# Two QSK Controllers for Amplifiers

*Editor's note: This article is an expanded version of material found in Chapter 24 of the* ARRL Handbook. *It was contributed by Jim Colville, W7RY, and Paul Christensen, W9AC. Figure and section references are from the 2014 edition of the* ARRL Handbook. *Additional information and support files relating to these projects may be found on the* Handbook *CD-ROM.*

Many CW operators feel that QSK — or *full break-in* — operation is the most natural and conversational way to operate. "Full" break-in switches between transmit and receive so quickly that the operator can hear anything happening on the channel between individual code element dots and dashes. (*Semi break-in* uses a VOX-like circuit, remaining in transmit until a delay timer expires.) That sense of transparency enables the operator to respond immediately to interference or requests from other stations. Originally developed in support of high-speed CW traffic passing, QSK today is most often used by contest operators and for high-speed ragchews.

For low-power operation at 100 to 200 W, QSK circuits can use relatively small relays or solid-state PIN diode switches. However, when an amplifier is used, the requirements for voltage and current-handling go up dramatically. This leads, in turn, to the use of vacuum relays and high-power PIN diodes. *Hot-switching* — opening or closing mechanical contacts during current flow — greatly accelerates wear and can even destroy the relay contacts. Preventing hot-switching requires strict timing and interlock design to make sure the proper sequence of switching-then-transmitting occurs every time.

QSK controllers generally fall into one of two general types: hardware-only, in which the timing and logic of the sequential operations are built-in to a hard-wired circuit, and software, in which the switching circuits are under the control of a microprocessor. This pair of QSK controllers includes one from each camp: Jim Colville, W7RY, designed an analog controller and Paul Christensen, W9AC, programmed an Arduino processor for his controller. You can choose to implement whichever project you feel most comfortable with. We'll begin with an overview of QSK operation by W7RY and then present both projects.

## SAFETY

Should you decide to add QSK to your amplifier, you'll be working inside the amplifier. Safety is the top priority in working on any equipment that contains high voltage, such as a vacuum tube amplifier. The shorting straps and interlocks are there for your safety, please respect them and be very careful! Read and follow the recommendations of the High Voltage Techniques section of the **Power Sources** chapter and the **Safety** chapter of this book.

Also be sure to operate the amplifier with all shields in place. You don't want to exceed the MPE (maximum permissible exposure) of RF energy to your body. And you just never know when the cat is going to jump up on your workbench!

## BASIC QSK PRINCIPLES

How is QSK different from PTT or semi-VOX operation in an amplifier? When switching is controlled by manual use of a PTT switch, the amplifier relays are usually energized long before the RF is output by the transmitter. With semi break-in, the receive/transmit transitions are usually between words or syllables rather than between dots and dashes.

Several things have to happen quite quickly with QSK, especially when you're sending CW at 30 WPM!

1. Switch the amplifying device bias from cutoff to the proper operating bias setting in less than 2 milliseconds.

2. Switch the RF relays from the bypass mode (in which the transceiver is connected directly to the antenna and the amplifier is biased OFF) to the transmit mode (in which the antenna is connected to the amplifier output and the transceiver is connected to the amplifier input). This must happen before RF starts flowing from the transceiver into the amplifier. (We are assuming the use of a modern transceiver for the remainder of this discussion. The same principles apply in switching separate receiver-transmitters.) **Fig 24.68** shows the basic relay wiring for a QSK system.

This design uses only a single-throw relay for routing transmitter output to the amplifier input. Using a double-throw relay with another contact for receive adds another opportunity for the contacts to become intermittent in the receive path. Henry Radio used the approach in Figure 24.68 for all of their later production runs of amplifiers. Relay contact materials that are rated for transmitter output levels can become intermittent at the extremely low levels of received signals.

### Basic Timing Considerations

When the key or keyer paddle is pressed, several things happen in the transceiver. First, the key or paddle state must be read by the rig's keyer or microprocessor. The transceiver then switches into transmit mode, which mutes the receiver, switches the amplifier keying circuit, and starts to output RF. Most modern transceivers have the option (usually a menu selection) for either a mechanical relay or FET amplifier keying circuit.

Proper QSK operation depends on the delay between when the transceiver's linear amplifier keying relay energizes (after contact bounce has stopped) and when the radio starts to transmit RF. This delay, which is easily measured, is the key element in control of linear amplifier antenna relay and bias switching. The author has measured many modern transceivers such as the ICOM IC-7600, IC-751A, IC-7200, IC-756 PRO-II, and IC-756 PRO-III. All of these transceivers typically have a delay from final contact closure to RF output of about 4 to 6 milliseconds, shown for the IC-7200 in **Fig 24.69**. (The IC-751A is actually adjustable with an internal control.) The timing in SSB and RTTY seems to follow the CW timing in most radios.

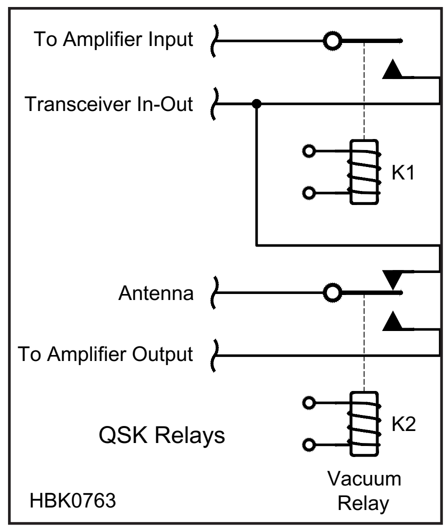



**Fig 24.68 — Basic organization of relay switching for QSK.**

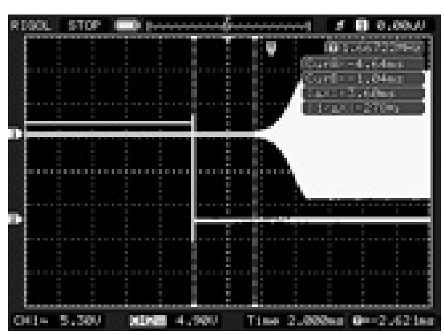


**Fig 24.69 — The relay-close-to-RF timing for an ICOM IC-7200. RF output appears 3.6 ms after the amplifier relay contacts close. The relay-to-RF time can be increased 1.5-2.0 ms by substituting a small switching transistor for the relay.**

