXERS
The Simplex System. The Duplex System. Need For Isolation. Receiver Selectivity & Desensing. Transmitter Noise. Isolation Between Trans. & Rec. How To Get Isolation. Horizontal Antenna Separation. Vertical Antenna Separation. Advantages Of A Duplexer. Things Duplexers Must Do. Losses Through The Duplexer. The Bandpass Duplexer. The Band-Reject Duplexer. Other Types Of Duplexers. Use Of Duplexers. Use Of Duplexers As Combiners.

REFERENCE TEXT 4-T, ANTENNAS AND LINES
Antenna System Concepts. Antenna Characteristics. Mounting & Phasing Arrays. Side-Mounted Antennas. Troubleshooting Antennas. Ground-Wave Propogation. Direct-Wave Component. Ground-Reflected Component. Surface-Wave Component. Tropospheric-Wave Component. Abnormal Effects Of Troposphere. Half And Quarter-Wave Antennas. Voltage And Electric Field. Current And Magnetic Field. Standing Waves. Velocity Of Propogation. Resonance, Resistance & Impedance. Transmission Lines. Basic Radiation Patterns. Dipole Radiation.

REFERENCE TEXT, TRANSMISSION LINES
Solid Air And Foam Dielectrics. Electrical Properties. Impedance And Velocity. Environmental Considerations. Connectors. Installation And PM. VSWR.

REFERENCE TEXT, BASE STATION ANTENNAS
What Is An Antenna? Matching And VSWR. Half-Wave Dipole. Polarity And Patterns. Gain. Side-Mounted Antennas. Noise. Bandwidth.

WHO SHOULD ENROLL?

The MTI program is designed for two major categories of technicians: those already employed in two-way radio servicing and those planning to enter this field. Because no other training is available that deals so specifically with this subject, most working technicians have "picked up" much of their knowledge through experience. The MTI course helps to expand this knowledge and to clarify or correct information acquired through observation.

The course offers the technician with no experience in two-way radio an opportunity to acquire a knowledge of the subject that would likely require years of on-the-job experience to obtain. Thus, they can become usefully productive in a shorter period of time. There are other categories of students who can benefit from the course as well.

PURPOSE OF THE COURSE

The purpose of the course is to provide a reasonably detailed analysis of the major components of an FM two-way radio system for the servicing technician. For this reason, mathematical analysis is avoided and a functional emphasis is stressed. Explanations are made in such a manner that the functions of a particular circuit are established and the relationship of its individual components to the whole is clarified. The desired purpose is to develop a type of working knowledge that will aid the technician when troubleshooting a malfunctioning unit. Because of the rapidity with which change occurs in electronics, more emphasis is placed on logical comprehension than on specific circuits.

The desired goal is to have the student better qualified to service FM two-way radios when they complete the course than when they started. MTI, to the best of our knowledge, has the only course that exclusively covers this specialized profession. It is written by people with extensive field experience for people who are working in the field.

Because of the possibilities for misunderstanding, we do not consider the acquisition of a job in this field, job promotions, salary increases and similar objectives as suitable goals to be promoted in our advertising. Such things are difficult to measure and can depend more upon economics, the job market, the individual's personality and perseverance, geographic location and similar matters.

THE MTI COURSE

MTI has one course which is offered in three options. These are:

COURSE D: Principles of Semiconductors. This includes the first 4 lessons of the course plus one reference text. It provides a background in both bipolar and unipolar (field effect) transistors, IC's, operational amplifiers and other solid state devices. Originally intended to upgrade the technician with experience in tube equipment, it also serves as a preparation for the other 30 lessons. It strengthens the students knowledge of semiconductor principles. These 4 lessons and one reference can stand alone as a separate course to provide the student with an overview of transistors and other semiconductor devices.

COURSE B: Professional FM Two-Way Mobile Radio, consists of the last 30 lessons of the course with 11 of the references. Nine major areas of study are covered: receivers, transmitters, power supplies, antennas, tone signaling, troubleshooting, test equipment, equipment installation, and preventive maintenance.

