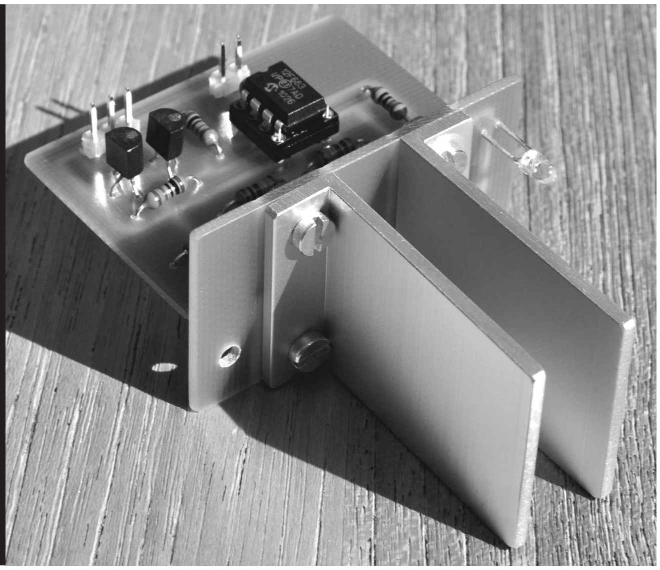

CapKey

PIC-based capacitive sensor-paddle for electronic morse keyers

Early sensor-paddles worked with the skin-resistance, which is a widely varying parameter and made two electrodes necessary - in the form of split or meandering paddles or solid paddles and a conductive hand pad. They were very unreliable and no pleasure to operate and that's why they gained a bad reputation.

the *CapKey* evolution

Being a passionate high-speed CW operator, in the late 1990s I had the idea for a sensor-paddle based on the capacitance of the human body to ground, which has a much more settled value of typically around 200 pF. So I developed a simple circuit around two CMOS ICs (4093/4013) which proved to be very reliable and precise in operation. Furthermore one single electrode per sensor now did the job - no slits or meanders, no conductive hand pad was necessary and the sensors could even be varnished or covered with plastic film. Since then all my mechanical paddles collect dust because I do not use them any more.

My second version appeared in 2004. It was based on a circuit by Milt Cram, W8NUE, which made use of the LTC1043 (a quite expensive switched-capacitor instrumentation IC) and worked with the capacitance formed by the finger across two electrodes [1]. I modified Milt's circuit so that it utilized the capacitance to ground and needed only one single elctrode per sensor exactly as my first version did. It worked as well as my original sensor-paddle and had even less current drain.

Both versions soon became quite popular among German CW operators, PCBs appeared on the scene and even completely assembled keyers based on these circuits were manufactured and offered by radio amateurs. During the following years, capacitive sensor-paddles gained popularity also abroad and a number of articles were published in amateur radio magazines [2,3]. Simultaneously industrial sensor-applications became widespread with specialized ICs appearing on the market. Today sensor-keyers for radio amateurs are commercially manufactured, for example by Sumner Eagerman, WA1JOS, who sells touch paddle keyers based on the QT113, a charge-transfer touch sensor IC made by Quantum / Atmel. However, the response time of these ICs is typically in the order of tens of milliseconds and they also exhibit a threshold hysteresis between "make" and "break" which makes them well suited for controlling electric devices but less suited for high-speed CW operation.

In 2011 I developed *CapKey* as the latest evolutionary stage of my initial idea. The result is a capacitive sensor-paddle controlled solely by software logic, utilizing one single re-programmable 8-pin PIC microcontroller 12F683 instead of discrete and specialized ICs. It is self-calibrating, needs no adjustments and responds about 100 times faster than the QT113 without any hysteresis - features which make it a very reliable high-precision instrument for the serious CW operator.

circuit details

The *CapKey* circuit is shown in **fig. 1**. Please note that this is not a complete CW keyer but a paddle that is able to control any imabic CW keyer. However, I have plans to add a keyer logic in the future. Programmed PICs 12F683 are available from the author. The BAT41 can be replaced by any other type of Schottky diode and the transistors are any general-purpose NPN types.