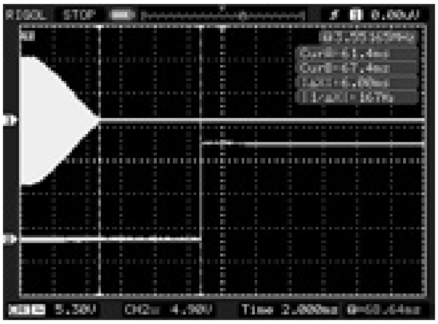


**Fig 24.70 — The same ICOM IC-7200 timing from RF-stop to relay contacts open. There is 6 ms between the end of the RF output and the relays returning to receive.**

The same process works in reverse when going from transmit to receive. RF output stops, the amplifier switching circuit changes back to receive, and the receiver is un-muted. This delay is typically a bit longer and **Fig 24.70** shows the IC-7200 delay, measured at about 6 ms.

If PIN diodes are used for switching the RF, speed is generally not an issue as the diodes switch in microseconds. If electromechanical relays are used, however, the few milliseconds available when going from receive to transmit require a fast relay. Reed relays are typically used for low power, such as the output of the transceiver, and are fast enough to use for QSK. Higher power, high-speed vacuum relays must be used at the amplifier output. These relays open and close in around 1 ms and are rated for millions of open-close cycles.

All mechanical relays and switches have contact bounce because of flexing in the relay's moving armature. Contact bounce is clearly visible with an oscilloscope when measuring the time it takes for a relay to close or open. All of the measurements in this article include the contact bounce time until the contacts are ready for power. A more detailed discussion of modifications to speed up the relay circuits is available in the PDF article "W7RY QSK Relay Timing" also included on the *Handbook's* CD-ROM

Proper control of switching timing has benefits other than operational convenience. As W7RY relates, "After adding QSK to a Drake L-4, a Kenwood TL-922, and a Heathkit SB-200, the pesky arcing in the tuning capacitor stopped. The TL-922 was especially prone to it and the Heathkit SB-200 did it quite often when I was checking out the amplifier after I had purchased it. What happened?

"The arcing stopped because the amplifier was no longer hot-switching the relays and applying RF drive before the output of the amplifier was transferred to the antenna system! The Kenwood TL-922 has two huge, slow and loud antenna change-over and bias switching relays. With those s-l-o-w relays, the RF drive was getting to the tubes before the output relay contacts had switched! It was that simple. The Drake had arced in the tuning capacitor at least once. Now, it's smooth as silk. I used my TL-922 with QSK in the 2012 and 2013 ARRL RTTY Roundup contests and it worked perfectly! No arcs or sparks in the entire 30 hour contest on 10, 15 and 20 meters."

Note that properly designed QSK systems prevent hot-switching of the relays and possible arcing in the output tuning network whether full QSK is used or not. This will reduce wear of the relays and stress on the amplifier, leading to more reliable operation.

### Tube Bias Control

In a vacuum tube linear amplifier, the QSK circuit must switch the tube's cathode-to-grid bias from cutoff in receive to a resting-current condition in preparation for transmit at the same rate as the antenna relays. The cutoff bias voltage must achieve the ZSAC (Zero Signal Anode Current, a.k.a. idling current) as stated by the tube manufacturer. For most 3-500Z amplifiers using ~3200 V, this voltage needs to be between 6 and 8 V.

### Components and Construction for QSK

Placement of the relays in the amplifier isn't critical, but installing the relays near the input and output connectors is usually the most convenient and keeps leads short. Relay mounting isn't critical except for keeping them quiet. The author recommends mounting the relay on a rubber grommet through a hole or on a "bed" of silicone glue/sealant. Lead connection has a lot to do with keeping the relays quiet. The shield braid of RG-174 coax works well to absorb vibration. Just make sure you don't get the braid full of solder, or the extra stiffness defeats the purpose. Bend the braid into a fairly large horseshoe shape and solder to the relay terminals, and then solder either to the RF connector directly or to the coax that connects the other circuitry.

Reed relays have glass-encapsulated contacts in a vacuum and a coil wound around the outside of that glass housing. The reed doesn't have to travel very far to make contact so the relay is extremely fast: closing is measured at less than 700 µs (0.7 ms) and opening slightly faster, on the order of 500 µs or less. A contact rating of 1 to 2 A is sufficient for 100 W or less of drive. Because of the speed, relay coil voltage is not critical. A resistor across the coil can compensate for higher or lower coil voltage and current. A 12 V coil reed relay is recommended.

Remember that when the amplifier is turned off or bypassed, the transmitter output RF doesn't pass through the reed relay. You can use a small mechanical relay, but they are slightly slower than a reed relay and are also noisier. Be cautious with the mounting and lead connections to keep the "sounding board" effect to a minimum.

The amplifier output vacuum relay must be of the smaller type such as the Jennings RJ1A, Kilovac HC1, Gigivac GH1, and the generic VHC-1. The Jennings RF1 style is just too slow, as are any of the glass-envelope vacuum relays. Do not use an HC3 or VHC-3 type of relay because they are rated only for dc, not RF.

The RJ1A relay's specified close time is 6 ms. Measurements show a typical closure time of about 3 ms. By using a higher initial voltage, the closure time can be reduced to as little as 1.5 ms, but the average time is around 2 ms.

The relay's release time depends on the relay coil's kickback suppression circuit. The usual circuit is a reversed-biased diode connected across the coil. A resistor in series with the diode dissipates some of the energy in the coil and helps release the relay armature more quickly.