The lessons are supplemented by 11 references, selected to provide basic and detailed information about various subjects discussed in the lessons. This system keeps the lessons themselves free of unnecessarily detailed or complex material, permitting the individual lesson to be understood more easily. These supplemental texts allow the student to pursue further those areas where he may be weak or have a special interest. The individual student is allowed some latitude in determining the depth with which he pursues the course.

COURSE F: FM Two-Way Radio Servicing, is a complete 34-lesson course, and is the combination of courses D and B. Thirteen references are supplied with this course.

WHY HOME STUDY?

Only a relatively small number of adults are able to take time away from their everyday responsibility of earning a living to attend a resident school. Basically, it is simply a matter of finances. What they are earning in their present job is required for day-to-day living expenses, family support, etc. Also, there is the rather sizable tuition costs and other fees that must be paid in addition to living expenses when attending a resident school. Those who would like to study professional FM two-way radio must also face the question of: "Where would I study?" There are few resident schools that provide any training in two-way radio. No other correspondence school has a detailed course devoted exclusively to FM two-way radio.

For such people, the MTI home-study courses offer an excellent alternative, with home study, no job time is lost and they maintain their present earning ability. The cost is low, and can be paid over a period of time. Add to these the fact that there is no relocation to unfamiliar surroundings, no commuting or similar problems, and home study looks even more attractive.

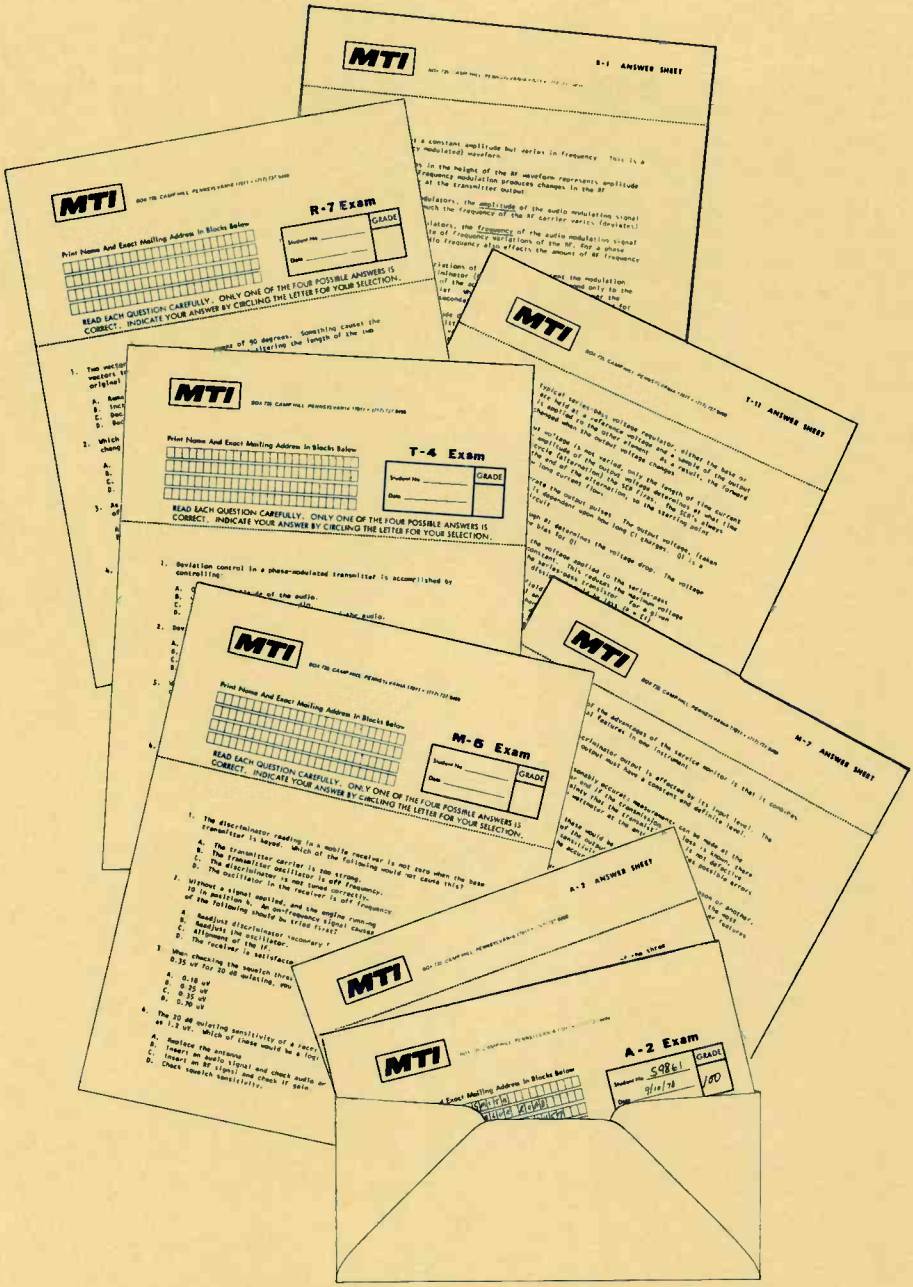
In addition to the technical knowledge you will receive from the MTI course, there are other advantages to a home study program. First, you are able to establish your own study schedule to fit with your other activities and work schedule. You are not required to attend a class at certain hours, and you will not be penalized should you find it necessary to temporarily discontinue your studies for a few days or more; you can make them up later when you have more time. In a home study program, you are allowed to set your own progress rate and are not tied down to a schedule which you *must* meet.