If the keyer and this sensor-paddle circuit are supplied together from one voltage source (and only in that case !) the 10K resistors and transistors may be replaced by two diodes with their cathodes (rings) pointing to Pin #2 and Pin #3. The supply-voltage range is +2.5 to +5.5 V. I recommend 3 AA batteries giving 4.5 V with a current drain of approx. 1 mA which is very low but still makes a switch necessary. Duracell MN1500 batteries for example should pro-

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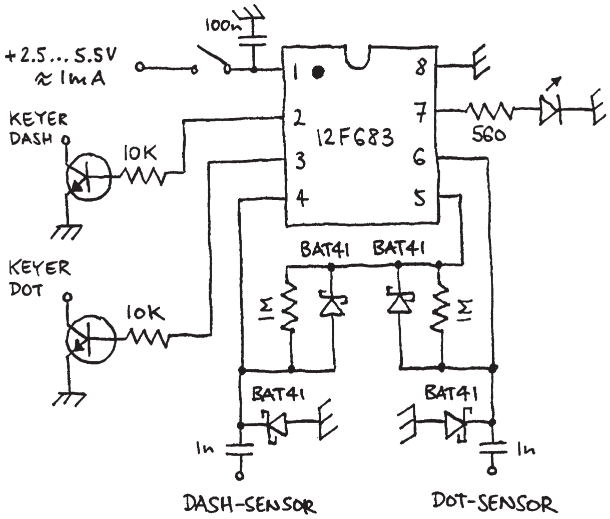


fig. 1. The *CapKey* schematic diagram.

vide more than 1000 service hours at 1 mA current drain.

In order to work reliably, the circuit must be able to make use of the high human body capacitance to ground and therefore paddle-ground must be connected to station-ground which is usually provided by the shield of the keying line.

construction notes

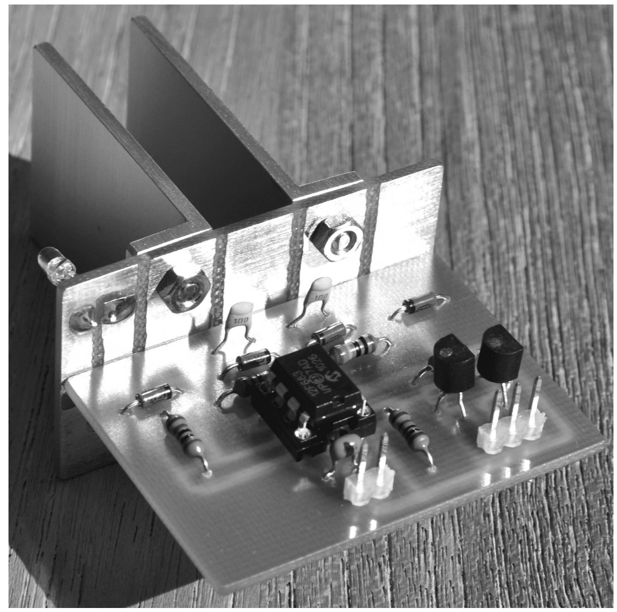
Because the circuit is so simple and construction straightforward, no detailed description and no PCB layout are presented here. Instead of an etched PCB you may use a small piece of perfboard. Or use single-sided PCB and mill out the copper traces with a dremel tool as I did with my demo version shown on the pictures - my preferred construction method for simple sircuits.

The sensors can be made of any conductive material, for example aluminium or single-sided PCB. In the latter case, the copper should be varnished or covered with self-adhesive plastic film with max. 0.1 mm thickness, otherwise the copper will be weared off after only a few months of intensive use. With varnish or plastic film the sensitivity is reduced but the paddle still works perfectly well. It is amazing what can be done with these cheap PICs. the 12F683 is capable of 5 MIPS (million instructions per second), in this application it runs with only 2 MIPS which enables it to securely detect capacitance changes of a mere 0.5 pF. The detection threshold for a sensor touch is set to four times that value or 2.0 pF. The sensor plates can be of any shape, but because the capacitance between them should not be higher than approx. 0.7 pF the following relations between sensor-area Sa and sensor-clearance Sc must be satisfied:

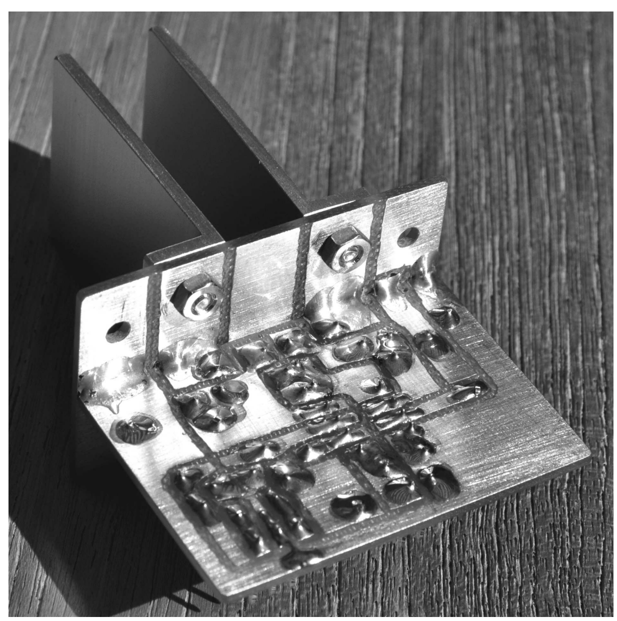
Sa [mm²] <= Sc [mm] x 80 mm
Sc [mm] <= Sa [mm²] / 80 mm

For example, if each sensor has an area of 40 x 30 mm = 1200 mm² their clearance should be at least 1200 mm² / 80 mm = 15 mm, which is the case for my demo version shown on the pictures. If both dot and dash are triggered when only one sensor is touched, the sensor area must be decreased or their clearance increased.

Please note that the PCB traces, wiring, sensors and any components in contact with Pin #4 and Pin #6 will become touch sensitive and should be treated with caution to limit the touch area to the sensor plates. All these components should have a clearance



***CapKey* demo version shown from rear top (above) and rear bottom (below). Two single-sided PCBs are solder-joined forming a "T", one holds the sensors and the other one holds the circuit. The sensors are made of anodized aluminium angle stock. The copper traces were milled out with a dremel tool.**



of at least 5 mm to conductive cabinet parts and the connectors between sensors and PCB should be as short as possible.

operation

During power-on keep your hands away from the sensors because an automatic sensitivity calibration of each sensor is done. After that very short initial calibration phase the LED will light up for two seconds. If no sensor is touched during the following LED transition from on to off, *CapKey* starts normal operation. However, if a sensor is touched the LED displays my callsign "DJ5IL" in slow morse code followed by four 2-digit numbers. The first value pair is for the dash-sensor, the second for the dot-sensor. The first value of each pair is the calibration-value and the second is the touch-value of that sensor giving double the sensor capacitance in pF (the maximum possible value is 64 = 32 pF).

For example "DJ5IL 04 25 06 07" means that the non-touched calibration capacitance was 2 pF for the dash-sensor / 3 pF for the dot-sensor and when a sensor was touched (when the LED went out) the capacitance was 12.5 pF for the dash-sensor / 3.5 pF for the dot-sensor. Thereafter *CapKey* resumes normal operation.

The LED flashes every few seconds as an operation indicator and reminder that *Capkey* is switched on. If you operate your CW keyer with dot- or dash-memory, in rare configurations the operation of the circuit might become erratic due to RFI (radio frequency interference). That problem does not exist if you operate without dot/dash-memory as I do. By the way: using plain iambic keying without dot/dash-memory brings the CW operator up to correct timing, a prerequisite for clean and melodic CW.

Due to the principle of operation, bypass capacitors from the sensors to ground to prevent RF pickup are not possible in this circuit. However, generally the very most RFI problems are not caused by radiation (pickup in RF fields) but by conduction (flow of RF currents) and usually can be cured by winding all lines entering or leaving the affected device onto high-permeability ferrite cores. A very good choice are toroidal cores by Amidon made of ferrite material #43.

references

1. Milt Cram, W8NUE, "The NUE Key - An Electronic Touch Sensor Paddle", QST, July 2004, p. 28.
2. Rod Kreuter, WA3ENK, "Not Another Touch Key", QST, November 2005, p. 28.
3. Allen Baker, KG4JJH, "Touch Paddle Keyer", QST, March 2007, p. 28.

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The pictures below show my *CapKey* prototype controlling a "CMOS Super Keyer III", all together powered by 3 AA batteries and built into a cabinet made of solder-joined single-sided PCB material. The sensors are also made of PCB with the copper covered by self-adhesive grey plastic film. The cabinet shell was salvaged from an old ETM-Keyer ...