## W7RY — Analog QSK Controllers

This project is really a series of controllers developed by W7RY for several popular non-QSK amplifier models. The SB-220 QSK controller shown in will be summarized as a design example — the schematic is shown in **Fig 24.71**. Additional construction details for the SB-220 controller are presented below. Design information for the Heathkit SB-200 and the Kenwood TL-922 QSK controllers are also included as separate packages of files on the CD-ROM.

The goal was to design a board that would be easy to install by anyone with electronics background with little to no support. The other requirement was little to no addition of major components to the amplifier. With the varieties of boards that the author designed, there is probably a board to fit most any amplifier. (See W7RY's web page **www.qrz.com/db/W7RY** for more information on these designs.)

As you may know, some older linear amplifiers used a fairly high voltage to switch the transmit-receive relay(s). Solid-state transceivers then had to use an external relay, which added even more delay to an already slow switching system, or install an aftermarket soft-key module into the amplifier.

The controllers use low voltage switching signals so that no additional power or interface signals are required. There is also a positive

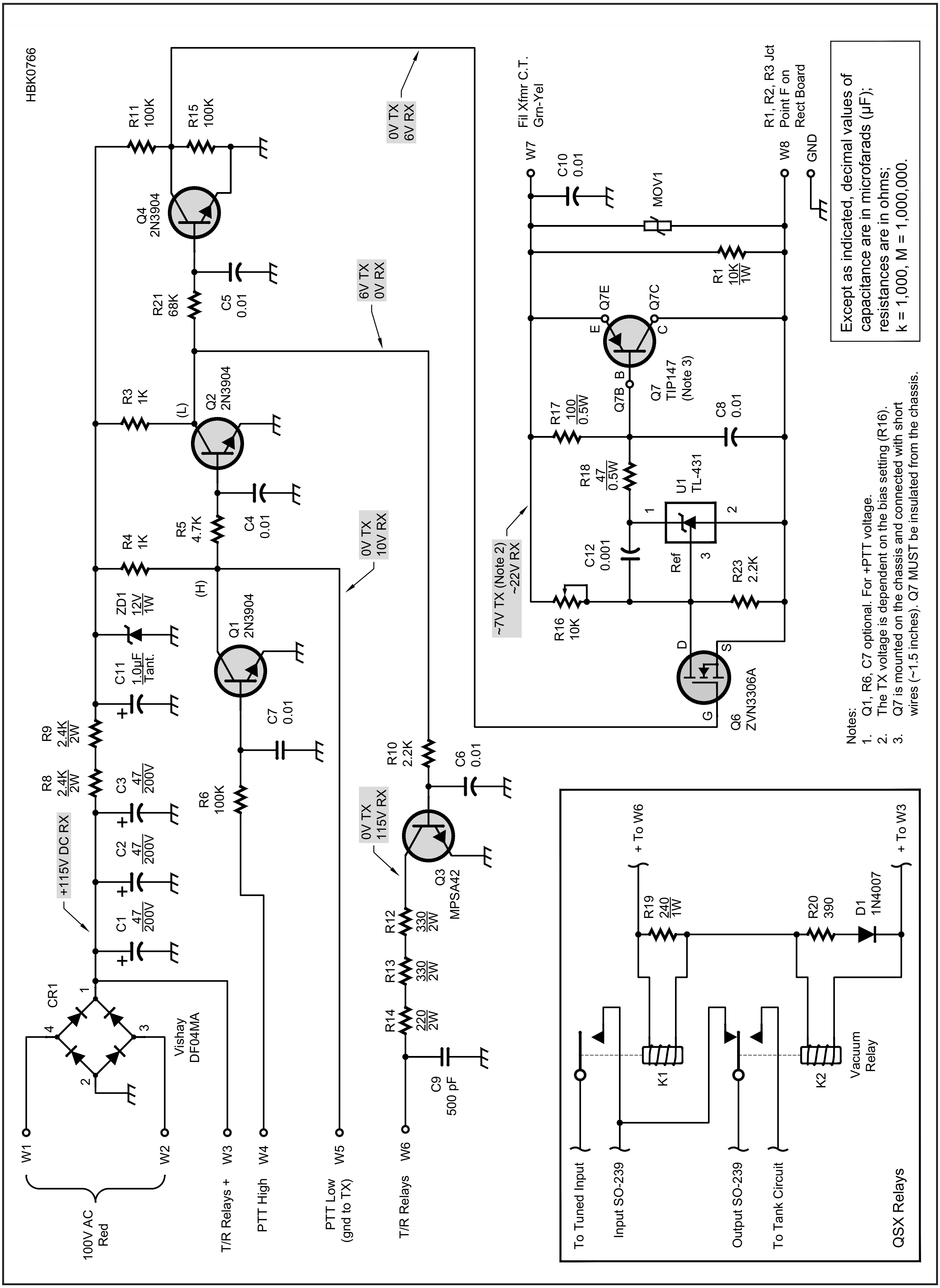



**Fig 24.71 — The schematic for the SB-220 QSK controller. A PC board and parts list may be found elsewhere on the CD-ROM.**

voltage input switching line if the available amplifier keying signal is positive-going. Some radios have a very fast positive-going keying signal that is even faster switching than the grounded amplifier relay switching signal. If the amplifier switching relay is a bit slow in your particular transceiver, you might be able to use a positive voltage to key the amplifier.

## SB-220 QSK BOARD — THEORY OF OPERATION

The W7RY QSK board uses hardwired transistor logic to switch the bias and QSK relays. The Parts List (all part numbers are Mouser Electronics) is included with the PCB layout as separate PDF files on the CD-ROM with this article.

The transceiver's amplifier keying line (also called PTT) can be either grounded during transmit (the usual case) or positive for transmit. If grounded during transmit, PTT should be connected to W5. If positive during transmit, PTT should be connected to W4. Q1 and R6 are required only if the amplifier is to be keyed from a positive going source such as T8 in the ICOM transceivers.

When in transmit, the PTT signal causes the base of Q2 to go low through pull-up resistors R4 and R5 which normally keep Q2 turned on. Grounding the base of Q2 turns it off, which turns on Q3 and Q4. Q3 turns on the QSK relays through R12, R13 and R14.