Furthermore, we all know that individuals progress at different speeds. Home study automatically takes care of this difference; you are not required to keep pace with a class when you want to take a little extra time to review some principle which was never too clear to you, and you are not held back by a class when you encounter something that you already know.

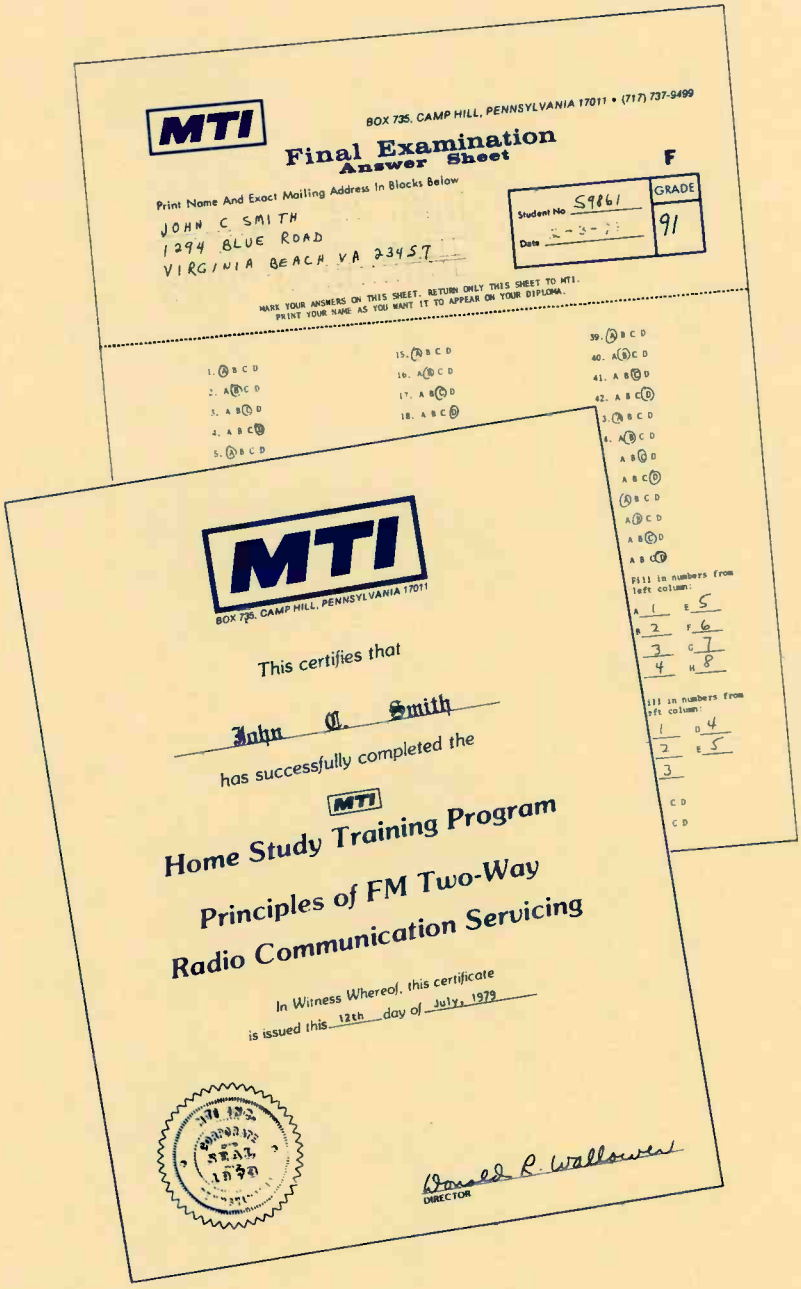
Another advantage of home study training is that you learn to make your own decisions. You become more self-reliant. There is nobody at your side to prod you along when you have some problem; you will learn to dig out the facts for yourself. Knowledge gained in this fashion is better understood and longer remembered.