Q4 grounds the gate of Q6, which is normally high, and keeps U1 turned off. With Q6 turned off during receive, the resulting cathode-to-grid bias on the 3-500Z tubes is approximately 22 V, which keeps the tubes cut off and no plate current flows.

During receive, the precision Zener reference, U1, provides no bias voltage to the base of Q7. During transmit, Q6, an N-channel MOSFET, turns off and U1 provides bias to the base of Q7. Q7 forms an adjustable regulator with the voltage adjusted by R16 to set the ZCAC (zero signal anode current) to the proper level. A ZCAC of approximately 130 to 150 mA is ideal for a pair of 3-500Z tubes.

The power supply for the board is derived from a simple bridge rectifier and three filter capacitors, C1-C3. The three capacitors were chosen to keep the height of the board low so it would fit under the SB-220 chassis. Voltage dropping resistors R8 and R9 along with ZD1 and C11 form the low voltage power supply for the switching circuits.

Originally recommended by Rich Measures, AG6K, this design uses a fairly high initial coil voltage derived from the original 120 V ac relay coil voltage supply to speed up the closing of the contacts on the relays. Heathkit used a 100 V winding in the SB-220 and a 120 V winding in the SB-200. These were easy to use for a high voltage supply to speed up the vacuum relay circuit.

To achieve the same results, use a simple voltage doubler in a QSK controller for the Drake L4/L7 as well as the Ameritron amplifiers. For the Drake controllers, the existing 21 V transformer winding was used for the stock transmit receive relay. On the Ameritron board, the only voltage available is a 12 V ac winding, so a small 21 to 24 V transformer must be added.

### SB-220 Modifications

A few modifications are made to the amplifier itself. Start by adding a 1N5408 (1 kV, 3 A) diode from the negative side of the power supply rail (B–) to chassis ground at Point D and Point C of the SB-220 diode and metering PC board. (See **Photo A.**) Connect the diode anode to ground. Add in parallel with the diode a 0.1 µF, 50 V ceramic capacitor across the diode.

The new diode/capacitor combination helps protect the meters and the metering resistors by limiting the fault current in the event of a fault in one of the tubes or other high voltage components. In the event of a fault, the capacitor will usually short. A detailed explanation of why this protects the meter is available on the W8JI website at **www.w8ji.com/fault_protection.htm**.

Remove the following components:

- Existing TR relay RL1, and R27
- Zener diode, ZD1 (the new board supplies bias for the tubes)
- Do not remove RFC6.
- ALC and existing relay power supply components — D18, C4, R4, R5, C5 and the terminal strip that supported all of these components. This is where the new QSK board will be installed.

Install the 10 Ω, 10 W wire-wound glitch resistor in the high voltage line of the SB-220 to limit current in the case of an internal arc in the tube(s). This is recommended for any tube type linear amplifier. Install the resistor between Point J of the rectifier metering board to the chassis feed-through that connects to RFC-2 on the inside of the tube compartment. Replace the wire between the feed-through and Point J with the resistor. You will have to bend the resistor leads a bit, but it will fit.

### Installing the QSK Board

Installation of the board in the amplifier is straightforward and the final result is shown in **Photo B**.

The two red wires from the filament transformer connect to W1 and W2 respectively. You may have to lengthen these wires depending on your particular amplifier construction. These wires were connected to D18 and ground. Remove the red transformer