If you are "stuck" on something, all is not lost. Simply send us a report of your problem, making the nature of the question as clear as possible. We will be glad to give you the help you need. Many times you will answer your own question by the mere fact that you have clearly defined it.

While correspondence study permits great flexibility and many personal decisions, you still have the benefits of an organized program and curriculum. Actually, all three ingredients of a learning situation are present: the student, the instructor and the instructional material. The major difference between correspondence study and classroom study is that communication between the student and teacher takes place with the written word instead of the spoken word.



There is a ten-question exam with each lesson to help you comprehend the material. An Answer Sheet is returned with your graded exam, and explains each answer.



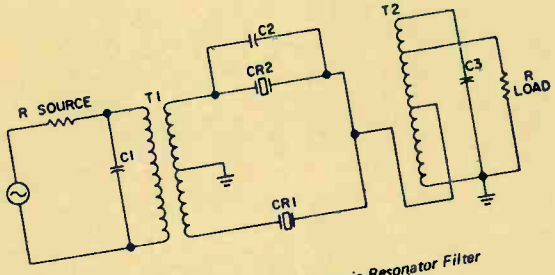
A Comprehensive Final Examination is used to test what you have learned. This is an open book exam. Successful completion of the course is rewarded with an attractive Certificate of Achievement.

is coupled to the tapped secondary, which feeds the two ceramic resonators (Y1 and Y2). Their frequencies are 448.5 and 461.3 KHz. The secondary of T1 and the two resonators form a bridge circuit. The input to the bridge being the two ends of the T1 secondary coil. The output is taken from the tap of T1 (ground) and the junction of Y1 and Y2.

The resonators have sharp attenuation beyond ±6 KHz of 455 KHz. The filter's overall 3dB bandwidth is 12 KHz. A 455 KHz signal will cause both resonators to conduct an equal amount. When the frequency shifts, one resonator will have lower output and the output of the other will increase. The addition of these two outputs will approximate the on-frequency output. Beyond ±6 KHz only one crystal will conduct and the output will drop sharply. C 30 is used to tune the bridge for balance, which is actually the point of minimum output (maximum rejection).

The output of this first section is coupled to a tap on L10, which with C31 and C32 form a resonant circuit tuned to 455 KHz, providing additional selectivity. The tap provides the required impedance match. The input to the second section of the filter is between the junction of Y3, Y4 and the tap of T2. This section performs the same as the first section. C33 adjusts the balance point for this second bridge. The output is coupled from the primary of T2 to the secondary, then to the base of the first IF amplifier, Q4, through C34 and C35. These two condensers have dissimiliar characteristics to provide temperature stability.

Q4 is a common-emitter amplifier, with base bias being provided by R15 and R16. The second and third IF amplifiers, Q5 and Q6 are essentially the same. The output of Q6 drives the limiter into saturation at all times.



Simplified Diagram Of Ceramic Resonator Filter

These are actual pages from MTI lessons.

A TWO-WAY RADIO COMMUNICATIONS TRAINING PROGRAM

LESSON T-3

The Phase Modulator

LICENSED BY PENNSYLVANIA DEPARTMENT OF EDUCATION

MTI

The Phase Modulator

LESSON T-3

TABLE OF CONTENTS

high-frequency components nor by high audio voltages originating at the microphone.

Transistor Phase Modulator

While the triode phase modulator was used almost exclusively in two-way radio transmitters for many years, the transistor phase modulator has had limited application. It has been used mostly in portables, and has largely been replaced by direct FM.

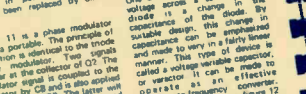
Figure 11 is a phase modulator from a portable. The principle of operation is identical to the triode phase modulator. Two signals appear at the collector of Q2. The oscillator signal is coupled to the collector by C8 and is also applied to the base of Q2. The latter will appear at the collector also, and will be approximately 180° out of phase with the oscillator signal from C8. The vectors in figure 10 can be applied to this circuit also.

The audio in figure 11 is applied to the emitter. As the audio signal changes from positive to negative the base-emitter bias increases and decreases. The amplified RF signal at the collector increases and decreases, the same as it did in figure 9. The variations in Eamp between B' and C'. As has been shown before, the advancing and retarding of phase produces a frequency modulated signal.

Varactor Phase Modulator

One of the effects of a changing voltage across a semiconductor diode is a change in the capacitance of the diode. By suitable design, this change in capacitance can be emphasized and made to vary in a fairly linear manner. This type of device is called a voltage variable capacitor, or varactor. It can be made to operate as an effective voltage to frequency converter. The phase modulator in figure 12 uses two voltage-variable capacitor diodes. The diodes are placed across two resonant circuits.

The oscillator output is applied to[o]

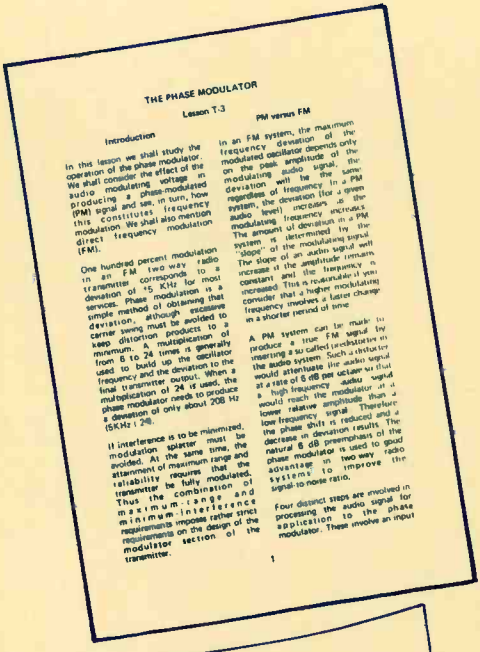


Low-Level Audio Produces Little Frequency Deviation

High Lev

the primary of inductively cou secondary. Varact series with C1 secondary of oscillator frequen reactance of C110 RF frequency ignored for prac primary functio the RF from T1101 is coupled T102 also is tuned to the by a varactor (reverse bias cathodes of R108 and obtained from and determin the two var applied. The resonance frequency b

When an a the junctio the bias, c This vari capacitanc decrease quiescen



THE PHASE MODULATOR

Lesson T-3

Introduction

In this lesson we shall study the operation of the phase modulator. We shall consider the effect of the audio modulating voltage on audio modulating a phase-modulated producing a phase-modulated (PM) signal and see, in turn, how this constitutes frequency modulation. We shall also mention direct frequency modulation (FM).

One hundred percent modulation in an FM two way radio transmitter corresponds to a deviation of 15 KHz for most services. Phase modulation is a simple method of obtaining that deviation, although excessive carrier swing must be avoided to keep distortion products to a minimum. A multiplication of from 6 to 24 times is generally used to build up the oscillator frequency and the deviation to the final transmitter output. When a multiplication of 24 is used, the phase modulator needs to produce a deviation of only about 208 Hz (15KHz ÷ 24).