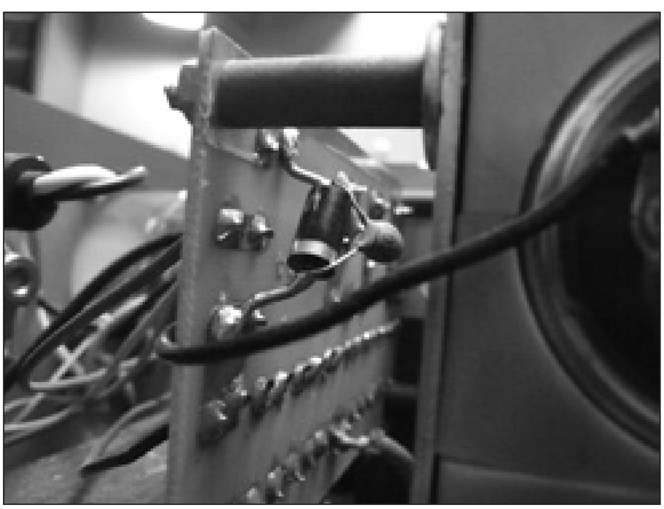


**Photo A — The location of the new 1N5408 and 0.1 µF capacitor.**

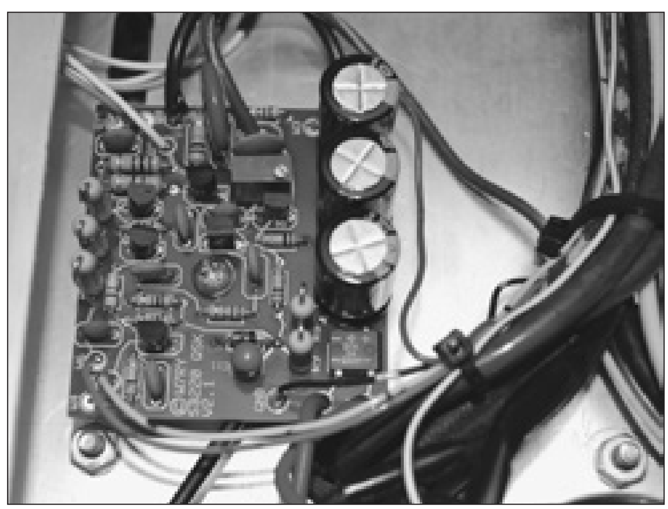


**Photo B — The W7RY QSK board installed in an SB-220 amplifier.**

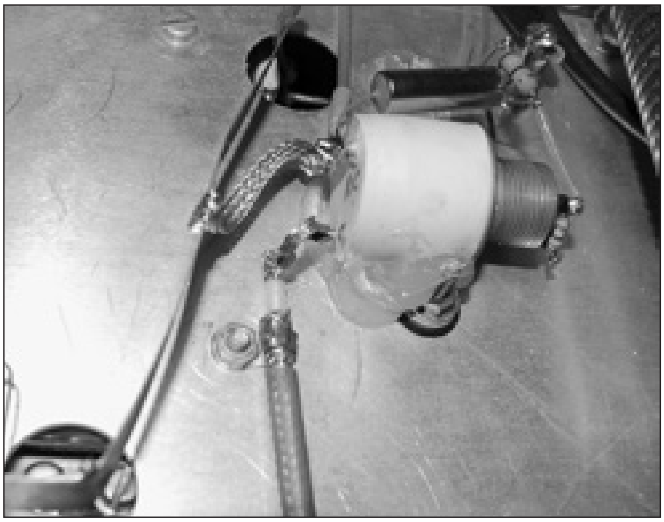


Photo C — The amplifier output relay is mounted on silicone adhesive for soundproofing.

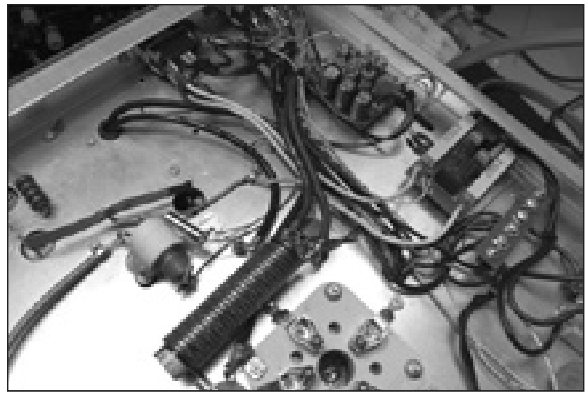


Photo D — The relays and completed QSK board installed in the SB-220.

wire that was connected to ground via the terminal strip.

W3 connects to the positive side and W6 connects to the negative side of the new QSK relays.

W7 connects to the center tap of the filament transformer, a green wire with a yellow stripe, which is also connects to the cathode of the amplifier tubes.

W8 connects to the point on the rectifier and metering board where the original ZD1 anode was connected. This point is the same circuit board trace on which point F is located.

Transistor Q7 is mounted to the chassis with an insulator and either a nylon machine screw or a shouldered insulating washer. Q7 must be insulated from the chassis. Use short wires to connect Q7 to the QSK board. Be careful to verify the emitter, base and collector pins of your particular transistor. Some manufacturers have different configurations of the pins.

Mount the vacuum relay on the chassis in a "bed" of silicone adhesive as shown in **Photo C**. This helps keep the relay quiet. You can also mount the vacuum relay on a small L bracket. For the input reed relay, mount a single standoff insulator onto the chassis and then mount the relay between the normally open (N.O.) contact of the vacuum relay and the standoff. Mount R19, the 240 Ω relay resistor across the terminals of the reed relay coil.

Use hookup wire to connect the resistor and the relay coil to the vacuum relay coil and to W6 as shown in **Photo D**. This picture shows the vacuum relay, reed relay and the QSK board. You can also see a W7RY step-start board mounted near the voltage-select terminal strip on the bottom of the Heathkit SB-220. Q7 is mounted under the step-start board.

Use RG-142 or RG-400 Teflon-insulated coax for the high power connections. It's much smaller and has more power handling capacity than RG-213. For the low power RF connections, use RG-316 which is also Teflon-insulated and about the size of #16 AWG wire, the same size as RG-174. RG-174 is not recommended. RG-316 handles 750 W at 30 MHz.

### Relay Substitutions

Do not substitute a different vacuum relay. You can substitute a different relay for the reed relay as long as it's fast enough with a switching time of less than 3 ms, with 2 ms preferred.

If you can't find the specifications for a relay, measure its speed using your transceiver. Connect the relay coil to the radio's amplifier keying output with the radio configured for full break in and connected to a dummy load. Use a 9 V battery and a 1 kΩ resistor in series with the relay contacts for measurement. Avoid using a regulated power supply because the contact closure can cause ringing in the measurements that will appear as contact bounce.

Using a dual-trace oscilloscope with one trace showing the coil voltage and the other showing voltage across the contacts, key the radio with a rapid string of dits and measure the time from the coil energizing to the time it takes the contacts to close with a good dual trace scope. A storage scope is best so you can analyze the data or trigger on the amp keying signal from the radio.

If you do substitute the input relay, calculate a new value for R9, the resistor in parallel with the relay coil. The parallel combination of R9 and the relay coil should draw the same amount of current at 12 V as the vacuum relay requires — which is approximately 80 mA. As currently designed, the current through R9 is 50 mA and the reed relay draws 30 mA for a total of 80 mA.

## W9AC Universal Sequential QSK (S-QSK) Controller

The Universal S-QSK (S-QSK) board (**Fig 24.72**) is designed to control many RF switching applications, all controlled by an on-board Arduino Nano or PIC microcontroller. Through a choice of microcontroller programs, one S-QSK board can manage many different types of switching functions. Sample code, line-by-line documentation, and structured flowcharts are provided to assist the novice programmer with code customization. Structured logic is used for easy code modification. Copy and paste the source code into the Arduino software's edit window, then upload to the Nano board with a mini USB cable.

Presently, three programs have been written for S-QSK: an amplifier QSK controller; a TR switch for separate receiver-transmitter combinations, and a protection circuit for receiver inputs. When used as a QSK controller, S-QSK is designed to be used with the user's choice of external RF relays or a PIN diode switch. Circuit boards to support PIN diode TR switching and remote outputs that will interface with S-QSK's headers are being developed by the author.