It interference is to be minimized, modulation splatter must be avoided. At the same time, the attainment of maximum range and reliability requires that the transmitter be fully modulated. Thus the combination of maximum-range and minimum-interference requirements imposes rather strict requirements on the design of the modulator section of the transmitter.

PM versus FM

In an FM system, the maximum frequency deviation of the modulated oscillator depends only on the peak amplitude of the modulating audio signal. The deviation will be the same, regardless of frequency. In a PM system, the deviation (for a given audio level) increases as the modulating frequency increases. The amount of deviation in a PM system is determined by the "slope" of the modulating signal. The slope of an audio signal will increase if the amplitude remains constant and the frequency is increased. This is reasonable if you consider that a higher modulating frequency involves a faster change in a shorter period of time.

A PM system can be made to produce a true FM signal by inserting a so called predistorter in the audio system. Such a distortion would attenuate the audio signal at a rate of 6 dB per octave so that a high frequency audio signal would reach the modulator at a lower relative amplitude than a low frequency signal. Therefore the phase shift is reduced and a decrease in deviation results. The natural 6 dB preemphasis of the phase modulator is used to good advantage in two way radio systems to improve the signal-to-noise ratio.

Four distinct steps are involved in processing the audio signal for application to the phase modulator. These involve an input

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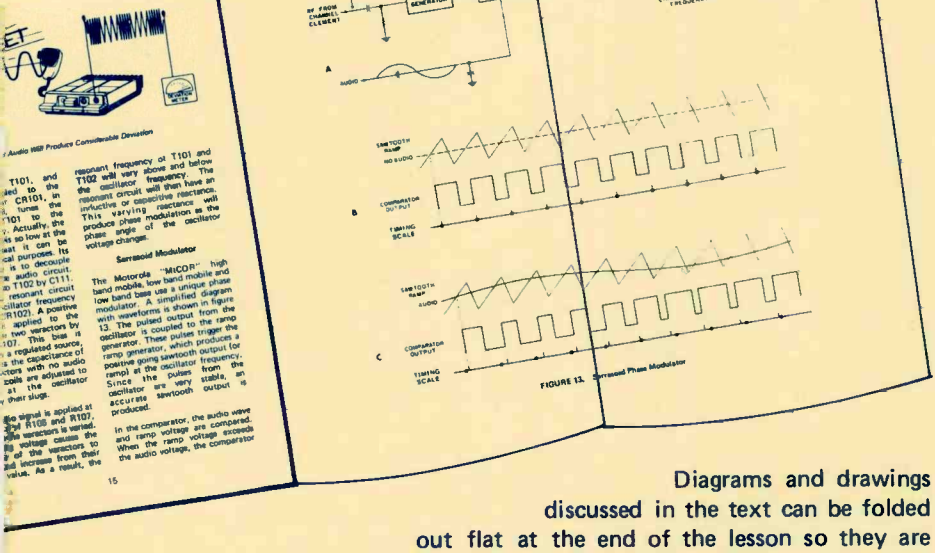


...Audio With Produce Considerable Deviation

...T101, and ...ded to the ...r CR103, in ...s, tunes the ...T101 to the ...r. Actually, the ...es so low at the ...eat it can be ...cal purposes. Its ...is to decouple ...e audio circuit ...to T102 by C111. ...resonant circuit ...illator frequency ...R102). A positive ... applied to the ... two varactors by ...107. This bias is ... a regulated source, ... the capacitance of ...ctors with no audio ...tools are adjusted to ...at the oscillator ...y their slugs.

...dio signal is applied at ...ction R105 and R107. ...ese varactors is varied. ...dio voltage causes the ...ity of the varactors to ...and increases from their ...value. As a result, the resonant frequency of T101 and T102 will vary above and below the oscillator frequency. The resonant circuit will then have an inductive or capacitive reactance. This varying reactance will produce phase modulation as the phase angle of the oscillator voltage changes.

Serrasoid Modulator

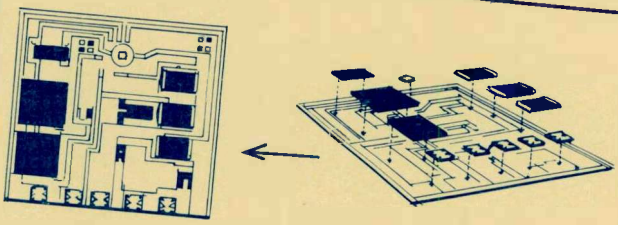
The Motorola "MICOR" high band mobile, low band mobile and low band base use a unique phase modulator. A simplified diagram with waveforms is shown in figure 13. The pulsed output from the oscillator is coupled to the ramp generator. These pulses trigger the ramp generator, which produces a positive going sawtooth output (or ramp) at the oscillator frequency. Since the pulses from the oscillator are very stable, an accurate sawtooth output is produced.

In the comparator, the audio wave and ramp voltage are compared. When the ramp voltage exceeds the audio voltage, the comparator

15

FIGURE 13. Serrasoid Phase Modulator

Diagrams and drawings discussed in the text can be folded out flat at the end of the lesson so they are always in front of you while reading through the text – similar to the way this foldout is arranged.

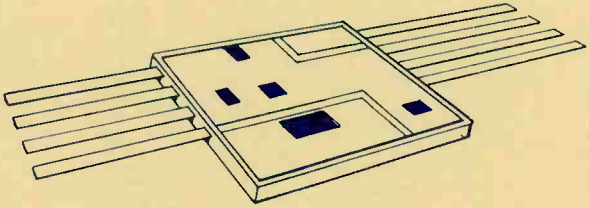


These Drawings Illustrate Construction Of A Thick-Film IC

even inductances. Because of their miniature construction, they are limited in their power handling ability and the values of the components. At this point, it is not feasible to include a 500 mF, 400 volt capacitor in an IC. The use of IC's in two-way receivers is constantly increasing.

There are two general classifications for IC's: The monolithic integrated circuit and the thin-film IC. Both types may be combined in one unit, of course. Monolithic means to compose a harmonious whole. Integrated means brought or fitted together, while circuit simply means a path over which electric current flows. Generally, a monolithic integrated circuit is designed to perform some complete function by itself - like an IF amplifier section, audio amplifier section, squelch section, etc.

The thin-film IC is built on a substrate made of some insulating material such as glass or ceramic. The passive components such as resistors, capacitors and the interconnecting "wiring" are deposited on the substrate by evaporation,



A Thin-Film Integrated Circuit

The MTI course is written for you, the service technician. It was written by authors with decades of actual FM two-way radio experience. The lessons are the size of this booklet, making for easy study. Look inside to see how the convenient foldouts work.

What Our

Students Say About Us

IS MORE IMPORTANT THAN

What We

Say About Ourselves

Student Comments

I just want to tell you how much I have enjoyed this course. It has helped me tremendously at work as we have quite a few Motorola radios.

As you can see, I have taken several correspondence courses. I have found your's to be the best presented. I was actually able to relax while studying your course and looked forward to sitting down and studying my lessons. The material was presented in an easy to follow and easy to understand manner. The promptness with which the lessons were serviced made a very favorable impression. The courtesy of your staff both in correspondence and on the phone was most pleasing.

As Advertised, I found your course To Be Clear, easily understood AND FULL of informative "EXTRAS"

I would like to take this opportunity to thank you for allowing me to review your newly revised MTI course. You have taken a difficult subject and through a thorough knowledge of the subject prepared an outstanding correspondence course in the field of electronics and its application in the field of two-way radio communications.

Your course was a bargain money wise and value wise and I feel fortunate in having the opportunity to gain the information contained in the course.

The course provided just the information that I was seeking.

Student Comments

Your MTI 2-way Radio Course is an excellent course – well thought-out and covers the scope of the 2 way Radio Field completely.

As an electronics instructor and a recent graduate of your Two-Way Radio Home Study Course, I am impressed by the completeness and practicality of your course and especially the texts.

Having taken your course has been most informative and enjoyable. I would recomend it to anyone interested in FM-Radio.