The schematic of the S-QSK is shown in **Fig 24.73** (See pages 8 and 9). A complete parts list, PCB layout drawings, flow charts, and C++ source code are additionally provided on the CD-ROM accompanying this book. In addition, a double-sided professionally-made PCB is available from the author via his website at **www.qrz.com/db/w9ac**. Updates and revision information will also

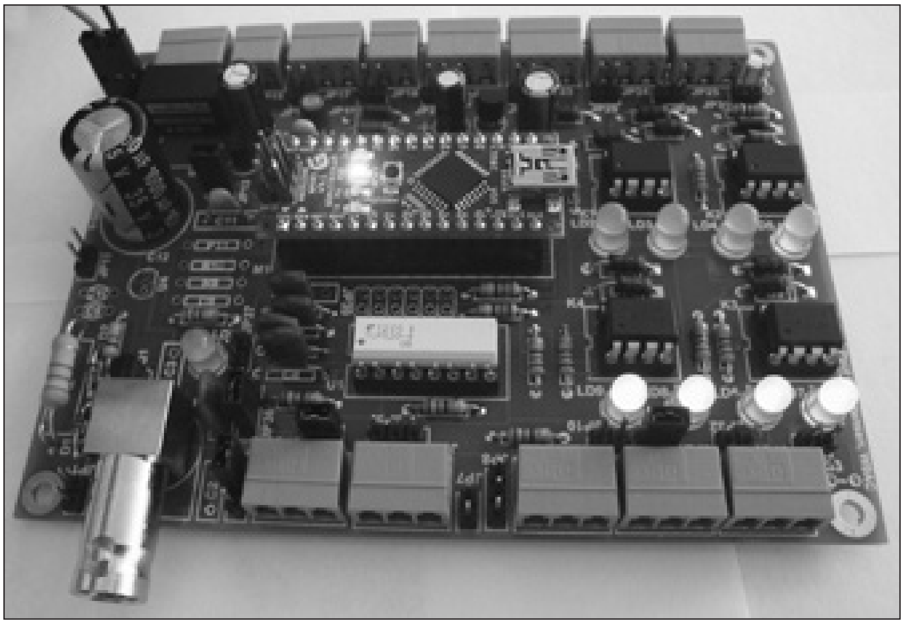


Fig 24.72 — The S-QSK board showing the Arduino microprocessor and the LED error indicators. The RF SENSE input connector is at the lower left. [Paul Christensen, W9AC, photo]

be made available on the same web page.

A powerful attribute of the Arduino microcontrollers is that they come pre-programmed with a bootloader, allowing the user to quickly upload new C++ code without the use of an external hardware programmer that is commonly needed for PIC and EEPROM chips. Connect a mini-USB cable to a PC USB port and you're ready to program. Optionally, the user can bypass the bootloader and program the microcontroller through the ICSP (In-Circuit Serial Programming) header.

The microcontroller and peripheral circuits are powered by the USB port during testing, and an external +7 to +12 V supply powers S-QSK during normal operation.

### S-QSK FEATURE SET

A common hardware platform is used to implement many applications where precise timing is required between switching events. The hardware remains the same; only the source code changes for different applications.

- An Arduino Nano or PIC microcontroller plugs into the S-QSK motherboard. Programming a Nano requires no special hardware — code is uploaded via a USB cable from the host PC. For advanced programmers, a 16F88 PIC chip can be used in place of the Nano;
- Uses screw-down Phoenix-style I/O connectors. Each I/O connector can be unplugged from the motherboard for easy assembly and servicing;
- Four digital input channels; eight digital output channels. Header for access to optional analog channels;
- Optically isolated I/O for maximum RFI immunity. Photo-Darlington transistors on the input and solid-state PhotoMOS relays on the output;
- Each input channel can be selected for dry contact closure, fed from a solid-state open collector — or any other solid-state switching device;
- Each output channel can be selected to float or reference circuit ground. Each output can be jumper-selected to function as a current sink or current source;
- RF sampling via BNC connector or 2-pin header. RF is converted to a dc level and conditioned to drive photo-coupler. RF sensing activates with less than 100 mW of RF power;
- Remote RF sensor board can be used to sample RF at a distant location or where a T RF connection presents an unacceptable line mismatch;
- On-board LED diagnostic status indicators on all output lines;
- Uses a +12 V dc-dc converter, bootstrapped to the +12 V supply to provide +24 V for vacuum relays;
- Two optional, jumper-selected relay coil accelerators;
- Board can be populated with only the circuits of interest, thereby saving on construction cost and assembly time;
- Precise control and delay of all steps in 1 ms timing increments;
- Significant hot-switch fault protection built into the code. Before anything can switch between steps, RF is first sampled and judged with the state of the input key line;
- Small board size: S-QSK measures 4.5 × 3.5 inches. The remote RF sensor is 1.7 × 1.6 inches.

## S-QSK OPERATION

S-QSK precisely sequences all critical timing elements between an RF power amplifier and transmitter/transceiver. The S-QSK board will work with QSK and non-QSK amplifiers. A sequenced electronic bias switching (EBS) system is created and supports both two-state and three-state bias control. Switching between types only requires a simple change to the microcontroller code.

The delay time between events is independently adjustable to accommodate various transmitter and amplifier timing characteristics. The input key and RF sensing lines are polled in a loop. Depending on the line states and the state of a flag bit, the S-QSK board's output key line, solid-state relays, and bias control are switched with time sequencing to avoid "hot-switch" effects. (See the flow chart files provided with the source code.)

S-QSK offers hot-switch RF protection by sampling the presence of the complete RF envelope. If RF excitation is present at the input to the S-QSK board before the input key line is active, a switch from receive to transmit is inhibited. Likewise, if the RF envelope has not decayed to zero after transmission, the S-QSK board will not switch back to receive. If either type of timing fault occurs, one of two LEDs will illuminate, showing a fault. The LEDs remain lighted until the timing fault clears. Each LED is pulsed to remain on for 0.5 second in the event of brief timing faults. Upon detection of a post-switch fault, bias lines are deactivated, providing further amplifier protection.

For three-stage EBS systems, "hang" bias is supported and is adjustable by the user from 0 ms to 255 ms in 1 ms increments.