I have learned more about Diodes and Transistors in these first 3 lessons than I did in two years with Bell and Howell and there I studied Transistors for about 9 months. Thank You.

I recently received my MTI certificate and am proud to display it next to my "first phone" license. The MTI courses certainly deserve more recognition than they get. Having taken several highly regarded correspondence courses, I believe that MTI would have to be classed as the "Rolls Royce" among them.

SPECIALISTS GIVE MTI HIGH RATING

An educational institution hired two independent Subject Specialists to review the MTI course. We don't know who they were, but we did obtain copies of their evaluations.

We are not permitted to tell you who the educational organization is. That's unfortunate, because you would be even more impressed by the evaluation if you knew.

Turn the page, and read what these specialists said about MTI. Remember, we did not hire them and have never knowingly had any contact with them!

EVALUATION
SPECIALIST #1

- The course covers theory of transistors, FM receivers and transmitters, test equipment, and troubleshooting. It is entirely adequate to meet these objectives.

- The material is up to date and covers modern servicing methods.

- The lessons are professionally written and easily understood. The reading level is correct. The lessons begin with the basic theory of transistors then progress through the various methods of usage and testing.

- The course is well organized. Every sentence is meaningful, there are no superfluous words. The course builds on acquired knowledge.

- There are no teaching devices; however, motivation appears to be adequate, although dependent upon the attitude of the student.

- The illustrations are profuse and to the point. Many are humorous cartoons. They are well chosen and adequate.

- This course combines the best of two worlds in so far as the format is concerned. The lessons are individually bound in small loose-leaf binders. The small size permits study in spare moments, such as commuting, while the loose-leaf feature permits the school to make modifications or up-dating easily.

EVALUATION
SPECIALIST #2

- This is the most complete and authoritative coverage of two-way radio I have ever seen.

- In my opinion, there is nothing as good as this material anywhere.

- The material is outstanding from the standpoint of both technical electronics and home study. It is very specifically addressed to the technician who might not know much mathematics but would not need it anyway. That is, there is no attempt to make nor to teach a PHD.

- I took a great deal of time evaluating this course material and was foiled at every attempt to find something wrong with it. It was frustrating, and at the same time very satisfying.

- Illustrations (some in cartoon form) are excellent and say what is necessary while providing relief from a complex subject. The fold-out circuitry diagrams are convenient to use and very good.

- Again, what could be more functional than conveniently carried small texts with double columns for easy reading? Reference materials are appropriate and supplement the text material very well.

All courses are written for the technician with some previous background in electronics. They are presented in a sequential, step-by-step analysis. This is especially valuable for the technician already employed in the communications industry, as well as for those working in other fields of electronics who desire to enter the communications profession.

The MTI course is different. Math has been eliminated. Instead of studying pure theory, circuits from actual two-way equipment that you might service are analyzed. Each MTI lesson and the related reference texts are clearly written to give you a thorough knowledge of the commercial two-way radio field.

As a prospective student, you must meet at least one of the following requirements:

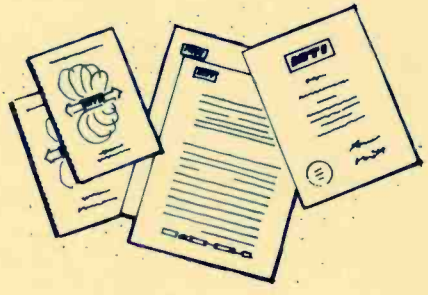
--FCC license (other than 3rd Class or restricted).
--Previous training in basic electronic theory; at least one year.
--At least two years experience servicing electronic equipment.
--Military electronics training.
--Minimum grade of 60% on MTI Entrance Examination.

If you're not certain that you qualify, ask for an entrance exam. There is no obligation and no salesman will call.

MTI offers this home study program to you as a self-development course, designed for those technicians who want to really know how FM two-way radios operate and how to service them efficiently. If you want to maximize your success in two-way. . . MTI training is the way!

If we haven't answered all your questions concerning MTI, direct a letter to Mr. Donald R. Wallower, Director.

If all of your questions have been answered. . . welcome to MTI, the only complete source for FM Two-Way Radio Communications Training.

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