In addition to establishing precise timing between amplifier switching elements, S-QSK can accelerate the relay activation time of frame-type output and input relays. The board contains two optional relay coil accelerators, each powered by a choice of +12 V or +24 V power buses. The accelerator circuits are engaged with header jumpers. For mechanical TR switching, Jennings RJ-1, Kilovac HC-1, and Gigavac GH-1 are all good choices for the RF output relay when they are powered at their rated supply voltage. For the input relay, consider the Aromat/Matsushita RSD-12V.

An RF input sample is capacitively coupled by C1 from the RF SENSE input connector J1 or JP1 header to a detector circuit consisting of R1-R3, C3, D1-D2 and Q1. RF sampling is optically isolated from the microcontroller digital inputs by a photo-transistor in U1. A remote RF sampling board (under development as this edition was being prepared — see the author's website) can also be used in instances where a T RF connection presents an unacceptable line mismatch or where the sample point is at a long distance from the main S-QSK board. The detector circuit will indicate the presence of RF at less than 100 mW of power.

## S-QSK CONTROL BOX FOR CLASSIC SEPARATES

For the QSK Control Box project, the S-QSK board is used as the foundation of a fast and silent QSK TR system for quickly switching classic transmitter and receiver "separates." A switching limitation of modern transceivers is that a common oscillator is used for both Receive and Transmit modes. For several reasons, stabilization of the oscillator is not instantaneous with the switching transition. Since separate VFOs are normally used with separates, it's possible to let the VFOs free-run without transmit offset interruption and perform the TR switching function external to the transmitter and receiver.

External RF switching relays are hot-switch protected by sampling the presence of the complete RF envelope. Lead and tail timing errors inhibit switching and activate fault LED indicators.

Of interest to CW operators is an auto-keyed element length retention algorithm that adds back the amount of lead-in delay to the RF envelope. Generally, it's the lead-in delay that otherwise results in so called "dit shortening" in modern transceivers.

With high-isolation RF switching, there's no need for a separate CW sidetone line; the receiver is tuned to the frequency of the transmitter. The microcontroller accepts an input from any electronic keyer, straight key or semi-automatic bug. Through software, lead-in and tail times are independently adjustable in 1 ms increments.

## S-QSK STATION RECEIVE ANTENNA AND PREAMP SEQUENCING

S-QSK can be used to emulate KD9SV's "Front End Saver," a device first described in the February 1997 issue of *CQ Magazine*. (See **www.radio-ware.com/products/fes.htm.**) The microcontroller code provides precise sequenced timing between switching events as well as hot-switch protection. The Front End Saver program minimizes the possibility of damaging a receiver's front end when using an auxiliary receive antenna such as a Beverage, flag or loop. The circuit is designed to: (1) disconnect the receive antenna during transmit; (2) deactivate a receive antenna preamp; (3) ground the receiver input port when transmitting; and (4) key an RF amplifier — all with sequenced timing and RF hot-switch fault protection. The C++ microcontroller code can be found in the file "S-QSK Front End Saver Code.txt" on the CD-ROM.

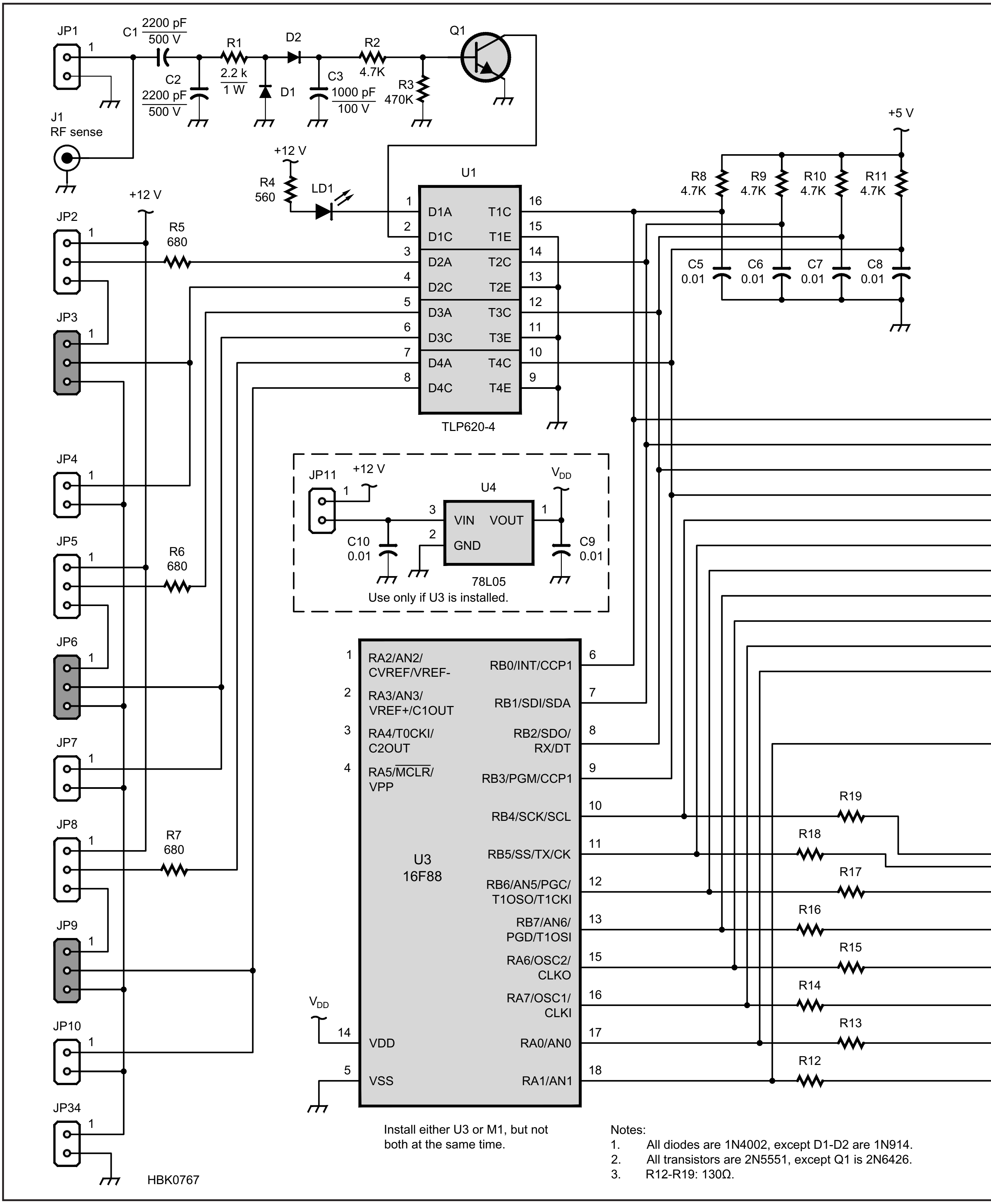
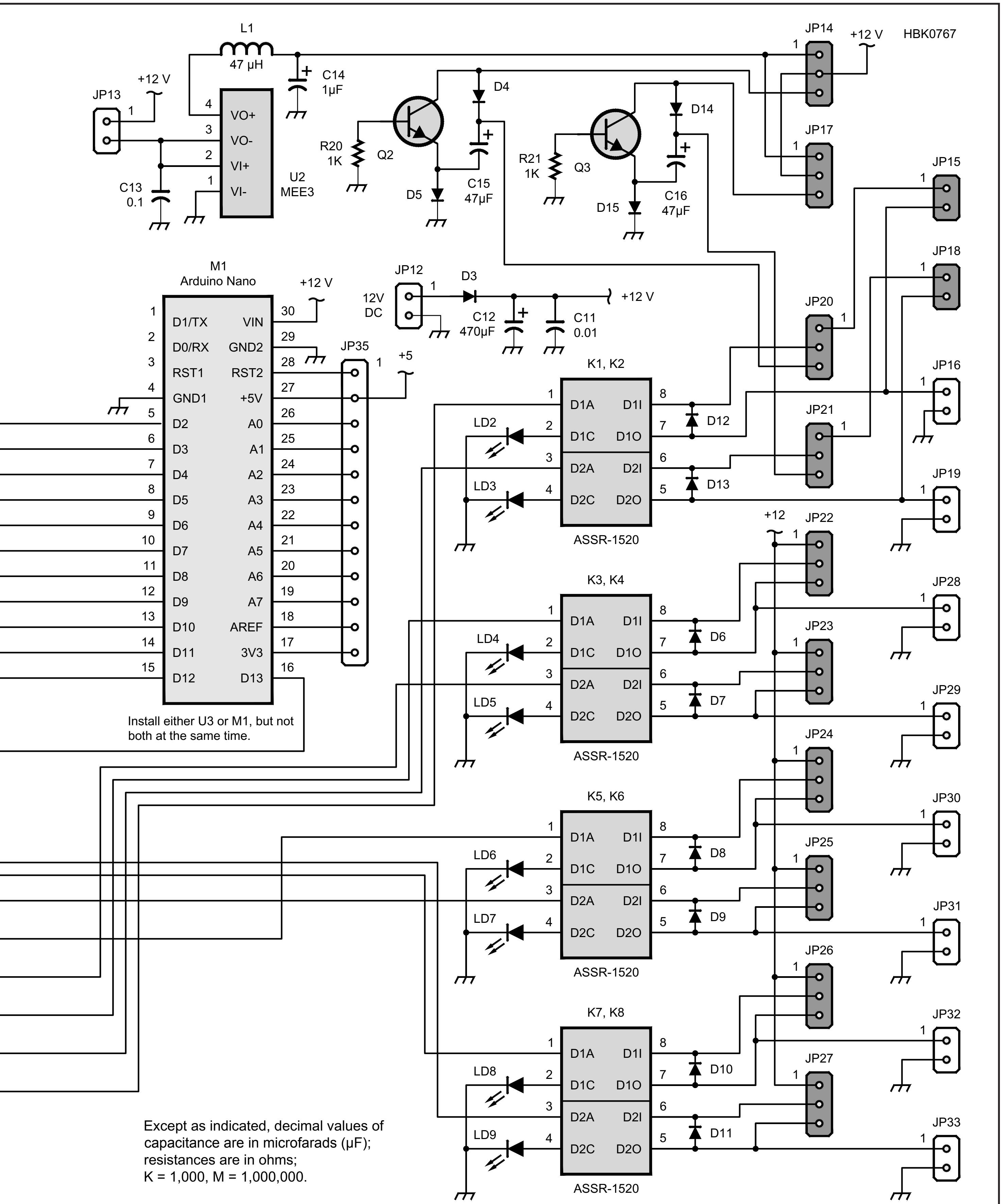



**Fig 24.73 — The S-QSK schematic. A complete parts list is provided as a separate file on the book's CD-ROM.**



HBK0767
L1
47 µH
C14
1µF
+12 V
JP13
U2
MEE3
VO+
VO-
VI+
VI-
C13
0.1
R20
1K
Q2
D4
D5
C15
47µF
R21
1K
Q3
D14
D15
C16
47µF
JP14
JP17
JP15
JP18
JP16
JP19
JP20
JP21
JP12
12V
DC
D3
C12
470µF
C11
0.01
M1
Arduino Nano
D1/TX
D0/RX
RST1
GND1
D2
D3
D4
D5
D6
D7
D8
D9
D10
D11
D12
VIN
GND2
RST2
+5V
A0
A1
A2
A3
A4
A5
A6
A7
AREF
3V3
D13
JP35
+5
Install either U3 or M1, but not both at the same time.
K1, K2
K3, K4
K5, K6
K7, K8
D1A
D1C
D2A
D2C
D1I
D1O
D2I
D2O
ASSR-1520
LD2
LD3
LD4
LD5
LD6
LD7
LD8
LD9
D12
D13
D6
D7
D8
D9
D10
D11
+12
JP22
JP23
JP24
JP25
JP26
JP27
JP28
JP29
JP30
JP31
JP32
JP33
Except as indicated, decimal values of capacitance are in microfarads (µF); resistances are in ohms; K = 1,000, M = 1,000,000.